UMTIK 2026

— İSTANBUL —

21. INTERNATIONAL CONFERENCE ON MACHINE DESIGN AND PRODUCTION

AUGUST 19-21, 2026

İSTANBUL TECHNICAL UNIVERSITY, TÜRKİYE

BOOK OF ABSTRACTS

İTÜ

MATIMAREN
Makina Mühendisliği Bölümü
Orta Doğu Teknik Üniversitesi
Ankara-Türkiye

21st INTERNATIONAL CONFERENCE
ON
MACHINE DESIGN AND PRODUCTION

CONFERENCE PROGRAMME
AND
BOOK OF ABSTRACTS

umtik 2026

19–21 August 2026

Istanbul–TÜRKİYE

MATIMAREN
DEPARTMENT OF MECHANICAL ENGINEERING
MIDDLE EAST TECHNICAL UNIVERSITY
ANKARA-TURKEY

Dedicated to the memory of

Prof. Dr. Turgut Tümer

and of all other IPC members we have lost in previous years.

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PREFACE

It is a great pleasure to welcome you to the 21st UMTIK – International Conference on Machine Design and Production. UMTIK is an international scientific event held biennially since 1984. Covering a wide range of contemporary topics—most notably mechanical engineering, but also manufacturing technologies, machine design, artificial intelligence applications, aerospace simulations, and industrial developments—the congress brings together academics, researchers, and industry representatives from around the world.

The theme of UMTIK 2026 is selected as "From Industry 4.0 to Industry 5.0 and Beyond: Building a More Sustainable World" for the following reasons.

The primary reason for the transition from Industry 4.0 to 5.0 is that production in Industry 4.0 focused entirely on machinery and digitalization and overlooked the human factor, environmental sustainability, and personalized production. Furthermore, production issues and supply chain problems experienced during the pandemic—along with the shortcomings of "dark factories" (a key focus of Industry 4.0)—are encouraging manufacturers to adopt resilient, human-centric, and sustainable production methods, which are the core tenets of Industry 5.0. The goal of this transition is to make systems smarter and greener by having technology work in collaboration with humans.

Taking all these factors into account, this topic was selected for UMTIK 2026 with the aim of bringing together organizations operating in the fields of machine design and manufacturing processes to facilitate knowledge sharing regarding the 2026 scope areas.

The Honorary Chairpersons of the Conference, the presidents of the universities, Prof. Dr. Hasan MANDAL of Istanbul Technical University and Prof. Dr. Ahmet YOZGATLIGİL of Middle East Technical University, will make significant contributions to UMTIK 2026 by participating in the panel session on "Building Human Capability for Collaborative Augmented Intelligence Ecosystems."

ROKETSAN will arrange a special session on Lifecycle Analysis of Modern Defense Systems, which will bring industry and academia together on the subject of defense systems that have started to receive more support due to the current geopolitical situation.

Additionally, UMTIK 2026 will include world-renowned keynote speakers who are experts in their fields, such as Prof. Dr. Alessandro BALSAMO, Prof. Dr. Yusuf ALTINTAŞ, Dr. Hakan YAVAŞ, Prof. Dr. Tamotsu MURAKAMİ, Prof. Dr. Feza KORKUSUZ, Dr. Andy GLEADALL, and Dr. Emel MAHMUTYAZICIOĞLU. It will also include a special session in memory of the late Professor Dr. S. Turgut Tümer, an esteemed scholar, educator, and researcher who made outstanding contributions to mechanical engineering education.

On August 18, 2026, the day before the UMTIK 2026 conference begins, a tutorial entitled "Metrology: Its Role in Production and Applications on Machine Tools" is arranged in consideration of the particular need for high-precision, high-value-added machine tools capable of precision manufacturing, especially within the defense and aerospace sectors.

The first-day program will start with the Opening Ceremony, including welcoming and opening speeches by the Conference Chair, Prof. Dr. S. Engin KILIÇ; the Rector of the host university (ITU), Prof. Dr. S. Hasan MANDAL; and the Rector of METU, Prof. Dr. Ahmet YOZGATLIGİL. It will be followed by the panel session "Building Human Capability for Collaborative Augmented Intelligence Ecosystems – Engineering Human-AI Collaboration for Industry 5.0 and Beyond," with panelists Prof. Dr. Hasan MANDAL, Prof. Dr. Ahmet YOZGATLIGİL, Donald H. TAYLOR, and Suat BAYSAN, moderated by Assoc. Prof. Tarkan GÜRBÜZ.

The first-day program in the afternoon starts with a plenary session featuring two keynote presentations. The first will be the keynote speech by Prof. Dr. Alessandro BALSAMO (the current President of CIRP) on "Coordinate Metrology in Manufacturing," chaired by Assoc. Prof. Dr. Tanfer YANDAYAN. The second is the keynote speech by Prof. Dr. Yusuf ALTINTAŞ (The University of British Columbia) on "Digital Machining of Blades," chaired by Prof. Dr. İbrahim Etem SAKLAKOĞLU.

There will be sponsor presentations by KALE PRATT & WHITNEY and RENISHAW between the sessions.

Later, there will be four parallel sessions with papers on Manufacturing Process Quality, Surface Engineering and Environmental Control; Structural Mechanics, Constitutive Modeling and Fracture Analysis; Mechanisms, Machine Components and Mechanical Performance; and a tutorial on "Digital Machining Principles and Industrial Practice,"

given by Prof. Dr. Yusuf ALTINTAŞ from The University of British Columbia.

The first-day program will be completed by the keynote presentation of Dr. Hakan YAVAŞ (FluxionSystem GmbH) on "Toward a Physics Foundation Model in Manufacturing: From Language Intelligence to Physics Intelligence," chaired by Assoc. Prof. Dr. Zekai Murat KILIÇ.

The second-day program starts with a panel entitled "Information Security in the Machinery Manufacturing Industry," in line with the previously mentioned topics. Our panelists are academics specializing in cybersecurity and information security: Prof. Prof. Dr. Şefik BAHTİYAR, Prof. Dr. Kemal BIÇAKÇI, Prof. Dr. İbrahim ÖZÇELİK, Prof. Dr. Alptekin KÜPÇÜ, and Prof. Dr. Mustafa ALKAN. We are addressing this subject because, in today's world, information assets, critical infrastructures, digital and smart manufacturing systems, supply chains, and industrial applications have become primary targets for cyberattacks. The panel will be moderated by Cüneyt DELİKTAŞ.

Later, a keynote presentation will be given by Prof. Dr. Tamotsu MURAKAMİ of The University of Tokyo on "Method for Creative Machine Design," chaired by Prof. Dr. Yoshiyuki MATSUOKA.

During the remainder of the second day, there will be four parallel sessions in three time slots through the end of the day (12 sessions in total). Papers in the special sessions will address Monitoring Technology for Manufacturing in Taiwan; Design of Personalized Medical Devices; Data-Driven Modeling and AI Applications in Engineering; Design Science and Timeaxis Design; and Design and Human Interface. Three special sessions on Lifecycle Analysis of Modern Defense Systems will be arranged by ROKETSAN. One paper session will focus on Robotics, and another local-language session will focus on metal forming and hybrid manufacturing.

There will be sponsor presentations by ONPLUS and KAE SYSTEMS between the parallel-session slots.

The third-day program begins with a plenary session dedicated to celebrating the life and achievements of Prof. Dr. Turgut Tümer, who passed away in 2025. The session will be presented by Prof. Dr. Nevzat ÖZGÜVEN and chaired by Prof. Dr. Birol KILKIŞ. Next, Prof. Dr. Feza KORKUSUZ from Hacettepe University will deliver his keynote speech on "Motion Analysis: From Basics to AI-Based Tools," chaired by Prof. Dr. Nevzat ÖZGÜVEN.

During the remainder of the third day, there will be four parallel sessions in three time slots through the end of the day (10 sessions in total). The papers will address Mechanisms, Machine Components and Mechanical Performance; Machining Mechanics, Composite Drilling and Cutting-Force Modeling; Digital Manufacturing and Tool Dynamics; Industrial Machine Design, Automation and Human-Centred Manufacturing; and AI Applications and Optimization in Manufacturing. One additional special session will be dedicated to the memory of Prof. Dr. S. Turgut Tümer. There will also be four sessions presented in Turkish.

Sponsor sessions featuring presentations by MEGA DANIŞMANLIK and BELGİN OIL will be held before the parallel-session slots.

In summary, the scientific program brings together 99 contributions presented in special and general sessions.

We would like to express our sincere thanks to the Presidency and all members of Istanbul Technical University for hosting UMTIK 2026 and providing its facilities. We hope all participants will feel the warm and positive atmosphere at Istanbul Technical University.

We highly acknowledge the Honorary Chairpersons of the Conference, the presidents of the universities: Prof. Dr. Hasan MANDAL of Istanbul Technical University and Prof. Dr. Ahmet YOZGATLIGİL of Middle East Technical University.

We would like to express our sincere appreciation to Assoc. Prof. Tarkan GÜRBÜZ for his hard work in organizing and moderating the first-day panel, together with panelists Prof. Dr. Hasan MANDAL, Prof. Dr. Ahmet YOZGATLIGİL, Donald H. TAYLOR, and Suat BAYSAN. We would also like to thank our Honorary Keynote Speaker, Prof. Yusuf ALTINTAŞ, and all other keynote speakers: Prof. Dr. Alessandro BALSAMO, Prof. Dr. Tamotsu MURAKAMİ, Dr. Hakan YAVAŞ, Prof. Dr. Feza KORKUSUZ, Dr. Andy GLEADALL, and Dr. Emel MAHMUTYAZICIOĞLU.

The second panel moderator, Cüneyt DELİKTAŞ, and the panelists, Prof. Dr. Abdül Halim ZAİM, Prof. Dr. Şefik BAHTİYAR, Prof. Dr. Kemal BIÇAKÇI, Prof. Dr. İbrahim ÖZÇELİK, Prof. Dr. Alptekin KÜPÇÜ, and Prof. Dr. Mustafa ALKAN, are highly acknowledged for their valuable contributions.

All chairpersons, authors, and participants are highly acknowledged for their valuable contributions. Asst. Prof. Dr. Bahram LOTFİ and Assoc. Prof. Dr. Tanfer YANDAYAN are gratefully acknowledged for the tremendous time and effort they spent in every phase of the conference organization and in the editorial work for the Conference

Proceedings and the Book of Abstracts.

Last but not least, we would like to thank the silver and bronze sponsors, members of the International Program Committee, Conference Secretariat “ORIGINEMC,” Scientific Secretariat (Research Assistants Yunus Emre NEHRİ and Mehmet Furkan ÖZBEY), and all who contributed to the success of UMTIK 2026.

We wish all participants a highly memorable time during their stay in ISTANBUL.

The Organizing Committee

UMTIK 2026

August 19th–21st, 2026

İstanbul, Türkiye

AUGUST 18, 2026 -- TUESDAY

08:00–09:00	**ENTRANCE HALL** **REGISTRATION**

09:00–12:30	**ROOM 1** **TUTORIAL** Metroloji; Üretimdeki Yeri ve Takım Tezgahlarındaki Uygulamaları Tutors: Doç. Dr. Tanfer Yandayan and Sibel Aslı Akgöz, TÜBİTAK UME

12:30–14:00	**LUNCH**

14:00–17:00	**ROOM 1** **TUTORIAL** CNC Takım Tezgahları üzerinde uygulama: Renishaw XM-60 Çok eksenli kalibrator ve QC20 ballbar sistemiyle takım tezgahlarının kalibrasyonu ve performans kontrolü uygulaması Tutors: Doç. Dr. Tanfer Yandayan, TÜBİTAK UME and Rıza Tuzcu, RENISHAW

AUGUST 19, 2026 -- WEDNESDAY

08:30–09:30	**ENTRANCE HALL** **REGISTRATION**
09:30–10:00	**ROOM 1** **OPENING CEREMONY** Welcoming Speech by Conference Chair, Prof. Dr. S. Engin Kılıç Speech by Host University (ITU) Rector, Prof. Dr. S. Hasan Mandal Speech by METU Rector, Prof. Dr. Ahmet Yozgatlıgil
10:00–10:30	**COFFEE BREAK**
10:30–12:30	**ROOM 1** **PLENARY SESSION – PANEL** **BUILDING HUMAN CAPABILITY FOR COLLABORATIVE AUGMENTED INTELLIGENCE ECOSYSTEMS** Engineering Human-AI Collaboration for Industry 5.0 and Beyond Moderator: Assoc. Prof. Tarkan Gürbüz Panelists: Prof. Dr. Hasan Mandal, Prof. Dr. Ahmet Yozgatlıgil, Donald H. Taylor and Suat Baysan
12:30–14:00	**LUNCH**
14:00–14:45	**ROOM 1** **PLENARY SESSION – KEYNOTE SPEECH** Speaker: Prof. Dr. Alessandro Balsamo “Coordinate Metrology in Manufacturing” Chair: Assoc. Prof. Tanfer Yandayan
14:45–15:00	**ROOM 1** **SPONSORS SESSION – KALE PRATT & WHITNEY**
15:00–15:45	**ROOM 1** **PLENARY SESSION – KEYNOTE SPEECH** Speaker: Prof. Dr. Yusuf Altıntaş “Digital Machining of Blades” Chair: Prof. Dr. İbrahim Etem Saklakoğlu
15:45–16:00	**ROOM 1** **SPONSORS SESSION – RENISHAW**
16:00–16:15	**COFFEE BREAK**

AUGUST 19, 2026 -- WEDNESDAY (CONT'D)

	ROOM 1	ROOM 2	ROOM 3	ROOM 4
16:15–17:45	**Tutorial: Digital Machining Principles and Industrial Practice** Tutor: Prof. Dr. Yusuf Altıntaş	**Manufacturing Process Quality, Surface Engineering and Environmental Control** 35, 50, 78, 79, 65	**Structural Mechanics, Constitutive Modelling and Fracture Analysis** 33, 42, 53, 69	**Additive Manufacturing** 7, 30, 41, 80

17:45–18:00	**COFFEE BREAK**

18:00–18:45	**ROOM 1** **PLENARY SESSION – KEYNOTE SPEECH** Speaker: Dr. Hakan YAVAŞ “Toward a Physics Foundation Model in Manufacturing: From Language Intelligence to Physics Intelligence” Chair: Assoc. Prof. Dr. Zekai Murat Kılıç

19:00	**WELCOME COCKTAIL**

AUGUST 20, 2026 -- THURSDAY

09:00–10:30	**ROOM 1** **PLENARY SESSION – PANEL** **INFORMATION SECURITY IN THE MACHINERY MANUFACTURING INDUSTRY** Moderator: Cüneyt Deliktaş Panelists: Prof. Dr. Şefik Bahtiyar, Prof. Dr. Kemal Bıçakçı, Prof. Dr. İbrahim Özçelik, Prof. Dr. Alptekin Küpçü and Prof. Dr. Mustafa Alkan
10:30–11:00	**COFFEE BREAK**
11:00–11:45	**ROOM 1** **PLENARY SESSION – KEYNOTE SPEECH** Speaker: Prof. Dr. Tamotsu Murakami “Method for Creative Machine Design” Chair: Prof. Dr. Yoshiyuki Matsuoka
11:45–12:00	**ROOM 1** **SPONSORS SESSION – ONPLUS**
12:00–13:30	**LUNCH**

	ROOM 1	ROOM 2	ROOM 3	ROOM 4
13:30–15:00	**SS: Monitoring Technology for Manufacturing in Taiwan** 5, 8, 13, 40, 58	**SS: Data-Driven Modeling and AI-Applications in Engineering** 15, 23, 111, 99	**SS: Design of Personalized Medical Devices** 21, 27	**SS: Lifecycle Analysis of Modern Defense Systems** 107, 102
15:00–15:30	**COFFEE BREAK**			
15:30–17:00	**SS: Design Science and Timeaxis Design** 25, 43, 44, 54	**SS: Data-Driven Modeling and AI-Applications in Engineering** 45, 47, 93	**SS: Design of Personalized Medical Devices** 36, 56, 72	**SS: Lifecycle Analysis of Modern Defense Systems** 103, 117, 118, 98

AUGUST 20, 2026 -- THURSDAY (CONT'D)

17:00–17:30	**COFFEE BREAK**

17:30–17:45	**ROOM 1** **SPONSORS SESSION – KAE SYSTEMS**

	ROOM 1	**ROOM 2**	**ROOM 3**	**ROOM 4**
17:45–19:15	**SS: Design and Human Interface** 14, 24, 34, 39	**Robotics** 37, 110, 125, 55	**Malzeme Şekillendirme, Kompozitler ve Hibrit İmalat** 6, 76, 87, 91	**SS: Lifecycle Analysis of Modern Defense Systems** UD, 106, 109, 101, 100

20:00	**GALA DINNER**

AUGUST 21, 2026 -- FRIDAY

09:00–09:45	**ROOM 1** **PLENARY SESSION** Celebration of the life and achievements of Prof. Dr. Turgut Tümer By: Prof. Dr. Nevzat Özgüven Chair: Prof. Dr. Birol Kılkış

09:45–10:30	**ROOM 1** **PLENARY SESSION – KEYNOTE SPEECH** Speaker: Prof. Dr. Feza Korkusuz "Motion Analysis: From Basics to AI-Based Tools" Chair: Prof. Dr. Nevzat Özgüven

10:30–11:00	**COFFEE BREAK**

11:00–11:15	**ROOM 1** **SPONSORS SESSION – MEGA DANIŞMANLIK**

	ROOM 1	ROOM 2	ROOM 3	ROOM 4
11:15–12:45	**SS: In Memory of Prof. Dr. S. Turgut Tümer** 49, 60, 74, 77, 124	**Mechanisms, Machine Components and Mechanical Performance** 22, 18, 26, 96	**Machining Mechanics, Composite Drilling and Cutting-Force Modelling** 64, 67, 82, 83	**Savunma ve Enerji Sistemlerinde Yapısal Tasarım ve Analiz** 31, 68, 73, 88, 105

12:45–14:15	**LUNCH**

14:15–14:30	**ROOM 1** **SPONSORS SESSION – BELGİN OIL**

	ROOM 1	ROOM 2	ROOM 3	ROOM 4
14:30–15:45	**Digital Manufacturing, Tool Dynamics** 84, 86, 90, 108	**Industrial Machine Design, Automation, and Human-Centred Manufacturing** 16, 10, 46, 51, 32	**Eniyileme** 19, 28, 122, 113	**AI Applications and Optimization in Manufacturing** 48, 52, 123, 120

15:45–16:15	**COFFEE BREAK**

AUGUST 21, 2026 -- FRIDAY (CONT'D)

	ROOM 1	ROOM 2	ROOM 3	ROOM 4
16:15–17:45	**Makine, Mekanizma ve Robotik Sistem Tasarımı** 3, 9, 114, 115	**Talaşlı İmalat, Kesme Dinamiği ve Yüzey Kalitesi** 12, 17, 112	–	–

AUGUST 18, 2026 (TUESDAY)

(T1)	**TUTORIAL** *Metroloji; Üretimdeki Yeri ve Takım Tezgahlarındaki Uygulamaları*	**ROOM 1**	**09:00--12:30**

Tutors: Assoc. Prof. Dr. Tanfer Yandayan and Sibel Aslı Akgöz

(T2)	**TUTORIAL** *CNC Takım Tezgahları üzerinde uygulama: Renishaw XM-60 Çok eksenli kalibrator ve QC20 ballbar sistemiyle takım tezgahlarının kalibrasyonu ve performans kontrolü uygulaması*	**ROOM 1**	**14:00--17:00**

Tutors: Assoc. Prof. Dr. Tanfer Yandayan and Rıza Tuzcu

(I1)	**PLENARY SESSION -- PANEL** *BUILDING HUMAN CAPABILITY FOR COLLABORATIVE AUGMENTED INTELLIGENCE ECOSYSTEMS*	**ROOM 1**	**10:30--12:30**

Moderator: Assoc. Prof. Tarkan Gürbüz

Engineering Human-AI Collaboration for Industry 5.0 and Beyond

Panelists: Prof. Dr. Hasan Mandal, Prof. Dr. Ahmet Yozgatlıgil, Donald H. Taylor and Suat Baysan

(I2)	**KEYNOTE SPEECH** *Coordinate Metrology in Manufacturing*	**ROOM 1**	**14:00--14:45**

Chaired by: Assoc. Prof. Tanfer Yandayan

Keynote Speaker: Prof. Dr. Alessandro Balsamo

(I3)	**SPONSORS SESSION** *KALE PRATT & WHITNEY*	**ROOM 1**	**14:45--15:00**

(I4)	**KEYNOTE SPEECH** *Digital Machining of Blades*	**ROOM 1**	**15:00--15:45**

Chaired by: Prof. Dr. İbrahim Etem Saklakoğlu

Keynote Speaker: Prof. Dr. Yusuf Altıntaş

(I5)	**SPONSORS SESSION** *RENISHAW*	**ROOM 1**	**15:45--16:00**

(A1)	**TUTORIAL** *Digital Machining Principles and Industrial Practice*	**ROOM 1**	**16:15--17:45**

Tutor: Prof. Dr. Yusuf Altıntaş

Metal cutting mechanics to predict torque, power consumption and cutting forces

Machine tool vibrations and measurement of machine dynamics using impact hammers

Chatter stability analysis for one- and multi-dimensional machining operations

Application of digital machining in industry to achieve high productivity without scrap

Demonstration of CUTPRO and MACHPRO technologies

(B1)	**SESSION** *Manufacturing Process Quality, Surface Engineering and Environmental Control*	**ROOM 2**	**16:15--17:45**

Chaired by: Assoc. Prof. Öncü Akyıldız

EFFECT OF ELECTRODE GEOMETRY ON THE MECHANICAL PROPERTIES OF DISSIMILAR RESISTANCE SPOT WELDED MS1500 AND SPFC590 STEELS (35)

Mehmet Görtan, Ümit Türkmen, Rahman Ehvan

EFFECT OF CLAMPING MECHANISM DESIGN ON DEFORMATION AND STRESS DISTRIBUTION IN A DOUBLE-HEAD CUTTING MACHINE (50)

Hasan Aytuğ Kurt, Eray Sürgeç, Mehmet Dağdelen, Mustafa Bakkal

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Uscan Uskaner, Zeynep Parlar

(C1)	**SESSION** *Structural Mechanics, Constitutive Modelling and Fracture Analysis*	**ROOM 3**	**16:15--17:45**

Chaired by: Dr. Nevzat Bircan Buğdaycı

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(D1)	**SESSION** *Additive Manufacturing*	**ROOM 4**	**16:15--17:45**

Chaired by: Prof. Dr. Ulaş Yaman

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Hongli Ju, Abdalla Omar, Wajira Mirihanage, Zekai Murat Kılıç

EFFECTS OF INFILL RATIOS ON THE STIFFNESS OF ADDITIVELY MANUFACTURED POLYLACTIC ACID CANTILEVER BEAMS (30)

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Structural Optimization and Performance Analysis of a Support Bracket for Additive Manufacturing (41)

Yaşar Üstünel, İzzet Özcan, Ferit Sait, Samet Akar

DESIGN, ANALYSIS, AND FABRICATION OF A MAGNETIC DRUG DELIVERY SYSTEM FOR LUNG CANCER (80)

Kübra Özer

(I6)	**KEYNOTE SPEECH** *Toward a Physics Foundation Model in Manufacturing: From Language Intelligence to Physics Intelligence*	**ROOM 1**	**18:00--18:45**

Chaired by: Assoc. Prof. Dr. Zekai Murat Kılıç

Keynote Speaker: Dr. Hakan Yavaş

(I7)	**PLENARY SESSION -- PANEL** *INFORMATION SECURITY IN THE MACHINERY MANUFACTURING INDUSTRY*	**ROOM 1**	**09:00--10:30**

Moderator: Cüneyt Deliktaş

Panelists: Prof. Dr. Şefik Bahtiyar, Prof. Dr. Kemal Bıçakçı, Prof. Dr. İbrahim Özçelik, Prof. Dr. Alptekin Küpçü and Prof. Dr. Mustafa Alkan

(I8)	**KEYNOTE SPEECH** *Method for Creative Machine Design*	**ROOM 1**	**11:00--11:45**

Chaired by: Prof. Dr. Yoshiyuki Matsuoka

Keynote Speaker: Prof. Dr. Tamotsu Murakami

(I9)	**SPONSORS SESSION** *ONPLUS*	**ROOM 1**	**11:45--12:00**

(A2)	**SPECIAL SESSION** *Monitoring Technology for Manufacturing in Taiwan*	**ROOM 3**	**13:30--15:00**

Chaired by: Prof. Dr. Ming-Chyuan Lu and Dr. Chung-Yu (Harkat) Tai

Physics-Condition-Gated Domain Adaptation for Robust Tool Wear Monitoring Under Varying Cutting Conditions Using Built-in Torque Signals (5)

Dong-Ru Zhan, Meng-Shiun Tsai, Yu-Sheng Lin, Jian-Ping Jhuang, Ting-Hua Zhang, Chien-Kuan Liu, Jai-Hong Jian, Yu-Wei Chiang

Wavefront-Dependent Femtosecond Laser Processing of Battery Anodes Enabled by a Novel Phase-Controlled Optical Setup (8)

Shuchen Zuo, Yu Wang, Olivier Allegre, Richard Fields

Tool Wear Classification in Milling Using Microphone Array-Based Beamforming and Machine Learning under Angular Installation Variations (13)

Kuan-Ming Li, Che-Wei Chang

Study of Lubrication Condition Monitoring for the Ball Screw System in a Machine Tool (40)

Cheng-Hong Lin, Ming-Chyuan Lu, Chung-Yu Tai

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(B2)	**SPECIAL SESSION** *Data-Driven Modeling and AI-Applications in Engineering*	**ROOM 1**	**13:30--15:00**

Chaired by: Prof. Dr. H. Özgür Ünver

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Max-Heiner Birk, Andreas Gaus, Christoph Reich, Michael Engler

MAINTENANCE SCHEDULING DECISION SUPPORT SYSTEM FOR AIRCRAFT MAINTENANCE EQUIPMENT USING MACHINE LEARNING (23)

Nilgün Fescioğlu Ünver, İzem Sude Ağbuga, Ayca Aslan, Cagatay Kuban, Ali Metehan Murathan, Selin Ruhi, Şevki Alper Sarıoğlu, Selman Emir Koç

Physical AI for Automotive Manufacturing Quality Intelligence: An Industrial Framework and Application Study (111)

Özgecan Sarı, Mükremin Çetinkaya, Hidayet Tunç

A KALMAN FILTER-BASED VIRTUAL SENSING FRAMEWORK FOR STRUCTURAL HEALTH MONITORING (99)

Ömer Dehan Özboz, Hakkı Özgür Ünver

(C2)	**SPECIAL SESSION**	**ROOM 2**	**13:30--15:00**
	Design of Personalized Medical Devices		

Chaired by: Dr. Ekaterina Smotrova-Kayalı

Special Session Keynote Speaker: Dr. Andy Gleadall

MECHANICAL BEHAVIOR AND FRACTURE OF BIOCOMPATIBLE POLYMERS FOR ADDITIVE MANUFACTURING (21)

Ilia Vindokurov, Mikhail Tashkinov

COMPUTATIONAL DESIGN OF POROUS METAMATERIALS WITH TAILORED MECHANICAL PROPERTIES FOR BONE-TISSUE ENGINEERING (27)

Mikhail Tashkinov, Nataliya Elenskaya, Vera Zatonskaya, Yulia Pirogova

(D2)	**SPECIAL SESSION**	**ROOM 4**	**13:30--15:00**
	Lifecycle Analysis of Modern Defense Systems		

Chaired by: Dr. Yağız Kayalı

Special Session Keynote Speaker: Dr. Emel Mahmutyazıcıoğlu

Application of Piezo Mechanism for Seeker (107)

Alican Bayram, Doğan Uğur Sakarya

Load-Dependent Model Reduction for Missile Modal Analysis (102)

Firat Ertürk, Ekin Oktay, Muhammed Faruk Pala

(A3)	**SPECIAL SESSION**	**ROOM 3**	**15:30--17:00**
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Chaired by: Prof. Dr. Yoshiyuki Matsuoka, Assoc. Prof. Takeo Kato and Prof. Dr. Akinari Hirao

Effect of Unit Cell Size on Pressure Distribution of 3D-Printed Gyroid Foam for Sitting Comfort (25)

Minh Tien Nguyen, Akinari Hirao

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Ikki Koda, Takeo Kato, Manabu Kikuchi, Katsuma Kitamura, Chiho Semba, Kenta Nishimura, Keita Ishii, Teppei Mori, Yukihiro Kiwaki

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Mimi Kawano, Kentaro Maeta, Takeo Kato, Kazutaka Ueda, Koji Koizumi, Hideyoshi Yanagisawa

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(B3)	**SPECIAL SESSION** *Data-Driven Modeling and AI-Applications in Engineering*	**ROOM 1**	**15:30--17:00**

Chaired by: Prof. Dr. H. Özgür Ünver

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Nedim İçten

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Ahmet Sayıl, Emirhan Aküzüm, Hasan Çakır, Mustafa Bakkal

Deep Learning-Based Design of 2D Metamaterials with Negative Poisson's Ratio (93)

Ata Umut Şahin, Cihan Tekoğlu

(C3)	**SPECIAL SESSION** *Design of Personalized Medical Devices*	**ROOM 2**	**15:30--17:00**

Chaired by: Dr. Ekaterina Smotrova-Kayalı

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Emre Ulusoy, Erhan İlhan Konukseven

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Anastasia Tarasova

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Muhammet Mustafa Er

(D3)	**SPECIAL SESSION** *Lifecycle Analysis of Modern Defense Systems*	**ROOM 4**	**15:30--17:00**

Chaired by: Dr. Ahmet Aydoğan

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(I10)	**SPONSORS SESSION** *KAE SYSTEMS*	**ROOM 1**	**17:30--17:45**

(A4)	**SPECIAL SESSION** *Design and Human Interface*	**ROOM 3**	**17:45--19:15**

Chaired by: Prof. Dr. Tetsuro Ogi and Assistant Prof. Kei Matsuoka

DEVELOPMENT OF AUGMENTED HAND SHADOW ART SYSTEM (14)

Hideo Miyachi

An Approach to Mental-Image Based Cognition for Intuitive Human-Robot Interaction --- Focusing on Human Ability of Problem Finding and Solving --- (24)

Masao Yokota, Rojanee Khummongkol

Generation of 3D models of historical Japanese castle town for virtual production use (34)

Towa Sakurai, Takahiro Yakoh

Development and Evaluation of a Barrier-Free Tourism Support System Using AIoT Avatars (39)

Yuki Kida, Hiroko Inokuma, Takahiro Yakoh, Tetsuro Ogi

(B4)	**SESSION** *Robotics*	**ROOM 2**	**17:45--19:15**

Chaired by: Prof. Dr. Erhan İlhan Konukseven

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Melikşah Beşir, Ahmet Alkan, Erhan İlhan Konukseven

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Metin Candan, Gökhan Mengütay, Erdoğan Türkoğlu, Mustafa Bakkal

(C4)	**SESSION (TÜRKÇE)** *Malzeme Şekillendirme, Kompozitler ve Hibrit İmalat*	**ROOM 1**	**17:45--19:15**

Chaired by: Dr. Hakan Kalkan

WASPALOY SÜPERALAŞIMININ DÖVÜLEBİLİRLİĞİ VE TERMO-MEKANİK DAVRANIŞI ÜZERİNE DENEYSEL BİR ÇALIŞMA (6)

Ceren Taçyıldız, Canan Gamze Güleryüz Parasız, Turgut Gülmez

Cam Elyaf Takviyeli PARA Malzemeden Üretilen Parçada Ring Yolluk Tasarımının Akış Davranışı ve Çarpılma Üzerindeki Etkisinin Araştırılması (76)

Murat Kaya, Samet Türkileri

HİBRİT İMALAT YÖNTEMLERİ ÜZERİNE NOTLAR (87)

Orhan Çakır, Tuğçe İşgüzar, Necdet Yakut, Mohammad Zaher Akkad

Atmosferik Basınçlı Soğuk Plazma Uygulamasının CFRP Kompozitin Yüzey Islanabilirliğine ve Yapıştırma Bağlantılarına Etkisinin İncelenmesi (91)

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Chaired by: Dr. Yağız Kayalı

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Industrial AI Applications for Production and Quality Assurance in High-Reliability Manufacturing (106)

Mehmet Can Baytekin, Beyzanur Zeybek

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Hüseyin Avni Yaşar, Abdurrahman Doğru

Modern Savunma Sistemlerinin Tasarım Doğrulama Süreçleri (101)

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Chaired by: Prof. Dr. Birol Kılkış

Speaker: Prof. Dr. Nevzat Özgüven

(I12)	**KEYNOTE SPEECH** *Motion Analysis: From Basics to AI-Based Tools*	**ROOM 1**	**09:45--10:30**

Chaired by: Prof. Dr. Nevzat Özgüven

Keynote Speaker: Prof. Dr. Feza Korkusuz

(I13)	**SPONSORS SESSION** *MEGA DANIŞMANLIK*	**ROOM 1**	**11:00--11:15**

(A5)	**SPECIAL SESSION** *In Memory of Prof. Dr. S. Turgut Tümer*	**ROOM 1**	**11:15--12:45**

Chaired by: Prof. Dr. Nevzat Özgüven

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Fatih Furkan Beköz, Yusuf Ata Ertürk, Tuba Okutucu-Özyurt

ENERGY SAVING METHODOLOGIES, OPPORTUNITIES, AND TRENDS IN THE TURKISH THERMAL POWER PLANTS (77)

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Behzat Bahadır Kentel, S. Turgut Tümer, A. Refik Güllü

(B5)	**SESSION** *Mechanisms, Machine Components and Mechanical Performance*	**ROOM 2**	**11:15--12:45**

Chaired by: Prof. Dr. Haydar Livatyalı

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FRICTION TORQUE LOSS IN RELATION TO FLEX THICKNESS ON ROTARY SHAFT SEALS (18)

Beliğ Tarık Otsay, Mustafa Cemal Çakır

INVERSE POSITION ANALYSIS OF A 4-RPR PLANAR PARALLEL ROBOT WITH CONFIGURABLE QUADRILATERAL PLATFORM (26)

İrem Ekici, Mustafa Özdemir

INTEGRATION OF MULTIPLE FOUR-BAR MECHANISM SYSTEMS: GUI IMPLEMENTATION AND CALCULATIONS (96)

Mustafa Can, Alpay Bilgiç, Onur Kendigel

(C5)	**SESSION**	**ROOM 3**	**11:15--12:45**
	Machining Mechanics, Composite Drilling and Cutting-Force Modelling		

Chaired by: Prof. Dr. Ulvi Şeker

INTEGRATING PRESSURE-DEPENDENCY INTO STRAIN-SOFTENING CONSTITUTIVE MODELS FOR FINITE ELEMENT SIMULATION OF SERRATED CHIP FORMATION IN Ti-6Al-4V (64)

Okan Yılmaz, Murat Büyük, Ramazan Hakkı Namlu

Cutting force modelling based on local tool angles and primary and secondary edge micro-geometry: application to threading (67)

Irati Malkorra Sarasola, Raphael Lorain

CHEMICAL ETCHANTS IN PCB MANUFACTURING AND WASTE MANAGEMENT OF USED ETCHANTS – SURVEY CASE IN TURKIYE (82)

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(D5)	**SESSION (TÜRKÇE)**	**ROOM 4**	**11:15--12:45**
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Chaired by: Prof. Dr. Mustafa Bakkal

ADR34 Gerekliliklerine Göre Farklı Tel Tasarımları İçin Üst Bağlantı Bölgesinin Yapısal Analizi (31)

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(I14)	**SPONSORS SESSION** *BELGİN OIL*	**ROOM 1**	**14:15--14:30**

(A6)	**SESSION** *Digital Manufacturing, Tool Dynamics*	**ROOM 1**	**14:30--15:45**

Chaired by: Dr. Bahram Lotfi

AN EXTENSIBLE PARAMETRIC FRAMEWORK FOR GEOMETRY-ADAPTIVE CNC TOOLPATH GENERATION AND SIMULATION IN MULTI-ISLAND MILLING CAVITIES (84)

Yunus Kızıltepe, Ulaş Yaman

MOLD-FREE INSPECTION OF CURVED SHEET-METAL WITH VISION ALIGNMENT (86)

Faraz Kaya, Alperen Aydın, Eren Karataş, Baran Can Ayvazoğlu

IMPROVING TOOL TIP RESPONSE BY INTEGRATING TMD COMBINED WITH CLD INSIDE A MILLING TOOL (90)

H. Elif Tola Demirel, Zekai Murat Kılıç

PDMS-BASED SURFACE REPLICATION FOR MICRO END MILL WEAR EVALUATION (108)

Ahmed Abotoor, Mohamed Hassan, Paulo Jds Bartolo, Zekai Murat Kılıç

(B6)	**SESSION** *Industrial Machine Design, Automation, and Human-Centred Manufacturing*	**ROOM 2**	**14:30--15:45**

Chaired by: Prof. Dr. Mustafa Cemal Çakır

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M. Çağrı Özkader, Barış Çetin, Öncü Akyıldız

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Yusuf Burak Açak, Ramazan Akar, Hüseyin Çıldır, Mustafa Bakkal

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(C6)	**SESSION (TÜRKÇE)** *Eniyileme*	**ROOM 3**	**14:30--15:45**

Chaired by: Prof. Dr. Orhan Çakır

DAİRE TESTERE İLE KESMEDE YAĞLAMA KOŞULLARI VE KESME PARAMETRELERİNİN KESME SICAKLIĞI VE YÜZEY KALİTESİ AÇISINDAN OPTİMİZASYONU (19)

Yunus Emre Kınacı, Mahmut Berkan Alisinoğlu, Ömer Fidan, Ebru Erdoğan, Kübra Kavut, Mehmet Alper Sofuoğlu

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(D6)	**SESSION** *AI Applications and Optimization in Manufacturing*	**ROOM 4**	**14:30--15:45**

Chaired by: Assoc. Prof. Tarkan Gürbüz

AI-Driven Parametric Optimization of CNC Workholding Systems via Surrogate Modeling and Customer-Specific Performance Indexing (48)

Alper Aydın, Eslem Tarcan, Yusuf Özkan, Mustafa Bakkal

Optimizing Compute Time and Material Yield in Cutting Optimization: A Hybrid Solution Architecture with Column Generation and Heuristic Algorithms (52)

İhsan Mahmutoğlu, Emine Aysu Şen, Utku Çetinkuş, Mustafa Bakkal

A MATHEMATICAL OPTIMIZATION APPROACH FOR MULTI-STAGE INDUSTRIAL PRINTING SCHEDULING WITH WAITING TIMES, BLOCKING, AND MAINTENANCE (123)

Osman Fırat Ede, Elif Zeynep Serper, Behzat Bahadır Kentel

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(A7)	**SESSION (TÜRKÇE)** *Makine, Mekanizma ve Robotik Sistem Tasarımı*	**ROOM 1**	**16:15--17:45**

Chaired by: Prof. Dr. Ali Oral

SAC İŞLEME MAKİNELERİ İÇİN TAM OTOMATİK DÖNDÜRME SİSTEMİ (3)

Emre Akagündüz

TEK MOTOR TAHRİKLİ ZİNCİR AKTARMA MEKANİZMASINA SAHİP DİKEY KATLANABİLİR, UYARLANABİLİR HAREKETLİ CEPHE SİSTEMİNİN TASARIMI, KİNEMATİK ANALİZİ VE PROTOTİP UYGULAMASI (9)

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Ahmet Yılmaz, Ömer Bayraktar, Ulvi Şeker

Scara Robot Tabanlı Frezeleme Sisteminin Tasarımı ve Geliştirilmesi (115)

Sıla Betül Kirzuk, Furkan Durmaz, Osman Atsan, Kerem Yağız Karakaş, Yunus Emre Nehri, Ali Oral

(B7)	**SESSION (TÜRKÇE)**	**ROOM 2**	**16:15--17:45**
	Talaşlı İmalat, Kesme Dinamiği ve Yüzey Kalitesi		

Chaired by: Dr. Ramazan Hakkı Namlu

ENDÜSTRİYEL DAİRE TESTERE KESİMİNDE AÇIKLANABİLİR YAPAY ZEKA İLE TIRLAMA KARAKTERİZASYONU VE TESPİTİ (12)

Rodi Göze, Yunus Emre Kınacı, Furkan Aydın, Mahmut Berkan Alisinoğlu, Mehmet Alper Sofuoğlu

DAİRE TESTERE İLE KESMEDE TIRLAMA TİTREŞİMLERİNİN FFT TABANLI SPEKTRAL ANALİZ İLE ARAŞTIRILMASI (17)

Yunus Emre Kınacı, Furkan Aydın, Mahmut Berkan Alisinoğlu, Mehmet Alper Sofuoğlu

İşlenmiş Yüzeylerde Yüzey Bütünlüğünü İyileştirmek İçin Düşük Maliyetli Bilyalı Ezme Aparatı Geliştirilmesi ve Test Edilmesi (112)

Fatih Karakaş, Şükran Katmer, Ulvi Şeker

KEYNOTE PAPERS

No.	Title	Keynote
I2	Coordinate Metrology in Manufacturing	Prof. Dr. Alessandro Balsamo
I4	Digital Machining of Blades	Prof. Dr. Yusuf Altıntaş
I6	Toward a Physics Foundation Model in Manufacturing: From Language Intelligence to Physics Intelligence	Dr. Hakan Yavaş
I8	Method for Creative Machine Design	Prof. Dr. Tamotsu Murakami
I12	Motion Analysis: From Basics to AI-Based Tools	Prof. Dr. Feza Korkusuz

About the Speaker

Prof. Dr. Alessandro Balsamo

Dr Alessandro Balsamo is senior scientist at the INRIM – the National Metrology Institute of Italy – in Turin. He is currently President of the CIRP, the International Academy for Production Engineering and co-chair of the Organising Committee of the CIRP General Assembly in Turin in August 2026.

He is Chair of the CCL-WG CM on Coordinate Metrology, which was established in 2024 and he is tasked to form and start.

He is Convenor of the ISO/TC 213/WG 4 Uncertainty and decision rule in the ISO Technical Committee Dimensional and Geometrical Product Specifications and Verification in charge of the ISO-GPS system of standards. He was project leader of three published international standards and one technical specification; he currently is of two future international standards. He also serves as Liaison Officers to the CIRP and the ISO/TC 213.

COORDINATE METROLOGY IN MANUFACTURING

Coordinate metrology is ubiquitous in manufacturing. Its appealing aspect is the capability of adaptation to virtually any geometry to measure, as opposed to other dimensional techniques and instruments that are task-specific. This distinctive feature is also a major metrological issue though: measurement tasks are virtually infinite and each is very different from all others, resulting in any new measurement to be studied on its own as to the measurement procedure, the assurance of traceability and the evaluation of the uncertainty.

Coordinate metrology has enjoyed an extraordinary development in the last 30 years and more and more techniques, sensors and apparatuses are available on the market. Among them, notably the optical techniques and devices and the computer tomography.

This talk aims to present the state of the art in coordinate metrology. This encompasses an overview of the principal measuring techniques, the available methods for evaluating the uncertainty in industry, the state of the art in ISO documents on the subject and the recent activity in the CCL (Consultative Committee for Length), the Committee of the CIPM (International Committee on Weights and Measures) in charge for length metrology.

About the Speaker

Prof. Dr. Yusuf Altıntaş

Professor Altintas obtained his Bachelor's degree from Istanbul Technical University (1975), his M.Sc. from the University of New Brunswick (1980), and his Ph.D. from McMaster University in Canada (1987). He worked as a machine tool manufacturing engineer in Turkey (1977–1978), a process development engineer at Pratt & Whitney Canada in Montreal (1980–1981), and the principal engineer of the Canadian Institute of Metalworking at McMaster University in Hamilton (1981–1982). He joined The University of British Columbia and founded the Manufacturing Automation Laboratory in 1986. His research covers metal cutting, machine tool vibrations, control, sensors and actuators for machine tools, and virtual machining. He has published 235 archival journal articles and 100 conference papers, with approximately 48,000 citations and an h-index of 112 on Google Scholar. He authored the widely used book "Manufacturing Automation: Principles of Metal Cutting Mechanics, Machine Tool Vibrations and CNC Design," first published in 2000 and followed by a second edition in 2012, as well as Chinese editions (2003 and 2017) and a Turkish edition (2017). He is the Chief Editor of CIRP Journal of Manufacturing Science and Engineering. His research laboratory created the advanced machining process simulation software CUTPRO, the virtual part-machining process simulation software MACHPRO, and the open-modular five-axis CNC system Virtual CNC. These technologies are used by more than 300 companies and research centers in machining and machine tools worldwide.

Professor Altintas is a fellow or member of the Royal Society of Canada, the National Academy of Engineering (USA), CIRP, ASME, SME, ACATECH (Germany), the European Academy of Engineering, CAE, EC, Tokyo University, P&WC, AvH, and ISNM. His honors include Pratt & Whitney Canada's University Partnership Award (1997), APEG BC's Meritorious Achievement Award (2002), APEG BC's R.H. McLachlan Award (2010), the UBC Killam Engineering Teaching Prize (2011), the Engineers Canada Gold Medal (2011), the SME Albert M. Sargent Progress Award (2012), the NSERC Synergy Award, the ASME Blackall Machine Tool and Gage Best Journal Paper Award, the Republic of Turkey's Special Scientific Award in Science and Engineering (2013), the Georg Schlesinger Production Engineering Award (Berlin, 2016), and the ASME William T. Ennor Manufacturing Technology Award (USA, 2016). He holds honorary doctorate degrees from Stuttgart University (2009) and Budapest University of Technology (2013). He served as President of CIRP, the International Academy for Production Engineering, in 2016–2017. Since 2017, he has held the title of Distinguished University Scholar at The University of British Columbia and has been appointed an Officer of the Order of Canada, the

country's second-highest honor. He is the founding coordinator of the Mechatronics Option and a co-founder of UBC's Manufacturing Engineering degree program.

He directed the NSERC CANRIMT Machining Research Network across Canada from 2010 to 2023 and held the NSERC–P&WC–Sandvik Coromant Industrial Research Chair Professorship from 2002 to 2025 to develop next-generation Digital Machining Twin Technology. He is also the founding president of MAL Manufacturing Automation Lab. Inc., which develops virtual machining technology for industry.

DIGITAL MACHINING OF BLADES

Our laboratory has been conducting research to model five-axis milling of highly flexible gas turbine blades for almost four decades. Integral bladed rotors, turbine blades, and compressor blades are machined from difficult-to-cut titanium and nickel alloys. Highly flexible blades experience chatter, severe forced vibrations, and static deflections during ball-end milling. Unless chatter is avoided and deflection marks are kept within the tolerances, the costly blades are scrapped. Trial-and-error-based tests are too costly; consequently, experience-based process plans lead to long cycle times or scrap. The physics of the process must therefore be modeled to conduct digital cutting tests and plan optimal tool paths that minimize machining time without damaging the part or cutting tools.

Thin-walled blades are modeled using shell elements at the “camber,” the mid-surface between the pressure and suction surfaces of the airfoil. The frequency response function (FRF) of the blade is predicted using a computationally efficient perturbation technique as the metal is removed. Chatter-free radial depth and axial step depth are optimally predicted for rough and finish machining of the blade using a “waterfall” machining approach. Once the tool path is generated, five-axis machining of the blade is simulated to predict chatter occurrence and frequency, surface location errors left on the blade due to tool and blade deflections, and forced-vibration amplitudes caused by cutting loads.

The algorithms have been experimentally proven in machining standard turbine blades and are currently being packaged for industrial use.

About the Speaker

Dr. Hakan Yavaş

Dr. Hakan Yavaş is a scientist and senior executive who has undertaken numerous important international studies in the fields of aerospace and materials science and has made significant contributions to the development of many technologies in materials engineering and digital transformation. Having completed his PhD in Materials Science and Engineering at Iowa State University – during which he served as a researcher at Ames National Laboratory, the University of California Santa Barbara, and Los Alamos National Laboratory – and conducted postdoctoral research at Johns Hopkins University, Department of Mechanical Engineering, and served as Research Professor at ČVUT v Praze, Dr. Yavaş has been awarded many prestigious international awards for his academic work. Throughout his career, he has served as a PI/Co-PI on various projects based in the US, Europe, and Turkey; and has successfully managed projects supported by reputable institutions such as the European Union Horizon 2020, TÜBİTAK, and the US Department of Energy. Currently, Dr. Yavaş is the Chief Science Officer at FluxionSystem GmbH, based in Germany, and continues his work on the integration of artificial intelligence-based manufacturing technologies into industrial processes. He previously served as the Development and Sustainability Unit Manager at Lilium GmbH, and as the Research and Technology Centers Manager and Additive Manufacturing Manager at Turkish Aerospace Industries (TUSAŞ). The owner of over 40 internationally recognized patents and scientific publications, Dr. Yavaş has won many prestigious awards, including the International ISIF Gold Medal, the Materials Research Society (MRS) Graduate Award, and the Iowa State University Research Excellence Award.

TOWARD A PHYSICS FOUNDATION MODEL IN MANUFACTURING: FROM LANGUAGE INTELLIGENCE TO PHYSICS INTELLIGENCE

The rapid advancement of artificial intelligence has demonstrated that machines can develop remarkable forms of domain-specific intelligence from natural language understanding to visual perception. Yet in manufacturing, AI remains predominantly limited to data-driven pattern recognition, falling short of capturing the complex physical phenomena that govern real-world production processes. This raises a fundamental question: can AI develop a genuine form of physics intelligence for manufacturing?

This keynote introduces the concept of the Physics Foundation Model (PFM) – a new frontier in which AI transcends data-driven pattern recognition to develop a genuine physics intelligence for manufacturing. While current industrial AI applications remain largely confined to statistical correlations within narrow domains, the PFM vision proposes a fundamentally different approach: an intelligent architecture that bridges the gap between data-driven machine learning and the underlying physics of manufacturing processes. By unifying synthetic data generation, adaptive process modeling, real-time edge intelligence, and physics-based simulation within a coherent orchestration framework, this architecture enables AI to move beyond curve fitting toward a deeper representation of physical phenomena across multiple domains.

Drawing on real-world implementations in advanced manufacturing including process parameter optimization and predictive quality systems – the presentation demonstrates how this integrated approach enables pre-production quality prediction and environment-adaptive process control. Beyond incremental improvements, the talk outlines a roadmap toward AI systems that do not merely model physics but discover it. Charting the path from language intelligence to physics intelligence as a foundational element of Industry 5.0.

About the Speaker

Prof. Dr. Tamotsu Murakami

Tamotsu Murakami is a Professor of Design Engineering Laboratory in Department of Mechanical Engineering at the University of Tokyo. He received his Bachelor of Engineering, Master of Engineering and Doctor of Engineering from the University of Tokyo in 1984, 1986 and 1989, respectively. His interests in research and education include design engineering from the viewpoints of “design by human” and “design for human”. He is a member of ASME and Fellow of JSME (Japan Society of Mechanical Engineers). He was the Chair of Design & Systems Division, JSME in 2005. He has been a jury member of Good Design Award, JDP (Japan Institute of Design Promotion) since 2009 and the Vice President of JSDE (Japan Society for Design Engineering) since 2017.

METHOD FOR CREATIVE MACHINE DESIGN

The ideation for creative machine design are complex thought processes that combine the conscious and unconscious, logic and intuition. Traditionally, methods for creative thought have been based on empirical rules, but in recent years, research in various fields, including design engineering, psychology, and cognitive neuroscience, has gradually shed light on the content of the thought process known as ideation. Based on a survey of these fields, this talk will introduce methods for creative machine design, presenting design examples.

About the Speaker

Prof. Dr. Feza Korkusuz

Feza Korkusuz MD (Scholar) (Avesis) attended medical specialization in Orthopedic Surgery and Traumatology at Gazi University Medical Faculty, Department of Orthopedic Surgery and Traumatology between 1987 and 1992, after graduating from Ankara University Medical Faculty in 1986. Between 1989 and 1990 he studied in Osaka University Faculty of Medicine, Department of Orthopaedic Surgery from where he graduated with a postgraduate diploma. His clinical and research studies focused on Spine Surgery, Sports Medicine and Basic Sciences. Dr. Korkusuz worked at the Middle East Technical University (METU) as an orthopedic surgeon and Medical Director at the Medical Center, and at the Department of Physical Education and Sports as the Head of the Department until 2013. In 1994 and in 2001 he became Associate Professor and Professor. In 1999 and 2000, he received the METU Prof. Dr. N. Parlar Foundation young investigator and the Scientific and Technological Research Council of Turkey (TÜBİTAK) Promotion Award in Medical Sciences.

Between 1991 and 2016, he was a member to the Orthopaedic Research Society. In 2008 he became an active member of the Association of Bone and Joint Surgeons (ABJS), and since 2006 he has been the corresponding and deputy editor of Clinical Orthopaedics and Related Research (CORR). In 2017, he became an active member to the Turkish Academy of Science (TUBA). He was the Advisor to the President of TÜBİTAK between 2018 and 2021. He currently is the Chairman of the Department of Hacettepe University Medical Faculty, Department of Sports Medicine. His current research interests are motion analysis, multi-omics, novel biosensors for osteoarthritis diagnosis and new therapeutics delivery using micro-needles.

MOTION ANALYSIS: FROM BASICS TO AI-BASED TOOLS

Human motion analysis has become an essential component of modern musculoskeletal medicine, rehabilitation, sports sciences, orthopedics and performance research. Movement reflects the integrated function of the musculoskeletal and neuromuscular systems, and abnormalities in movement patterns frequently precede structural deterioration, pain, or measurable functional decline.

Historically, movement assessment relied predominantly on observational examination performed by clinicians and therapists. Although experienced observers can identify major biomechanical abnormalities, traditional observational methods are inherently subjective and limited by interobserver variability, inconsistency, and inability to quantify subtle movement alterations.

Advances in biomechanics, computer vision, wearable technologies, and artificial intelligence have substantially transformed the field of motion analysis. Conventional laboratory-based motion capture systems provide highly accurate kinematic and kinetic measurements, but their routine implementation in outpatient clinics and large-scale real-world monitoring has remained limited.

Recent developments in AI-based computer vision technologies have enabled markerless motion analysis systems. These systems use standard video recordings combined with deep learning algorithms to detect body landmarks, reconstruct human movement, and generate quantitative biomechanical data without reflective markers or wearable sensors.

One important development in this area is the MAI Motion platform, an AI-based markerless motion analysis system capable of three-dimensional movement assessment using standard video recordings. The system evaluates movement quality through the C.R.A.F.T. framework: Control, Repetition, Asymmetry, Flow, and Rotational Dynamics.

Recent studies demonstrate the clinical applicability of AI-assisted markerless motion analysis in patients with knee osteoarthritis. Serial movement assessments following orthobiologic interventions showed progressive improvements in overall C.R.A.F.T. scores across treatment groups over time.

The integration of AI into motion analysis extends beyond kinematic measurement to automated pattern recognition, predictive analytics, longitudinal monitoring, and individualized performance profiling. As these technologies continue to evolve, they may reshape rehabilitation, orthopedics, sports medicine, and human performance sciences.

ABSTRACTS

ENGLISH PAPER ABSTRACTS - SPECIAL SESSIONS

PHYSICS-CONDITION-GATED DOMAIN ADAPTATION FOR ROBUST TOOL WEAR MONITORING UNDER VARYING CUTTING CONDITIONS USING BUILT-IN TORQUE SIGNALS (5)

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ABSTRACT

Cross-condition generalization remains challenging in tool wear prediction for smart manufacturing. Although spindle current is a low-cost alternative to external sensors, variations in cutting conditions (e.g., spindle speed and feed rate) cause shifts in signal distributions. Without physical constraints, these shifts can lead to divergence and negative transfer in data-driven models, reducing predictive performance under unseen conditions. To address this issue, this study proposes a physics-informed deep learning framework that combines tool engagement-based signal decoupling with a dual-stream neural network. Built on a 1D Temporal Convolutional Network (1D-TCN), it uses the immersion ratio per tooth as a physical prior to separate torque signals into active cutting and air-cutting (machine noise) segments.Furthermore, a Physical Condition Gating mechanism maps cutting cycles and cumulative energy into dynamic attention weights. This enables adaptive feature calibration during fusion, facilitating the autonomous learning and decoupling of non-linear background noise. To evaluate the proposed approach, experiments were conducted across ten distinct cutting conditions, encompassing variations in spindle speed, feed rate, depth of cut, width of cut, and climb/conventional milling. The dataset was partitioned by condition: eight conditions (24,026 samples) formed the training set, while two independent conditions served as the validation set (2,273 samples) and the testing set (3,791 samples) for the tool wear regression task. Compared to a data-driven baseline lacking physical guidance, the physics-informed model reduced the Root Mean Square Error (RMSE) on the validation set from 37.40 µm to 4.92 µm, and on the testing set from 21.88 µm to 4.56 µm. These results demonstrate that stable tool wear monitoring is achievable relying solely on built-in torque signals, thereby reducing the reliance on expensive external sensors and manual downtime costs.

Keywords: Built-in torque signals, Physics-condition-gated domain adaptation, Varying cutting conditions

WAVEFRONT-DEPENDENT FEMTOSECOND LASER PROCESSING OF BATTERY ANODES ENABLED BY A NOVEL PHASE-CONTROLLED OPTICAL SETUP (8)

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ABSTRACT

This study presents a phase-characterised optical set-up for shaped-beam femtosecond laser processing of double-sided lithium-ion battery anodes. The phase response was found to be power-independent, with consistent phase scaling across applied powers and a 2π phase shift completed at approximately 220-225 grey levels (GL). The measured degree of polarisation remained high, at approximately 0.93-0.97 for 8.5, 13.3 and 21.6 mW. The generated beam profiles were in good agreement with MATLAB simulations, confirming reliable wavefront control. Under identical processing conditions, wavefronts carrying different orbital angular momentum (OAM) produced distinct kerf morphologies: m=0 gave a deeper cut with a taper angle of approximately 37°, while m=1 gave a shallower groove with a steeper taper of around 53°, indicating different Cu-layer interaction and ejecta behaviour.

Keywords: Femtosecond laser processing, Anodes enabled by, Phase-controlled optical setup

TOOL WEAR CLASSIFICATION IN MILLING USING MICROPHONE ARRAY-BASED BEAMFORMING AND MACHINE LEARNING UNDER ANGULAR INSTALLATION VARIATIONS (13)

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ABSTRACT

Compared with other non-contact sensing approaches, microphone arrays offer greater flexibility in installation and adjustment for industrial applications. However, previous studies have typically required precise and time-consuming calibration of microphone array orientation and position to ensure high experimental repeatability. To address this issue, this study investigates tool wear classification in milling using microphone array-based beamforming and machine learning under angular installation variations. The effects of angular deviations on classification performance are evaluated using either a single microphone or a Uniform Linear Array (ULA). First, sound signals were collected using a single microphone, and a random forest classifier was trained using signals acquired without angular deviation. The trained model was then tested under different angular installation conditions. The classification accuracy reached 85% when no angular deviation was present, but decreased to 76% as the angular deviation increased. To improve robustness against angular variations, three different methods were proposed. In Method 1, a model trained using non-deviated single-microphone signals was applied to signals processed by Delay-and-Sum (DS) beamforming before classification. The resulting classification accuracy was similar to that obtained without beamforming. In Method 2, separate machine learning models were trained using raw sound signals collected at three incident angles (0°, -5°, and -10°). The Direction of Arrival (DoA) of the sound signals was first estimated, and the corresponding angle-specific model was selected for prediction. This approach improved the classification accuracy to 85%-94%. In Method 3, DS beamforming and DoA-based model selection were combined. However, due to the high background noise in the enclosed machining environment, the effectiveness of beamforming was limited, and only marginal improvement was achieved compared with Method 2.

Keywords: Tool wear classification, Milling, Microphone array-based beamforming

STUDY OF LUBRICATION CONDITION MONITORING FOR THE BALL SCREW SYSTEM IN A MACHINE TOOL (40)

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ABSTRACT

Insufficient lubrication of a ball screw can reduce operational stability and accelerate screw wear. This study investigates the relationship between lubrication film conditions and vibration signals, and establishes a lubrication film condition monitoring system. To ensure the selection of the most suitable sensor type and improve the sensitivity and stability of sensor signals, the vibration signal was selected based on the results of preliminary studies. Subsequently, signal analysis was employed to determine the optimal feed rate for the ball screw, the motion for signal acquisition, and the timing for starting the data acquisition. To investigate the relationship between lubrication film conditions and vibration signals, feature analysis of vibration signals under different lubrication supply conditions was performed. Classification indices were further used to quantify the detection capability for each feature for identifying lubrication film conditions. The developed monitoring model adopted a Backpropagation Neural Network (BPNN) integrated with feature and decision fusion to detect the four-stage lubrication film condition. To collect sensor data required for signal analysis and system development, experiments and system development were first conducted on a single-axis research platform in the laboratory. The developed methodology was then applied to a mill-turn machine for evaluation in an industrial environment. The results demonstrated that the system developed on the laboratory platform achieved 100% classification rate for four different lubrication supply conditions. Furthermore, by following the development procedure established in the laboratory, a lubrication condition monitoring system for the ball screw was successfully implemented on the industrial mill-turn machine and achieve 100% classification rate as well.

Keywords: Study, Lubrication condition monitoring, Ball screw system

A PHYSICS-INFORMED DEEP LEARNING FRAMEWORK FOR CRACK RISK PREDICTION IN ALUMINUM INGOT CASTING PROCESSES (58)

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ABSTRACT

The direct chill (DC) casting of aluminum ingots involves complex interactions between melt temperature and cooling conditions, exhibiting highly non-linear characteristics. In industrial practice, the scarcity of abnormal samples presents a significant challenge known as the small-sample imbalance problem. Conventional data-driven models are prone to overfitting under data-constrained scenarios, while traditional numerical simulations fail to meet the requirements of real-time early warning due to their high computational cost. This study proposes a physics-informed deep learning framework that integrates physical feature engineering with Long Short-Term Memory (LSTM) networks for predicting crack risks in aluminum ingots. Seven physically derived features, including the shell thermal stress index and solidified shell thickness, were formulated to reflect the solidification mechanism, thereby enhancing the model's perception of the underlying physical states of the process. To address the class imbalance, Focal Loss was incorporated to optimize the gradient update strategy during model training. Experimental results demonstrate that after incorporating physical features, the F1 Score of the LSTM model significantly increased from 0.6576 to 0.8658. Furthermore, a decision support system was constructed by combining Retrieval-Augmented Generation (RAG) with Small Language Models (SLM) to translate predictive insights into expert-level operational recommendations. The findings indicate that the physics-informed architecture effectively overcomes the limitations of small datasets, providing a high-reliability real-time monitoring solution for high-risk casting processes.

Keywords: Deep learning framework, Crack risk prediction, Ingot casting processes

AI-BASED INTERPRETATION OF TECHNICAL DRAWINGS FOR VARIANT-SPECIFIC INFORMATION PROVISION IN BROWNFIELD ASSEMBLY (15)

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ABSTRACT

In variant-rich brownfield assembly, technical drawings often contain essential target information for variant interpretation, but their unstructured PDF format prevents direct integration into automated workflows. This paper presents a modular AI-based pipeline for extracting machine-readable target information from such drawings. The method combines PDF rendering, title-block masking, YOLOv8-based detection, geometric filtering, left-right assignment and rule-based size classification. It was evaluated on 63 technical drawings from hydraulic component production. Within the investigated dataset, all drawings were processed correctly by the final workflow. The results indicate that the approach is suitable as a target-information module for downstream assembly automation.

Keywords: Technical drawings, Brownfield assembly, Ai-based interpretation

MAINTENANCE SCHEDULING DECISION SUPPORT SYSTEM FOR AIRCRAFT MAINTENANCE EQUIPMENT USING MACHINE LEARNING (23)

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ABSTRACT

This study proposes a decision support system integrating machine learning and operations research methods to predict failures of aircraft maintenance equipment and optimize maintenance planning. Remaining Useful Life (RUL) is estimated using XGBoost and integrated into a Mixed Integer Linear Programming (MILP) model to generate a 60-day maintenance schedule. Results indicate improved prioritization of high-risk equipment, balanced workload distribution, and enhanced operational efficiency, with an estimated annual economic benefit of approximately 2.45 million USD.

Keywords: Decision support system, Aircraft maintenance equipment, Machine learning

PHYSICAL AI FOR AUTOMOTIVE MANUFACTURING QUALITY INTELLIGENCE: AN INDUSTRIAL FRAMEWORK AND APPLICATION STUDY (111)

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ABSTRACT

Physical AI is emerging as a new generation of intelligent systems capable of perceiving, understanding, and acting within the physical world. While recent advances in Artificial Intelligence have transformed digital decision-making, manufacturing environments require AI systems that can interact directly with physical assets, production processes, and industrial equipment. Automotive quality control represents a particularly relevant application domain due to the significant costs associated with manufacturing defects, rework operations, quality escapes, and production variability. This study presents an industrial framework for applying Physical AI to automotive manufacturing quality control. The framework is derived from Automated Quality Inspection (AQI) applications developed for multiple automotive production environments, including press shop, body-in-white, and engine assembly operations. The proposed approach combines simulation-driven synthetic defect generation, deep learning-based computer vision, application-specific inspection architectures, and reinforcement learning-supported optimization within a unified quality intelligence workflow.

Keywords: Physical ai, Industrial framework, Manufacturing quality intelligence

A KALMAN FILTER-BASED VIRTUAL SENSING FRAMEWORK FOR STRUCTURAL HEALTH MONITORING (99)

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ABSTRACT

This study presents a Kalman filter-based virtual sensing framework derived from a Finite Element Model (FEM) to reconstruct dynamic responses at unmonitored locations. The method is experimentally validated on a Carbon Fiber Reinforced Polymer (CFRP) plate under random white-noise excitation. Using sparse strain measurements from piezoelectric sensors, the framework estimates velocity, which is verified against laser vibrometer data.

Keywords: Virtual sensing framework, Structural health monitoring

STRUCTURAL DESIGN OPTIMIZATION OF THE HYBRID COMPOSITE BATTERY ENCLOSURE OF AN ELECTRIC VEHICLE (45)

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ABSTRACT

This study presents structural design and optimization of a carbon fiber and glass fiber reinforced hybrid battery enclosure for electric vehicles. Structural integrity of the battery enclosure is evaluated through static stiffness, vibration, and crash analyses using the commercial finite element analysis software LS-DYNA. To map the design space, a Latin hypercube sampling plan was established to develop five surrogate models: Artificial neural networks, Gaussian process regression, Support vector regression as well as Quadratic and Cubic response surface models. The study compares the prediction accuracy and optimization performance of these models. It is found that the optimized hybrid design achieves a comparable mass to the baseline aluminum design while offering significantly superior structural stiffness and enhanced safety margins.

Keywords: Battery enclosure, Hybrid composites, Surrogate modeling

SENSORLESS FORCE ESTIMATION IN ROTARY SWAGING OF AISI 4140 STEEL PIPES USING MACHINE LEARNING (47)

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ABSTRACT

This study investigates machine learning-based sensorless force estimation in 4140 steel pipes formed by the rotary swaging method. Accordingly, industrial motor current signals and dynamic finite element analysis force data were mapped. By utilizing machine learning algorithms, current variations were directly transformed into mechanical force, establishing a digital twin that predicts instantaneous stresses with high accuracy. The developed sensorless model ensures simultaneous part quality while extending die life. Findings provide a high-efficiency optimization framework for industrial manufacturing processes focused on predictive maintenance.

Keywords: Rotary swaging, Cold forming, 4140 Steel

DEEP LEARNING-BASED DESIGN OF 2D METAMATERIALS WITH NEGATIVE POISSON'S RATIO (93)

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ABSTRACT

This study proposes a deep learning-based framework for designing two-dimensional metamaterials with a negative Poisson's ratio. A convolutional neural network (CNN) encoder-decoder architecture is developed to predict optimized metamaterial topologies while reducing the computational cost of conventional topology optimization. The effects of model scale, image resolution (32 × 32 and 64 × 64 pixels), dataset size, and learning rate are systematically investigated in terms of prediction accuracy, generalization capability, model complexity, and training efficiency. Results show that the reduced-order model achieves predictive performance comparable to the larger architecture while using approximately 75% fewer trainable parameters and reducing training time by nearly 17%, demonstrating an efficient surrogate framework for metamaterial topology optimization.

Keywords: Metamaterials, Negative poisson's ratio, Deep learning

MECHANICAL BEHAVIOR AND FRACTURE OF BIOCOMPATIBLE POLYMERS FOR ADDITIVE MANUFACTURING (21)

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ABSTRACT

This work investigates the mechanical behavior and fracture mechanisms of biocompatible polymers (PLA and PEEK) manufactured by fused deposition modeling (FDM). A comprehensive experimental methodology was developed, including tensile, compressive, flexural, and fracture toughness testing, as well as structural analysis before and after exposure to liquid environments. The influence of infill angle, printing parameters, and thermal treatment on mechanical performance was evaluated (Vindokurov et al., 2022). The results demonstrated pronounced anisotropy of FDM structures and improved properties of thermally treated PEEK due to enhanced crystallinity and interlayer adhesion (Vindokurov et al., 2022). Additionally, porous and lattice structures exhibited increased sensitivity to degradation (Elenskaya et al., 2024; Pirogova et al., 2025).

Keywords: Fracture, Mechanical behavior, Biocompatible polymers

COMPUTATIONAL DESIGN OF POROUS METAMATERIALS WITH TAILORED MECHANICAL PROPERTIES FOR BONE-TISSUE ENGINEERING (27)

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ABSTRACT

Porous architected metamaterials are promising for bone-tissue engineering because they can reproduce the hierarchical morphology and mechanical behavior of native bone. This work presents a computational framework for designing porous scaffolds based on triply periodic minimal surfaces (TPMS) and random bicontinuous structures with controllable mechanical and morphological properties. Parametric geometry control, homogenization-based evaluation, morphology grading, and multi-objective optimization are combined to tailor stiffness, anisotropy, and porosity for tissue-specific applications (Elenskaya et al., 2025, 2023; Kononov and Tashkinov, 2025; Pirogova et al., 2025). The proposed framework supports the development of additively manufactured patient-specific implants with improved mechanical compatibility and structural functionality, including scaffolds mimicking trabecular-cortical transitions.

Keywords: Bone-tissue engineering, Computational design, Porous metamaterials

DESIGN OF A TOGGLE ASSISTED SPRING MECHANISM FOR ENHANCED GRASPING IN A SINGLE-DOF PROSTHETIC HAND (36)

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ABSTRACT

This study investigates a dual preloaded spring mechanism for the finger transmission of an active myoelectric hand prosthesis. It covers backlash analysis of the lead-screw transmission and finger joints, the design of symmetric thumb-side and index-side springs with springs with over-center behavior about a toggle position, integration into a commercial myoelectric hand, and analytical evaluation of its effect on backlash, grasp retention on rigid objects, and motor energy consumption. The study aims to suppress backlash-induced free motion caused by accumulated clearances, enable reliable grasping of rigid objects, and reduce actuator load and associated energy consumption. The findings contribute to mechanism-level design strategies for improving grasp stability in active upper-limb prostheses.

Keywords: Toggle-assisted mechanism, Myoelectric prosthesis, Preloaded spring mechanism

NUMERICAL ANALYSIS OF THERMOMECHANICAL BEHAVIOR OF AUXETIC RING-SHAPED LATTICES (56)

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ABSTRACT

Auxetic metamaterials with a negative Poisson's ratio attract increasing interest due to their unique deformation behaviour, including lateral expansion under tensile loading enabled by geometric design [Tarasova and Tashkinov, 2024]. Ring auxetics are particularly promising for applications requiring controllable radial compliance. This study proposes a design where the auxetic mechanism activates in planes perpendicular to the ring axis [Tarasova and Tashkinov, 2025]. Numerical analysis investigates the impact of re-entrant unit cell geometry (angle, cell quantity, thickness) on the mechanical response under thermomechanical loading. The results demonstrate that geometric tailoring provides an effective means of controlling radial deformability, highlighting the potential of ring-shaped auxetic lattices for advanced engineering applications, including personalized biomedical devices.

Keywords: Numerical analysis, Thermomechanical behavior, Auxetic ring-shaped lattices

MECHANICAL DESIGN OF HYDRAULIC MONOCENTRIC MICROPROCESSOR-CONTROLLED KNEE JOINT (72)

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ABSTRACT

This study investigates the mechanical design of hydraulic monocentric microprocessor-controlled knee joint for transfemoral amputees. It covers the monocentric kinematic structure, a double-acting hydraulic piston supported by an accumulator, and a valve system used to control the damping characteristics of the piston. The main aim of this study is to develop a knee joint that can effectively imitate human knee kinematics and natural gait patterns while maintaining reliable and efficient mechanical operation. The findings of this study are expected to contribute to the development of advanced lower-limb prosthetic systems with improved walking stability, motion performance, and user comfort.

Keywords: Mechanical design, Microprocessor-controlled knee joint

EFFECT OF UNIT CELL SIZE ON PRESSURE DISTRIBUTION OF 3D-PRINTED GYROID FOAM FOR SITTING COMFORT (25)

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ABSTRACT

Prolonged sitting can increase discomfort and physical stress on the human body, making seat foams comfort an important factor in user experience and seating design. Recently, 3D-printed foam structures have received increasing attention for seating applications because of their lightweight characteristics and design flexibility. However, previous studies have mainly focused on physical testing and prototype development, with limited using simulation methods. In this study, a combined testing and finite element simulation approach was used to investigate the mechanical behavior of gyroid structures under sitting condition. Pressure distribution and surface deformation obtained from physical tests were used to validate the simulation results. After validation, the simulation model was applied to investigate the influence of unit cell size, one of the main design parameters of gyroid structures, on contact pressure distribution. The results indicate that the proposed approach can support design based on simulation for improved sitting comfort.

Keywords: Pressure distribution, Unit cell size, Sitting comfort

ANALYSIS OF THE IMPRESSION STRUCTURE OF TYRE TREAD DESIGN (43)

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ABSTRACT

This study aimed to clarify the impression structure of tire treads and its relationship with their geometric features. Semi-structured interviews and an evaluation experiment using the Semantic Differential method were conducted, followed by factor analysis. Three factors, comfort, aesthetic quality, and trust, were extracted. CatBoost regression models were then constructed to predict the factor scores from geometric features calculated using a two-dimensional discrete Fourier transform. The models were interpreted using SHAP, revealing characteristic combinations of groove angle and frequency related to each factor.

Keywords: Analysis, Impression structure, Tyre tread design

ANALYSIS OF BRAIN ACTIVITY DURING SKETCH-BASED IDEA TRANSFORMATION (44)

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ABSTRACT

This study investigated how design expertise influences cognitive strategies during idea transformation in sketching-based design tasks using EEG microstate analysis. Based on Goel's framework, ideation processes were categorized into New Generation (NG), Vertical Transformation (VT), and Lateral Transformation (LT). Comparisons between students and designers showed significantly higher microstate class A coverage in designers during LT. Further analysis among students, novice designers, and experienced designers revealed higher class A coverage in designers across all conditions, whereas students showed higher class C coverage than experienced designers. These findings suggest expertise-related differences in visual imagery and memory-based cognitive processing during idea transformation.

Keywords: Analysis, Sketch-based idea transformation

DETECTING PHYSICAL FATIGUE AND DROWSINESS DURING LONG-TERM TRUCK DRIVING USING CENTER OF PRESSURE DYNAMICS (54)

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ABSTRACT

In truck transportation, preventing accidents caused by drowsiness and physical distress during long-duration driving is a critical challenge. While existing systems focus on drowsiness, methods to decouple these two fatigue factors remain unestablished. This study proposes a non-intrusive method to differentiate mental and physical fatigue using Center of Pressure (COP) dynamics. We conducted a 100-minute continuous driving experiment using a driving simulator with 12 participants. The experiment revealed distinct behavioral patterns: increased physical distress significantly elevated both COP path length and standard deviation (SD), whereas increased drowsiness significantly increased SD but had no significant effect on path length. Based on these findings, we developed a four-quadrant model to classify driver states. Physiological data, including core body temperature, validated the model's accuracy. This approach enables specific interventions, such as recommending either a nap or a stretch, based on the identified fatigue source.

Keywords: Center, Detecting physical fatigue, Long-term truck driving

DEVELOPMENT OF AUGMENTED HAND SHADOW ART SYSTEM (14)

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ABSTRACT

Shadow puppetry is an art form created by projecting three-dimensional objects onto a two-dimensional screen. In Japan, in particular, hand shadow puppetry, using human hands, has been a beloved part of Japanese culture since the 17th century. However, since many shadow puppet performances are educational shows aimed at children, it is difficult to operate them on a self-sustaining basis, and they tend to be supported by subsidies from the national government and local authorities for the purpose of cultural preservation. This research aims to enhance the artistic value of hand shadow puppetry and achieve economic sustainability by developing an advanced system. The proposed system employs image processing and AI to add color to typically monochromatic images and enables a single performer to manipulate multiple shadows simultaneously. This paper presents the proposed prototype system and the enhanced shadow puppetry video created as a trial.

Keywords: Development, Shadow art system

AN APPROACH TO MENTAL-IMAGE BASED COGNITION FOR INTUITIVE HUMAN-ROBOT INTERACTION --- FOCUSING ON HUMAN ABILITY OF PROBLEM FINDING AND SOLVING --- (24)

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ABSTRACT

Nowadays, great progress in artificial intelligence (AI) and robotics may well predict a world in the very near future where ordinary people and home robots will be interacting very naturally in casual scenes, finding and solving various problems cooperatively. Particularly, in the field of AI, deep-learning (DL) based methodologies have been widely utilized to simulate some aspects of human cognition, such as pattern recognition (based on discriminative AI) and natural language processing (based on generative AI (GAI) with large language models (LLMs)), with remarkable outcomes. In fact, GAI improves technical effectiveness in this field in comparison with traditional rule-based AI. However, many conventional AI models, particularly those based on DL, are not transparent or explainable in reasoning, which makes it difficult to understand how they make decisions. Moreover, all benchmarks of the applications are based on behaviorism and do not require the process from input to output to be cognitively human-like in the sense of strong psychological equivalence. Yokota, M. has proposed a computational model of mental image in his original semantic theory named Mental Image Directed Semantic Theory, within traditional rule-based AI. This paper proposes a methodology to provide robots with problem finding/solving ability based on the mental image model. The application system CoMaS (Conversation Management System) has shown a good result in problem finding/solving as question-answering through natural language.

Keywords: Cognition, Problem finding, Approach

GENERATION OF 3D MODELS OF HISTORICAL JAPANESE CASTLE TOWN FOR VIRTUAL PRODUCTION USE (34)

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ABSTRACT

This paper proposes a generative AI system for reconstructing Japanese castle towns. The system generates three-dimensional (3D) models that incorporate historical town configuration rules, detailed town planning, such as specific town types and block sizes, and topographical correlations, based on given location, era, and scale parameters, to ensure historical accuracy. This paper validates spatial accuracy through comparison with historical records and demonstrates the flexibility to generate various town models tailored to user-defined parameters.

Keywords: Japanese castle town, Generation, 3D models

DEVELOPMENT AND EVALUATION OF A BARRIER-FREE TOURISM SUPPORT SYSTEM USING AIOT AVATARS (39)

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ABSTRACT

When people with disabilities engage in tourism, they require prior research of accessible routes and facilities, while some information may still be difficult to obtain on-site. This study aims to enable access to information without such preparation by developing a barrier-free tourism support system using AIoT avatars. These avatars are anthropomorphized objects created using generative AI and engage users in autonomous conversations. Experiments were conducted at a hotel, souvenir shop, and cafe. The results suggested that the system provided users with the information necessary for tourism activities, enabling them to correctly reach their destinations or place orders and make purchases.

Keywords: Tourism support system, Aiot avatars, Development

EFFECT OF IMU MOUNTING LOCATION ON VIBRATION BEHAVIOR IN FIXED-WING UAV FUSELAGES: MODAL AND HARMONIC ANALYSIS (49)

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ABSTRACT

Navigation accuracy in fixed-wing UAVs depends on the quality of IMU data, which is often degraded by motor-induced structural vibrations. This study investigates the impact of IMU mounting locations on vibration behavior using Abaqus for modal and harmonic analyses. By identifying natural frequencies and mode shapes, the dynamic response of the fuselage was evaluated under operational loads. Results indicate that traditional Center of Gravity (CoG) placement can coincide with vibration antinodes, leading to increased noise. Conversely, positioning the IMU at structural nodal points significantly minimizes mechanical interference at the source. This methodology reduces reliance on software-based filters and offers a physical optimization strategy for sensor placement in UAV design.

Keywords: Imu mounting location, Vibration behavior, Effect

EFFECT OF Y2O3 CONTENT ON THE COMPRESSIVE AND HARDNESS BEHAVIOUR OF AZ91 MAGNESIUM MATRIX COMPOSITES FABRICATED BY POWDER METALLURGY (60)

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ABSTRACT

AZ91 magnesium alloy was reinforced with 5, 10, and 15 wt.% Y2O3 by ball milling and uniaxial hot pressing at 550 °C under 100 MPa in argon. Vickers microhardness and uniaxial compression tests showed that both properties increased with reinforcement content and reached a maximum at 10 wt.% Y2O3, where the compressive strength rose from 185 to 258 MPa and the hardness from 82 to 121 HV1. Further addition up to 15 wt.% caused a partial decline (245 MPa, 110 HV1), attributed to Y2O3 agglomeration. The optimum at 10 wt.% is explained by combined Hall-Petch, Orowan, thermal-mismatch, and load-transfer mechanisms.

Keywords: Compressive, Effect, Y2o3 content

INVESTIGATION OF 3-D PRINTING POTENTIAL OF BIO-INSPIRED COLD PLATES FOR ELECTRIC VEHICLE BATTERY THERMAL MANAGEMENT (74)

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ABSTRACT

A bio-inspired cold plate compatible with 3-D printing steps is developed for the thermal management of electric vehicle batteries. Gyroid-based cooling channels with high heat transfer potential are designed. To reduce the inherent hydraulic resistance of gyroid structures, Murray's Law is utilized as a design criterion. Field-Driven Design is utilized to grade the gyroid wall thicknesses based on local flow parameters. Validations via Lattice Boltzmann simulations proved that multi-field grading achieves an optimized pressure drop and stable flow within standard pump capacities. This framework establishes a highly efficient, optimized hydraulic foundation for subsequent thermal analyses directly influencing battery performance.

Keywords: Investigation, 3-D printing potential, Bio-inspired cold plates

ENERGY SAVING METHODOLOGIES, OPPORTUNITIES, AND TRENDS IN THE TURKISH THERMAL POWER PLANTS (77)

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ABSTRACT

This paper presents a new model about the burden of nearly avoidable carbon dioxide emissions arising from exergy destruction in the built environment, as defined by the Second Law. This model establishes a direct relationship between exergy destruction and carbon dioxide emission responsibility to trace the root cause of the emissions. Yet, it is recognised that the actual carbon footprint share of the Turkish power industry is inflated in the literature because most emissions result from exergy destruction by power-demanding sectors rather than power plants themselves. With such an appraisal of the root causes of emissions beyond measuring them at power plant stacks, this model also underscores sustainable, realistic energy-saving measures in the built environment and offers new opportunities beyond current trends. The waste heat from power plants has been investigated for its potential utilisation for useful work, such as district heating and cooling. A case study is provided about district heating and cooling options in the Afşin-Elbistan region, utilising the waste heat from the existing lignite power plant and receiving make-up water from the Ceyhan River, about 30 kilometres away. Three scenarios were compared: The current situation, the district energy system, and, thirdly, a three-step fluidised-bed combustion system for the power plant. Results indicate that emission savings from 50,000 household-equivalent new, recovered, and refurbished habitations following the major earthquake in 2022 in the Kahramanmaraş area of Türkiye exceed 60% in the second scenario and reach 100% in the third scenario.

Keywords: Global warming, Energy saving, Decarbonization

IMPROVED GAIT DATA EVALUATION USING NORMAL BANDS AND AUTOCORRELATION ANALYSIS (124)

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ABSTRACT

Confidence and prediction bands provide a statistically robust approach for evaluating and interpreting gait data, offering an alternative to the commonly used mean ±1 standard deviation bands. In this study, gait data collected at the Biomechanics Laboratory of the Mechanical Engineering Department at METU were analyzed for three groups: healthy subjects, patients with gonarthrosis, and patients with calcaneus fractures. Confidence and prediction bands (90%) were constructed for all joint angles of the healthy group. Pelvic obliquity, hip abduction, and sagittal plane hip, knee, and ankle angles exhibited distinct patterns with relatively low variability, whereas pelvic rotation and rotational joint angles showed high variability, limiting their statistical significance. Confidence bands effectively captured characteristic joint angle behavior and enabled meaningful comparisons between healthy and pathological gait patterns. Comparisons of sagittal plane confidence bands clearly distinguished the gait characteristics of the patient groups. Prediction bands were shown to classify individual gait data within a population with a known error level. To address the influence of experimental errors and data variability, autocorrelation analysis was incorporated into prediction band construction. Although autocorrelation-based prediction bands improved statistical reliability, they reduced the physical interpretability of the data. Therefore, using prediction bands both before and after autocorrelation analysis is recommended to provide complementary statistical and biomechanical insights into gait analysis.

Keywords: Autocorrelation analysis, Gait data evaluation, Normal bands

ENGLISH PAPER ABSTRACTS - GENERAL SESSIONS

EFFECT OF ELECTRODE GEOMETRY ON THE MECHANICAL PROPERTIES OF DISSIMILAR RESISTANCE SPOT WELDED MS1500 AND SPFC590 STEELS (35)

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ABSTRACT

This study examines the influence of electrode geometry and welding current on the mechanical behavior of resistance spot welded dissimilar MS1500 and SPFC590 steel sheets with a thickness of 1.2 mm. The investigated electrode geometries, selected according to ISO 5821 recommendations for this sheet thickness, were G0-6 mm, G0-8 mm, and A0. The joints were evaluated based on tensile-shear load capacity, absorbed failure energy, and fracture characteristics. Among the investigated geometries, the G0-6 mm electrode exhibited excessive expulsion at comparatively lower welding currents due to its smaller contact area, resulting in inferior mechanical performance. The highest combination of tensile-shear strength and energy absorption was achieved using the G0-8 mm electrode geometry, with values of 19.42 kN and 43.81 J, respectively. In the case of the A0 electrode geometry, a similar maximum tensile-shear load of 19.68 kN was obtained; however, the corresponding failure energy remained lower at 40.94 J. Tensile-shear tests conducted under the optimum welding conditions revealed that all joints failed through a pull-out fracture mode, indicating sufficient weld nugget strength relative to the surrounding material.

Keywords: Electrode geometry, Effect, Mechanical properties

EFFECT OF CLAMPING MECHANISM DESIGN ON DEFORMATION AND STRESS DISTRIBUTION IN A DOUBLE-HEAD CUTTING MACHINE (50)

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ABSTRACT

In double-head aluminum profile cutting machines, clamping is important for keeping the workpiece stable during cutting. In the examined machine, the pneumatic piston repeatedly clamps and releases the profile, causing local deformation and stress concentration in the support and angle plate region. This study compares how different clamping designs affect deformation and load transfer using linear static finite element analysis in ANSYS Mechanical under a 320 N clamping load. The baseline design exhibited a maximum deformation of 0.0450 mm and a maximum Von Mises stress of 12.8 MPa. Four design alternatives were analyzed. The mechanical vise reduced the maximum deformation to 0.00754 mm (83.2% reduction) and the maximum stress to 5.24 MPa, providing the best overall structural performance.

Keywords: Deformation, Effect, Clamping mechanism design

EXPERIMENTAL INVESTIGATION OF THE EFFECTS OF LASER MICRO-ENGRAVING PARAMETERS ON SURFACE ROUGHNESS IN AISI H13 HOT-WORK TOOL STEEL (78)

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ABSTRACT

This study investigates the effects of scanning direction, laser power, and scanning speed on the surface roughness of laser-micro-engraved AISI H13 tool steel. An 18-run full-factorial design was employed. Surface roughness (Ra) was measured and analyzed using three-way ANOVA, while surface morphology was examined using optical microscopy. The results showed that laser power was the only statistically significant factor affecting surface roughness ($p < 0.05$), with higher power increasing Ra. The minimum Ra (2.70 μm) was obtained at 60% laser power and 700 mm/s scanning speed using an alternating 45°/90° scanning strategy. Optical microscopy qualitatively supported the roughness results. The findings provide guidance for improving the surface quality of AISI H13 tool steel during laser micro-engraving.

Keywords: Surface roughness, Effects, Experimental investigation

SURFACE INVESTIGATION OF PLA MATERIAL USING MAGNETIC SURFACE TREATMENT SYSTEM (79)

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ABSTRACT

Industrial components can achieve the desired surface quality through Magnetic Abrasive Finishing (MAF), where magnetic abrasive particles align under a magnetic field to form a flexible abrasive brush. In this study, a Magnetic Abrasive Robot inspired by the MAF process was investigated. Al_2O_3 was used as the abrasive material, and NdFeB magnets generated the magnetic field. The magnets were fixed onto a rigid epoxy body to improve finishing performance. PLA specimens produced by 3D printing were processed at 200 rpm, and the resulting surface roughness values were evaluated using machine learning techniques.

Keywords: Finishing, Surface roughness, Abrasive machining

PREDICTION OF TENACITY AND ELONGATION IN FILAMENT DRAWING PROCESS USING MOTOR MOMENT BASED MECHANICAL TRANSFORMATION (65)

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ABSTRACT

This study relates draw ratio, godet temperature, and an unloaded-moment-compensated effective motor moment (τ) to the final mechanical properties of a 550 dtex / 144 filament POY yarn drawn on the USLAN SpinLab system, using a tenacity gain ratio (G_σ) and elongation retention ratio (R_ε). G_σ increased and R_ε fell sharply with draw ratio, to about 0.06 at DR 2.25 and above. Temperature governed the processability window: DR 2.50 was sustainable at 80-90 °C but not at 25 or 100 °C. A preliminary polynomial model relates DR, T and τ to G_σ and R_ε, requiring validation with larger data sets.

Keywords: Tenacity, Elongation, Motor moment

INVESTIGATION OF THE EFFECT OF HYPERELASTIC MATERIAL MODEL AND DESIGN PARAMETERS ON GASKET BEHAVIOR USING THE FINITE ELEMENT METHOD (33)

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ABSTRACT

Elastomer gaskets are widely used in sealing applications, and their performance is strongly influenced by material behavior, gasket geometry, and bolt preload. In this study, the effects of hyperelastic material modeling and design parameters on gasket behavior were investigated using the Finite Element Method (FEM). EPDM and polyurethane (PU) gaskets were comparatively analyzed in flange connections within the ANSYS environment using the Mooney-Rivlin hyperelastic material model.

Finite element analyses were performed for gasket thicknesses between 2-5 mm under different preload conditions. Material, geometric, and contact nonlinearities were considered throughout the simulations. The results showed that thicker gaskets exhibited more homogeneous deformation, while thinner gaskets experienced localized compression and instability. In addition, the relationship between preload and compression ratio was found to be nonlinear. EPDM showed higher deformation capability, whereas PU generated higher contact pressures due to its stiffer behavior.

The study demonstrates that reliable sealing performance requires the combined optimization of gasket thickness and bolt preload, and confirms the effectiveness of hyperelastic FEM modeling for gasket design applications.

Keywords: Effect, Hyperelastic material model, Design parameters

INVESTIGATING RESIDUAL STRESS AND STRAIN RATE EFFECTS IN COLD-FORMED SIGMA CONVEYOR BEAMS USING FINITE ELEMENT ANALYSIS (42)

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ABSTRACT

Cold-formed steel (CFS) Sigma sections are widely used as long-span conveyor side beams due to their high strength-to-weight ratio and improved torsional rigidity compared with conventional C-sections. However, current design approaches, including the Direct Strength Method (DSM), generally assume isotropic material behavior and may not fully account for the mechanical complexity introduced during manufacturing. In particular, residual stresses and strain-rate-related hardening effects may significantly influence the structural performance and buckling resistance of CFS Sigma beams.

This study investigates the structural response of Sigma beams subjected to eccentric conveyor loading by incorporating manufacturing-induced residual stresses and strain-rate effects into the numerical model. The proposed methodology is based on nonlinear finite element analysis performed using ANSYS. The structural behavior is evaluated under representative conveyor loading conditions, including vertical gravity loads and eccentric torsional moments induced by maintenance walkways.

The study compares the ultimate load capacity, deformation response, and failure modes of conventional models with those of manufacturing-aware models. Preliminary results indicate that strain-rate-induced hardening in the Sigma stiffener regions can enhance local buckling resistance and improve the predicted ultimate flexural capacity. The findings highlight the importance of considering manufacturing-related effects in the design and assessment of CFS Sigma beams and demonstrate their potential contribution to weight optimization in industrial conveyor structures.

Keywords: Finite element analysis, Investigating residual stress, Strain rate effects

EXPERIMENTAL DETERMINATION OF JOHNSON-COOK PARAMETERS FOR COLD-DRAWN AISI 303 AUSTENITIC STAINLESS STEEL AND VALIDATION VIA IMPACT TESTS (53)

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ABSTRACT

In this study, the plastic and damage behaviour of cold-drawn AISI 303 stainless steel was investigated under different temperatures and strain rates. Tensile, compression and notched tensile tests at room temperature; high-temperature tensile tests between 300 °C and 700 °C; and SHPB tests in the 888-4686 s^{-1} range were carried out. For verification under impact conditions, impact tests were performed at velocities of 200-300 m/s. Using the experimental data, Johnson-Cook plasticity and damage parameters were calibrated and the model was then validated through three-dimensional explicit analyses in Ansys/Autodyn. The high agreement between numerical and experimental deformation profiles demonstrates that the calibrated model successfully represents the dynamic behaviour of AISI 303 steel.

Keywords: Experimental determination, Johnson-cook parameters, Austenitic stainless steel

ONE-WAY FLUID-STRUCTURE INTERACTION (FSI) ANALYSIS OF A GFRP WIND TURBINE BLADE UNDER DIFFERENT WIND VELOCITIES (69)

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ABSTRACT

In this study, a one-way Fluid-Structure Interaction (FSI) analysis of a wind turbine blade manufactured from Glass Fiber Reinforced Polymer (GFRP) material was investigated. The analyses were performed in the ANSYS Workbench environment by the coupling of the Fluent and Static Structural modules. The blade structure was tested under five different wind speed conditions ranging from 8 m/s to 72 m/s. The effects of fluid-induced surface pressures on deformation, Von Mises stress, and elastic strain distributions on the structural behavior were examined. The analysis results showed that the blade structure operated safely up to a wind speed of 40 m/s, whereas at the extreme wind speed condition of 72 m/s, the stress exceeded the material tensile strength limit of 900 MPa, leading to structural damage.

Keywords: Interaction fsi analysis, Different wind velocities

OVERCOME "OOZING" DURING THE FILAMENT-BASED MELT ELECTROWRITING PROCESS (7)

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ABSTRACT

Melt electrowriting (MEW) is an additive manufacturing technique capable of producing highly ordered microscale fibres with precise spatial control. In filament-based MEW systems, however, unintended melt extrusion (oozing) can occur before or during printing because continuous filament feeding generates internal nozzle pressure while low-viscosity molten polymer readily flows at typical processing temperatures. This study investigated oozing in a polycaprolactone (PCL)-based MEW system and evaluated two practical mitigation strategies: (i) nozzle cleaning followed by loading fresh PCL filament, and (ii) active cooling of the filament above the heater block to suppress premature melting. Both strategies prevented observable oozing in ten repeated trials and enabled stable jet formation. These findings provide simple and effective routes to improve process stability, print quality, and reproducibility in filament-based MEW.

Keywords: Overcome oozing during, Melt electrowriting process

EFFECTS OF INFILL RATIOS ON THE STIFFNESS OF ADDITIVELY MANUFACTURED POLYLACTIC ACID CANTILEVER BEAMS (30)

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ABSTRACT

In additively manufactured components, the infill ratio specified during the slicing and G-code generation stages is known to exert a significant influence on structural stiffness. To systematically quantify this effect, a series of experimental investigations was conducted on cantilever beam specimens. More specifically, in this study, cantilever beams fabricated from polylactic acid (PLA) via the fused filament fabrication (FFF) process were examined to evaluate the relationship between infill ratio and effective stiffness. The primary objective is to establish a quantitative correlation between the selected infill ratios and the resulting stiffness of the printed cantilever beams.

Keywords: Stiffness, Infill ratios, Effects

STRUCTURAL OPTIMIZATION AND PERFORMANCE ANALYSIS OF A SUPPORT BRACKET FOR ADDITIVE MANUFACTURING (41)

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ABSTRACT

This study investigates a weight-reduction methodology for military vehicle engine auxiliary equipment brackets through the combined use of topology optimization and additive manufacturing. The primary objective is to optimize the bracket topology in order to minimize mass while preserving the required structural strength, stiffness, and dynamic performance.

During operation, the auxiliary equipment bracket is subjected to loads transmitted through the belt-pulley mechanism. Static analyses were performed to evaluate the structural response of the existing design under operational loading conditions, while modal analyses were conducted to assess the stiffness characteristics and natural frequencies of the bracket. The numerical analyses and optimization procedures were carried out using HyperMesh and OptiStruct.

The optimized design achieved a weight reduction of 55.8%, decreasing the bracket mass from 3.913 kg to 1.728 kg, while maintaining stress, displacement, and stiffness levels comparable to those of the original structure. The results demonstrate that topology optimization, particularly when supported by additive manufacturing, is an effective approach for reducing the weight of military vehicle components without compromising structural performance.

Keywords: Topology optimization, Additive manufacturing, Weight reduction

DESIGN, ANALYSIS, AND FABRICATION OF A MAGNETIC DRUG DELIVERY SYSTEM FOR LUNG CANCER (80)

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ABSTRACT

In this study, NdFeB permanent magnet configurations are optimized to enhance magnetic drug targeting efficiency in lung cancer treatment. The target region was modeled three-dimensionally by importing computed tomography images into 3D Slicer. In computational fluid dynamics analyses, the magnetic small-scale robot's flow behavior was numerically investigated. This study aims to stabilize the robot in the target region and determine simulation parameters like magnet configurations and flow velocity. Numerical data were compared with experimental results of a 3D-printed physical test model, identifying the optimum magnetic field configurations ensuring stable robot immobilization with minimal deviation.

Keywords: Lung cancer, Design analysis, Fabrication

DINOV2-BASED FEW-SHOT ANOMALY DETECTION FOR MANUFACTURING QUALITY INSPECTION: A COMPARATIVE STUDY OF FOUNDATION VISION MODELS (37)

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ABSTRACT

Automated visual quality inspection in manufacturing requires rapid adaptation to new products and defect types. Traditional deep learning approaches necessitate large labeled datasets and retraining for each new component, creating a critical bottleneck for flexible production lines. This study investigates the effectiveness of self-supervised foundation vision models, specifically DINOv2, for few-shot anomaly detection in industrial quality control. We propose a training-free pipeline that builds a nearest-neighbor memory bank from DINOv2 patch-level features using only 1-10 reference images of normal parts. Through systematic evaluation on six categories across two manufacturing datasets (MVTec AD and MPDD), we demonstrate that DINOv2 features achieve a mean pixel-level AUROC of 93.7% with only 10 reference images, outperforming ImageNet-supervised ResNet features (90.5%) by 3.2 percentage points. Critically, we show through ablation studies that adding CLIP text-guided semantic features via multimodal fusion degrades localization performance in all tested categories, demonstrating that structural patch matching alone is sufficient for manufacturing defect detection. The proposed approach requires no gradient computation, no domain-specific training, and can be deployed in under 5 seconds by simply collecting a handful of defect-free reference images.

Keywords: Few-shot anomaly detection, Foundation vision models, Manufacturing quality inspection

DEVELOPMENT OF MODEL PREDICTIVE CONTROLLED 12-DOF BIPEDAL ROBOT (110)

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ABSTRACT

State-of-the-art push recovery algorithms for bipedal robots frequently demand prohibitively expensive and computationally intensive hardware. To address these constraints, this study introduces a two-phase control architecture tailored for low-budget bipedal systems. Grounded in the Linear Inverted Pendulum Model (LIPM), the framework generates nominal walking trajectories offline by employing Zero-Moment Point (ZMP) preview control, a derivative of Model Predictive Control (MPC). For the preservation of balance during walking, real-time push recovery is facilitated by an online Linear Quadratic Regulator (LQR). This approach validates that stability against external perturbations can be effectively achieved utilizing resourceconstrained, low-cost microcontrollers.

Keywords: Development, 12-Dof bipedal robot

HYBRID AGENTIC ROBOTICS FOR MANIPULATION TASKS: COMBINING VISION-LANGUAGE- ACTION MODELS, GENERATIVE POLICIES, AND KNOWLEDGE REPRESENTATION (125)

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ABSTRACT

Industrial robots have traditionally relied on manually programmed task sequences and structured environments, limiting their adaptability to changing production requirements. Recent advances in agentic artificial intelligence have enabled robotic systems to interpret high-level goals, reason about task execution, generate action plans, and adapt their behavior according to environmental changes. This review investigates hybrid agentic robotic architectures that integrate knowledge-based reasoning with learning- based methods for robotic manipulation tasks. Knowledge representation techniques, including ontologies, knowledge graphs, and symbolic task models, provide explicit semantic reasoning, interpretable task structures, and constraint management [1], [2]. In contrast, Vision-Language-Action (VLA) models enable flexible perception and instruction understanding by directly mapping visual observations and natural language commands to robot actions [4],[5]. Generative motion planning approaches, including diffusion policies and flow-based policies, further enhance robotic autonomy by producing adaptable manipulation trajectories while representing multiple possible solutions [6], [7]. A potential hybrid framework combines these complementary capabilities, allowing VLA models to interpret tasks, symbolic knowledge representations to support high-level reasoning, and generative policies to execute manipulation actions. Such integration has the potential to improve flexibility in assembly, workstation preparation, sorting, packaging, and warehouse automation. The review also discusses current research challenges, including symbolic-to-continuous integration and generalization beyond training data. Generative planners must additionally address safety, physical feasibility, and real-time execution requirements [7], [8]. Overall, hybrid agentic robotics represents a promising direction toward inte

Keywords: Knowledge representation, Hybrid agentic robotics, Models generative policies

HIGH-SPEED AND ENERGY-OPTIMIZED ROBOTIC PALLET STACKING MACHINE FOR IMPROVED LOGISTICS EFFICIENCY IN PRODUCTION LINES (55)

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ABSTRACT

This study presents the development of a high-speed and energy-optimized robotic pallet stacking machine designed to overcome logistics bottlenecks in high-volume production lines and provides synchronization with the production line. Manual stacking processes often present significant ergonomic risks and operational delays, necessitating advanced automation solutions to adapt to a fast-paced manufacturing environment. The proposed system integrates optimization software which calculates the maximum number of user-defined packages in a user-defined palette based on exact mathematical models to determine optimal pallet layouts for identical boxes with 90-degree rotations. The software provides 4 palletizing options but the final call belongs to the operator. Mechanically, the system utilizes a 4-axis modular robotic arm (X, Y, Z, and a 360° rotary A-axis) equipped with one or multiple vacuum gripping systems. Experimental results demonstrate a fourfold increase in energy efficiency compared to traditional methods and a stacking throughput of approximately 440 packages per hour. The system allows for rapid synchronization with production speeds and can switch between packaging states in just five seconds, providing a scalable and efficient solution for modern industrial logistics.

Keywords: High-speed, Pallet stacking machine, Production lines

DESIGN, MANUFACTURING, AND TORSIONAL CHARACTERIZATION OF MACHINED SPRINGS: A COMPARATIVE STUDY BETWEEN NUMERICAL MODELLING AND TESTING (22)

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ABSTRACT

This study presents a comprehensive, multi-stage workflow for the development of high-performance machined springs, encompassing analytical sizing, material characterization, advanced numerical simulation, precision manufacturing, and experimental validation. Initially, the geometry of the spring was derived utilizing analytical methods directly driven by specific torque capacity, physical and rotational requirements. The material properties of the selected C350 maraging steel were obtained from the supplier and used as input for the numerical simulations. Utilizing the empirically derived material data, a robust numerical modeling strategy was employed to evaluate and optimize the design. A dual-solver approach was utilized for this purpose: an Implicit Finite Element Method (FEM) was first conducted to assess the static stress distribution, yield limits, and overall structural integrity of the spring under a twisted, pre-loaded state. Subsequently, an Explicit FEM solver was implemented to simulate the actual operational kinematics of the spring. This explicit approach was critical for capturing highly non-linear interactions, potential coil-to-coil contacts, and ultimately proving the fulfillment of the dynamic operational requirements. Upon numerical verification, the prototype was fabricated. The production phase encompassed a detailed process plan utilizing precision CNC machine tools, ensuring that the complex as-designed profile and tight geometric tolerances were accurately realized. Finally, the physical prototypes were subjected to experimental torque testing on a custom test rig. The experimental torque-rotation data were systematically compared with the numerical predictions. The comparative analysis demonstrates a high correlation between the physical tests and the FEM models, confirming that the proposed end-to-end methodology provides a highly reliable framework for the engineering of custom machined springs.

Keywords: Machined springs, Testing, Design manufacturing

FRICTION TORQUE LOSS IN RELATION TO FLEX THICKNESS ON ROTARY SHAFT SEALS (18)

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ABSTRACT

In all types of machinery and mobility, friction losses from rotary shaft seals are contributing to significant energy consumption and putting thermal strain on rotating members. This study experimentally investigates the main relationship between flex thickness of rotary shaft seal and its effect on friction torque. In this study tests are conducted in controlled shaft speed and lubrication conditions while using seals with different flex thickness. Friction torque measured constantly and used to cross examine other results. Results show clear correlation between flex thickness, radial force and friction torque.

Keywords: Flex thickness, Relation, Rotary shaft seals

INVERSE POSITION ANALYSIS OF A 4-RPR PLANAR PARALLEL ROBOT WITH CONFIGURABLE QUADRILATERAL PLATFORM (26)

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ABSTRACT

Parallel robots with configurable platforms constitute a new class of parallel robots that can perform multi-tasking through the simultaneous operation of multiple end-effectors. This paper presents an inverse position analysis of one such robot, namely a 4-RPR planar parallel robot with a configurable quadrilateral platform. This four-degree-of-freedom robot has two end-effectors, each possessing two degrees of freedom. An analytical solution is obtained for the inverse position kinematics of this robot. A numerical example is also provided to illustrate the solution procedure. The study contributes to the analytical developments in the emerging area of configurable-platform parallel robots.

Keywords: Inverse position analysis, Planar parallel robot, Configurable quadrilateral platform

INTEGRATION OF MULTIPLE FOUR-BAR MECHANISM SYSTEMS: GUI IMPLEMENTATION AND CALCULATIONS (96)

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ABSTRACT

This paper presents an Excel-based, real-time approach for kinematic and torque analysis of four-bar mechanisms and their multi-system integration via a simple graphical user interface (GUI). Using node/link tables, cell-referenced Freudenstein equations, and the Kutzbach criterion, the method models single and coupled four-bar assemblies (common-shaft connection) without 3D geometry. Results update instantly when parameters change, enabling rapid visualization of angular positions and required driving torque across configurations. The approach accelerates design iteration compared with manual calculations or 3D tools. Extensions to mechanisms with higher degrees of freedom are also discussed in the context of the study.

Keywords: Four-bar mechanism, Excel modeling, Real-time kinematic analysis

INTEGRATING PRESSURE-DEPENDENCY INTO STRAIN-SOFTENING CONSTITUTIVE MODELS FOR FINITE ELEMENT SIMULATION OF SERRATED CHIP FORMATION IN TI-6AL-4V (64)

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ABSTRACT

Predicting serrated chip formation in Ti-6Al-4V is vital for optimizing aerospace machining processes, yet conventional constitutive models often fail to capture the material's inherent pressure sensitivity and tension-compression asymmetry. This study investigates the implementation of the MAT_224_GYS (General Yield Surface) material model within an LS-DYNA 2D orthogonal cutting framework. Unlike standard analytical models, the MAT_224_GYS approach utilizes tabulated experimental data to account for the complex stress states and Lode-angle effects in the primary shear zone. Orthogonal cutting tests were conducted at a constant cutting speed (Vc = 60 m/min) with varying uncut chip thicknesses (f = 0.05, 0.075, 0.1, 0.15 mm). Cutting and thrust forces were measured using a Kistler dynamometer to provide a high-fidelity validation baseline. The results demonstrate that incorporating a pressure-dependent yield surface significantly enhances the prediction of the thrust force (Ft) and the Serration Index, which are traditionally underestimated by von Mises-based models. This study provides a validated numerical framework for predicting the thermo-mechanical response of Ti-6Al-4V under varying feed conditions, offering a more reliable tool for industrial tool life and part integrity assessments.

Keywords: Ti-6al-4v, Serrated chip formation, Strain-softening constitutive models

CUTTING FORCE MODELLING BASED ON LOCAL TOOL ANGLES AND PRIMARY AND SECONDARY EDGE MICRO-GEOMETRY: APPLICATION TO THREADING (67)

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ABSTRACT

This paper presents a modelling approach for predicting the forces acting on a tap during the threading of 40CrMo8 steel. A detailed three-dimensional geometrical model of the tool is developed using real tool images and industrial grinding machine parameters, enabling the representation of both macro- and micro-scale geometrical features. The cutting edges are extracted from the model to implement an oblique cutting force formulation capable of predicting the forces generated by both primary and secondary cutting edges during tapping. The proposed methodology is qualitatively validated through experimental tests. The study provides valuable insight into the mechanics of tapping operations.

Keywords: Primary, Threading, Cutting force modelling

CHEMICAL ETCHANTS IN PCB MANUFACTURING AND WASTE MANAGEMENT OF USED ETCHANTS - SURVEY CASE IN TURKIYE (82)

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ABSTRACT

Printed circuit boards (PCBs) are electronic components manufactured using advanced technology. In Turkey, the production of these components is carried out by a limited number of companies. The manufacturing of PCBs involves numerous process stages, and various chemical solutions are commonly used in these stages (Fig.1). The most important stage in PCB manufacturing is the chemical etching of the thin copper on the epoxy board. Different chemical etching agents can be used in the chemical machining of the thin copper on the PCB. Selection of machining parameters, such as concentration, Redox, pH, process temperature, are depending on the chosen chemical etchants. Additionally, there will be waste management for used chemical etchants. This is vital to be properly handled, because environmental problems will be too costly due to strict regulations. Therefore, the used etchants must be carefully regenerated and, if possible, etched material should be recovered by using various recycling process. In Turkey, PCB manufacturing is carried out by a limited number of companies, and efforts are being made to improve/develop the technology used by these companies. There are also various applications for utilizing the waste chemical etching agent after the chemical processing of the copper. In this study, contact was made with companies involved in PCB manufacturing in Turkey, and a survey conducted with these companies was evaluated. Furthermore, interviews with authorized individuals in the PCB manufacturing sector and the results obtained were evaluated in detail. A survey and discussions with expert consultants focused on the usage conditions, usage times, and disposal of waste chemical abrasives used in the chemical processing of copper on epoxy plates.The study aimed to identify ways to ensure environmentally friendly and sustainable manufacturing practices closely.

Keywords: Printed circuit board manufacturing, Chemical etchant, Chemical machining of copper

EXPLORATORY MILLING OF MUONIONALUSTA IRON METEORITE USING CRN-, ALTIN-, AND TIALN-COATED SOLID-CARBIDE END MILLS: PRELIMINARY CUTTING-FORCE ANALYSIS (83)

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ABSTRACT

This paper presents the results of an exploratory milling study conducted on Muonionalusta iron meteorite samples at Michigan State University in collaboration with EMUGE-Franken. Three cutter families-Aero 5 (CrN), TiNoxNF (AlTiN), and Topcut (TiAlN)-were evaluated at multiple feed conditions using cutting force signals. The signals show a clear monotonic rise of force RMS with feed for every tool family, and one condition (the 6-flute cutter at the highest feed) exhibits a force spike 5-10× larger than all other tests, consistent with a tool-failure event observed during the experiment. The dataset provides a systematic basis for comparing tool performance on a compositionally heterogeneous extraterrestrial workpiece and supports ongoing research into advanced manufacturing processes relevant to in-space resource utilization.

Keywords: Exploratory milling, Muonionalusta iron meteorite, Crn- altin-

AN EXTENSIBLE PARAMETRIC FRAMEWORK FOR GEOMETRY-ADAPTIVE CNC TOOLPATH GENERATION AND SIMULATION IN MULTI-ISLAND MILLING CAVITIES (84)

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ABSTRACT

This paper presents an extensible parametric framework for automated 2D milling toolpath generation and coverage simulation from vector DXF input within a visual programming environment. A shared, method-agnostic preprocessing core computes safety offsets, culls stock-edge-parallel segments, and separates closed and open contours for arbitrary multi-island cavities, then feeds a common linking, optimisation, and simulation back-end. Any toolpath strategy plugs into this core. Two are demonstrated here: a contour-parallel offset path with a numerically derived pass count, and a direction-parallel zig-zag. Across six test geometries the best-matched strategy reaches 97 to 100% coverage, motivating geometry-adaptive selection over one fixed method.

Keywords: Simulation, Extensible parametric framework, Cnc toolpath generation

MOLD-FREE INSPECTION OF CURVED SHEET-METAL WITH VISION ALIGNMENT (86)

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ABSTRACT

Conventional QC for curved sheet-metal parts in low-volume production and rapid prototyping is labor-intensive, slow, and costly because each geometry requires dedicated single-use molds/fixtures, causing lead time, waste, and validation bottlenecks. This paper presents a mold-free, reconfigurable 50 × 50 cm inspection platform with 16 linear actuators that approximate the CAD-model underside, reducing tooling cost and time. MATLAB processes STL files to compute actuator heights; Python/OpenCV with ArUco markers aligns the part; Arduino, TB6600 drivers, and AS5600 encoders provide closed-loop control. Experiments show ±0.2 mm deviation and 25 fps vision feedback, with scalable modular actuator density.

Keywords: Curved sheet-metal, Mold-free inspection, Vision alignment

IMPROVING TOOL TIP RESPONSE BY INTEGRATING TMD COMBINED WITH CLD INSIDE A MILLING TOOL (90)

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ABSTRACT

Constrained layer damping (CLD) is obtained by placing a viscoelastic layer between a vibrating structure and a stiff constraining layer that introduces a passive chatter suppression strategy in machining. When machining vibration occurs, relative deformation between the layers produces shear strain in the viscoelastic material, allowing vibration energy to be dissipated through not only tensile and compression strain but also shear strain, increasing overall energy dissipation capacity. In this study, the CLD concept is combined with a tuned mass damper (TMD) for a new cutting tool design for milling. An analytical model is established to predict the response of the cutting tool and results shows promising improvement in tool tip Frequency Response Functions (FRFs).

Keywords: Integrating tmd combined, Cld inside, Milling tool

PDMS-BASED SURFACE REPLICATION FOR MICRO END MILL WEAR EVALUATION (108)

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ABSTRACT

A non-destructive, low-cost method for evaluating micro end mill wear is presented using PDMS surface replication. Two worn 0.5 mm TiSiN-coated tools are examined to demonstrate the method's capabilities and limitations. Polydimethylsiloxane (PDMS) moulds are optically imaged and compared with scanning electron microscopy of the actual tools. The replicas capture bottom-edge flank wear with reduced glare relative to direct optical imaging. In the first tool, flank wear is reproduced with small error on one edge and moderate underestimation on the other, while in the second tool, the wear is captured accurately on both edges, indicating capability for near shop-floor inspection.

Keywords: Pdms-based surface replication, Mill wear evaluation

DEVELOPMENT OF A PROCESS-CONTROLLED CALENDERING MACHINE (16)

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ABSTRACT

In this study, a precision-controlled prototype calendering machine was developed to enhance the fabrication quality of lithium-ion battery electrodes. The system was engineered to provide control over critical process parameters, such as roller speed, electrode thickness, operating temperature, and compression force. This control infrastructure was specifically designed to balance between densification and resistive losses, ensuring consistent electrode properties.

Keywords: Development, Process-controlled calendering machine

DESIGN, KINEMATIC ANALYSIS, AND PERFORMANCE EVALUATION OF A BIOCLIMATIC PERGOLA SYSTEM WITH A SINGLE-ACTUATOR SYNCHRONIZED LOUVER MECHANISM (10)

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ABSTRACT

Bioclimatic pergola systems are among innovative architectural solutions that enable the year-round comfortable use of outdoor spaces by integrating control over solar radiation, natural ventilation, and environmental conditions. However, existing systems often involve multiple motors, complex mechanical linkages, and high-precision installation requirements, which introduce limitations in terms of cost, maintenance, and operational continuity. In this study, a modular bioclimatic pergola system featuring a single motor drive and an adjustable louver mechanism is presented, aiming to overcome these limitations. The proposed system enables the simultaneous and controlled movement of all louvers through a synchronized transmission mechanism driven by a single tubular motor. To mitigate deflection effects arising from louver connections, the system is reinforced with a grid support structure, enhancing overall rigidity. Under summer conditions, partially open louvers promote natural air circulation and facilitate the removal of hot air through the “stack effect,” while in winter conditions, controlled light transmittance allows for passive heat gain. Mechanical limiters defining motion boundaries, anti-reverse locking mechanisms, and structural profile solutions that enhance long-term stability are integrated into the system design. The modular configuration allows adaptation to different dimensions and functional requirements, while enabling variation in louver materials and surface finishes. The developed prototype has been subjected to full-scale mechanical performance and functional validation tests. The aim of this study is to demonstrate, from a mechanical design perspective, that bioclimatic pergola systems based on a single-actuator synchronized motion principle offer an effective solution in terms of energy efficiency, user comfort, and manufacturability.

Keywords: Bioclimatic pergola system, Design kinematic analysis, Performance evaluation

ENERGY-EFFICIENT HIGH-SPEED MOVING JAW DESIGN FOR CONTINUOUS-MOTION VERTICAL PACKAGING MACHINES AND ADAMS-BASED DYNAMIC VALIDATION (46)

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ABSTRACT

This study presents the design methodology of the CMP 444 horizontal sealing system for continuous VFFS(Vertical Form Fill Seal) machines. Focused on the flying jaw concept, the design employs a lightweight body and timing belt drive. The mechanism incorporates a spring-supported energy recovery structure to reduce servo motor loads and integrated damping chambers for kinetic energy absorption. Geometric optimization and precision alignment slots ensure high stability across extreme stroke ranges. The innovative design offers high efficiency with reduced maintenance. This work provides a novel engineering solution for enhancing speed and reliability in high-capacity packaging technologies.

Keywords: Moving jaw design, Vertical packaging machines, Adams-based dynamic validation

DESIGN AND THERMAL PERFORMANCE EVALUATION OF A STONE WOOL INSULATION COVER FOR A PVC WELDING MACHINE HEATING PLATE (51)

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ABSTRACT

This study investigates the effect of a stone wool insulation cover on the thermal performance and cycle time of a four-head PVC welding machine. A U-shaped cover made of İzocam SL2 Stone Wool Industrial Board was designed in SOLIDWORKS to reduce convective and radiative heat losses from the heating plate during idle periods between welding cycles. Transient and steady-state thermal analyses were performed in ANSYS 2022 R2 for both insulated and non-insulated configurations under identical boundary conditions. The results show that the insulation cover reduced the time required to reach the target plate temperature of 250 °C from 500 s to 450 s, limited the average temperature drop during one minute of free cooling from 10 °C to 2 °C, and decreased the steady-state power required to maintain the operating temperature from 337.72 W to 64.78 W, corresponding to an approximately 81% reduction in heat loss. These findings demonstrate that the proposed cover significantly improves heating efficiency and reduces energy consumption during idle periods.

Keywords: Design, Wool insulation cover, Thermal performance evaluation

ADDITIVE MANUFACTURING APPLICATIONS IN MEDIUM VOLTAGE SWITCHGEAR: DESIGN, ANALYSIS, VALIDATION, AND FUTURE CHALLENGES (32)

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ABSTRACT

This study investigates the application of additive manufacturing (AM) as a rapid prototyping approach for medium voltage switchgear, providing an alternative to thermoset and thermoplastic designs produced by conventional injection molding and machining. A 24 kV switchgear component has been redesigned using Selective Laser Sintering (SLS) with PA2200 polyamide and optimized through iterative finite element analysis targeting deformation and sealing behavior. Topology optimization, reinforcement rib integration, and bolt layout refinement achieved up to an 86% reduction in deformation and a 50% improvement in sealing gaps, demonstrating that AM-fabricated polymer components meet the mechanical and electrical requirements for medium-voltage applications.

Keywords: Additive manufacturing applications, Design analysis validation, Future challenges

AI-DRIVEN PARAMETRIC OPTIMIZATION OF CNC WORKHOLDING SYSTEMS VIA SURROGATE MODELING AND CUSTOMER-SPECIFIC PERFORMANCE INDEXING (48)

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ABSTRACT

Mechanical engineering constitutes a fundamental discipline within the field of technology. A discipline which achieves its most significant through manufacturing processes, where conceptual designs are converted into precise physical components. Machining is a critical process among these techniques, as it is essential for achieving the high levels of dimensional accuracy and surface integrity demanded by modern engineering applications. The aerospace, automotive, and defense industries are critically reliant on advanced machining processes to achieve the precise dimensional accuracies and complex geometries required by their respective applications.The success of machining processes relies heavily on the effectiveness of workholding systems, given their direct impact on the dimensional stability and surface quality of the final product.

Despite these critical roles, the design of machining fixtures, such as CNC vises, remains a highly complex process that predominantly relies on a designer's experience and implicit knowledge. The designs are mostly dependent on the experience of the designer. To improve design efficiency, this study integrates artificial intelligence (AI) with structural analysis to predict the mechanical behavior of a CNC vise under varying parameters. Instead of performing iterative and time-consuming Finite Element Analysis (FEA) for each design change, the plan is to use an AI-based model to estimate the location and magnitude of maximum stress and strain.

Keywords: Ai-driven parametric optimization, Via surrogate modeling, Customer-specific performance indexing

OPTIMIZING COMPUTE TIME AND MATERIAL YIELD IN CUTTING OPTIMIZATION: A HYBRID SOLUTION ARCHITECTURE WITH COLUMN GENERATION AND HEURISTIC ALGORITHMS (52)

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ABSTRACT

This article discusses the use of optimization frameworks for One-Dimensional Cutting Stock Problem (1D-CSP) in collaboration with the profile manufacturer Yılmaz Machine, to minimize material waste and operational costs. 1D-CSP refers to a partitioning problem commonly encountered in the manufacturing industry, where specific parts with varying sizes are to be cut from standardized stock products. Prominent industrial approaches include Column Generation (CG) which identifies numerous solution patterns using subsets, and Heuristic Algorithms (HA) to achieve near-optimal results for large-scale problems. This paper focuses on a hybrid methodology that implements CG and HA to decompose the problem into a series of Knapsack Problems to achieve high-efficiency solutions.

Keywords: Column generation, Heuristic algorithms, Optimizing compute time

A MATHEMATICAL OPTIMIZATION APPROACH FOR MULTI-STAGE INDUSTRIAL PRINTING SCHEDULING WITH WAITING TIMES, BLOCKING, AND MAINTENANCE (123)

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ABSTRACT

Unlike conventional assembly lines with continuous material flow, industrial printing processes are constrained by material dependent physical and chemical properties. When production orders, intermediate storage allocation, and maintenance shutdowns are scheduled independently, this often creates severe bottlenecks, machine blocking, and extended operational delays. This study develops a mathematical model that jointly considers these factors to minimize the makespan, providing a structured decision-support framework for industrial printing lines.

Keywords: Maintenance, Mathematical optimization approach, Industrial printing scheduling

INVESTIGATION OF THE EFFECT OF THRESHOLDING AND ILLUMINATION TYPES REGARDING DIGITAL IMAGE PROCESSING BASED ASSESMENT OF ASTM D3359 TEST RESULTS (120)

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ABSTRACT

The ASTM D3359 standard is a widely used test to assess the adhesion performance of coating and painting applications on metallic substrates. Conventionally, test evaluation relies on empirical methods, which depend heavily on visual comparisons with reference diagrams provided by the standard authority. However, with recent advancements in digital image processing, automated qualitative and quantitative analysis can replace conventional methods swiftly and effortlessly. This study develops a dedicated MATLAB algorithm designed specifically for this purpose. Because target coatings, paints, and base metals present a wide spectrum of colors and brightness levels, preprocessing adjustments regarding thresholding algorithms and illumination types are critical. This study evaluates these alternative digital approaches and demonstrates the specific contributions of illumination and thresholding parameters on evaluation accuracy

Keywords: Thresholding, Digital image processing, Investigation

TURKISH MANUSCRIPTS WITH ENGLISH ABSTRACTS

TURKISH SPECIAL SESSIONS

ARAYICI SISTEMLERINDE PIEZO MEKANIZMASI UYGULAMASI (107)

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ÖZET

Füze uygulamalarında kompakt arayıcı tasarımı, sürükleme katsayısını azaltmak, performans/kütle oranını artırmak ve uçuş motoru performansını en üst düzeye çıkarmak açısından önemlidir. Geleneksel gimbal ve titreşim bastırma çözümleri füze çapını ve montaj karmaşıklığını artırabilmektedir. Bu çalışmada, görüntüdeki titreşim etkilerini azaltmak ve karmaşık gimbal mekanizmalarına duyulan ihtiyacı sınırlamak amacıyla piezo aktüatörlü bir sistem ele alınmıştır. Optik tasarım gerçekleştirilmiş, kamera, gimbal ve piezo mekanizması üretilerek laboratuvarda test edilmiştir. Sistem performansı kolimatör düzeneğinde ve otomatik hedef edinme algoritması kullanılarak titreşim test profili altında nicel olarak değerlendirilmiştir.

Anahtar Kelimeler: Arayıcı sistemi, Piezo aktüatör, Titreşim bastırma

APPLICATION OF PIEZO MECHANISM FOR SEEKER (107)

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ABSTRACT

In missile applications, compact seeker design plays a vital role. Main reason is to reduce drag coefficient, thus to increase performance/mass ratio and maximize flight motor performance. In project timeline, all of these factors are optimized in different phases of the project. For decades gimbals and, alternatively, vibration/supression methods are popular. Utilizing a gimbal system can end up in an increase of the missile diameter to include complex mechanisms to eliminate vibration effect. Additionally, this requires an increase in assembly complexity. New methods can be proposed, which are vulnerable to jitter on image. Therefore, complex gimbal mechanisms can be removed from seeker. In order to minimize the effects from the jitter on the image, piezo actuator system can be utilized. In this work, an optical design is conducted, a camera module is produced. Performance of the camera module is analyzed in simulation and tested in laboratory setup. In addition, gimbal module and piezo mechanism are produced and tested in the laboratory. Consequently, possible target is illustrated in the collimator system to measure the performance of the system. Later, camera module performance is tested under the vibration test profile with automatic target acquisition algorithm to compare results of the system quantitively. On the end, results are analyzed to show piezo actuator effects on vibration test profile.

Keywords: Seeker, Application, Piezo mechanism

FÜZE MODAL ANALIZI İÇIN YÜKE BAĞLI MODEL İNDIRGEME (102)

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ÖZET

Uçuş koşullarındaki modal parametrelerin doğru belirlenmesi, roket sistemlerinin aeroelastik analizi ve uçuş kontrol tasarımı için kritik önemdedir. Uçuş yükleri ile boşluk ve bağlantı gibi yapısal doğrusal olmayanlıklar modal davranışı değiştirirken, bunların geleneksel sonlu eleman yöntemleriyle modellenmesi yüksek hesaplama maliyetine yol açmaktadır. Bu çalışmada cıvatalı flanşlar ve ayrılma mekanizmalarındaki yüke bağlı temas doğrusal olmayanlıklarını ele alan bir model indirgeme yaklaşımı sunulmuştur. Simetrik yapısal bölümlere ait yük-yer değiştirme eğrileri kullanılarak montaj doğrusal olmayan yaylarla temsil edilmiş; yaylar belirli eksenel kuvvet ve eğilme momentlerindeki çalışma noktalarında doğrusallaştırılarak eşdeğer kesit rijitlikleri elde edilmiştir. ROKETSAN tarafından geliştirilen bir füze sistemine uygulanan yöntem, uçuş ve modal test verileriyle doğrulanmış ve doğal frekansları %0,1–%7,4 hata aralığında tahmin etmiştir.

Anahtar Kelimeler: Model indirgeme, Füze modal analizi, Temas doğrusal olmayanlığı

LOAD-DEPENDENT MODEL REDUCTION FOR MISSILE MODAL ANALYSIS (102)

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ABSTRACT

Accurate identification of modal parameters under flight conditions is crucial for the aeroelastic analysis and flight control design of rocket systems. In-flight mechanical loads and structural non-linearities, such as clearances and joints, alter modal behavior. However, accounting for these effects through conventional finite element methods incurs high computational costs and delays design iterations.

This paper presents a novel model reduction approach that addresses load-dependent contact non-linearities in bolted flanges and separation mechanisms. By utilizing load-displacement curves from symmetric structural segments, the assembly is represented via non-linear springs. These springs are linearized at their operational points under specific axial forces and bending moments, establishing equivalent sectional stiffnesses. The method was successfully implemented on a missile system developed at ROKETSAN A.S. Validation against flight and modal test data demonstrated that the approach predicts in-flight natural frequencies with error margins between 0.1% and 7.4%. Ultimately, this approach successfully linearizes the structural complexities, drastically reducing computation time through simplified equivalent models.

Keywords: Load-dependent model reduction, Missile modal analysis

COMWO: KOMPOZIT SARGILI BASINÇLI KAPLAR İÇIN OTOMATIK ÖN İŞLEME (103)

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ÖZET

Filament sarım yöntemiyle üretilen metal astarlı kompozit tankların yapısal analizi, sarım geometrisinden kaynaklanan yerel açı ve kalınlık değişimleri nedeniyle karmaşık bir modelleme süreci gerektirir. Bu çalışmada, tasarımcıdan alınan üretim proses verilerini doğrudan kullanarak farklı kesitlerin tabaka özelliklerini otomatik tanımlayan CoMWo otomasyon betiği ve analitik altyapısı sunulmuştur. Abaqus entegrasyonu ile ön işleme aşamasını otomatikleştiren yöntem, geleneksel yaklaşımlara dinamik bir alternatif oluşturmaktadır. Geliştirilen betiğin doğruluğu gerçek patlatma testleri ile sayısal analiz sonuçları karşılaştırılarak incelenmiş ve %4,5 gibi düşük bir sapma elde edilmiştir. Betikli ve betiksiz modelleme süreçlerinin karşılaştırılması, yöntemin yüksek doğruluğun yanında modelleme süresinde önemli iyileşme sağladığını göstermiştir.

Anahtar Kelimeler: Otomatik ön işleme, Kompozit basınçlı kap, Filament sarım

COMWO: AUTOMATED PRE-PROCESSING FOR COMPOSITE OVERWRAPPED PRESSURE VESSELS (103)

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ABSTRACT

Structural analyses of metal-lined composite tanks produced by the filament winding technique require a complex modeling process due to local angle and thickness variations arising from the winding geometry. In this study, the ”CoMWo” automation script and analytical infrastructure are introduced, which stand out by directly using manufacturing process data from the designer to automatically define the layer properties of different cross-sections. This methodology, which autonomizes the preprocessing stage through Abaqus integration, offers a dynamic alternative to traditional approaches and similar plugins in the literature (WCM). The accuracy of the developed script was examined by comparing the results of real burst tests conducted with numerical analyses, and a low discrepancy rate of 4.5% was obtained. Modeling processes with and without the script were compared in terms of time efficiency. The results reveal that the CoMWo methodology provides a highly significant optimization in modeling times along with high accuracy.

Keywords: Comwo automated pre-processing, Overwrapped pressure vessels

SU2-NEMO KULLANILARAK TERMOKIMYASAL DENGESIZLIK İÇEREN HIPERSONIK AKIŞ SIMÜLASYONLARININ DOĞRULANMASI VE UYGULANMASI (117)

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ÖZET

Bu genişletilmiş özet, SU2-NEMO çözücüsü kullanılarak gerçekleştirilen termokimyasal dengesizlik içeren hipersonik akış simülasyonlarının doğrulanmasını ve uygulanmasını sunmaktadır. HEG silindiri, CUBRC çift konisi ve ELECTRE yeniden giriş kapsülü; yüksek entalpili şok tabakası akışı, şok dalgası-laminer sınır tabaka etkileşimi ve yeniden giriş ısınması açısından incelenmiştir. Uygulama bölümünde HEXAFLY-INT konfigürasyonunun iki boyutlu orta düzlem kesiti ele alınmış; reaktif, donmuş ve kalorik olarak mükemmel gaz modelleri basınç, ısı akısı, şok ayrılma mesafesi, Damköhler sayısı ve termokimyasal dengesizlik etkileri bakımından karşılaştırılmıştır. Sonuçlar basınç tahminlerinin güvenilir olduğunu, ısı akısının ise duvar katalitikliği ve modelleme varsayımlarına daha duyarlı olduğunu göstermektedir.

Anahtar Kelimeler: Hipersonik akış, Termokimyasal dengesizlik, Su2-nemo

VALIDATION AND APPLICATION OF HYPERSONIC FLOW SIMULATIONS WITH THERMOCHEMICAL NONEQUILIBRIUM USING SU2-NEMO (117)

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ABSTRACT

This extended abstract presents the validation and application of thermochemical-nonequilibrium hypersonic-flow simulations using SU2-NEMO. The HEG cylinder, CUBRC double cone, and ELECTRE re-entry capsule assess high-enthalpy shock-layer flow, shock-wave/laminar-boundary-layer interaction, and flight-based re-entry heating. A two-dimensional mid-plane section of HEXAFLY-INT is then studied. Reacting, frozen, and calorically perfect-gas models are compared for pressure, heat flux, shock stand-off distance, Damköhler number, and nonequilibrium effects. SU2-NEMO predicts pressure distributions reliably, while heat flux is more sensitive to wall catalycity, separated-flow heating, and modeling assumptions. Reactive-chemistry effects increase with velocity and decreasing altitude, particularly for stagnation-point heat flux and shock-layer structure.

Keywords: Hypersonic flow, Thermochemical nonequilibrium, Su2-nemo

KURUM İÇI VE TICARI ARAÇLARLA YÜKSEK HIZLI AERODINAMIK VERITABANININ HIZLI OLUŞTURULMASI (118)

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ÖZET

Yüksek hızlı tehditleri modelleyen araç tasarımları, karmaşık uçuş koşulu matrislerini kapsayan geniş aerodinamik veritabanları gerektirir. Bu koşullar için yüksek kaliteli RANS CFD sonuçlarının üretilmesi önemli zaman ve hesaplama kaynağı gerektirmektedir. Bu çalışmada, genel bir yüksek hızlı araç için aerodinamik veritabanı oluşturmak amacıyla CFD verilerini Kriging üst modelleriyle birleştiren kurum içi ve ticari çerçeveler karşılaştırılmıştır. Python tabanlı kurum içi araç ile ANSYS optiSLang kullanılarak aerodinamik katsayı tahminleri için iki süreç geliştirilmiştir. Sonuçlar, Kriging tabanlı yaklaşımların uçuş çözüm matrisindeki hesaplanmamış noktaları etkili biçimde tahmin ettiğini; yunuslama momenti katsayısında en fazla %4,5, diğer katsayılarda ise daha düşük sapmalar sağladığını göstermiştir.

Anahtar Kelimeler: Aerodinamik veritabanı, Kriging, Yüksek hızlı araç

RAPID GENERATION OF A HIGH-SPEED AERODYNAMIC DATABASE USING IN-HOUSE AND COMMERCIAL TOOLS (118)

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ABSTRACT

The vehicle design to model high-speed threats requires extensive aerodynamic database efforts, which typically involve complex matrices of flight conditions. However, generating high-quality RANS CFD results for these combinations entails significant constraints regarding time and computational resources. Surrogate modeling has emerged as an efficient and robust alternative to explore the design space with a reduced number of CFD simulations. This paper compares in-house and commercial frameworks that integrate CFD data with Kriging metamodels to construct an aerodynamic database for a generic high-speed vehicle. The methodology utilizes a custom in-house Python-based tool alongside ANSYS optiSLang software to consolidate the prediction processes of aerodynamic coefficients. Two alternative processes are developed and compared in terms of their accuracy and predictive capability. The results demonstrate that the proposed Kriging-based approaches effectively capture the unresolved locations of the flight solution matrix, achieving a maximum deviation of 4.5% for the pitching moment coefficient, with even lower error margins observed for other aerodynamic coefficients. This provides a satisfactory and computationally efficient foundation for high-speed design exploration and database generation purposes.

Keywords: In-house, Rapid generation, High-speed aerodynamic database

TEL BESLEMELI EKLEMELI İMALAT ILE HAFIF YAPISAL BILEŞENLERIN ÜRETIMI (98)

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ÖZET

Bu çalışmada ER2319 alüminyum telden güçlendiricili hafif yapıların tel beslemeli eklemeli imalat ile bütünleşik üretimi incelenmiştir. CMT Additive prosesiyle 600 mm çap ve boya sahip iki silindirik gövde üretilmiş, takım yolları çevrimdışı robot simülasyonuyla doğrulanmıştır. Bilgisayarlı tomografi, lazer tarama, mikroyapı, sertlik ve çekme testleri uygulanmıştır. Üretildiği durumdaki yüzeyde görünür CT porozitesi %3 olarak belirlenmiş ve yüzey pürüzlülüğünün sınıflandırmayı etkilediği görülmüştür. Çözündürme ve yapay yaşlandırma sonrasında boyutsal sapmalar -1,0/+0,4 mm; ortalama akma ve çekme dayanımları sırasıyla 260 ve 330 MPa olarak ölçülmüştür. Bulgular proses, takım yolu, ısıl işlem ve doğrulamanın bütünleşik bir üretim zinciri olarak yönetilmesi gerektiğini göstermektedir.

Anahtar Kelimeler: Tel beslemeli eklemeli imalat, Er2319 alüminyum, Proses doğrulama

PRODUCTION OF LIGHTWEIGHT STRUCTURAL COMPONENTS BY WIRE ARC ADDITIVE MANUFACTURING (98)

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ABSTRACT

This study investigates the integrated Wire Arc Additive Manufacturing (WAAM) of reinforced lightweight structures using ER2319 aluminum wire. Two cylindrical bodies, 600 mm in diameter and height, were produced by CMT Additive, and their toolpaths were verified by offline robot simulation. Computed tomography, laser scanning, microscopy, hardness, and tensile tests were applied. Apparent CT porosity on the as-built surface was 3%, with surface roughness affecting classification. After solution treatment and artificial aging, dimensional deviations were -1.0/+0.4 mm; average yield and ultimate tensile strengths were 260 and 330 MPa. The findings demonstrate that process, toolpath, heat treatment, and verification should be managed as an integrated production chain.

Keywords: Wire arc additive manufacturing, Er2319 aluminum, Process verification

YÜKSEK GÜVENILIRLIKLI İMALATTA ÜRETIM VE KALITE GÜVENCESI İÇIN ENDÜSTRIYEL YAPAY ZEKÂ UYGULAMALARI (106)

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ÖZET

Bu bildiri, Roketsan'da yüksek güvenilirlikli imalatta üretim ve kalite güvence süreçlerini geliştirmek amacıyla yürütülen endüstriyel yapay zekâ çalışmalarını sunmaktadır. Uygulamalar; görsel kusur tespiti, görsel-dil modeli destekli parça muayenesi, kontrol listesi tabanlı teknik resim incelemesi, video tabanlı proses anomalisi tespiti ve doğal dil işleme ile kalite kayıtlarının analizini kapsamaktadır. Her uygulama için veri özellikleri, model seçimi, devreye alma kısıtları ve proses etkisi değerlendirilmiştir. Güvenli şirket içi ortam nedeniyle veri güvenliği, insan doğrulaması ve mevcut üretim akışlarıyla entegrasyon ele alınmış; kestirimci bakım, gerçek zamanlı izleme, kök neden analizi ve bütünleşik karar destek sistemleri gelecek çalışmalar olarak sunulmuştur.

Anahtar Kelimeler: Endüstriyel yapay zekâ, Kalite güvencesi, Görsel muayene

INDUSTRIAL AI APPLICATIONS FOR PRODUCTION AND QUALITY ASSURANCE IN HIGH-RELIABILITY MANUFACTURING (106)

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ABSTRACT

This paper presents ongoing industrial artificial intelligence studies conducted at Roketsan to improve production and quality assurance processes in high-reliability manufacturing. The study covers both implemented applications and planned extensions within a unified industrial AI roadmap. Implemented use cases include computer-vision-based visual defect detection on manufactured parts, vision-language-model-assisted inspection of components, checklist-based technical drawing review, video-based process anomaly detection, and natural-language-processing-based analysis of quality records. For each use case, the paper discusses the problem definition, data characteristics, model or pipeline selection, deployment constraints, and observed process impact. The applications are evaluated through indicators such as inspection time reduction, defect detection performance, standardization of expert decisions, traceability improvement, and decreased manual review effort. Since the studies are deployed or evaluated within a secure on-premise environment, data security, human-in-the-loop verification, and integration with existing production workflows are also considered. Finally, the paper presents future extensions including predictive maintenance, real-time process monitoring, automated root-cause analysis, and integrated decision support systems for production and quality management.

Keywords: Industrial ai, Quality assurance, Visual inspection

MODERN SAVUNMA SISTEMLERININ YAŞAM DÖNGÜSÜ BOYUNCA YAPAY ZEKÂ DESTEKLI KARAR DESTEĞI: ALANA ÖZGÜ UYGULAMALAR VE BENIMSEME GÜÇLÜKLERI (109)

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ÖZET

Modern savunma sistemleri; gereksinim, tasarım, yüksek doğruluklu analiz, üretim, entegrasyon, test, doğrulama, kalifikasyon ve saha geri bildirimini kapsayan eşgüdümlü yaşam döngüsü faaliyetleri gerektirir. Bu çalışma yapay zekâyı beş karar destek rolü altında inceler: hızlı tahmin ve analiz hızlandırma, tasarım uzayının taranması, model-simülasyon-üretim-test verilerinin bütünleştirilmesi, durum ve anomali değerlendirmesi ile kanıt ve izlenebilirliğin ilişkilendirilmesi. Farklı savunma alanlarından örnekler yöntemin alanlar arasında aktarılabileceğini, ancak doğrulama gerekçesinin kararın niteliği ve hata sonucuna göre yeniden kurulması gerektiğini göstermektedir. Seyrek ve gizli veri, ekstrapolasyon, fiziksel tutarlılık, belirsizlik, denetlenebilirlik ve araç zinciri entegrasyonu temel güçlüklerdir. Yapay zekâ, fizik tabanlı analiz ve mühendislik yargısını tamamlayan doğrulama duyarlı bir karar destek katmanı olarak konumlandırılmaktadır.

Anahtar Kelimeler: Yapay zekâ, Karar desteği, Savunma sistemleri

AI-ENABLED DECISION SUPPORT ACROSS THE LIFECYCLE OF MODERN DEFENSE SYSTEMS: DOMAIN-SPECIFIC APPLICATIONS AND ADOPTION CHALLENGES (109)

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ABSTRACT

Modern defense systems require coordinated lifecycle activities spanning requirements, design, high-fidelity analysis, production, subsystem integration, testing, verification, qualification, and field feedback. The engineering value of AI depends less on the algorithm itself than on the decision it supports, the consequence of error, and how its output can be verified. This paper presents a structured review and perspective organized around five recurring engineering decision-support roles: rapid prediction and analysis acceleration; design-space screening and critical-case prioritization; integration of models, simulations, production, and test data; condition, deviation, and anomaly assessment; and linkage of evidence, traceability, and engineering knowledge. Applications from aerodynamic and aerothermal design, structural and protective systems, propulsion and combustion, energetic and pyrotechnic subsystems, electromechanical and sensor systems, production/quality feedback, and test and qualification are used as domain-specific examples. The cited studies are selected to representatively cover major decision-support roles across the lifecycle; the framework complements discipline-specific reviews. The review argues that method families can transfer across domains, whereas the validation argument cannot be transferred without considering the supported decision, lifecycle stage, and consequence of model error. Key adoption challenges include sparse and confidential data, extrapolation, physical consistency, uncertainty, model-test correlation, auditability, and toolchain integration. AI is therefore positioned as a validation-aware decision-support layer that complements physics-based analysis, testing, and engineering judgment through explicit validity bounds, evidence, uncertainty information, and expert review.

Keywords: Artificial intelligence, Decision support, Defense systems

MODERN SAVUNMA SISTEMLERININ TASARIM DOĞRULAMA SÜREÇLERI (101)

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ÖZET

Tasarım doğrulama süreci tüm sistem/altsistem gereksinimlerinin Sistem/Altsistem Geliştirme Şartnamelerinde belirtilen doğrulama yöntemleri ile doğrulandığı süreçtir. Bu sürecin başarı ile tamamlanması ürün ve üretim hattı kalifikasyon sürecine geçiş için zorunludur. Bu bildiride modern savunma sistemlerinin tasarım doğrulama süreçleri hakkında bilgi verilmektedir.

Anahtar Kelimeler: Tasarım doğrulama, Savunma sistemleri, Kalifikasyon

DESIGN VERIFICATION PROCESSES OF MODERN DEFENSE SYSTEMS (101)

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ABSTRACT

Design verification is the process by which all system and subsystem requirements are verified using the methods specified in the System/Subsystem Development Specifications. Successful completion of this process is mandatory before proceeding to product and production-line qualification. This paper provides an overview of design-verification processes for modern defense systems.

Keywords: Design verification, Defense systems, Qualification

GELIŞEN SAVUNMA SANAYII STANDARTLARINDA ENTEGRASYON TEST ALTYAPISI YAKLAŞIMLARININ GELIŞTIRILMESI (100)

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ÖZET

Bu çalışma, Türk savunma sanayiinin tasarım ve seri üretim aşamalarındaki sıkışık takvim ve yüksek maliyet kısıtlarını ele almak amacıyla bütünleşik, hiyerarşik ve otomatik test mimarisi yaklaşımları sunmaktadır. Dört yöntem ele alınmıştır: test sistemi tasarımında ortak altyapı ve yerlileştirme, yüksek teknoloji olgunluk seviyeli operasyonel aviyoniklerin erken aşamada entegrasyonu, System-in-the-Loop darboğazlarını azaltan Algorithm-in-the-Loop platformları ve CI/CD hatlarına entegre test sistemi otomasyonu. Bu yöntemler test altyapılarını geçici doğrulama araçlarından tekrarlanabilirliği ve ortaklığı sağlayan, sistem yaşam döngüsü boyunca çevik mühendisliği destekleyen stratejik ürünlere dönüştürmektedir.

Anahtar Kelimeler: Entegrasyon testi, Test otomasyonu, Savunma sistemleri

DEVELOPING INTEGRATION TEST INFRASTRUCTURE APPROACHES IN EVOLVING DEFENSE INDUSTRY STANDARDS (100)

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ABSTRACT

This study presents integrated, hierarchical, and automated test architecture approaches to address tight schedules and high-cost constraints in the design and serial production phase of the Turkish defense industry. Four methodological approaches are introduced: common infrastructure and localization in test system design, early-stage integration of high-TRL operational avionics, Algorithm-in-the-Loop (AIL) platforms to alleviate System-in-the-Loop bottlenecks, and test system automation integrated into CI/CD pipelines. These methodologies transform test infrastructures from temporary verification tools into living strategic products, ensuring repeatability, commonality, and driving agile engineering processes across the system lifecycle.

Keywords: Integration testing, Test automation, Defense systems

TURKISH GENERAL SESSIONS

WASPALOY SÜPERALAŞIMININ DÖVÜLEBİLİRLİĞİ VE TERMO-MEKANİK DAVRANIŞI ÜZERİNE DENEYSEL BİR ÇALIŞMA (6)

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ÖZET

Bu çalışmada, nikel esaslı Waspaloy süperalaşımının sıcak dövülebilirliği, laboratuvar ölçekli karakterizasyondan endüstriyel doğrulamaya uzanan bütüncül bir yaklaşımla incelenmiştir. Gleeble sıcak basma deneyleriyle akma eğrileri belirlenmiş, proses haritası oluşturulmuştur. Güvenli şekillendirme penceresi esas alınıp sonlu elemanlar analizlerinin de yardımıyla tav süresi, kalıp sıcaklığı ve operasyon sayısı optimize edilmiş; tasarlanan sıcak kalıp dövme prosesi hidrolik preste endüstriyel ölçekte uygulanmıştır. Dövme ve ısıl işlem sonucunda yüzey kusuru içermeyen, mekanik özellikleri iyileşmiş parçalar elde edilmiştir. Sonuçlar, proses haritalama ve sayısal modellemenin dövme proses tasarımı için güvenilir bir araç olduğunu göstermektedir.

Anahtar Kelimeler: Waspaloy, Sıcak dövme, Proses haritalama

AN EXPERIMENTAL STUDY ON THE FORGEABILITY AND THERMOMECHANICAL BEHAVIOR OF WASPALOY SUPERALLOY (6)

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ABSTRACT

This study investigates the hot forgeability of the nickel-based Waspaloy superalloy through an integrated approach extending from laboratory characterization to industrial validation. Flow curves and a process map were obtained by Gleeble hot-compression tests. Based on the safe forming window and finite-element analyses, soaking time, die temperature, and the number of operations were optimized, and the designed hot-die forging process was implemented on an industrial hydraulic press. Forging and heat treatment produced defect-free parts with improved mechanical properties. The results demonstrate that process mapping and numerical modeling are reliable tools for forging-process design.

Keywords: Waspaloy, Hot forging, Process mapping

CAM ELYAF TAKVIYELI PARA MALZEMEDEN ÜRETILEN PARÇADA RING YOLLUK TASARIMININ AKIŞ DAVRANIŞI VE ÇARPILMA ÜZERINDEKI ETKISININ ARAŞTIRILMASI (76)

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ÖZET

Cam elyaf takviyeli poliarilamid (PARA) malzemelerin enjeksiyon kalıplama prosesinde akış dengesizlikleri, çarpılma ve yüzey kusurlarına neden olabilmektedir. Bu çalışmada, ring yolluk tasarımının akış davranışı ve boyutsal kararlılık üzerindeki etkileri incelenmiştir. Tek girişli ve dört girişli ring yolluk tasarımları Moldex3D analizleri ile karşılaştırılmış, sonuçlar üretim denemeleri, CMM ölçümleri ve üç boyutlu tarama yöntemleriyle doğrulanmıştır. Bulgular, ring yolluk tasarımının akış dengesini iyileştirdiğini, çarpılmayı yaklaşık %25 azalttığını ve çevrim süresini 10 saniye kısalttığını göstermektedir.

Anahtar Kelimeler: Ring yolluk, Para, Enjeksiyon kalıplama

INVESTIGATION OF THE EFFECTS OF RING-RUNNER DESIGN ON FLOW BEHAVIOR AND WARPAGE IN A GLASS-FIBER-REINFORCED PARA PART (76)

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ABSTRACT

Flow imbalances during the injection molding of glass fiber reinforced polyarylamide (PARA) materials may cause warpage and surface defects. This study investigates the effects of a ring runner design on flow behavior and dimensional stability. Conventional single-gate and four-gate ring runner designs were compared using Moldex3D simulations, and the results were validated through production trials, coordinate measuring machine (CMM) measurements, and three-dimensional scanning. The findings indicate that the ring runner design improves flow balance, reduces warpage by approximately 25%, and shortens the cycle time by 10 seconds.

Keywords: Ring runner, Para, Injection molding

HİBRİT İMALAT YÖNTEMLERİ ÜZERİNE NOTLAR (87)

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ÖZET

Günümüzde imalat teknolojileri konusunda gelişmeler yeni ve farklı özelliklere sahip bir döneme girmiştir. 1990'lardan itibaren, hibrit imalat yöntemleri konusunda başlayan çalışmalar, günümüzde çok büyük aşamalar kat ederek yeni ve cazip imalat yöntemleri olarak karşımıza çıkmaktadır. Son 20 yılda yapılan çalışmaların miktarı ve endüstriyel uygulanabilirlikleri ile dikkat çeken bu yöntemler üzerine farklı yaklaşımların ortaya çıktığı görülmektedir. Karmaşık geometrik şekillerin üretiminde, çok sayıda işlem parametresinin eş zamanlı olarak kontrol edilmesini gerektiren hibrit imalat yöntemlerinden yararlanılmaktadır. Hibrit üretim, the International Academy for Production Engineering (CIRP) tarafından "iki veya daha fazla üretim teknolojisini yeni bir sistemde birleştirerek her yöntemin avantajlarını entegre bir şekilde kullanma yeteneği" olarak tanımlanmaktadır [1]. Başka bir deyişle, hibrit üretim, aynı işleme bölgesinde farklı (kimyasal, fiziksel, kontrollü) işleme prensiplerinin eş zamanlı olarak uygulanmasıdır [2]. Hibrit teknolojinin gelişmesiyle birlikte, yenilikçi ve alternatif üretim yöntemleri geleneksel üretim yöntemlerinin yerini almıştır. Maliyet faktörüne ek olarak, geleneksel üretim yöntemlerinin üretim sürecinde yarattığı zorluklar ve sorunlar, yeni üretim yöntemlerine yönelme eğilimine yol açmıştır. Hibrid imalat yöntemlerinin endüstriyel kullanımlarının genişliği ve ortaya çıkarttığı olumlu avantajların değerlendirildiği bu çalışmada, bu yöntemlerin çevresel duyarlılık ve sürdürebilirlik konuları da dikkate alınarak detaylı değerlendirmeler yapılmıştır. Özellikle imalat dünyasında yeniden tanımlamaların yapıldığı bu dönemde, modern imalat yöntemleri kapsamında değerlendirilen hibrit imalat yöntemlerinin gelecekteki potansiyeli, bu yöntemlere uygun tezgahların ortaya çıkması ile daha fazla potansiyele sahip olmalı beklenmektedir. Detaylı literatür araştırmasının, konu kapsamında çıkan dört kitap [3-6], verilmesi amaçlanmıştır.

Anahtar Kelimeler: Hibrit imalat, Modern imalat yöntemleri, Sürdürülebilirlik

NOTES ON HYBRID MANUFACTURING METHODS (87)

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ABSTRACT

Hybrid manufacturing has developed rapidly since the 1990s and has become an attractive route for producing complex geometries that require simultaneous control of many process parameters. CIRP defines hybrid manufacturing as combining two or more manufacturing technologies in a new system so that their advantages are used in an integrated manner; different chemical, physical, or controlled principles may operate simultaneously in the same processing zone. This review evaluates the industrial scope, benefits, environmental sensitivity, and sustainability of hybrid methods and discusses their future potential as suitable machine tools and integrated processes continue to emerge.

Keywords: Hybrid manufacturing, Advanced manufacturing, Sustainability

ATMOSFERIK BASINÇLI SOĞUK PLAZMA UYGULAMASININ CFRP KOMPOZITIN YÜZEY ISLANABILIRLIĞINE VE YAPIŞTIRMA BAĞLANTILARINA ETKISININ İNCELENMESI (91)

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ÖZET

Bu çalışmada, Karbon Fiber Destekli Polimer kompozit malzemelerin yüzey ıslanabilirliği ve yapıştırma performansını geliştirmek amacıyla atmosferik basınçlı soğuk plazma uygulamasının etkileri araştırılmıştır. Plazma uygulama mesafesi (10, 15 ve 20 mm) ile uygulama sayısı (3, 5 ve 7 paso) işlem parametresi olarak seçilmiş ve tam faktöriyel deney tasarımı uygulanmıştır. Plazma işlemi sonrasında yüzeylerin ıslanabilirliği temas açısı ölçümleriyle değerlendirilmiş, ardından tek kademeli bindirme numuneleri oluşturulup, çekme testine tabi tutularak bindirme kayma dayanımı değerleri belirlenmiştir. Plazma uygulanmamış numunelerde temas açısı 85,8° olarak ölçülürken, plazma uygulanan numunelerde ortalama temas açısı 49,1° olarak elde edilmiştir. Plazma uygulanmamış numunelerde bindirme kayma dayanımı 14,06 N/mm2 iken, plazma uygulanan numunelerde ortalama dayanım 15,2 N/mm2 olarak belirlenmiştir. Atmosferik basınçlı soğuk plazma uygulamasının yüzey ıslanabilirliğini artırdığı ve yapıştırma bağlantılarında mekanik performansı iyileştirdiği görülmüştür.

Anahtar Kelimeler: Soğuk plazma, Cfrp, Yapıştırma bağlantısı

EFFECT OF ATMOSPHERIC-PRESSURE COLD PLASMA ON THE SURFACE WETTABILITY AND ADHESIVE JOINTS OF CFRP COMPOSITES (91)

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ABSTRACT

Atmospheric-pressure cold plasma was investigated to improve the wettability and adhesive performance of CFRP composites. Treatment distance (10, 15, and 20 mm) and number of passes (3, 5, and 7) were varied in a full-factorial design. Wettability was assessed through contact-angle measurements, and single-lap specimens were tensile tested to determine lap-shear strength. The untreated contact angle of 85.8 degrees decreased to an average of 49.1 degrees after treatment, while average lap-shear strength increased from 14.06 to 15.2 N/mm². The results show that cold-plasma treatment improves both surface wettability and joint performance.

Keywords: Cold plasma, Cfrp, Adhesive bonding

ADR34 GEREKLILIKLERINE GÖRE FARKLI TEL TASARIMLARI İÇIN ÜST BAĞLANTI BÖLGESININ YAPISAL ANALIZI (31)

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ÖZET

ADR34 (Australian Design Rule), Avustralya'da araç güvenlik gerekliliklerini tanımlayan ve çocuk koltuğu bağlantı noktalarının dayanım kriterlerini içeren bir regülasyondur. Bu çalışmada, ADR34 gereklilikleri doğrultusunda M1 sınıfı 40/60 oranlı bir araç koltuğunun sonlu elemanlar analizi gerçekleştirilmiştir. Top Tether bağlantısının koltuk sırt tel yapısı üzerinde konumlanması nedeniyle çalışmada, koltuğun arka sırt bölgesindeki tel yapısına odaklanmıştır. Çalışma kapsamında üç farklı tel opsiyonu değerlendirilmiştir. Sürekli dikey telli yapı "A Tasarımı", yarım telli yapı "B Tasarımı" ve telsiz yapı ise "C Tasarımı" olarak adlandırılmıştır. Koltuğun arka sırt bölgesi, %60'lık kesitte bu üç tasarım aynı yükleme ve sınır koşulları altında karşılaştırılmıştır. Analiz modeli Altair HyperMesh ortamında oluşturulmuş olup, koltuğun yapısal bütünlüğü ve plastik deformasyon davranışları incelenmiştir. Top Tether bağlantısı, çarpışma sırasında oluşan yüklerin koltuk yapısına güvenli şekilde iletilmesini sağlayan kritik bir güvenlik bileşenidir. Bu çalışmada, ADR34 standardı gereklilikleri esas alınarak yalnızca Top Tether bağlantı bölgesinin yapısal dayanımı değerlendirilmiştir. Top Tether bağlantısının doğrudan araç gövdesi yerine koltuk sırt yapısına entegre edildiği durumlarda, ADR 34/03 Clause 11 kapsamında ek dayanım gereklilikleri tanımlanmaktadır. Bu doğrultuda analizlerde, Top Tether'dan kaynaklanan en az 3.4 kN'luk kuvvete ek olarak koltuğun toplam ağırlığının yirmi katına karşılık gelen yapısal yük dikkate alınmıştır. Elde edilen sonuçlara göre B Tasarımı ve C Tasarımı için koltuk sırt telinde kritik seviyede gerinmeler oluştuğu gözlemlenmiştir. SAE 1008 malzemesinin mekanik özellikleri dikkate alındığında, bu gerinme değerlerinin kabul edilebilir sınırların üzerinde olduğu belirlenmiştir. A Tasarımı'nda elde edilen maksimum gerinme değerlerinin malzeme sınırı olan %20 değerinin oldukça altında kaldığı görülmüştür.

Anahtar Kelimeler: Adr34, Top tether, Sonlu elemanlar analizi

STRUCTURAL ANALYSIS OF THE TOP-TETHER REGION FOR DIFFERENT WIRE DESIGNS ACCORDING TO ADR34 REQUIREMENTS (31)

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ABSTRACT

ADR34 defines Australian vehicle-safety requirements, including strength criteria for child-seat anchorage points. This study performs finite-element analysis of a 40/60 split M1-class vehicle seat and focuses on the rear-seatback wire structure carrying the Top Tether connection. Three concepts-a continuous vertical wire, a half wire, and a wire-free design-were compared under identical loads and boundary conditions in Altair HyperMesh. In accordance with ADR 34/03 Clause 11, the model included at least 3.4 kN from the Top Tether plus a structural load equal to twenty times the seat mass. The half-wire and wire-free designs produced critical strains above the acceptable range of SAE 1008, whereas the continuous-wire design remained well below the 20% material limit.

Keywords: Adr34, Top tether, Finite-element analysis

SAVAŞ GEMİLERİNDE PATLAMA YÜKLERİ ALTINDA DÖNER TABLA RULMANLARININ KARŞILAŞTIRMALI DAYANIM VE ÖMÜR ANALİZİ (68)

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ÖZET

Çalışmada blast etkisi altında tek sıra ve çift sıra bilyalı, makaralı döner tabla rulmanlarının yük taşıma kabiliyeti, temas karakteri, eşdeğer dinamik yük ve ISO 281 temel ömür yaklaşımı bakımından karşılaştırıldı. Analizde sabit patlama mesafesinde üç TNT yükündeki tehdit senaryoları değerlendirildi. Mesafe yaklaşımı ile blast şiddeti sınıflandırıldı ve rulmana aktarılan tasarım kuvvetleri hesaplandı. Ardından farklı rulman tipleri için yük dağıtım katsayıları tanımlanarak temel ömür değerleri karşılaştırıldı. TNT miktarı arttıkça ölçekli mesafenin azaldığını, dinamik yükün arttığını ve rulman ömrünün 30 kata kadar düştüğünü göstermektedir. Değerlendirmede makaralı rulmanın çizgisel temas karakteri ve yüksek dinamik yük kapasitesi nedeniyle blast etkisine daha dirençli olduğu görüldü.

Anahtar Kelimeler: Döner tabla rulmanı, Patlama yükü, Iso 281 ömrü

COMPARATIVE STRENGTH AND LIFE ANALYSIS OF SLEWING BEARINGS UNDER BLAST LOADS ON WARSHIPS (68)

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ABSTRACT

Single-row and double-row ball and roller slewing bearings were compared under blast loading in terms of load capacity, contact behavior, equivalent dynamic load, and ISO 281 basic rating life. Three TNT threat levels at a fixed stand-off distance were evaluated. Blast severity was classified using the scaled-distance approach, design forces transferred to the bearing were calculated, and load-distribution coefficients were defined for each bearing type. Increasing TNT mass reduced scaled distance, increased dynamic load, and decreased bearing life by as much as thirtyfold. Roller bearings were more resistant to blast effects because of their line contact and higher dynamic load capacity.

Keywords: Slewing bearing, Blast loading, Iso 281 life

KODLANMIŞ METAYÜZEY YÖNTEMİYLE RADAR KESİT ALANI (RSC) AZALTMA VE ANALİZİ (73)

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ÖZET

Bu çalışmanın temel amacı, askeri sezinleme sistemlerinde yaygın olarak kullanılan X-bandı (8-12 GHz) frekans aralığında yüksek performans gösteren, ultra ince ve optimize edilmiş bir ”Kodlanmış Metayüzey” tasarımı gerçekleştirerek bu kısıtlamaları aşmaktır. Önerilen metayüzey tasarımı, mikrodalga frekanslarında tam yansıtma ve faz kontrolü sağlamak amacıyla üç katmanlı bir sandviç model mimarisine dayanmaktadır. Sonlu Elemanlar Yöntemi (FEA) tabanlı simülasyon sonuçlarına göre, tasarlanan metayüzey X-bandının tamamında askeri standartlarca kabul gören -10 dB eşik değerinin altında bir performans sergilemiştir. Yapılan yüzey akımı analizleri, yapının elektriksel ve manyetik rezonans mekanizmaları sayesinde elektromanyetik enerjiyi yüksek bir verimlilikle ısı enerjisine dönüştürdüğünü ve endüstriyel üretim dayanıklılığına sahip olduğu doğrulanmıştır.

Anahtar Kelimeler: Kodlanmış metayüzey, Radar kesit alanı, X-bandı

RADAR CROSS-SECTION REDUCTION AND ANALYSIS USING A CODING METASURFACE (73)

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ABSTRACT

This study develops an ultrathin optimized coding metasurface for high performance in the X-band (8-12 GHz) used by military detection systems. The proposed design employs a three-layer sandwich architecture to provide reflection and phase control at microwave frequencies. Finite-element simulations show performance below the -10 dB threshold accepted by military standards across the X-band. Surface-current analyses confirm that electrical and magnetic resonance mechanisms convert electromagnetic energy efficiently into heat while maintaining industrial manufacturability and durability.

Keywords: Coding metasurface, Radar cross-section, X-band

PIYADE TÜFEKLERI İÇIN KOLAY DEĞIŞTIRILEBILEN BIR KOMPAKT TELESKOBIK DIPÇIK GELIŞTIRILMESI (88)

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ÖZET

Piyade tüfeklerinde kullanılan yekpare dipçikler standart omuzlukla üretilmekte ve sahada kolay deforme olmaktadırlar. Her kullanıcının silah kullanması farklı olduğu için yekpare dipçikler kullanıcılara zorluk yaşatmakta ve bu durum kullanıcının silahı kullanma kabiliyetini düşürmektedir. Bu çalışmada, yekpare dipçilerden farklı olarak omuzluk kısmı opsiyonel olarak kolayca değiştirilebilen bir kompakt teleskobik dipçik geliştirilmesi hedeflenmiştir. Bu amaçla, dipçiğe kolayca monte edilebilen ve enjeksiyon kalıplamaya uygun yeni bir omuzluk tasarımı yapılmıştır. Omuzluk topoğrafyasının darbe sönümleme kabiliyetine etkisini araştırmak için altı farklı geometri hazırlanmıştır. Bu geometrilere sayısal mukavemet analizleri uygulanmıştır. Analizler sonucunda en iyi bulunan geometriler enjeksiyon kalıplamayla üretilmiş ve özel bir düzenekte düşme testleri yapılmıştır. Modüler dipçik tasarımında, dipçik gövdesi altı farklı termoplastik matrisli kompozit, omuzluk iki farklı termoplastik elastomer ile üretilmiştir. Geliştirilen yeni plastik matrisli kompozit tasarım sayesinde dipçik aynı mukavemeti sağlarken, dipçiğin ağırlığı, birim üretim süresi ve maliyetleri düşürülmüştür.

Anahtar Kelimeler: Teleskobik dipçik, Kompozit malzeme, Darbe sönümleme

DEVELOPMENT OF AN EASILY REPLACEABLE COMPACT TELESCOPIC STOCK FOR INFANTRY RIFLES (88)

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ABSTRACT

Conventional one-piece rifle stocks use a standard butt pad, can deform in field use, and do not accommodate different users. This study develops a compact telescopic stock with an easily replaceable butt pad suitable for injection molding. Six pad geometries were designed and numerically analyzed for impact absorption; the best concepts were manufactured and subjected to drop tests. The stock body was produced from six thermoplastic-matrix composites and the pad from two thermoplastic elastomers. The resulting modular composite design maintained strength while reducing weight, unit production time, and cost.

Keywords: Telescopic stock, Composite material, Impact absorption

RÜZGAR TÜRBİNİ KULESİNDE KARBON FİBER TAKVİYESİYLE YAPISAL ÖZELLİKLERİN İYİLEŞTİRİLMESİ (105)

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ÖZET

Bu çalışmada, rüzgar türbini kule gövdesi yapılarında yaygın olarak kullanılan S355 yapısal çeliğin yorulma performansının incelenmesi hedeflenmiştir. ASTM E466 standardına uygun olarak üretilmiş kaynaklı-karbon fiber kaplı, kaynaksız-karbon fiber kaplı, kaynaklı-karbon fiber kaplamasız ve kaynaksız-karbon fiber kaplamasız olmak üzere dört farklı numune grubunun değerlendirilmesi planlanmıştır. Deneylerde karbon fiber takviye malzemesi olarak CX400 -45/+45 Biaxial Karbon Elyaf, CX600 -45/+45 Biaxial Karbon Elyaf ve Horse Karbon HM 300 UD kullanılmış olup, bu farklı elyaf türlerinin yorulma davranışlarının karşılaştırmalı olarak gözlemlenmesi amaçlanmıştır. Deney düzeneği, elektrik motoru tahrikli krank-biyel mekanizması aracılığıyla dönel hareketin doğrusal ileri-geri harekete dönüştürüldüğü ve numune plakasının iki yay arasında tekrarlı yüklere maruz bırakılabildiği özgün bir sistem olarak tasarlanmıştır. Numunelere uygulanan gerilme genlikleri değiştirilerek elde edilen veriler doğrultusunda S-N (Wöhler) eğrilerinin oluşturulması ve yorulma ömürlerinin karşılaştırmalı olarak değerlendirilmesi beklenmektedir. Analizlerin, özellikle kaynaklı birleşimlerin yorulma dayanımı üzerindeki belirleyici etkisini ortaya koyması; karbon fiber kaplamanın gerilme yığılmalarını azaltarak çatlak başlama gecikmesini sağlaması ve çatlak ilerleme davranışını olumlu yönde etkilemesi beklenmektedir. Ayrıca karbon fiber takviyesinin yüzey gerilme dağılımını modifiye ederek yapısal bütünlüğe katkı sağlaması ve yorulma ömründe belirgin artışlara yol açması hedeflenmiştir. Çalışmanın, rüzgar türbini kulelerinde kullanılan çelik yapı elemanlarının servis ömrünün artırılmasına yönelik kompozit güçlendirme uygulamalarının etkinliğini ortaya koyarak, mühendislik tasarım ve modelleme süreçlerinde karbon fiber elyaf kullanımıyla çelik plaka kalınlığının azaltılmasının hedeflenmesi ve bakım stratejilerine katkı sunması beklenmektedir.

Anahtar Kelimeler: Rüzgar türbini kulesi, Karbon fiber takviye, Yorulma ömrü

IMPROVEMENT OF STRUCTURAL PROPERTIES IN A WIND-TURBINE TOWER USING CARBON-FIBER REINFORCEMENT (105)

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ABSTRACT

This study evaluates the fatigue performance of S355 structural steel used in wind-turbine towers. Four ASTM E466 specimen groups-welded and unwelded, with and without carbon-fiber coating-are examined using three reinforcement systems. A custom crank-slider rig applies repeated loading, and S-N curves are used to compare fatigue lives. The study investigates whether carbon-fiber reinforcement reduces stress concentration, delays crack initiation and propagation, improves structural integrity, and enables reduced steel-plate thickness and longer service life, particularly in welded joints.

Keywords: Wind-turbine tower, Carbon-fiber reinforcement, Fatigue life

DAİRE TESTERE İLE KESMEDE YAĞLAMA KOŞULLARI VE KESME PARAMETRELERİNİN KESME SICAKLIĞI VE YÜZEY KALİTESİ AÇISINDAN OPTİMİZASYONU (19)

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ÖZET

Daire testere ile kesme, yüksek kesme hızı ve verimliliği ile talaşlı imalat hatlarında yüksek kullanım oranına sahip bir işlemdir. İş parçası, kesme hızı, ilerleme oranı, soğutma sıvısı gibi parametreler bu işlemde yüzey kalitesi ve kesme sıcaklığını doğrudan etkilemektedir. Oluşan yüksek sıcaklıklar ve uygun olmayan kesme parametreleri iş parçası yüzey kalitesini olumsuz etkilemektedir. Dolayısıyla, daire testere ile kesme işlemlerinde kesme parametreleri ve soğutma sıvısının optimizasyonu önemli bir rol oynamaktadır. Bu çalışmada daire testere ile kesmede yağlama koşulları ve kesme parametrelerinin iş parçası yüzey kalitesi ve kesme sıcaklıklarına etkisi deneysel olarak incelenmiştir. Deneyler, farklı formülasyonlar ile geliştirilen üç farklı biyobozunur ester bazlı MQL sıvılar (1: ESTER+ EP+AW+ Diğer katkılar, 2: ESTER+ 2xEP+AW+ Diğer katkılar, 3: ESTER + Su+ EP+ Diğer katkılar), üç farklı kesme hızı (100-120-140 m/dk) ve üç farklı ilerleme oranı (0,035-0,050-0,065 mm/diş) seviyelerinde Taguchi L9 deney tasarımı ile gerçekleştirilmiş, kesme bölgesinden ölçülen sıcaklık ve iş parçası yüzey pürüzlülük değerleri ile sonuçlar analiz edilmiştir. Optimum parametreler ve bu parametrelerin sonuçlar üzerindeki etki oranı, sinyal/gürültü ve varyans analizleri ile belirlenmiştir.

Anahtar Kelimeler: Daire testere, Minimum miktarda yağlama, Taguchi optimizasyonu

OPTIMIZATION OF LUBRICATION CONDITIONS AND CUTTING PARAMETERS IN CIRCULAR SAWING FOR CUTTING TEMPERATURE AND SURFACE QUALITY (19)

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ABSTRACT

Circular sawing is extensively used in machining lines because of its high speed and productivity. Cutting speed, feed, workpiece properties, and coolant directly influence cutting temperature and surface quality. This study experimentally investigates three biodegradable ester-based minimum-quantity-lubrication fluids, three cutting speeds (100, 120, and 140 m/min), and three feeds (0.035, 0.050, and 0.065 mm/tooth) using a Taguchi L9 design. Cutting-zone temperature and workpiece surface roughness were measured. Optimum parameters and their contribution ratios were determined through signal-to-noise and variance analyses.

Keywords: Circular sawing, Minimum quantity lubrication, Taguchi optimization

CFRP/TI HİBRİT İSTİF KOMPOZİTLERİN DELİK DELME İŞLEMİNİN İNCELENMESİ (28)

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ÖZET

Bu çalışmada CFRP/titanyum hibrit istif yapıların delinme performansı deneysel olarak incelenmiştir. Deneylerde üç farklı kesme hızı, üç farklı ilerleme oranı ve iki farklı istifleme sırası kullanılmıştır. İşleme performansının değerlendirilmesi için kesme kuvvetleri, yüzey pürüzlülüğü ve titanyum tabakasındaki çapak uzunlukları ölçülmüştür. Kesme parametrelerinin etkilerini incelemek ve en uygun kesme koşullarını belirlemek amacıyla Taguchi L18 deney tasarımı uygulanmıştır. Sonuçlar, ilerleme oranı ve kesme hızının delik kalitesi ile çapak oluşumu üzerinde önemli etkileri olduğunu göstermiştir. Çalışma, hibrit kompozit yapıların delinmesinde parametre optimizasyonuna katkı sağlamayı amaçlamaktadır.

Anahtar Kelimeler: Cfrp/titanyum istif, Delik delme, Taguchi yöntemi

INVESTIGATION OF DRILLING CFRP/TI HYBRID STACK COMPOSITES (28)

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ABSTRACT

This study involves an experimental investigation of the drilling performance of CFRP/titanium hybrid composite structures. The experiments utilized three different cutting speeds, three different feed rates, and two different stack orders. For evaluating the machining performance, cutting forces, surface roughness, and burr lengths in the titanium layer were measured. A Taguchi (L18) experimental design was used to analyze the effects of cutting parameters and determine the optimal cutting conditions. The results revealed that feed rate and cutting speed have significant effects on hole quality, and burr formation. The study aims to contribute to parameter optimization in the drilling processes of hybrid composite structures.

Keywords: Cfrp/titanium stack, Drilling, Taguchi method

ENDÜSTRİYEL ASENKRON MOTORLARDA FİZİĞE DAYALI YARI-DENETİMLİ ANOMALİ TESPİTİ (122)

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ÖZET

Bu çalışma, etiketlenmiş arıza verisi içermeyen gerçek SCADA telemetrisi üzerinde fiziğe dayalı yarı-denetimli bir anomali tespit çerçevesi sunmaktadır. Çok-frekanslı sensör akışları, 39,4 saatlik elektriksel kesintinin tespiti ve segment-farkında füzyonla 23.373 analiz penceresine dönüştürülmüş; NEMA MG-1 ve ISO 20816-3 standartlarından türetilen kırk fizik-tabanlı özellik Yeo-Johnson dönüşümüyle normalleştirilmiştir. Aykırılık ormanı ve LSTM Otokodlayıcı, AND kesişim sözde-etiketleme stratejisiyle birleştirilip ablasyon analiziyle doğrulanmıştır. En başarılı sınıflandırıcı RBF-SVM; hassasiyet 0,873, F1 0,687, AUC-ROC 0,992 ve 1,34 ms gecikmeyle gerçek zamanlı dağıtıma hazırdır. Harici doğrulama, tüm özelliklerde anlamlı dağılım kayması tespit ederek çevrimiçi izleme gerekliliğini kanıtlamıştır.

Anahtar Kelimeler: Asenkron motor, Anomali tespiti, Yarı-denetimli öğrenme

PHYSICS-BASED SEMI-SUPERVISED ANOMALY DETECTION IN INDUSTRIAL INDUCTION MOTORS (122)

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ABSTRACT

This study presents a physics-based semi-supervised anomaly-detection framework using real SCADA telemetry without labeled fault data. Multi-frequency sensor streams were converted into 23,373 analysis windows after detecting a 39.4-hour electrical interruption and applying segment-aware fusion. Forty physics-based features derived from NEMA MG-1 and ISO 20816-3 were normalized using the Yeo-Johnson transformation. Isolation Forest and an LSTM autoencoder were combined through AND-intersection pseudo-labeling and validated by ablation analysis. The best RBF-SVM classifier achieved 0.873 precision, 0.687 F1, 0.992 AUC-ROC, and 1.34 ms latency. External validation revealed significant distribution shift, demonstrating the need for online monitoring.

Keywords: Induction motor, Anomaly detection, Semi-supervised learning

KARTON TÜKETIMINI AZALTAN ÇEVRECI VE YENILIKÇI BIR OTOMATIK KOLILEME MAKINESININ TASARIMI (113)

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ÖZET

Günümüzde ambalajlama sektöründe artan sürdürülebilirlik gereksinimleri ve maliyet baskıları, malzeme kullanımını optimize eden yenilikçi kolileme sistemlerine olan ihtiyacı artırmaktadır. Bu çalışmada, ürün akışıyla senkronize çalışan ve koliyi hazır olarak kullanmak yerine makine içerisinde oluşturan sürekli çalışma prensibine sahip otomatik bir etraf sarma (wrap-around) kolileme sistemi tasarlanmıştır. Sistem, koliyi ürünün gerçek boyutlarına göre şekillendirerek dayanımı artırmakta ve gereksiz karton kullanımını azaltmaktadır.

Geliştirilen sistem, yüksek hızlı üretim hatlarında kesintisiz çalışabilecek şekilde tasarlanmış olup farklı ürün ve koli boyutlarına uyum sağlayan esnek bir yapıya sahiptir. Koli taşıma ve yan kapama mekanizmaları sayesinde farklı ölçülerde güvenilir çalışma sağlanmaktadır. Ürüne özel koli oluşturma yaklaşımı, geleneksel hazır koli kullanımına kıyasla malzeme tüketiminin azaltılmasına olanak vermektedir.

Yapılan çalışmalar sonucunda ESM300 etraf sarma kolileme sisteminin, geleneksel yöntemlere göre yaklaşık %30 daha az karton kullanarak aynı üretim kapasitesini sürdürebileceği öngörülmektedir. Ayrıca kapasitenin dakikada 10 koliden 15 koliye çıkarılması hedeflenmektedir.

Sistemde ürün algılama, konum doğrulama ve proses kontrolü amacıyla fotoelektrik, endüktif ve analog mesafe sensörleri ile enkoderler kullanılmıştır. Özellikle SICK OD2000-3502T15 analog mesafe sensörleri, farklı ürün ve koli ölçülerine geçişlerde mekanik ayar ihtiyacını ortadan kaldırarak otomatik ve hassas konumlandırma sağlamaktadır. Geliştirilen özel algoritma sayesinde sensör verilerine göre çalışma parametreleri operatör müdahalesi olmadan otomatik olarak ayarlanmakta ve farklı ölçülere hızlı adaptasyon sağlanmaktadır. Böylece operasyonel esneklik, üretim verimliliği ve proses sürekliliği artırılmaktadır.

Anahtar Kelimeler: Etraf sarma kolileme, Karton tasarrufu, Otomasyon

DESIGN OF AN ECO-FRIENDLY AND INNOVATIVE AUTOMATIC CASE-PACKING MACHINE THAT REDUCES CARDBOARD CONSUMPTION (113)

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ABSTRACT

This study designs a continuously operating wrap-around case-packing system that forms each case inside the machine in synchronization with product flow. Forming the case to actual product dimensions increases strength and reduces unnecessary cardboard. The flexible system supports different product and case sizes and is designed for uninterrupted high-speed lines. The ESM300 concept is expected to use about 30% less cardboard while increasing capacity from 10 to 15 cases per minute. Photoelectric, inductive, and analog distance sensors and encoders provide product detection, position verification, and automatic parameter adjustment without operator intervention.

Keywords: Wrap-around case packing, Cardboard reduction, Automation

SAC İŞLEME MAKİNELERİ İÇİN TAM OTOMATİK DÖNDÜRME SİSTEMİ (3)

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ÖZET

Büküm ve sac şekillendirme süreçlerinde, folyolu veya hassas kaplamalı sacların yönlendirilmesi, üretim verimliliği ve yüzey kalitesi açısından büyük önem taşımaktadır. Geleneksel manuel yöntemler, operatör müdahalesine bağımlı olduğu için hem hız hem de kalite açısından sınırlı kalmaktadır. Bu bağlamda, farklı boyut ve geometrideki sacların herhangi bir operatör müdahalesi olmadan hassas şekilde döndürülmesini sağlayacak otomatik çözümler gerekmektedir. Proje kapsamında, özellikle Punch, Makas ve Panel Bender makinelerinin bir arada kullanıldığı hat sistemlerinde, makineden çıkan sac malzemeler ilgili makineye otomatik olarak beslendiğinde bazı durumlarda bükümden önce döndürülmesi gerekmektedir. Sistem, vakumlu veya yumuşak kaplı tutucular ile parçayı güvenli şekilde kavrayıp, programlanmış açılarda hassas şekilde döndürmektedir. Döndürme işlemi, parçanın ağırlık merkezi ve boyutlarına göre otomatik olarak ayarlanabilir; farklı geometri ve ölçülerde saclarla uyumlu esnek bir çalışma kabiliyeti sunmaktadır. Döndürme masası sistemi, mevcut CNC büküm makineleri ile bütünleşmiş çalışabilmekte ve Endüstri 4.0 kapsamında otomasyon hatlarına uyumlu olarak tasarlanmıştır. Bu sayede üretim süreleri kısalmakta, yüzey kalitesi korunmakta ve insan kaynaklı hatalar minimize edilmektedir. Günümüzde, folyolu sacların yüksek kaliteli ve hızlı üretimi için bu tür otomatik döndürme sistemleri, üretim süreçlerinde kritik bir teknoloji olarak öne çıkmaktadır.

Anahtar Kelimeler: Otomatik döndürme sistemi

FULLY AUTOMATIC ROTATION SYSTEM FOR SHEET-METAL PROCESSING MACHINES (3)

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ABSTRACT

In bending and sheet-forming processes, the orientation of foil-coated or sensitive sheets is critical to production efficiency and surface quality. Manual methods depend on operator intervention and are therefore limited in speed and consistency. This study develops an automatic system that grips sheets safely with vacuum or soft-coated holders and rotates them precisely to programmed angles before feeding them to punch, shear, and panel-bender machines. Rotation is adjusted automatically according to the part dimensions and center of gravity. The system is integrated with existing CNC bending machines and Industry 4.0 production lines, reducing cycle time and human error while preserving surface quality.

Keywords: Sheet-metal handling, Automatic rotation, Cnc bending

TEK MOTOR TAHRİKLİ ZİNCİR AKTARMA MEKANİZMASINA SAHİP DİKEY KATLANABİLİR, UYARLANABİLİR HAREKETLİ CEPHE SİSTEMİNİN TASARIMI, KİNEMATİK ANALİZİ VE PROTOTİP UYGULAMASI (9)

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ÖZET

Uyarlanabilir cephe çözümleri, gün ışığı ve güneş kazançlarının kontrolü ile doğal havalandırmayı destekleme potansiyeli nedeniyle bina kabuğunda önemli bir mekanik tasarım problem alanı oluşturmaktadır. Bununla birlikte mevcut dinamik sistemler sıklıkla çoklu aktüatör kullanımına, karmaşık bağlantı kinematiklerine veya montaj toleranslarına yüksek derecede duyarlı mekanizmalara dayanmakta; bu durum maliyet, bakım gereksinimi ve işletme güvenilirliği açısından endüstriyel uygulanabilirliği sınırlamaktadır. Bu çalışmada, söz konusu kısıtları azaltmayı hedefleyen patentli bir dikey katlanabilir dinamik cephe modülü tanıtılmaktadır. Önerilen modül, tek bir tubular motorun tahrik ettiği zincir mekanizması üzerinden senkronize hareket eden katlanır panellerden oluşur. Sistem, iki panel konfigürasyonunda ana ürün olarak kurgulanmış; üç panel seçeneği ve panel dolgu malzemesi (ana çözüm: bondingli ısı yalıtımlı cephe camı; opsiyonel: metal mesh veya ahşap) ile farklı tasarım gereksinimlerine uyarlanabilir şekilde modülerleştirilmiştir. Kinematik hareket, yapısal güvenliği artırmak amacıyla dönüş limitleri ile sınırlandırılmış; ters hareketi önleyen kilitleme-yönlendirme detayı ile sıkışma durumlarında akıcı açılmayı destekleyen alt mafsallı sabitleme düzeni tasarıma entegre edilmiştir. İki panelli prototip, 2800 × 1600 mm boyutlarında 1:1 ölçekte, cam dolgu ile üretilmiş ve işlevsel doğrulama testlerine tabi tutulmuştur. Tasarımın ölçeklenebilir ürün sınırı 2500 mm yatay ve 3000 mm düşey boyutlar olarak hedeflenmiştir. Çalışmanın amacı, tek tahrikli senkron kinematik yaklaşımının, cephe ölçeğinde güvenilir ve üretime uygun bir mekanik çözüm potansiyeli sunduğunu mekanik tasarım perspektifinden ortaya koymaktır.

Anahtar Kelimeler: Mekanik tasarım, Dinamik cephe modülü, Adaptif cephe

DESIGN, KINEMATIC ANALYSIS, AND PROTOTYPE IMPLEMENTATION OF A VERTICALLY FOLDABLE ADAPTIVE KINETIC FAÇADE SYSTEM WITH A SINGLE-MOTOR CHAIN DRIVE (9)

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ABSTRACT

Adaptive façades can control daylight and solar gains and support natural ventilation, but many existing systems rely on multiple actuators or tolerance-sensitive mechanisms. This study presents a patented vertically foldable façade module whose panels move synchronously through a chain mechanism driven by a single tubular motor. The modular design supports two- or three-panel configurations and glass, metal-mesh, or timber infill. Rotation limits, an anti-reverse locking guide, and a lower articulated fixing improve safety and smooth operation. A full-scale 2800 × 1600 mm two-panel glazed prototype was manufactured and functionally tested. The results show that the single-drive synchronized concept offers a reliable and manufacturable façade-scale mechanical solution.

Keywords: Adaptive façade, Kinetic mechanism, Mechanical design

HYPERLOOP SISTEMLERI İÇIN HALBACH DIZILIMLI LEVITASYON DISKLERININ AÇI VE MESAFEYE BAĞLI İTKISINI ÖLÇEN TEST CIHAZI (114)

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ÖZET

Bu çalışmada, Hyperloop araçlarında kullanılmak üzere geliştirilen Halbach dizilimli levitasyon disklerinin farklı açı ve disk-plaka mesafelerinde oluşturduğu kaldırma ve itki kuvvetlerini fiziksel ortamda ölçebilen bir test cihazı tasarlanmış ve imal edilmiştir. Çalışmanın çıkış noktası, döner Halbach diskleri için sonlu elemanlar analiziyle elde edilen kuvvet değerlerinin gerçek sistem koşullarında doğrulanmasına yönelik erişilebilir ve yeniden yapılandırılabilir bir deney düzeneği ihtiyacıdır. Test sisteminin şasisi Al6063-T6 malzemeden 30 x 30 mm ağır tip sigma profillerle oluşturulmuştur. Diskin düşey konumu 1-60 mm aralığında ayarlanabilmekte, açı mekanizması ise saat yönü ve tersi yönde 25 dereceye kadar hareket sağlayabilmektedir. Kuvvet verileri yük hücreleri, HX711 yükseltici kartı ve ESP32 tabanlı ölçüm zinciriyle toplanmıştır. Ansys Maxwell ortamında 3300 RPM çalışma koşulu için yaklaşık 78 N olarak hesaplanan kuvvet, geliştirilen test cihazında yaklaşık 76 N olarak ölçülmüştür. Deneysel değer ile analiz sonucu arasındaki uyum %97,44, bağıl fark ise %2,56 olarak belirlenmiştir. Sonuçlar, geliştirilen düzeneğin Halbach dizilimli levitasyon disklerinin tasarım doğrulamasında kullanılabileceğini göstermiştir. Ölçüm doğruluğunun artırılması için moment etkilerini azaltacak S tipi yük hücresi kullanımı ve kontrollü deney tekrarları önerilmiştir.

Anahtar Kelimeler: Halbach dizilimi, Manyetik levitasyon, Hyperloop

A TEST DEVICE FOR MEASURING ANGLE- AND DISTANCE-DEPENDENT THRUST OF HALBACH-ARRAY LEVITATING DISKS FOR HYPERLOOP SYSTEMS (114)

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ABSTRACT

A reconfigurable device was designed and manufactured to measure lift and thrust produced by rotating Halbach-array levitation disks at different angles and disk-plate gaps. The aluminum-profile frame permits a 1-60 mm vertical gap and ±25-degree angular adjustment. Forces were acquired using load cells, HX711 amplification, and an ESP32-based chain. At 3300 rpm, Ansys Maxwell predicted approximately 78 N and the device measured approximately 76 N, corresponding to 97.44% agreement and a 2.56% relative difference. The setup is therefore suitable for design verification of Halbach levitation disks.

Keywords: Halbach array, Magnetic levitation, Hyperloop

SCARA ROBOT TABANLI FREZELEME SISTEMININ TASARIMI VE GELIŞTIRILMESI (115)

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ÖZET

Bu çalışmada, düşük kesme kuvvetli talaşlı imalat uygulamaları için kompakt, düşük maliyetli ve enerji verimli bir SCARA robot tabanlı frezeleme prototipi geliştirilmiştir. Sistem, 2B CAD çizimlerini DXF formatında işleyerek Python tabanlı yazılım ve ters kinematik denklemler aracılığıyla robot eklem açılarına dönüştürmektedir. Arduino Mega 2560 kontrollü step motorlar ve DC spindle ile 2,5 eksende otomatik talaş kaldırma sağlanmıştır. Çalışma, G-koda ihtiyaç duymayan yazılım mimarisi ve taşınabilir robotik işleme yaklaşımıyla prototipleme, eğitim ve küçük ölçekli üretim uygulamalarına katkı sunmaktadır.

Anahtar Kelimeler: Scara robot, Robotik frezeleme, Ters kinematik

DESIGN AND DEVELOPMENT OF A SCARA-ROBOT-BASED MILLING SYSTEM (115)

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ABSTRACT

A compact, low-cost, and energy-efficient SCARA-robot-based milling prototype was developed for low-cutting-force applications. The system processes two-dimensional CAD drawings in DXF format and converts them into robot-joint angles using Python software and inverse-kinematics equations. Arduino Mega 2560-controlled stepper motors and a DC spindle provide automated 2.5-axis material removal. By eliminating the need for G-code and offering portable robotic machining, the architecture supports prototyping, education, and small-scale production.

Keywords: Scara robot, Robotic milling, Inverse kinematics

ENDÜSTRİYEL DAİRE TESTERE KESİMİNDE AÇIKLANABİLİR YAPAY ZEKA İLE TIRLAMA KARAKTERİZASYONU VE TESPİTİ (12)

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ÖZET

Bu çalışmanın temel amacı, endüstriyel dairesel testere kesim süreçlerinde karşılaşılan tırlama problemini yüksek doğrulukla tespit etmek ve bu kararsızlık rejimlerinin fiziksel altyapısını anlamlandırmaktır. Bu doğrultuda, kararlı kesim durumları ile tırlama anlarındaki sensör verileri detaylıca karşılaştırılarak, kararsızlık anında sensörlerde oluşan hareketliliklerin ve sinyal farklılıklarının analiz edilmesi hedeflenmiştir. Geleneksel ”kara kutu” makine öğrenmesi modellerinin ötesine geçilerek, tırlama anında özellikle iş mili motor yüklenmesi ve yapısal titreşim ivmesinde meydana gelen anlık değişimler Açıklanabilir Yapay Zeka (XAI) yaklaşımlarıyla çözümlenmiştir. Böylece, geliştirilen algoritmanın karar mekanizması salt istatistiksel bir sınıflamadan ziyade, normal ve anormal kesim rejimleri arasındaki fiziksel sinyal farklılıklarıyla doğrulanmış, güvenilir bir tırlama karakterizasyon çerçevesi sunmaktadır.

Anahtar Kelimeler: Daire testere, Tırlama titreşimi, Makine öğrenmesi

EXPLAINABLE-AI-BASED CHATTER CHARACTERIZATION AND DETECTION IN INDUSTRIAL CIRCULAR SAWING (12)

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ABSTRACT

This study aims to detect chatter in industrial circular-saw cutting with high accuracy and to explain the physical basis of unstable cutting regimes. Sensor signals from stable and chatter conditions are compared to identify transient changes in spindle-motor load and structural vibration acceleration. Going beyond black-box machine-learning models, Explainable Artificial Intelligence methods are used to interpret these variations. The resulting framework validates algorithmic decisions against physical signal differences between normal and abnormal cutting and provides a reliable basis for chatter characterization.

Keywords: Circular sawing, Chatter vibration, Explainable ai

DAİRE TESTERE İLE KESMEDE TIRLAMA TİTREŞİMLERİNİN FFT TABANLI SPEKTRAL ANALİZ İLE ARAŞTIRILMASI (17)

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ÖZET

Daire testere ile kesme işlemi, talaşlı imalatta özellikle yüksek kesme hızı, düşük işleme süresi ve seri üretime uygunluğu nedeniyle üstün bir imalat yöntemidir. Bu işlemde kesme kalitesi, yüzey pürüzlülüğü, titreşim, kesme doğruluğu ve takım aşınması gibi çıktılar ikincil imalat prosesleri ve toplam üretim verimliliğini doğrudan etkiler. Bu nedenle daire testere ile kesme, yalnızca malzeme ayırma operasyonu değil, aynı zamanda seri üretimde kritik rol oynayan bir aşamadır. Bu çalışma, daire testere ile kesme işlemlerinde meydana gelen ve işleme kalitesini olumsuz etkileyen tırlama titreşimlerini analiz etmeyi amaçlamaktadır. Deneyler beş farklı kesme hızı (110-130 m/dk) ve dört farklı ilerleme oranı (0.055-0.070 mm/diş) kullanılarak tam faktöriyel tasarım ile gerçekleştirilmiştir. Kesici takım üzerinde gezer çekiç yöntemi kullanılarak modal analiz gerçekleştirilmiş, kesme işlemleri sırasında alınan ses kayıtlarına Fast Fourier Transformation (FFT) analizi uygulanmıştır.

Anahtar Kelimeler: Daire testere, Tırlama titreşimi, Fft analizi

INVESTIGATION OF CHATTER VIBRATIONS IN CIRCULAR SAWING USING FFT-BASED SPECTRAL ANALYSIS (17)

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ABSTRACT

Circular sawing is widely used because of its high cutting speed, short processing time, and suitability for mass production. Surface quality, vibration, dimensional accuracy, and tool wear directly affect downstream operations and overall productivity. This study investigates chatter vibrations that impair circular-saw cutting quality. Experiments were performed using a full-factorial design with five cutting speeds (110-130 m/min) and four feeds (0.055-0.070 mm/tooth). Modal analysis of the saw was conducted using an impact-hammer method, and Fast Fourier Transform analysis was applied to acoustic recordings acquired during cutting.

Keywords: Circular sawing, Chatter vibration, Fft analysis

İŞLENMIŞ YÜZEYLERDE YÜZEY BÜTÜNLÜĞÜNÜ İYILEŞTIRMEK İÇIN DÜŞÜK MALIYETLI BILYALI EZME APARATI GELIŞTIRILMESI VE TEST EDILMESI (112)

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ÖZET

Bu çalışmada havacılık, uzay ve savunma sanayinde yaygın olarak kullanılan yüksek mukavemetli Al 7075-T6 alaşımının yüzey bütünlüğünü iyileştirmek amacıyla, freze tezgâhları için düşük maliyetli bir bilyalı ezme aparatı geliştirilmiştir. Endüstride kullanılan takımların aksine, kademe (faturalı mil) tasarımıyla parça sayısı minimuma indirilmiş ve aparat AISI C45 mil ile sabit rulman seti kullanılarak imal edilmiştir. Deneyler, 2x2x3 tam faktöriyel tasarım modeline göre 12 deney olarak (L1-L12) yürütülmüştür. Kontrol edilebilir proses faktörleri olarak ezme yönü (dik, paralel), ezme hızı (V=110 m/dk ve V=220 m/dk), ilerleme hızı (f_z=80 mm/dk, f_z=160 mm/dk ve f_z=224 mm/dk) seçilmiştir. Ezme derinliği ise 0,02 mm değerinde sabit tutulmuştur. Sürtünmeden dolayı oluşan ısıyı uzaklaştırmak için deneyler kesme sıvısıyla gerçekleştirilmiştir. Varyans analizine (ANOVA) göre, lineer parametreler içerisinde Ra yüzey pürüzlülüğünü en çok etkileyen faktörün %18,72 etki oranıyla ilerleme hızı f_z olduğu, ezme hızının V tekil etkisinin ise %9,99 seviyesinde kaldığı tespit edilmiştir. Deney tasarımında oluşturulan modelin Ra üzerindeki toplam varyasyonu açıklama oranı %88,37 olarak hesaplanmıştır ve istatistiksel güvenilirliğe (P = 0,000) sahip olduğu doğrulanmıştır. Bilyalı ezme işlemi neticesinde, ortalama yüzey pürüzlülüğü Ra değerinde %74,18, Rz değerinde ise %61,81 oranında bir iyileşme gözlemlenmiştir. Vickers HV20 test yükü ile gerçekleştirilen mikro sertlik ölçümlerinde, sertliğin numunelerde %21 ile %28 aralığında artış sağladığı görülmüştür. Deformasyon bölgesindeki ulaşılan en yüksek bağıl sertlik artış oranı %28,79 olarak elde edilmiştir. Geliştirilen bilyalı ezme aparatı, kaba iş parçalarında bile yüzey bütünlüğünü iyileştirip üretim maliyetlerini düşürdüğü için KOBİ ölçekli işletmelerde kullanılabileceği kanıtlanmıştır.

Anahtar Kelimeler: Bilyalı ezme, Yüzey bütünlüğü, Al 7075-t6

DEVELOPMENT AND TESTING OF A LOW-COST BALL-BURNISHING TOOL FOR IMPROVING SURFACE INTEGRITY (112)

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ABSTRACT

A low-cost ball-burnishing tool was developed for milling machines to improve the surface integrity of Al 7075-T6. A simplified stepped-shaft design reduced the part count. Twelve experiments followed a 2×2×3 full-factorial design using burnishing direction, speed, and feed as factors at a constant 0.02 mm depth. ANOVA showed feed to be the strongest linear factor affecting Ra. The model explained 88.37% of Ra variation. Ball burnishing improved average Ra by 74.18% and Rz by 61.81%, while microhardness increased by 21-28%. The tool therefore offers a practical low-cost option for improving surface integrity in small and medium-sized enterprises.

Keywords: Ball burnishing, Surface integrity, Al 7075-t6

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