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25.02.2026, Wednesday, Online Session-1, Hall-1

Ankara Local Time: ***10:00-12:00***

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HEAD OF SESSION: Asst. Prof. Dr. Emre DEMİRCİ		
AUTHOR(S)	**ORGANISATION**	**TOPIC TITLE**
Şenay YETİŞİR ER Kübra YILDIZ Yeşim SEÇER KAVASOĞLU Burak ATİK Şükran Merve TÜZEMEN Yusuf Burak BOZKURT Yakup UZUN Halim KOVACI Ayhan ÇELİK Ömer ERDOĞAN	*Atatürk University, Türkiye*	EFFECTS OF LASER MARKING PARAMETERS ON SURFACE MORPHOLOGY AND QUALITY IN AISI 316L STAINLESS STEEL
Fethi Ahmet ÇAKMAK Fatih SELİMEFENDİGİL	*Manisa Celal Bayar University, Türkiye*	THE EFFECT OF INTERNAL SURFACE OPTICAL PROPERTIES ON EFFICIENCY IN SOLAR DISTILLERS: MATTE BLACK PAINT APPLICATION
Abdullah Emre DEMİR Prof. Dr. Dilek KUMLUTAŞ Dr. Utku Alp YÜCEKAYA Dr. Hasan AVCI Merih GÜLEN Öncel DİLBAZ	*Franke Kitchen and Bathroom Systems Inc., Türkiye* *Dokuz Eylül University, Türkiye*	INVESTIGATION OF THE INDUSTRIAL APPLICABILITY OF RECYCLED MATERIAL USE IN THERMOPLASTIC RAW MATERIALS FOR RANGE HOOD APPLICATIONS
Asst. Prof. Dr. Emre DEMİRCİ	*Bursa Technical University, Türkiye*	EFFECT OF 3D LATTICE DESIGNS ON THE STRUCTURAL PERFORMANCE OF AN AUTOMOTIVE BRAKE PEDAL
Prof. Dr. Ufuk CEBECİ Res. Asst. Arda ASLAN	*Istanbul Technical University, Türkiye*	A DIGITAL TWIN–ENABLED HYBRID ANOMALY DETECTION AND DECISION SUPPORT SYSTEM FOR SPACECRAFT TELEMETRY DATA

25.02.2026, Wednesday, Online Session-2, Hall-1

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Asst. Prof. Muhammad FAISAL	*Allama Iqbal Open University, Pakistan*	IMPLEMENTATION FRAMEWORK FOR INTERNATIONAL-STANDARD AI INTEGRATION IN PAKISTAN RAILWAYS, A STRATEGIC ROADMAP FOR THE IT DIRECTORATE
Asst. Prof. Muhammad FAISAL	*Allama Iqbal Open University, Pakistan*	STRATEGIC FRAMEWORK FOR AI IMPLEMENTATION IN PAKISTAN RAILWAYS, A ROADMAP FOR THE IT DIRECTORATE
Amadi Oko AMADI Osita Ngozika ANN Ifeanyi Moses IWUEZE Okpo Charles NNANNA	*Akanu Ibiam Federal Polytechnic, Nigeria* *Federal Polytechnic Nekede, Nigeria*	3D/4D BIOMEDICAL IMAGE PROCESSING WITH SPATIO-TEMPORAL TRANSFORMERS
Nabil Ahmed KHAN Rehan KHAN Mohd KHALID Mohammad PARVEJ Ahmad Yusuf ADHAMI	*Aligarh Muslim University, India* *IIT Hyderabad, India*	HYBRID MACHINE LEARNING–DRIVEN FORECASTING AND NEUTROSOPHIC OPTIMIZATION OF CRYPTOCURRENCY MARKETS
Vaibhav Kant SINGH Kapil Kumar NAGWANSHI Samanvay SINGH	*Guru Ghasidas Vishwavidyalaya, India*	LITERATURE REVIEW AND PROPOSING AN EYE DISEASE (CATARACT) DETECTION CMS USING THE LATEST CV AND ML TECHNOLOGIES FOR THE CONSERVATION OF TRIBES OF CHHATTISGARH
Mr. Pramant MAHTO	*Srinath University, India*	DEEP LEARNING ARCHITECTURES FOR COMPUTER VISION
Bonouali OUMAIMAA Hamza ALAA Fatima AQEL	*Hassan 1st University, Morocco*	A FOURIER NEURAL OPERATORS APPROACH FOR SIMULATING OF A CLASS OF NONLINEAR PERIODIC DIFFERENTIAL SYSTEMS

25.02.2026, Wednesday, Online Session-3, Hall-1

Ankara Local Time: ***15:00-17:00***

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HEAD OF SESSION: Muzamal HUSSAIN		
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MITULRAAMSUNDAR G	*R.M.K. Engineering College, India*	MAXIMA MINIMA AND ITS APPLICATIONS IN ENGINEERING
J Nanda KISHORE Nagaraj P G Narasapuram NEERAJ Rahul Sai BUJJI Rahul T Revanth Kumar N S	*R.M.K. Engineering College, India*	MULTIPLE INTEGRALS AND CHANGE OF ORDER OF INTEGRATION – AREA ENCLOSED BY CARTESIAN COORDINATES IN ENGINEERING APPLICATIONS
Muzamal HUSSAIN	*University of Rasul, Pakistan*	A NOVEL APPROACH FOR THE SIMULATION OF FLEXIBLE COMPOSITES: EVALUATING THE STRENGTH OF POISSON'S RATIO
Janaardan S Jeyanth R Barani Chandran S Lokeshwaran T Santhosh C Bharathi S	*RMK Engineering College, India*	A STUDY ON MATRICES AND CALCULUS FOR ENGINEERING APPLICATIONS
G.P. ASHWINKUMAR U. SHIVAKUMARA B. RANJANA P. NANDA C. SULOCHANA	*Vijayanagara Sri Krishnadevaraya University, India* *Government First Grade College, India*	INSIGHTS INTO ENHANCED HEAT TRANSFER IN MGO+CUO HYBRID NANOFLUID DUE TO MODIFIED XUE AND MAXWELL NANOMODELS
Shafiya F. TAMBOLI A. B. MAHADIK Mohammad Azim U. PATHAN Sadaf M. SHERKAR	*Bharati Vidyapeeth College of Engineering (Diploma), India*	SPIROAI: INNOVATION TECHNOLOGY FOR ADVANCED LUNG HEALTH MONITORING

26.02.2026, Thursday, Online Session-1, Hall-1

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Meeting ID: 847 7043 0612 / Passcode: 121212

HEAD OF SESSION: Merve KÜÇÜK		
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Lect. Osman AKÇAY Mustafa ÇULLU	*Gümüşhane University, Türkiye*	INVESTIGATION OF THE EFFECTS OF CONCRETE MIX DESIGN VARIATIONS ON SULFATE RESISTANCE
Dr. Aytekin ULUTAŞ	*Balikesir University, Türkiye*	DISPERSION–INTERFACE INTERACTION DRIVEN THERMAL DEGRADATION KINETICS: THE CASE OF PMMA/CO_3O_4 NANOCOMPOSITES
Prof. Dr. Alptekin KISASÖZ Lect. Dr. Yahya BAYRAK Nilda Buket KARA	*Yildiz Technical University, Türkiye*	PRODUCTION AND PROPERTIES OF PURE ALUMINIUM MATRIX B_4C–CEO_2 REINFORCED COMPOSITES
Uğur BAŞKAYA Assoc. Prof. Dr. Funda AK AZEM	*Dokuz Eylul University, Türkiye*	METALLURGICAL AND MECHANICAL CHARACTERISTICS OF LPDC-PRODUCED A356 WHEELS USING SCRAP WHEEL–DERIVED ALUMINUM INGOTS
Enes KOÇ Işılay GÖZÜBEK Prof. Dr. Hasan ARSLANOĞLU	*Çanakkale Onsekiz Mart University, Türkiye*	IMPROVEMENT OF ELECTRICAL PERFORMANCE OF LEAD-FREE (BI0.47NA0.47BA0.06)TIO3 (BNT-6BT) PIEZOELECTRIC CERAMICS BY DUAL DOPING WITH CEO2 AND LA2O3
Ozgen YALCIN Nouf F SH N ALMUTAIRI	*American University of the Middle East, Kuwait*	COMPUTATIONAL INVESTIGATION OF VOLATILE ORGANIC COMPOUNDS (VOC) ADSORPTION TRENDS ON UIO-66 CLUSTER MODELS

26.02.2026, Thursday, Online Session-2, Hall-1

Ankara Local Time: ***12:30-14:30***

Meeting ID: 847 7043 0612 / Passcode: 121212

HEAD OF SESSION: SOUICI Abdelaziz		
AUTHOR(S)	**ORGANISATION**	**TOPIC TITLE**
OUMAIMA EL MTIOUY HAMID ESSABIR	*National School of Applied Sciences of Agadir, Ibn Zohr University, Morocco*	VALORIZATION OF AGRICULTURAL WASTE IN SUSTAINABLE BIOCOMPOSITES: ENHANCING MECHANICAL PROPERTIES WITH NATURAL FIBER REINFORCEMENTS
Dr. Shama ISLAM Dr. Syed Shahabuddin ASHRAF Dr. Zubair ASLAM Dr. Mohd SHOAB	*Jamia Hamdard, India*	INTEGRATED PHOTOCAPACITOR BASED ON CNT DOPED POLYMER ELECTRODE, SYNTHESIS MORPHOLOGY AND ELECTROCHEMICAL PERFORMANCE
RAHAL Nacer BENMAHDI Khaled BEGHDAD Houda SOUICI Abdelaziz	*Mustapha Stambouli University, Algeria*	EFFECT OF CONSTANT AXIAL LOADS ON THE RESPONSE OF REINFORCED CONCRETE COLUMNS
BEGHDAD Houda RAHAL Nacer SOUICI Abdelaziz	*Mustapha Stambouli University, Algeria*	THE TEMPORAL BEHAVIOR OF AXIALLY LOADED CFST COLUMNS
SOUICI Abdelaziz RAHAL Nacer BEGHDAD Houda	*Mustapha Stambouli University, Algeria*	EXPLOITATION OF RHEOROLOGY SYSTEMS IN THE STUDY OF THE DEFLEXION OF A MIXED BEAM SUBJECTED TO THE EFFECTS OF CONCRETE SHRINKAGE

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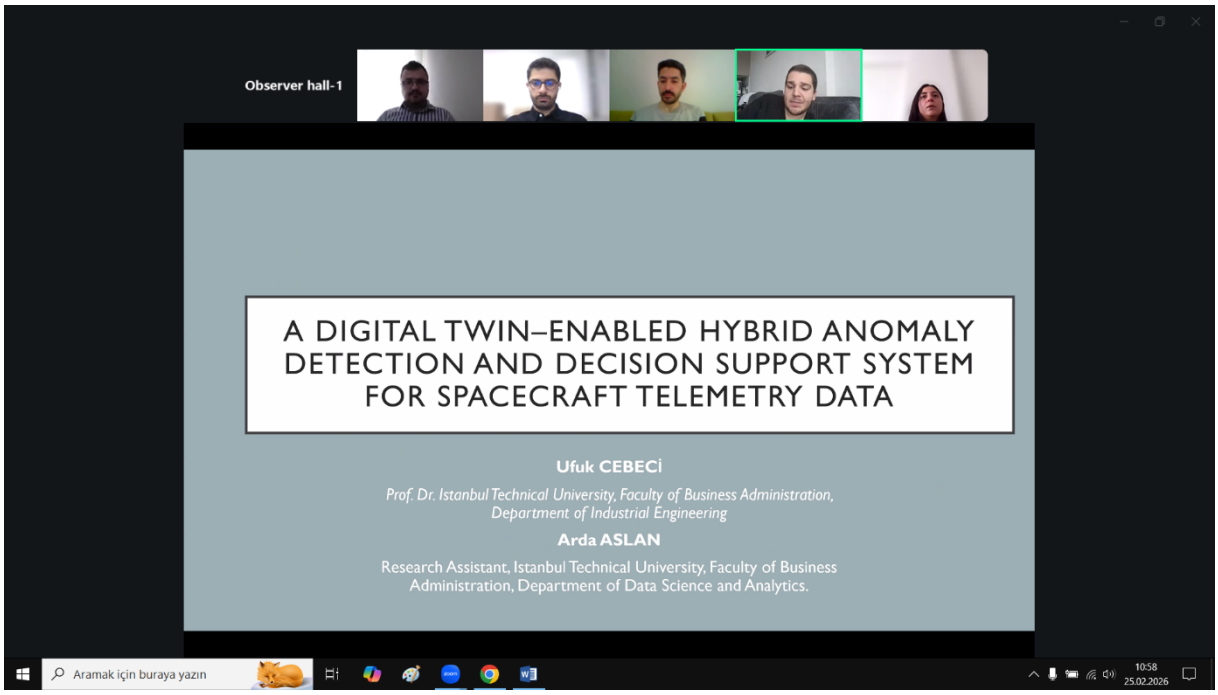

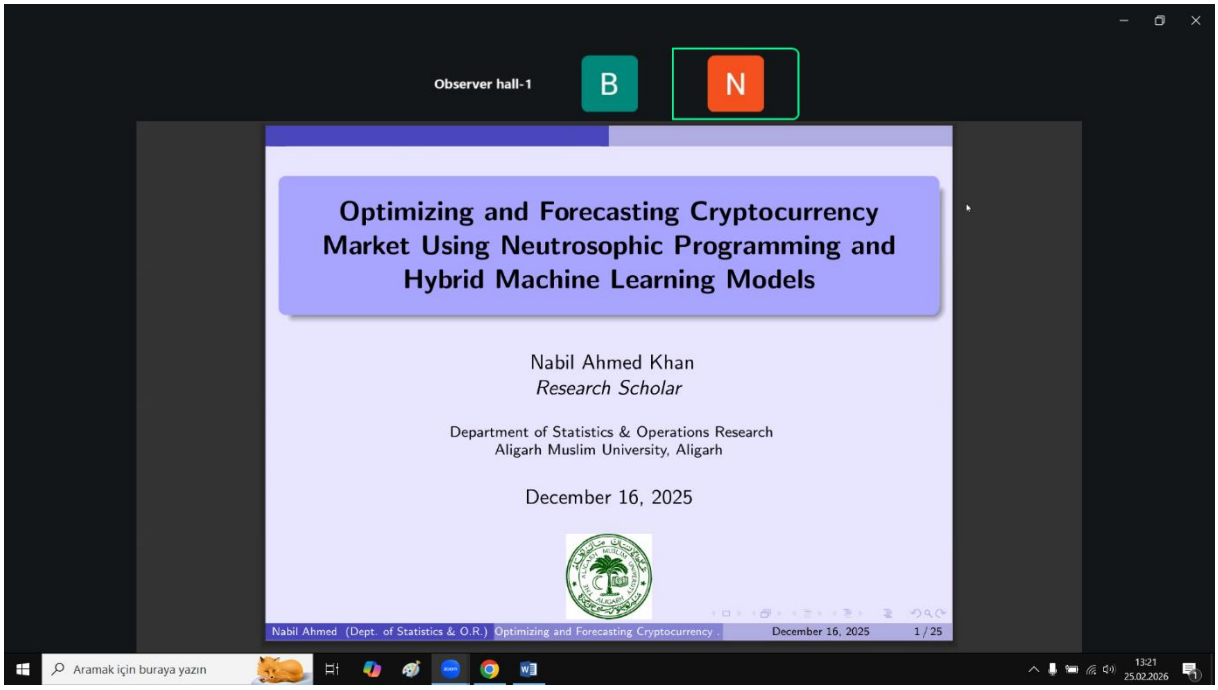

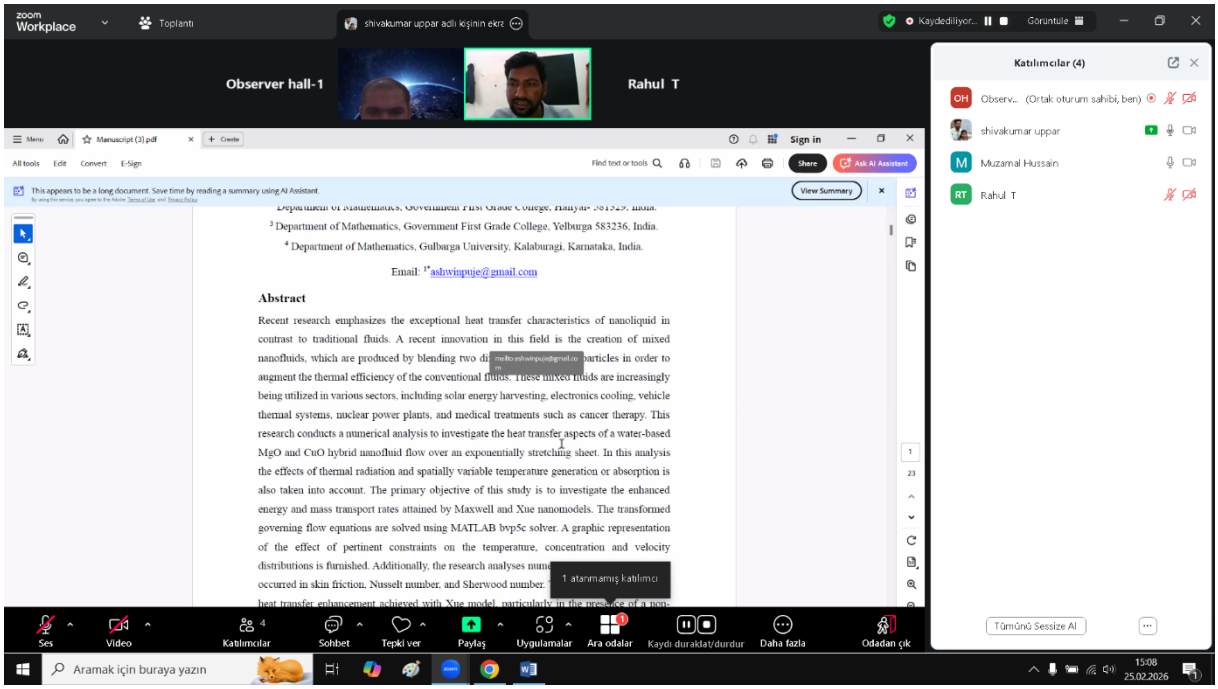
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Muzamal Hussain
Rahul T
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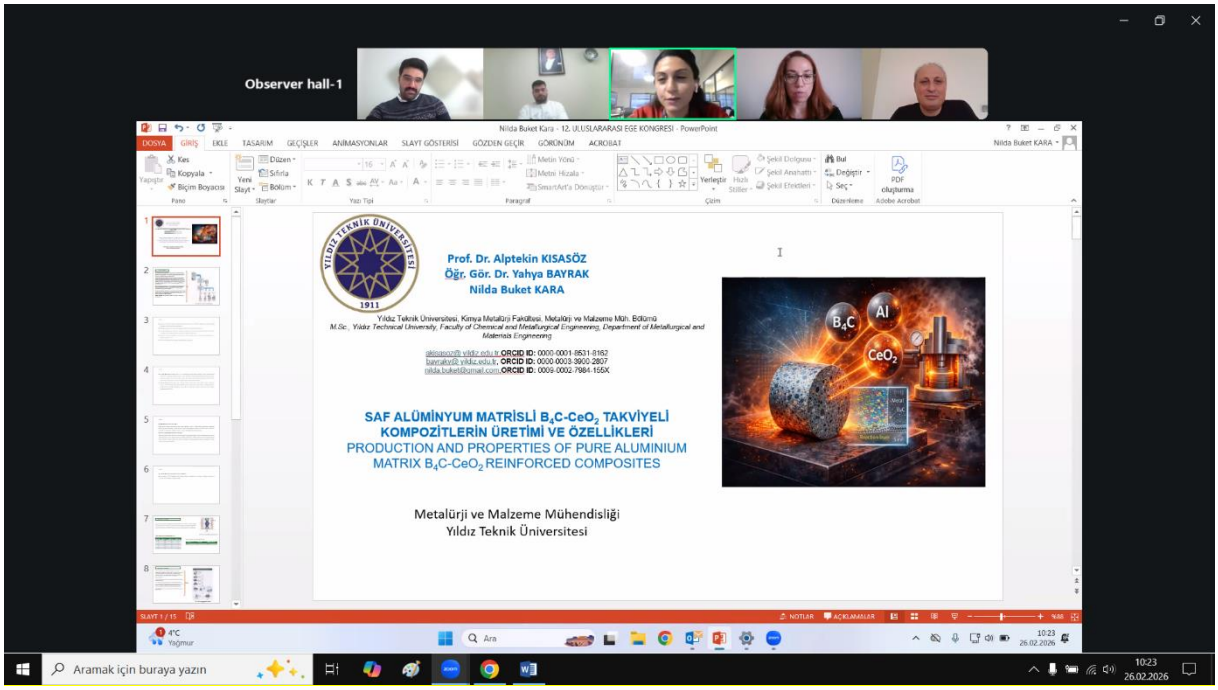
Observer hall-1
Prof. Dr. Alptekin KISASÖZ
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SAF ALÜMİNYUM MATRİSLİ B4C-CeO2 TAKVİYELİ KOMPOZİTLERİN ÜRETİMİ VE ÖZELLİKLERİ
PRODUCTION AND PROPERTIES OF PURE ALUMINIUM MATRIX B4C-CeO2 REINFORCED COMPOSITES
Metalürji ve Malzeme Mühendisliği
Yıldız Teknik Üniversitesi

TABLE OF CONTENTS

AISI 316L PASLANMAZ ÇELİKTE LAZER MARKALAMA PARAMETRELERİNİN YÜZEY MORFOLOJİSİ VE KALİTESİ ÜZERİNE ETKİLERİ

EFFECTS OF LASER MARKING PARAMETERS ON SURFACE MORPHOLOGY AND QUALITY IN AISI 316L STAINLESS STEEL

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ÖZET

Lazer markalama (LM), metal yüzeylerde ısıl etkileşime dayalı olarak renklendirme, topoğrafya ve mekanik özelliklerin yerel ve kontrollü şekilde değiştirilmesini sağlayan gelişmiş bir yüzey işleme tekniğidir. Bu çalışmada, yüzey işleme yöntemlerinden biri olan LM kullanılarak AISI 316L paslanmaz çelik numuneler üzerinde lazer gücü (25, 50 ve 75 W) ile pulse süresinin (500, 1000 ve 1500 ns) yüzey pürüzlülüğü ve mikro sertlik üzerindeki etkileri deneysel olarak incelenmiştir. Lazer markalama işlemi sonrasında yüzey pürüzlülüğü ve mikro sertlik ölçümleri gerçekleştirilerek yüzey niteliği belirlenmiştir.

Ayrıca yüzey görüntüleri optik mikroskop ile değerlendirilmiştir. Elde edilen sonuçlar neticesinde, lazer gücü ve pulse süresinin sertlik ve pürüzlülük üzerinde belirgin etkiye sahip olduğu gözlemlenmiştir. Pulse süresinin artışı ile lazer-malzeme etkileşim süresinin uzaması sebebiyle yüzeydeki erime/katılaşma prosesi sebebiyle pürüzlük değerlerinde artış gözlemlenmiştir. Aynı şekilde güç miktarının artışı ile enerji yoğunluğunun artışı ergime havuzunun niteliğini değiştirerek yüzey pürüzlülüğünü artırmıştır. Yüzey sertliği açısından, güç değerinin artışı ile artmakta ancak pulse süresinin artışı ile azalmaktadır. Yüzeyde oluşan oksit tabakanın kalınlığı, hızlı erime/katılaşma ve tane incelmesi bu durumu değiştiren sebeplerdir. Sonuç olarak, LM işlem proses parametrelerinin optimizasyonu ile AISI 316L paslanmaz çelik numunesi için optimum yüzey kalitesi elde edilebileceği ortaya konulmuştur.
Anahtar Kelimeler: Lazer markalama, AISI 316L paslanmaz çelik, Mikro sertlik, Pürüzlülük, Oksit tabakası, Yüzey renk değişimi.

ABSTRACT

In Laser marking (LM) is an advanced surface treatment technique that enables the localized and controlled modification of color, topography, and mechanical properties on metal surfaces based on thermal interaction. In this study, the effects of laser power (25, 50, and 75 W) and pulse duration (500, 1000, and 1500 ns) on surface roughness and microhardness were experimentally investigated on AISI 316L stainless steel specimens using LM, one of the surface treatment methods. After the laser marking process, surface roughness and microhardness measurements were performed to determine the surface quality. In addition, surface images were evaluated using an optical microscope. The results obtained showed that laser power and pulse duration had a significant effect on hardness and roughness. An increase in roughness values was observed due to the melting/solidification process on the surface caused by the longer laser-material interaction time resulting from the increase in pulse duration. Similarly, the increase in energy density due to the increase in power altered the quality of the melt pool, increasing surface roughness. In terms of surface hardness, it increases with the increase in power value but decreases with the increase in pulse duration. The thickness of the oxide layer formed on the surface, rapid melting/solidification, and grain refinement are the factors that change this situation. As a result, it has been demonstrated that the optimum surface quality for the AISI 316L stainless steel sample can be achieved by optimizing the LM process parameters.
Keywords: Laser marking, AISI 316L Stainless steel, Microhardness, Roughness, Oxide layer, Surface color change.

INTRODUCTION

Laser technology is a new technology used in the production process that facilitates the development of industrial applications. With the increasing use of this technology over time, the damage caused to the environment and the amount of waste material generated have decreased. Marking is actually the process of placing a mark on a specific part of a product for the purpose of explaining and identifying it. Examples of these marking methods include ink marking, mechanical engraving, or electrochemical techniques (Jundt and Junghans 1987). The laser marking method is one of the new and emerging marking methods. With the laser marking technique, models, photographs, and text are marked on the material with minimal damage. Compared to other traditional methods, the laser marking method has many advantages, such as no wear on the tools, a very high level of automation, and free programming. One of the most important criteria in marking is that the marking must be very clear. To achieve this goal, it is critical to select the most appropriate production (processing) parameters used during marking. In laser marking technology, there are many parameters such as pulse frequency, electric current, and scanning speed (Chryssolouris et al. 2003; Khatami et al. 2025; Qi et al. 2003; Sun and Brandt 2013). Laser marking is not merely a visual process; with the appropriate parameters, it can alter the mechanical properties of the surface at an engineering level. Optimal processing parameters enable the development of many material properties, such as low surface roughness, high hardness, and tribological properties. Commercially available AISI 316L stainless steel is widely used in various industrial fields such as aerospace, marine, automotive, and biomedical. The reason for the use of this material in different fields is its properties such as superior cutting resistance, ductility, fracture toughness, and excellent corrosion resistance (Ahmedabadi et al. 2013; Karimi et al. 2021; Li et al. 2017; Wang et al. 2016).

However, in addition to all these, many surface modifications are made due to its low tribological properties and insufficient mechanical properties (Borgioli et al. 2005; Ahmed et al., 2014; Yazıcı et al., 2018).

In recent years, laser processing has become one of the most popular applications for improving the surface properties of materials (Dywel et al., 2020). Laser marking can be performed on different types of materials such as polymers and metals. Khan and colleagues (Khan et al. 2015) performed laser marking on AISI 316L stainless steel. This type of steel was chosen because of its high heat and corrosion resistance. The effects of laser parameters such as laser power, scanning speed, and laser frequency on marking time or surface roughness were investigated. It was found that as the laser power increased, the surface roughness increased, and as the scanning speed decreased, the surface became rougher. Dywel and colleagues (Dywel et al. 2020) performed laser marking on AISI 304 and AISI 316 stainless steels. Parameter characteristics such as pulse repetition rate and repetition speed were considered. It was revealed that surface roughness is related to the overlap distance and the energy provided by a single pulse. Kučera and colleagues (Kučera et al. 2018) determined that a longer pulse duration and higher repetition rate are the most suitable parameters for preserving the corrosion resistance of stainless steel using the laser marking method. In laser marking, changes in the morphology of the material surface are observed as a result of thermal oxidation caused by the interaction of the laser beam with the material surface. An improvement in surface hardness is observed with the selection of optimal parameters. In a study conducted by Majid and colleagues (Majid et al., 2024), it was stated that surface hardness is affected by changes in laser frequency and scanning speed. As a result of the findings, an increase in laser power increased the microhardness value. Pandey et al. (2023) reported in their study that increasing the scanning speed on 304 stainless steel samples reduced the heat interaction time with the sample, and consequently, lower scanning speed values provided maximum trace density. Hristov et al. (2023), on the other hand, observed an inverse relationship between speed and scan trace in the laser marking process on AISI 304 stainless steel, with higher scanning speeds reducing color change and roughness. Pandey and Doloi (2022) observed that increasing the scanning speed reduces the time required for laser marking, thereby reducing oxidation due to less heat interaction time.

Within the scope of this study, the effects of different laser marking process parameters on the surface microstructure and mechanical properties of AISI 316L stainless steel were investigated. In order to determine the microstructural changes occurring on the surface during the laser marking process, the laser process parameters were varied, and the effects of these parameter changes on surface properties were evaluated comparatively. Laser pulse and laser power were selected as the basic variables for the laser marking parameters, and sample groups with different parameter combinations were prepared accordingly. Vickers microhardness measurements were performed to reveal the changes in the surface mechanical properties of the samples before and after the laser marking process. In order to examine the morphological changes in the surface microstructure, the surfaces of samples with and without laser marking were imaged using an optical microscope. As a result, this study comprehensively revealed the relationship between the variable parameters of the laser marking process and the surface microstructure and microhardness behavior.

METOD

Samples Preparation

AISI 316L stainless steel is an austenitic stainless steel type with low carbon content and is widely used in engineering and biomedical applications due to its high corrosion resistance and biocompatibility properties. For this reason, it was chosen for this study. After cutting the AISI 316L stainless steel samples, the sample preparation stage was initiated. First, to reduce the roughness on the surface of the AISI 316L stainless steel and obtain a homogeneous surface before laser marking, the samples were sequentially sanded with SiC abrasive from 60 to 2000 mesh. After each grinding process, the surface of the samples was cleaned with ethanol and dried. Finally, the surface was polished with alumina to prepare it.

Laser Marking Process

The sample groups given in Table 1 were obtained by changing the power and pulse parameters using the Laser Marking Method (LM) on the EZCAD 2 brand.

Table 1. Sample codes and process parameters used in the study.

Samples Code	Power (W)	Pulse (ns)
S1	25	500
S2	25	1000
S3	25	1500
S4	50	500
S5	50	1000
S6	50	1500
S7	75	500
S8	75	1000
S9	75	1500

The LM method is a contactless and precise surface treatment technique that uses high-energy laser beams to create permanent patterns on the surface of the material at three predetermined pulse values (500-1000-1500 ns) and power levels (25-50-75 W) as shown in Table 1. As shown in Figure 1, the laser beam is focused to a small point via mirrors and focusing lenses, causing discoloration and surface roughening on AISI 316L stainless steel with high energy.

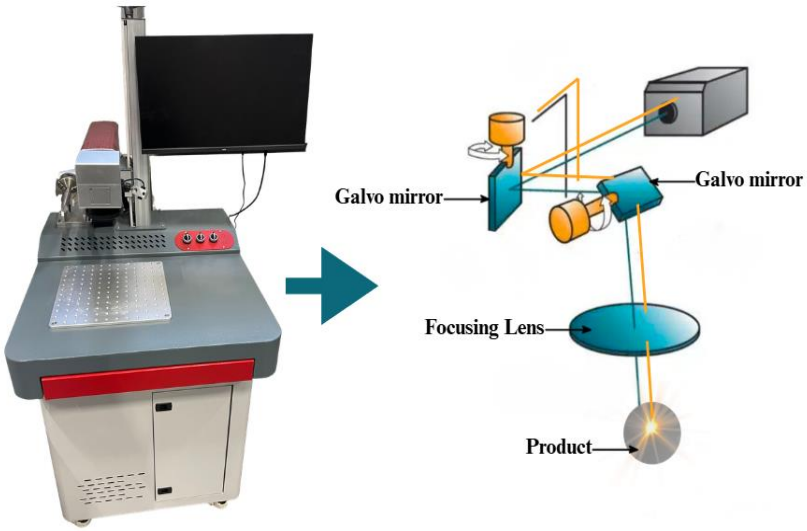

Figure 1. Laser Marking Method on the EZCAD 2 Brand.

Characterization and Analysis

Hardness measurements of AISI 316L stainless steel samples were performed using a Vickers hardness tester before and after the surface marking process. Surface images after the surface treatment were obtained using an optical microscope. Additionally, surface roughness measurements were taken using a Mahr brand roughness tester.

RESULTS AND DISCUSSION

The surface roughness and hardness values obtained in the samples after the Laser Marking (LM) process are given in Table 2. In the LM marking process, the surface morphologies obtained under 25 W laser power with different pulses (500, 1000, and 1500 ns) are presented in Figure 2. In LM, a thin oxide film is formed on the metal surface with a certain heat input to the material's surface. Thus, a color change occurs due to the light interference reflected from the oxide layer on the material surface. The thickness of the oxide layer formed on the material, heat value, pulse duration, and power, such as laser processing parameters, contribute to the formation of different colors on the surface (Sun et al., 2022). In the sample with the shortest pulse duration (Figure 2a), the surface color darkens, yellowish-brown tones appear, and scanning traces become more pronounced. This situation can be assumed to be related to increased heat accumulation and oxide layer formation due to the laser remaining on the surface.

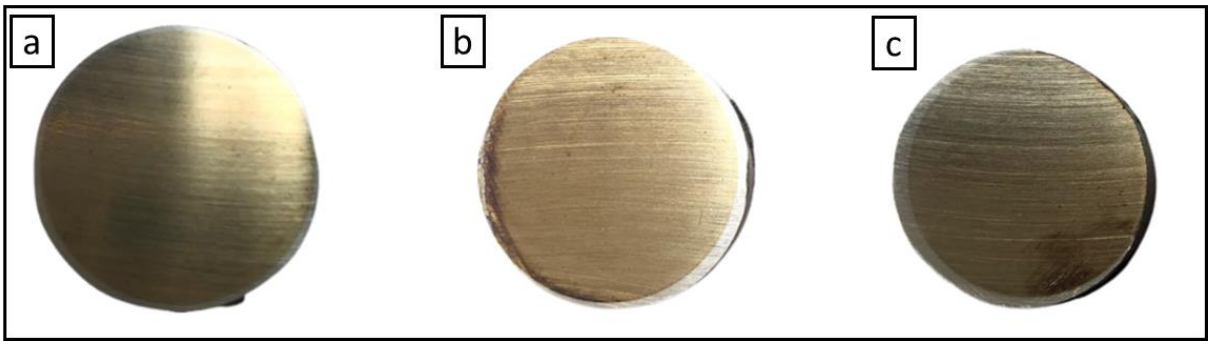

Figure 2. Laser marking process for 25W power and a) 500 ns pulse b) 1000 ns pulse c) 1500 ns pulse.

An increase in surface hardness was observed at low pulse values. In the sample where the pulse value was increased to 1000 ns (Figure 2b), the surface color was observed to be lighter and more homogeneous. Although scan traces were visible, the oxide layer was observed to develop in a more controlled manner. Under these conditions, the roughness value increased (0.468 µm) and a decrease in surface hardness occurred. At the same time, the hardness value in sample S2 decreased compared to S1. This situation is explained by the laser's energy transfer time on the surface. The longer the surface-laser interaction occurs on the surface, the lower the cooling rate and the longer the heat diffusion process. This causes coarsening in grain size, reducing the hardness value. Similarly, the amount of roughness increases. In the sample with the highest pulse value (Figure 2c), the surface color is more solid and metallic in appearance, and the scanning traces are largely blurred. The increase in pulse value directly affects the thermal interaction on the surface. Thus, the surface topography changes. The increase in pulse duration causes greater interaction with the material. While ~ 207 HV0.01 is obtained in sample S2, this value is ~ 203 HV0.01 in sample S3.

Table 2. Surface roughness and hardness values of the samples.

Samples	Ra (µm)	Hardness ($HV_{0.01}$)
S1	0.423-0.429	210-217
S2	0.465-0.471	205-212
S3	0.492-0.499	200-208
S4	1.309-1.326	220-226
S5	2.104-2.131	215-219
S6	2.936-2.974	210-214
S7	3.096-3.136	225-231
S8	4.850-4.914	220-226
S9	4.977-5.042	215-219

Figure 3 shows the surface morphologies obtained under 50 W laser power at different pulse durations (500, 1000, and 1500 ns). In the sample with the lowest pulse value (Figure 3a), the surface color is light but with a metallic tone that is beginning to dull, and scanning traces are clearly visible. This situation indicates that, due to the increased laser-material interaction time, a controlled but noticeable thermal effect is formed on the surface, leading to an increase in roughness and an effect on surface hardness. At the same pulse value, the hardness value is ~ 213 HV0.01 at 25W power and ~ 223 HV0.01 at 50W. The surface roughness value is 0.42 µm for 25W power at the same pulse value, while this value is 1.316 µm in sample S4. This is attributed to the increase in energy density on the surface with increasing power (Vorobyev and Gua 2013). In the sample shown in Figure 3b, the surface color has shifted distinctly to golden-brown tones, and the oxide layer has developed more homogeneously and stably. Along with the scanning traces becoming more regular, an increase in roughness value was also observed. While a roughness of 1.316 µm was obtained in the S4 sample, this value is at the level of 2.115 µm in S5. In sample S6 (Figure 3c), the roughness value is 2.915 µm.

The literature supports the increase in surface roughness (Skoulas et al., 2017). In addition, a layer of oxide film was observed to form on the surface.
It has been observed that the hardness value (Table 2) increases at 50W power compared to 25W power. Surface hardness has increased, particularly due to the increase in the oxide layer on the surface with the increase in power. With the increase in power, the energy density on the material surface has increased, and as a result, the hardness value has increased due to reasons such as the formation of fine grains and high dislocations.

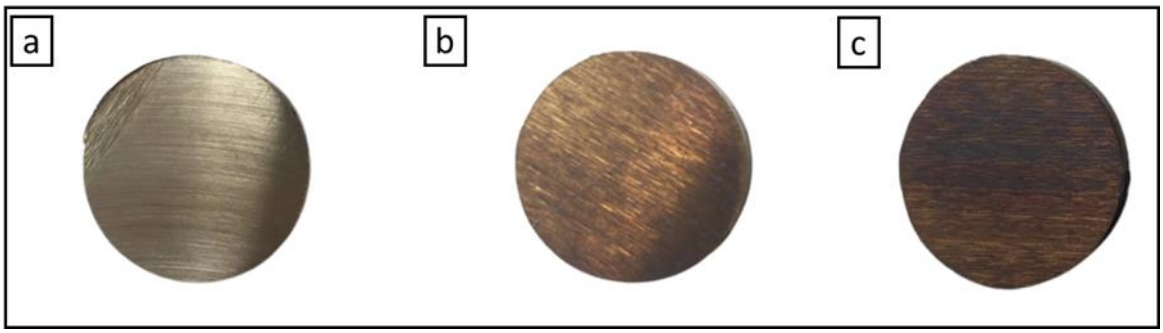

Figure 3. Laser marking process for 50 W power and a) 500 ns pulse b) 1000 ns pulse c) 1500 ns pulse.

Figure 4 shows the surface morphologies obtained at different pulse durations (500, 1000, and 1500 ns) under a 75 W laser power. In the sample with the lowest scanning speed (Figure 4a), the surface turns dark blue-gray and acquires a matte appearance. The reason for such a color change on the surface of the material is the formation of a Cr2O3 layer on the surface. An increase in the thickness of this layer has resulted in an increase in the oxide layer. However, at a power value of 75 W, excessive darkening occurred on the surface as a result of high energy transfer. However, a decrease in hardness was observed. This situation is attributed to the disruption of the continuity of the hard oxide layer formed on the surface due to the increased heat accumulation at high power (Lehmuskero et al., 2010). At a power value of 75W, the highest hardness value obtained was ~ 227 HV0.01, while the lowest was ~ 217 HV0.01. Furthermore, a heterogeneous distribution of the oxide layer on the surface was observed. Similarly, the surface roughness value increased with the increase in pulse value. The increase in pulse duration on the material's surface caused an increase in molten metal flow. Thus, a more wavy topographic surface was obtained. When the pulse value was increased to 1000 ns (Figure 4b), the sample exhibited a heterogeneous structure with a bluish-metallic tone on the surface. At the highest pulse value (Figure 4c), the surface color of the sample is observed to be in lighter brown-blue tones, with a tendency for the hardness value to decrease as the scanning traces become faint. The oxide layer on the surface has become a thin layer. This explains the decrease in the hardness value.

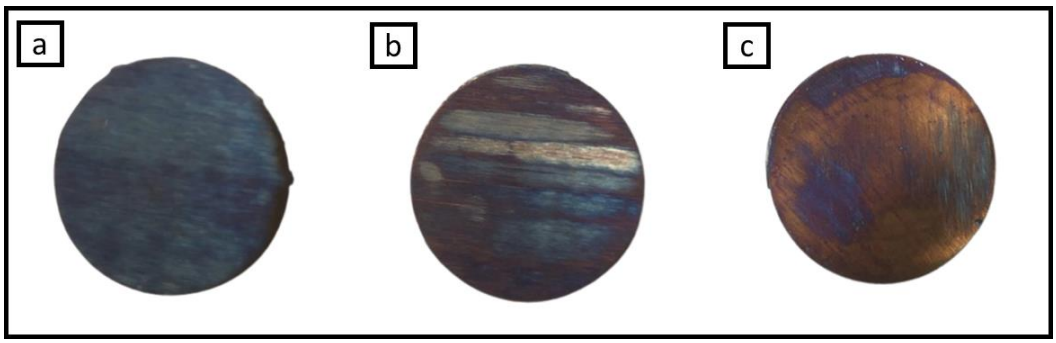

Figure 4. Power source in laser marking process 75 and a) 500 ns pulse b) 1000 ns pulse c) 1500 ns pulse.

When examining the surface images of the samples after the laser marking process, it is evident that laser power and pulse duration are related to metal surface properties. In combinations of low pulse and

high laser power, darkening of the surface color (blue-brown tones), increased visibility of scan lines, and thickening of the oxide layer were observed (Veiko et al., 2016; Gorbatyuk et al., 2020; Jurčs et al., 2024). Under these conditions, surface roughness exhibited an increasing trend due to the increased heat accumulation. Increasing the pulse duration and power value increased the surface roughness of the material. An increase in surface hardness has been observed with increasing power. Increasing the power value (from 25W to 75W) increases the dislocation density on the surface due to the increase in energy density and rapid melting/solidification. It also contributes to the hardness value with the formation of fine grains. Furthermore, the formation of a hard ceramic-like oxide layer on the surface increases. Thus, the hardness value on the surface improves. Tutins et al. (2024) investigated the effects of different laser powers and scanning speeds on surface color and roughness during the LM process on AISI 304 stainless steel. The study revealed that as laser power increased, noticeable color changes occurred on the surface, and roughness increased by 15% at 9.6 W compared to 6.4 W and by 85% compared to 4.8 W. Similarly, Ghalot et al. (2023) investigated the effects of scanning speed and power on the surface roughness and microhardness of copper samples during laser marking. It was observed that roughness and microhardness increased with increasing power, whereas increasing scanning speed resulted in a reduction of roughness by approximately 20 times and microhardness values by 2.5 times.

CONCLUSION

In this study, the effects of laser power (25, 50, and 75 W) and pulse duration (500, 1000, and 1500 ns) on surface roughness and microhardness during the laser marking (LM) process of AISI 316L stainless steel were systematically investigated. The results obtained show that laser power and pulse duration have a decisive effect on color change, roughness, and surface hardness on metal surfaces in laser marking. Under conditions of low pulse duration (500 ns) and high laser power (75 W), the laser-material interaction time and the energy transferred per unit area increase, resulting in a darker surface color (blue-brown tones) and more distinct scan lines. In the LM process, it is observed that the increase in laser power is directly related to increased thermal effects in the metal substrates, which leads to more melting and consequently rougher surfaces. The increase in laser power and pulse duration has increased surface roughness. An increase in surface hardness has been observed with the increase in laser power. This is attributed to the thickening of the oxide layer on the surface and the formation of fine grains as a result of rapid melting/solidification. An increase in pulse duration resulted in a decrease in hardness value. High cooling rates at short pulse durations produced relatively higher hardness values.

As a result, it has been demonstrated that surface roughness, surface color change, and hardness values in the LM process are strongly related to laser power and pulse duration. These findings reveal that LM parameters are critical for optimizing the surface quality of AISI 316L stainless steel and achieving repeatable, high-quality markings.

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THE EFFECT OF INTERNAL SURFACE OPTICAL PROPERTIES ON EFFICIENCY IN SOLAR DISTILLERS: MATTE BLACK PAINT APPLICATION

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ABSTRACT
A large portion of the world is covered by water. Most of the water resources are saltwater. The remainder consists of very little freshwater. Therefore, distilling water has become increasingly important, especially in arid regions. There are many methods of water distillation. Solar-powered distillers are frequently preferred today because they are a renewable and environmentally friendly method. In a world where access to clean water is becoming increasingly difficult, solar stills offer an alternative solution. Due to their low efficiency, many researchers are working on solar stills using passive and active systems. This study experimentally investigated the effect of painting the still's bottom in matte black on efficiency. For this purpose, the interior surface of one of two single-slope stills was painted matte black, while the other was left unpainted. The still's peripheral equipment consists of 1 mm thick galvanized sheet metal. The still is positioned to receive the most effective south-facing sunlight. Galvanized sheet metal reflects sunlight, affecting efficiency. The still's interior is coated in matte black, a color that minimizes sun reflection while simultaneously increasing absorption. When the still model with a matte black interior paint was compared to the unpainted still model, an efficiency increase of 31.73% was observed.
Keywords: Solar energy, Productivity, Desalination, Sustainability.

INTRODUCTION
Freshwater resources are rapidly depleting worldwide. Access to clean water, especially in arid and semiarid regions, has become increasingly critical. Only a small portion of the world's water consists of freshwater, and only a small fraction of this water is accessible [1,2]. Water can be made potable through distillation. Mechanical, chemical, electrical, and thermal methods are used for distillation. Many of these methods require fossil fuels as energy, which has led to the search for alternative methods from both economic and environmental perspectives. Solar-powered distillers belong to the thermal class and have become a frequently preferred distillation method today due to their economic, accessible, and positive environmental impacts compared to other methods. Solar stills work by evaporating water and then condensing it to accumulate [3,4]. Solar stills are renewable, independent of fossil fuels, and have advantages over other methods in terms of environmental impact [5]. Low efficiency of these distillers is considered as a disadvantage and many researchers are doing numerical and experimental research on passive and active systems in order to increase efficiency [6]. In passive systems, the aim is to increase efficiency by making modifications within the distiller apparatus. These include methods such as insulating the distiller base, using PCM in the base, using fins in the base, using nanoparticles in different parts of the system (in the water, in the PCM, in the base layer, and on the condenser surface), cooling the condenser surface, insulating the surrounding equipment, and using different distiller designs (pyramid, double-slope, single-slope, cylindrical, and spherical). In active systems, efficiency is increased by adding external systems to the distiller apparatus. These include applications such as heating the water using solar collectors or using solar panels to increase efficiency. Many studies have been conducted and continue to be conducted today applying both active and passive systems. Painting the interior surfaces of stills black can easily increase efficiency. This paint, which typically increases solar absorption and increases the water temperature, allows for more water to evaporate [7]. Black surfaces can absorb almost 90% of the sunlight reaching them. Painting the interior of solar stills a dark color is a common practice in research. Some researchers have even increased efficiency by using nanoparticles in conjunction with the paint on the still's interior [8,9].

This study experimentally investigated the effect of painting the interior surface of solar stills with matte black on efficiency. Coating the interior with matte black offers advantages over gloss black, as it reflects less light and absorbs more. Experimental results indicated that the painted test setup performed better in terms of efficiency than the unpainted version.

MATERIALS AND METHOD

The experiments were conducted in Manisa, Turkey, during August. Two single-slope solar still models were designed and tested. The experimental setups were designed with a base of 50x50 cm, a sloped surface height of 50 cm, and a 35° inclination angle to the base. The surrounding reinforcement was made of 1 mm thick galvanized sheet metal, and the condenser surface was made of 4 mm glass. The experimental setups are presented in Figure 1. The setup shown as number 1 has an unpainted interior surface, while the setup shown as number 2 has a completely matte black interior surface. The experiments were conducted between 09:00 and 17:00. During the experiment, solar radiation, ambient and other temperatures, and wind speed were measured and recorded at regular intervals. For this purpose, the necessary measurements were made using a solar meter (measuring solar radiation intensity), anemometer (wind meter), data logger, and K-type thermocouples. Additionally, the amounts of distilled water obtained from the two experimental setups at the end of the day were measured on precision scales and compared.

Figure 1. Experimental setups (Model number 1: unpainted, model number 2: interior surface matte black painted model)

RESULTS AND DISCUSSION

In our study, the effect of painting the inner surface of the still with matt black paint on efficiency was investigated experimentally. Throughout the experiment, solar radiation intensity, ambient temperature, ambient wind intensity, and temperature data from various points within the still were recorded. At the end of the day, the distilled water quantities were measured on a precision scale and comparisons were made. Table 1 shows the hourly measured solar radiation intensity, ambient temperature, and wind intensity values. In Table 1, Ta is the ambient temperature, I is the radiation intensity, and v is the wind intensity.

Table 1. Hourly measured radiation, ambient temperature and wind intensity values

Time	I (W/m^2)	Ta (^{o}C)	v (m/s)
09:00	500	33.2	1
10:00	630	36.5	1.5
11:00	750	37.4	0.8
12:00	860	41.8	1.5
13:00	880	40.1	1.
14:00	800	41.3	0.6
15:00	860	44.3	1.5
16:00	880	40	0.4
17:00	500	37	0.7

Water temperatures within the two experimental setups were recorded periodically throughout the experiment. The graph in Figure 2 shows that the water temperature in the matte black painted model was higher throughout the day than in the unpainted model. These results were achieved thanks to the matte black surface's ability to absorb 90–98% of sunlight and minimize reflection.

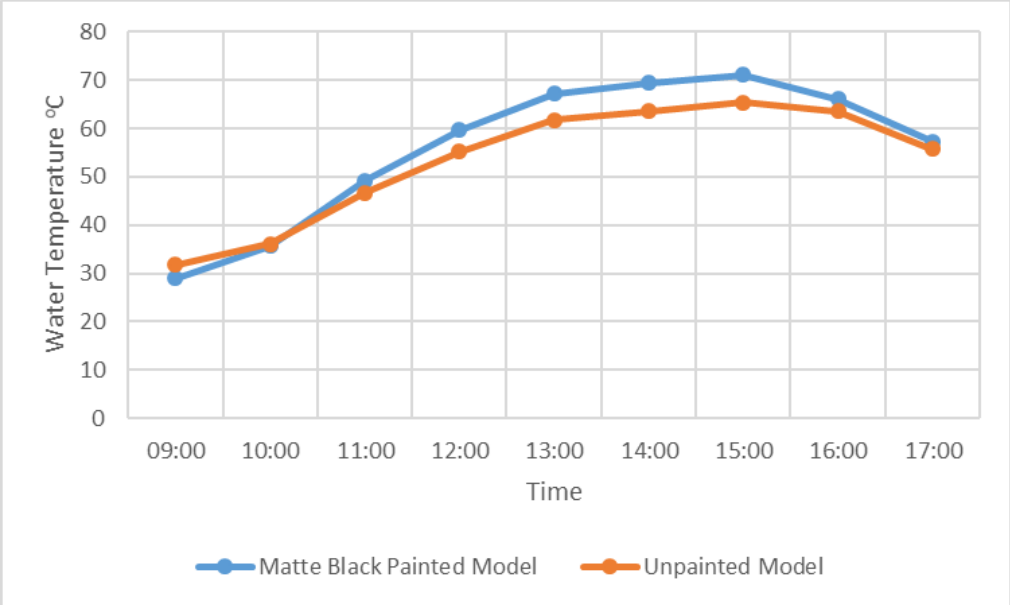

Figure 2. Hourly values of water temperature in two experimental setups.

During the experiment, the amounts of distilled water obtained from the stills were measured hourly using precision scales. Figure 3 shows a graph of the hourly measured values. The values show that the model with the matte black interior surface was able to distill more water throughout the day than the unpainted version. At the end of the day, measurements were made at 2.2 kg/m² for the matte black model, while the unpainted version was 1.67 kg/m². The painted model was found to be 31.73% more efficient than the unpainted version.

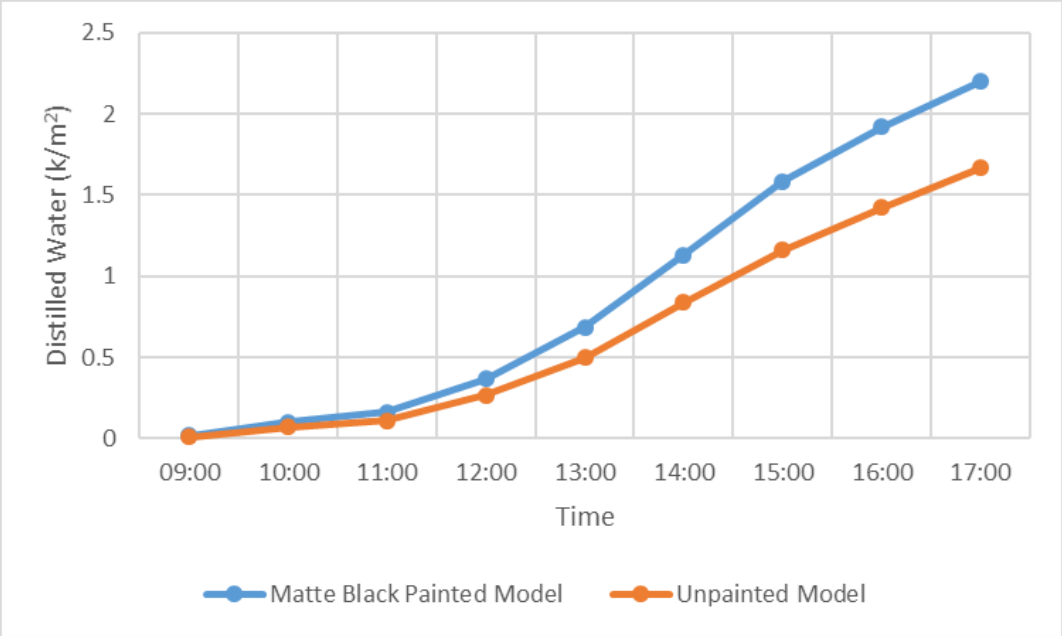

Figure 3. Hourly measured amounts of distilled water

CONCLUSION

This study experimentally investigated the effect of modifying the internal surface properties of distillers on efficiency. For this purpose, two experimental setups were designed: one conventional type and the other with its internal surface completely painted matte black. The setup with a matte black internal surface proved more efficient than the conventional type distiller. It was experimentally demonstrated that matte black surfaces absorb solar energy better, thus raising the water temperature in the reservoir. The experimental results are listed below.

- It has been observed that painting the still bottom is more efficient than not painting it.
- When the water temperature inside the still was examined, it was found to be higher at all times of the day compared to the unpainted condition.
- When the amount of distilled water was examined, it was observed that the dyed and unpainted conditions yielded 2.2 kg/m² and 1.67 kg/m², respectively, representing a 31.73% increase in efficiency.
- Choosing matte black instead of gloss black for the interior surface paint is another parameter that increases efficiency.

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DAVLUMBAZ UYGULAMALARI İÇİN TERMOPLASTİK HAMMADDELERDE GERİ DÖNÜŞTÜRÜLMÜŞ MALZEME KULLANIMININ ENDÜSTRİYEL UYGULANABİLİRLİĞİNİN İNCELENMESİ

INVESTIGATION OF THE INDUSTRIAL APPLICABILITY OF RECYCLED MATERIAL USE IN THERMOPLASTIC RAW MATERIALS FOR RANGE HOOD APPLICATIONS

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ÖZET

Bu bildirinin amacı, davlumbaz uygulamalarında kullanılan termoplastik hammaddelerde geri dönüştürülmüş içerik oranının artırılmasının, mekanik, ısıl ve yanmazlık performansı ile endüstriyel uygulanabilirlik üzerindeki etkilerini deneysel bulgular ışığında değerlendirmektir. Bu kapsamda öncelikle geri dönüştürülmüş termoplastik hammaddelere yönelik malzeme ve tedarikçi araştırmaları gerçekleştirilmiş, farklı tedarikçilerden temin edilen alternatif Polipropilen (PP) esaslı hammaddeler için reçete geliştirme çalışmaları yürütülmüştür. Farklı tedarikçiden sağlanan dört farklı geri dönüştürülmüş hammadde, numune plakalar üzerinden mekanik dayanım, ısıl dayanım ve yanmazlık performansı açısından deneysel olarak değerlendirilmiştir. Elektrikli/elektronik cihaz ve ekipmanlarda kullanılan plastik malzemelerin yanıcılık performansının sınıflandırılması standardının, dikey yanma testi yanmazlık sınıfı (UL94 V2) hedefi doğrultusunda farklı yanmazlık katkı sistemleri denenmiş ve ürün gereksinimleri ile uyumlu kombinasyonlar belirlenmiştir. Elde edilen deneysel bulgular doğrultusunda, ürün performans kriterleri korunarak geri dönüştürülmüş içerik oranındaki artışın, seri üretim koşulları altında endüstriyel uygulanabilirliği ortaya konulmuştur.

Anahtar Kelimeler: Davlumbaz, Termoplastik, Geri Dönüştürülmüş Malzeme, Deneysel Çalışma

ABSTRACT

The aim of this study is to experimentally evaluate the effects of increasing the recycled content ratio in thermoplastic raw materials used for range hood applications on mechanical, thermal, and flame-retardant performance, as well as on industrial applicability. Within this scope, material and supplier investigations were first conducted for recycled thermoplastic raw materials, and formulation development studies were carried out for alternative PP-based materials obtained from different suppliers.

Four different recycled materials supplied by different vendors were experimentally evaluated on specimen plates in terms of mechanical strength, thermal resistance, and flame-retardant performance. In line with the vertical burning flammability classification (UL94 V-2) defined by the standard for classifying the flammability performance of plastic materials used in electrical and electronic devices and equipment, various flame-retardant additive systems were investigated, and material combinations compatible with product requirements were identified. Based on the experimental findings, the industrial applicability of increased recycled content ratios under mass-production conditions was demonstrated while preserving product performance criteria.
Keywords: Range Hood, Thermoplastic, Recycled Material, Experimental Study

EFFECT OF 3D LATTICE DESIGNS ON THE STRUCTURAL PERFORMANCE OF AN AUTOMOTIVE BRAKE PEDAL

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ABSTRACT
Lightweighting of safety-critical automotive components is key to improving vehicle efficiency without compromising structural integrity. Among these components, the brake pedal must satisfy strict stiffness and strength requirements while offering opportunities for mass reduction through advanced design methods. In this comparative study, the effect of different lattice structures on a lightweight brake pedal design is investigated by combining conventional topology optimization with lattice infill strategies. A baseline solid brake pedal was first evaluated under identical loading and boundary conditions using Altair Inspire. Then, a topology-optimised design was generated to identify low-utilization regions suitable for material removal, achieving an approximate 21% mass reduction relative to the solid baseline; however, this came with an approximately 15% increase in maximum stress and about a 14% increase in displacement. Subsequently, the material-removal regions were replaced with different lattice structures including body-centered cubic (BCC), simple cubic–body-centered cubic (SC–BCC), simple cubic (SC), face-centered cubic (FCC), and octet-truss (OT). Each configuration was evaluated using linear static finite element analysis in terms of displacement, maximum stress, and mass. The lattice-reinforced designs achieved mass reductions of approximately 15% to 29% relative to the solid baseline. Of these, the BCC configuration achieved the best balance, reducing mass by around 27% while limiting the increase in maximum stress to approximately 4% and the increase in displacement to around 23%. The OT variant produced the lowest peak stress, slightly below the solid baseline, together with an approximately 15% mass reduction and about a 13% increase in displacement. In contrast, the SC lattice, despite providing the largest mass saving, exhibited excessive compliance and severe stress concentration, with displacement increasing by roughly 46% and maximum stress rising by more than 160%, indicating poor suitability for this application. Overall, the results demonstrate that lattice integration can provide substantial mass savings while maintaining acceptable stress and stiffness levels.
Keywords: Lightweighting, Brake Pedal, Lattice Structures, Finite Element Analysis.

INTRODUCTION
Two of the most crucial topics that currently attract the attention of both academic and industrial sectors are undoubtedly the increasing prevalence of electric vehicles in the automotive industry and the growing adoption of 3D printing technologies in the manufacturing sector. With the rising number of electric vehicles, lightweight design, which was already important for automotive engineers, has gained even greater significance due to the driving range problems.

In order to design a structural component to be lighter without compromising its strength, researchers generally explore the use of new-generation materials or revise the design through optimization methods (Kahraman et al., 2020; Yildirim et al., 2023; Cui et al., 2011). Topology optimization is one of the most commonly used methods in the automotive industry for the study of lightweight design of components (Yang and Chahande, 1995). Using this method, many parts such as the engine components (Yıldız et al., 2019), the mechanical shaft (Koçak and Bayraklılar, 2023), the brake caliper (Tyflopoulos et al., 2021) and the control arm (Viqaruddin and Reddy, 2017) have been made lighter without compromising the required strength. Many similar lightening studies have been carried out on the pedal part which is the subject of this study. Albak (2019) applied topology optimization to the brake pedal of a Formula SAE car and reduced the weight by 11%. Doğan et al. (2020) used shape and topology optimization for the brake pedal of a heavy trucks and achieved a weight reduction of 50% with respect to the original design. In addition to optimization methods, brake pedal lightening studies can also be carried out using alternative design and manufacturing methods (Ergenç et al., 2017).

In recent years, with the widespread adoption of additive manufacturing, lattice structures have emerged as prominent structural elements for lightweight design. They are attractive because they provide high stiffness and strength at low weight. By varying the unit-cell topology and relative density, the stiffness level and the crushing mode can be controlled, which helps to achieve more stable deformation. Under compression, many lattice designs exhibit a long, plateau-like response, enabling high energy absorption while keeping the mass low. Additive manufacturing also makes functionally graded lattices practical, with denser regions in highly loaded areas and more open regions elsewhere (Maconachie et al., 2019; Pan et al., 2020).

In this study, a lightweight brake pedal is investigated using topology optimization and lattice infill as two successive design steps. First, a solid baseline pedal is analyzed under identical loading and boundary conditions, and a topology-optimised geometry is obtained by removing low-utilization regions. Then, the removed regions are filled with different lattice architectures (BCC, SC–BCC, SC, FCC, and octet-truss), and each design is evaluated via linear static finite element analysis. The configurations are compared in terms of mass, maximum stress, and displacement to identify lattice options that provide meaningful weight reduction while keeping stiffness and stress levels within an acceptable range for a safety-critical component. In addition, the results highlight how lattice topology influences the trade-off between mass saving and structural response under the same loading scenario.

MATERIALS AND METHOD

In this study, first, the baseline solid brake pedal was designed in a computer-aided design (CAD) environment. 316L stainless steel was selected as the pedal material, as it is widely used in additive manufacturing (Sargini et al., 2021). For 316L stainless steel, the elastic modulus and yield strength were taken as 174 GPa and 350 MPa, respectively (Bevan et al., 2017). The analysis was carried out in Altair Inspire using a linear static finite element approach. A uniform element size of 0.6 mm was used for meshing. The boundary conditions applied to the baseline solid brake pedal are shown in Figure 1. A force of 823 N was applied to the pedal-pad surface, following Limpert (2011), which reports an approximate maximum right-foot pedal force of 823 N for males. The pedal mounting region was fully constrained by fixing all degrees of freedom.

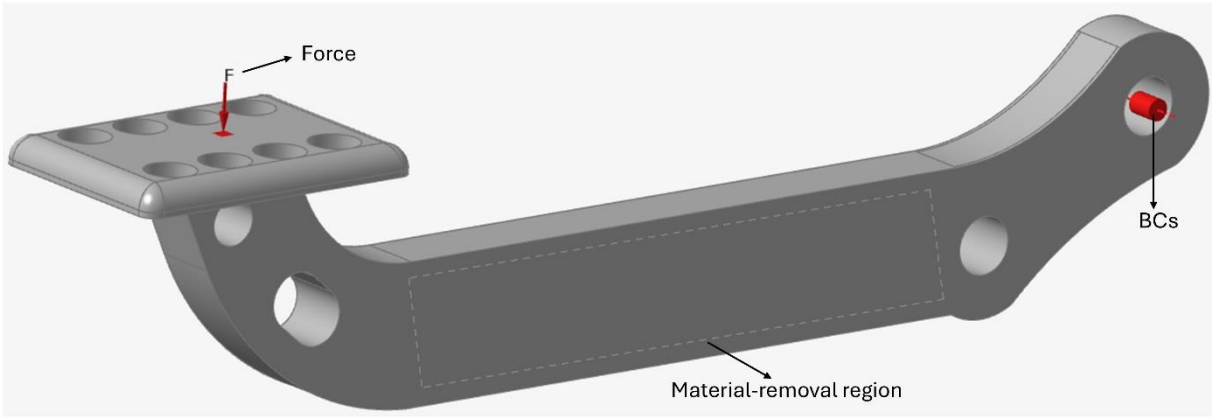

Figure 1. Baseline brake pedal model.

After the baseline model was analyzed, topology optimization was applied to the brake pedal. Topology optimization involves arranging the distribution of elements within the design volume, subject to specified constraints, to reduce weight while increasing strength or natural frequency (Yildiz, 2008). In this study, the material-removal region on the brake pedal was defined as the design domain for topology optimization. The optimization objective was set to minimize mass, while a stress-based constraint was imposed by specifying a minimum safety factor of 1.2.

Following conventional topology optimization, five different strut-based lattice structures (BCC, SC–BCC, SC, FCC, and OT) were implemented within the material-removal region to restore load-carrying capacity while enabling further mass reduction. To ensure a fair comparison between the lattice topologies, the geometric parameters were kept constant across all designs.

Accordingly, the rod diameter was fixed at 1 mm, and the unit-cell dimensions were set to 5 × 5 × 5 mm for each lattice type. The lattice-filled brake pedal configurations generated in this manner are presented in Figure 2.

For comparative evaluation, the maximum von Mises stress, maximum displacement, and mass were selected as the primary performance metrics for all configurations. The acceptance criteria were defined such that the maximum stress remained below the material yield strength, and the maximum displacement did not exceed 1.5 mm.

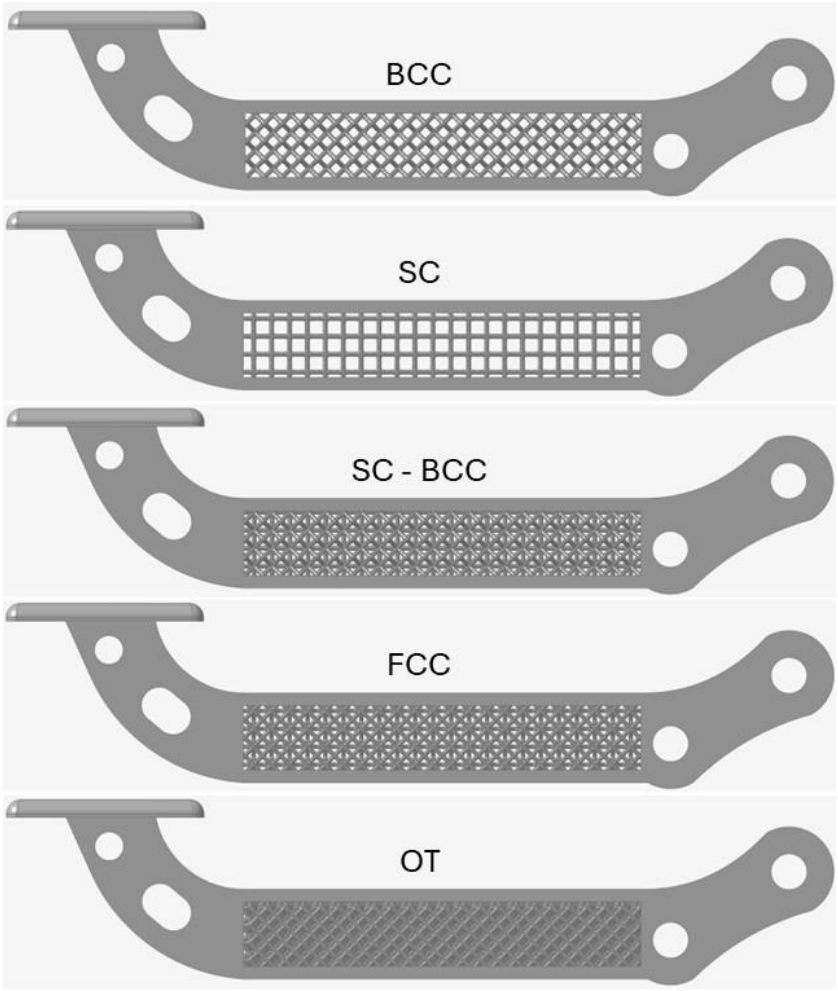

Figure 2. Lattice-filled brake pedal designs with different unit-cell topologies.

RESULTS AND DISCUSSION

The baseline solid brake pedal was first analyzed as a reference case to establish a benchmark for evaluating the subsequent topology-optimised and lattice-filled designs under identical loading and boundary conditions. For the baseline model, the maximum von Mises stress was 258.1 MPa, while the maximum displacement reached 1.177 mm.

For the baseline model, the von Mises stress distribution is presented in Figure 3a. This model was then used as the starting point for topology optimization, and the resulting material distribution highlighted the low-utilization regions suitable for material removal (Figure 3b). Based on this outcome, the brake pedal was redesigned accordingly, and the reconstructed topology-optimised geometry is shown in Figure 3c. The redesigned pedal was subsequently analyzed under the same loading and boundary conditions, and the corresponding stress distribution is given in Figure 3d. This design resulted in a maximum displacement of 1.343 mm and a maximum von Mises stress of 295.5 MPa. Thus, while the mass was reduced by 21.1%, both stress and displacement remained below the predefined limits.

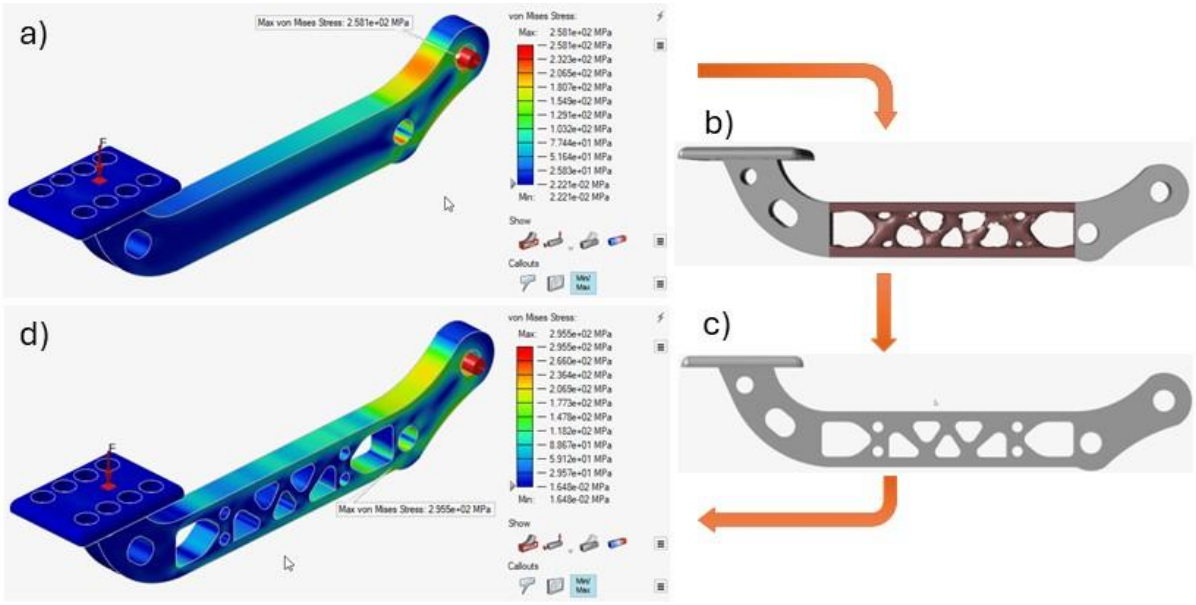

Figure 3. Baseline and topology-optimised brake pedal design process and stress distributions: a) baseline von Mises stress, b) topology-optimization material distribution, c) reconstructed topology-optimised geometry, d) von Mises stress of the redesigned pedal.

Although topology optimization provided a notable mass reduction while keeping the stress and displacement within the predefined limits, the redesign still relies on a fully solid load path in the remaining material. This raises the question of whether further lightweighting can be achieved without compromising stiffness and strength by replacing the material-removal region with lattice infill. Therefore, the low-utilization region identified by topology optimization was filled with different lattice architectures, and their effects on mass, maximum stress, and displacement were evaluated and compared. The complete set of analysis results is summarized in Table 1, while the von Mises stress distributions of the lattice-infilled configurations are presented in Figure 4.

Table 1. Finite element results of all brake pedal configurations.

Configuration	Max. Stress (MPa)	Stress Change (%)	Displacement (mm)	Disp. Change (%)	Mass (kg)	Mass Change (%)
Baseline	258.1	-	1.177	-	0.525	-
Topology-Opt.	295.5	14.5	1.343	14.1	0.414	-21.1
BCC	269.2	4.3	1.447	22.9	0.381	-27.4
SC	675.7	161.8	1.716	45.8	0.371	-29.3
SC-BCC	261.5	1.3	1.411	19.9	0.393	-25.1
FCC	272.6	5.6	1.425	21.1	0.391	-25.5
OT	254.0	-1.6	1.334	13.3	0.444	-15.4

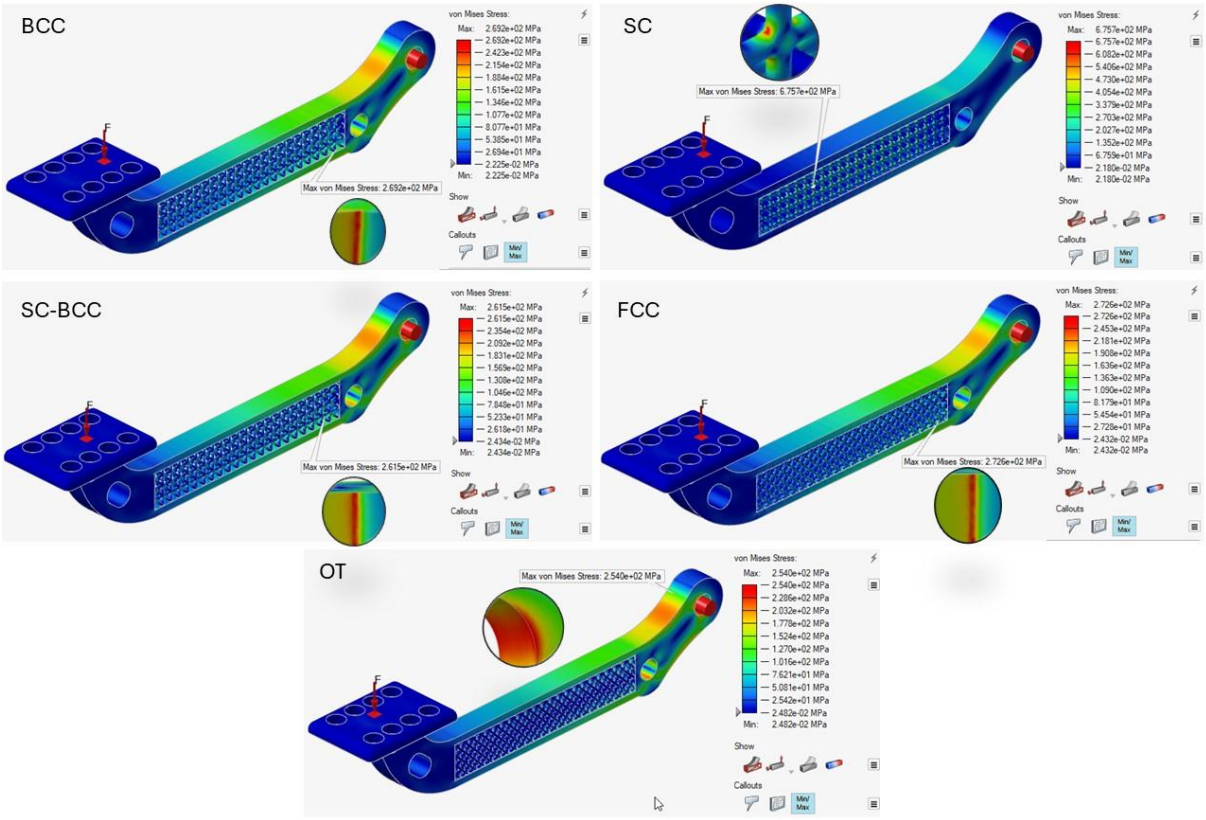

Figure 4. Stress distributions of lattice-infilled brake pedal configurations.

Table 1 and Figure 4 show that lattice infill can push the lightweighting beyond topology optimization while still meeting the basic acceptance limits for most structures. Among the lattice-filled designs, BCC, SC–BCC, FCC, and OT remain within the displacement limit and below the yield strength. BCC provides the most aggressive weight saving among the feasible options, reducing mass by 27.4% (0.381 kg) while keeping the peak stress at 269.2 MPa and displacement at 1.447 mm. SC–BCC yields a slightly smaller mass reduction but achieves one of the lowest stress penalties (261.5 MPa) with 1.411 mm displacement. FCC behaves similarly to BCC in global stiffness, with 272.6 MPa peak stress, 1.425 mm displacement, and 25.5% mass reduction (0.391 kg). OT stands out by producing the lowest peak stress among all variants (254.0 MPa, slightly below the baseline), while also keeping displacement relatively low (1.334 mm); however, its mass reduction is more modest (15.4%, 0.444 kg), indicating a more conservative lightweighting outcome under the selected unit-cell and strut dimensions.

The stress maps in Figure 4 also clarify where each topology tends to concentrate load. For BCC, SC–BCC, and FCC, the maximum von Mises stress occurs at the lower surface near the end of the radiused transition region, where the curvature ends and the section changes. This is consistent with a bending-dominated load case in which the highest stresses accumulate around geometric transitions (a classic stress-raiser), and the lattice mainly influences stiffness/mass rather than eliminating the global hotspot. In contrast, the SC lattice is clearly unfeasible for this brake pedal under the current design rules. Although it provides the largest mass reduction (29.3%, 0.371 kg), it violates both acceptance targets, showing a peak stress of 675.7 MPa and a displacement of 1.716 mm. Importantly, the peak stress forms directly on a lattice rod, indicating that the load is being carried by a small number of struts, creating severe local stress concentration and an overly compliant response. Practically, this implies a high risk of early yielding and/or local failure in the lattice members, which is unacceptable for a safety-critical pedal.

The OT configuration shifts the maximum stress location to the constrained mounting-hole surface, rather than the lower-radius transition seen in BCC/SC–BCC/FCC. This indicates that the OT lattice distributes the bending load more effectively through the infill region, moving the governing hotspot toward the load-transfer/constraint zone.

While this is beneficial from a "lower peak stress" standpoint, it also highlights that the reported maximum may be sensitive to the idealized fully fixed boundary condition. Even with that conservative hotspot, OT remains well below yield and under the displacement limit, making it feasible and mechanically robust, especially if peak stress minimization is prioritized over maximum mass saving.

CONCLUSION

The results indicate that lattice infill can further reduce the brake pedal mass beyond topology optimization while keeping stress and stiffness within acceptable limits for most configurations. Among the investigated designs, the BCC lattice provided the best overall balance by delivering the highest lightweighting potential among the feasible cases without exceeding the displacement limit and while maintaining peak stress at an acceptable level. SC–BCC and FCC also satisfied the criteria, showing slightly lower mass savings with comparable structural responses, whereas OT produced the lowest peak stress but with a more conservative weight reduction. In contrast, SC was not suitable due to excessive compliance and pronounced stress concentration directly on the lattice struts.

Future work may focus on improving lattice-integrated pedals through local refinement in critical zones, particularly around geometric transitions and load-transfer regions. Approaches such as functionally graded lattices or local strut-thickness increases can be applied only where needed to reduce stress concentrations without sacrificing global mass savings. In addition, optimizing the unit-cell size and strut diameter for each lattice topology is expected to further improve the mass–stiffness trade-off.

Finally, extending the present linear static framework to include material nonlinearity, strut buckling, and fatigue durability would provide a more realistic assessment under service-like conditions. Incorporating additive-manufacturing constraints such as minimum printable strut diameter, surface roughness, and post-processing considerations is also recommended to strengthen the practical feasibility of the proposed designs.

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A DIGITAL TWIN–ENABLED HYBRID ANOMALY DETECTION AND DECISION SUPPORT SYSTEM FOR SPACECRAFT TELEMETRY DATA

UZAY ARACI TELEMETRİ VERİLERİ İÇİN DİJİTAL İKİZ DESTEKLİ HİBRİT ANOMALİ TESPİTİ VE KARAR DESTEK SİSTEMİ

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ABSTRACT

Space missions are characterized by high costs, limited intervention capabilities, and critical safety in operational conditions. Therefore, real-time monitoring, early anomaly detection, and rapid decision-making capabilities are essential. Due to these necessities, a digital twin architecture is needed, representing a digital equivalent of the physical spacecraft and operating continuously synchronously with the real system. This study develops a digital twin-based mission adaptation and autonomous decision support architecture to enhance safety and operational continuity in spacecraft operations. The proposed system collects multidimensional telemetry data from orbit, power, thermal, and communication subsystems in real time and processes this data through data cleaning, normalization, and feature extraction stages. Machine learning methods are integrated with rule-based validation mechanisms to ensure reliable decision-making. Unsupervised learning algorithms such as Isolation Forest, One-Class SVM, and Local Outlier Factor are used for anomaly detection. A hybrid structure supported by physical thresholds enables interpretable and explainable decisions. In the model, detected deviations are prioritized via a risk scoring module, and automatic action recommendations are presented to operators. The system's performance is evaluated based on... Trajectory error analysis is evaluated using metrics such as alarm rate, false positive rate, and overall improvement score. This enables the achievement of low error, high accuracy, and stable operational behavior. The model also incorporates scalable data processing pipelines, real-time analytics infrastructure, and cloud/distributed system integration. This study demonstrates the effective use of digital twin technology in operational task management by presenting an integrated engineering solution encompassing data science, data analytics, pattern recognition, machine learning, and decision support systems.

Keywords: Digital twin, spacecraft operations, telemetry analysis, machine learning.

ÖZET

Uzay görevleri; yüksek maliyet, sınırlı müdahale imkânı ve güvenliği kritik operasyon koşullarına sahiptir. Bu nedenle gerçek zamanlı izleme, erken anomali tespiti ve hızlı karar verme yetenekleri gerekli olmaktadır. Bu zorunluluklar nedeniyle, fiziksel uzay aracının sayısal bir eşleniğini temsil eden ve gerçek sistem ile sürekli senkronize çalışan dijital ikiz mimarisine ihtiyaç bulunmaktadır. Bu çalışma kapsamında, uzay aracı operasyonlarında güvenliği ve operasyonel sürekliliği artırmak amacıyla dijital ikiz tabanlı bir görev uyarlama ve otonom karar destek mimarisi geliştirilmektedir. Önerilen sistem, yörünge, güç, termal ve iletişim alt sistemlerinden çok boyutlu telemetri verilerini gerçek zamanlı olarak toplamak ve bunları veri temizleme, normalleştirme ve özellik çıkarma aşamalarından geçirmektir. Güvenilir karar vermeyi sağlamak amacıyla makine öğrenme yöntemleri kural tabanlı doğrulama mekanizmalarıyla entegre edilmektedir. Anomali tespiti için Isolation Forest, One-Class SVM ve Local Outlier Factor gibi denetimsiz öğrenme algoritmaları kullanılmaktadır. Bu süreçte fiziksel eşiklerle desteklenen hibrit bir yapı, yorumlanabilir ve açıklanabilir kararlara ulaşılmasını sağlamaktadır. Modelde, tespit edilen sapmalar, bir risk puanlama modülü aracılığıyla önceliğe göre sıralanmakta ve operatörlere otomatik olarak eylem önerileri sunulmaktadır.

Sistemin performansı; yörünge hatası analizi, alarm oranı, yanlış pozitif oranı ve genel iyileştirme puanı gibi ölçütler kullanılarak değerlendirilmektedir. Böylece düşük hata, yüksek doğruluk ve istikrarlı operasyonel davranış elde edilmesi mümkün olmaktadır. Modelde ayrıca, ölçeklenebilir veri işleme hatları, gerçek zamanlı analitik altyapı ve bulut/dağıtık sistem entegrasyonu uygulanmaktadır. Bu çalışma, veri bilimi, veri analitiği, örüntü tanıma, makine öğrenimi ve karar destek sistemlerini kapsayan entegre bir mühendislik çözümü sunarak, dijital ikiz teknolojisinin operasyonel görev yönetiminde etkin kullanımını göstermektedir.
Anahtar kelimeler: Dijital ikiz, uzay aracı operasyonları, telemetri analizi, makine öğrenmesi

IMPLEMENTATION FRAMEWORK FOR INTERNATIONAL-STANDARD AI INTEGRATION IN PAKISTAN RAILWAYS, A STRATEGIC ROADMAP FOR THE IT DIRECTORATE

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ABSTRACT
As Pakistan The modernization of Pakistan Railways (PR) stands at a critical juncture, transitioning from legacy operational models to data-driven digital ecosystems. This research proposes a comprehensive framework for the initiation of international-level Artificial Intelligence (AI) mechanisms within the PR IT Directorate. As the department moves toward the completion of its "Railway Advanced Infrastructure Network" (RAIN) by 2026, the integration of AI is essential to shift from descriptive digitization to prescriptive intelligence. The paper identifies three primary AI-driven pillars necessary for global competitiveness: **Predictive Infrastructure Management**, **Intelligent Traffic Regulation**, and **Dynamic Revenue Optimization**. In the realm of infrastructure, the study advocates for the deployment of Deep Learning models integrated with the 1,700-km fiber optic network on the ML-1 corridor to monitor track health and locomotive telemetry in real-time, reducing accidents and maintenance costs. For traffic regulation, it explores the transition to AI-based computerized interlocking systems that minimize human-induced delays. Lastly, the research details how AI can enhance the "Rabta" ecosystem through Generative AI chatbots and demand-forecasting algorithms to meet the government's revenue target of Rs. 1 trillion by 2026. Aligned with Pakistan's National AI Policy 2025, the proposed mechanism emphasizes a "Secure AI Ecosystem" with robust cybersecurity protocols for critical rail infrastructure. The findings suggest that by establishing an "AI Excellence Hub" within the IT Directorate, Pakistan Railways can achieve the 42% operational efficiency gains seen in international railway benchmarks, positioning the nation as a regional leader in smart transport logistics.
Keywords: Artificial Intelligence (AI), Pakistan Railways, IT Directorate, RAIN Project, Predictive Maintenance, Smart Signaling, National AI Policy 2025, Digital Transformation.

STRATEGIC FRAMEWORK FOR AI IMPLEMENTATION IN PAKISTAN RAILWAYS, A ROADMAP FOR THE IT DIRECTORATE

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ABSTRACT
As Pakistan Railways (PR) undergoes a massive digital transformation, aiming for a revenue target of Rs. 1 trillion by 2026, the role of the IT Directorate is shifting from a support function to a strategic driver. This paper proposes a comprehensive framework for the implementation of Artificial Intelligence (AI) to modernize legacy systems, enhance operational safety, and optimize passenger services. Key focus areas include predictive maintenance for aging rolling stock, AI-driven traffic management, and automated ticketing systems. By aligning with Pakistan's National AI Policy 2025, this framework provides a roadmap for the IT Directorate to lead PR into a new era of data-driven efficiency.
Keywords: massive digital transformation, strategic driver, predictive maintenance, rolling stock

3D/4D BIOMEDICAL IMAGE PROCESSING WITH SPATIO-TEMPORAL TRANSFORMERS

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ABSTRACT
The rapid growth of volumetric and time-resolved biomedical imaging has created unprecedented opportunities for understanding dynamic physiological processes, yet the high dimensionality of 3D and 4D data continues to challenge conventional deep learning methods. Recent studies indicate that convolutional networks struggle to capture long-range dependencies across slices and temporal frames, leading to suboptimal modeling of organ motion and disease progression (Chen et al., 2021; Wang & Gupta, 2022). This research proposes a spatio-temporal transformer framework for unified processing of 3D and 4D medical images, enabling joint learning of spatial anatomy and temporal dynamics from ultrasound, cardiac MRI, and CT sequences.
Empirical evaluation was conducted on three datasets: 1,860 cardiac MRI volumes for ejection-fraction estimation, 1,240 4D obstetric ultrasound sequences for fetal motion analysis, and 1,015 lung CT time-series for nodule evolution tracking. The proposed model employs hierarchical windowed self-attention with temporal positional encoding and deformable token aggregation. Compared with 3D-CNN and ConvLSTM baselines, the approach achieved a Dice score of 0.93 for cardiac segmentation, mean absolute error of 4.8% for ejection-fraction prediction, and 91.6% accuracy for lung-nodule progression classification. Temporal consistency improved by 18% as measured by inter-frame structural similarity, confirming the capacity of transformers to model long-range physiological motion (Zhang et al., 2023).
Ablation experiments demonstrated that cross-frame attention contributed the largest gain, while model compression using token pruning reduced computation by 42% without significant accuracy loss, supporting feasibility for clinical deployment (Kumar & Lee, 2022). The findings provide empirical evidence that spatio-temporal transformers outperform convolutional paradigms for high-dimensional biomedical imaging tasks and offer improved interpretability through attention maps highlighting clinically relevant regions.
This study contributes a generalizable architecture, training protocol, and benchmark for 3D/4D image analysis and supports emerging calls for transformer-based digital phenotyping in precision medicine (Okeke & Silva, 2024). Implications for real-time surgical guidance, disease monitoring, and integration with hospital PACS are discussed.
Keywords: spatio-temporal transformers, 3D imaging, 4D imaging, medical image processing, cardiac MRI, ultrasound dynamics

HYBRID MACHINE LEARNING–DRIVEN FORECASTING AND NEUTROSOPHIC OPTIMIZATION OF CRYPTOCURRENCY MARKETS

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Abstract
Fluctuations in cryptocurrency markets present a significant problem to the accuracy of forecasting trends and prices in this field. This paper proposes a new method of improving cryptocurrency forecasting by applying machine learning algorithms to a hybrid model. The framework integrates, a neural network model, with auto regressive integrated moving average (ARIMA) and trigonometric, Box-Cox, ARMA, Trend, Seasonal (TBATS) to capture the intricate relationship and dynamics in the data. Because most aspects affecting the cryptocurrency's price are uncertain, we propose that fuzzy parameters be used to reflect this uncertainty in the market. Furthermore, we apply neutrosophic programming to optimize predictions where the indeterminacy of the data is considered. The hybrid model thus incorporates short-term market volatility and long-term market trends, making the model rigid and accurate. Here, we compare this approach's performance with other forecasting models using actual cryptocurrency data. The results indicate that the hybrid model developed achieves better predictive accuracy and is more flexible than the conventional models. To sum up, this research offers significant knowledge of applying the newest machine learning methods to enhance cryptocurrency prediction and improve its efficiency for investors, traders, and financial institutions.
Keywords: Hybrid modeling, Machine learning, Neural networks, Time series forecasting, Neutrosophic programming.

LITERATURE REVIEW AND PROPOSING AN EYE DISEASE (CATARACT) DETECTION CMS USING THE LATEST CV AND ML TECHNOLOGIES FOR THE CONSERVATION OF TRIBES OF CHHATTISGARH

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Abstract
In the current paper we are focusing on the issue of saving the Tribal Life. We the authors of the paper belong to Chhattisgarh where the majority population is Tribe. Tribes are very innocent and the conservation of the heritage that the tribes have is the aim of this paper. The majority population relies on agriculture. If agriculture is not good because of any reason the life of tribes is in stake. Since the whole year and for living the Tribes are dependent on agriculture. Agriculture need to have some support for Tribes. In Chhattisgarh we are having Agriculture institutions where how to do effective and efficient agriculture is taught. The paper comprises of literature survey on the current ways of how to deal with eye disease. And next we will have a Machine Learning based system that is going to help the Tribes of chhattisgarh to check whether they are suffering from eye disease that is cataract or not via there smart phones.
Keywords: AI, ML, Doctor, Eye, Disease.

DEEP LEARNING ARCHITECTURES FOR COMPUTER VISION

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ABSTRACT

Recent advances in deep learning have significantly transformed the field of computer vision by enabling automated feature extraction and high-accuracy visual understanding. This paper presents a comprehensive study of modern deep learning architectures for computer vision applications, including Convolutional Neural Networks (CNNs), Vision Transformers (ViTs), and hybrid CNN-Transformer models. The proposed framework analyzes architectural design principles, feature learning mechanisms, and performance optimization strategies for tasks such as image classification, object detection, and semantic segmentation.The study evaluates various architectures on benchmark datasets to compare their accuracy, computational efficiency, and generalization capabilities. Special emphasis is placed on attention mechanisms, transfer learning, and model scalability for real-time and edge-based applications. Experimental results demonstrate that transformer-based and hybrid architectures outperform traditional CNN models in capturing global contextual information while maintaining competitive performance in resource-constrained environments.

The findings highlight the importance of architectural innovation in improving robustness, efficiency, and interpretability of vision systems. This research contributes to the development of scalable and intelligent computer vision models suitable for applications in healthcare, autonomous systems, and surveillance.

Keywords: Deep Learning, Computer Vision, CNN, Vision Transformers, Image Classification, Object Detection, Hybrid Models.

A FOURIER NEURAL OPERATORS APPROACH FOR SIMULATING OF A CLASS OF NONLINEAR PERIODIC DIFFERENTIAL SYSTEMS

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Abstract
The aim of this work is to focus on the study of a class of periodic systems derived from biological phenomena modeling. Such models are generally cooperative. After developing a criterion for the existence of periodic solutions, the algorithms for their numerical simulations are designed. we opted for Deep Learning (FNO). The numerical results obtained show the robustness and efficiency of the proposed method.
Keywords: Periodic, cooperative system, Fourier Neural Network, AMS

MAXIMA MINIMA AND ITS APPLICATIONS IN ENGINEERING

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ABSTRACT

Introduction and Purpose

Maxima and minima are fundamental concepts in differential calculus that focus on determining the extreme values of functions. These concepts are essential in engineering mathematics, as many real-world engineering problems involve optimization of performance, cost, efficiency, and safety. Maxima represent the highest achievable value of a function, while minima represent the lowest. Engineers rely on these concepts to design systems that operate under optimal conditions. The purpose of this study is to highlight the theoretical significance of maxima and minima and to emphasize their practical applications in solving engineering optimization problems.

Materials and Methods

This study follows a theoretical and analytical approach to explain the concepts of maxima and minima for single-variable functions. The use of first-order and second-order derivatives is discussed to identify critical points and determine the nature of extreme values. Mathematical conditions for local and global maxima and minima are presented. Standard examples from mechanical, electrical, civil, and industrial engineering are examined to demonstrate how optimization techniques based on maxima and minima are applied in engineering practice.

Results

The analysis shows that maxima and minima techniques provide an effective framework for solving optimization problems in engineering systems. These methods help identify optimal design parameters, minimize material usage, reduce energy consumption, and maximize system efficiency. The application of derivative-based optimization improves accuracy in engineering calculations and supports better decision-making during system design and analysis.

Discussion and Conclusion

The study concludes that maxima and minima are essential tools in engineering mathematics and play a critical role in optimization and system analysis. A strong conceptual understanding of these topics enables engineers to model real-world problems efficiently and achieve optimal solutions. Integrating application-based learning of maxima and minima in engineering education can significantly enhance analytical skills and practical problem-solving abilities among students and researchers.

Keywords: Maxima and Minima; Differential Calculus; Optimization; Engineering Mathematics; Derivatives

MULTIPLE INTEGRALS AND CHANGE OF ORDER OF INTEGRATION – AREA ENCLOSED BY CARTESIAN COORDINATES IN ENGINEERING APPLICATIONS

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ABSTRACT
Multiple integrals form an essential part of engineering mathematics and are widely used to analyze physical systems involving more than one independent variable. Double and triple integrals are applied to compute areas, volumes, mass distributions, centroids, and moments of inertia in mechanical, civil, and electrical engineering. One of the most important techniques associated with multiple integrals is the change of order of integration, which allows a difficult integral to be simplified by interchanging the sequence of integration. This technique is particularly useful when evaluating areas enclosed by curves expressed in Cartesian coordinates. In many cases, the original limits of integration are complicated or lead to integrals that are difficult to evaluate, whereas changing the order of integration transforms the region into a simpler form. This paper presents a detailed study of multiple integrals, focusing on double integrals and the method of changing the order of integration. The geometric interpretation of regions bounded by curves is emphasized, along with step-by-step procedures for determining new limits of integration. Engineering-oriented examples are included to demonstrate the practical significance of these concepts in real-world applications such as area estimation, load distribution, heat transfer, and material analysis.
Keywords: Multiple Integrals, Double Integrals, Change of Order of Integration, Area, Cartesian Coordinates, Engineering Applications

INTRODUCTION
Engineering problems frequently involve quantities that depend on two or more variables. Examples include temperature distribution over a surface, pressure variation across a plate, and material density varying within a region. Single-variable calculus is insufficient to analyze such systems, and multiple integrals provide a natural extension. Double integrals enable engineers to compute areas and accumulated quantities over planar regions, while triple integrals are used for volume-related calculations in three-dimensional domains. Among these, double integrals play a particularly important role in determining the area enclosed by curves in Cartesian coordinates.

In practical applications, the region of integration is often bounded by curves such as parabolas, straight lines, or circles. Setting up the limits of integration correctly is a crucial step in evaluating a double integral. However, the initially chosen order of integration may lead to complicated limits or integrands. The method of changing the order of integration provides a systematic approach to overcome this difficulty by redefining the region of integration and simplifying the evaluation process.

THEORY OF MULTIPLE INTEGRALS

A double integral of a function f(x, y) over a region R in the xy-plane is defined as the limit of a Riemann sum as the partition size approaches zero. Geometrically, a double integral represents the volume under the surface z = f(x, y) above the region R. When f(x, y) = 1, the double integral reduces to the area of the region R. This interpretation forms the basis for using double integrals to compute areas enclosed by curves.

Regions of integration are broadly classified into rectangular regions and non-rectangular regions. In rectangular regions, the limits of integration are constants, whereas in non-rectangular regions, at least one limit is a function of the other variable. Most engineering problems involve non-rectangular regions bounded by curves, making the choice of limits an important consideration.

CHANGE OF ORDER OF INTEGRATION

The change of order of integration involves interchanging the sequence of integration in a double integral. For example, an integral of the form ∫[a to b] ∫[g1(x) to g2(x)] f(x, y) dy dx can be rewritten as ∫[c to d] ∫[h1(y) to h2(y)] f(x, y) dx dy, provided the region R remains the same. This requires a clear understanding of the geometry of the region.

To change the order of integration, the region of integration must first be sketched in the Cartesian plane. By analyzing the boundaries of the region, new limits of integration can be determined. This process often simplifies the integral, especially when the integrand is easier to integrate with respect to one variable before the other.

AREA ENCLOSED BY CURVES IN CARTESIAN COORDINATES

The area enclosed by curves in Cartesian coordinates can be evaluated using double integrals by integrating the constant function 1 over the region of interest. For regions bounded by curves of the form y = f(x) and y = g(x), the area is given by the integral ∫[a to b] ∫[g(x) to f(x)] 1 dy dx. When the region is more conveniently described in terms of x as a function of y, changing the order of integration leads to a simpler expression.

Common examples include regions bounded by straight lines, parabolas, and combinations of linear and quadratic curves. In such cases, changing the order of integration reduces the problem to evaluating standard integrals with simpler limits.

ENGINEERING APPLICATIONS

Multiple integrals and change of order of integration are widely used in engineering practice. In civil engineering, they are applied to determine the area of irregular land sections and load distributions over structural elements. In mechanical engineering, these techniques are used to compute mass, centroid, and moment of inertia of plates with variable density. In electrical engineering, double integrals are employed to analyze charge distributions and electric flux over surfaces.

In heat transfer and fluid mechanics, double integrals help evaluate total heat flow or fluid quantity across a surface when the flux varies with position. The ability to change the order of integration allows engineers to choose the most efficient computational approach, reducing time and minimizing errors.

RESULTS AND DISCUSSION

The study demonstrates that changing the order of integration significantly simplifies the evaluation of double integrals in many practical problems. Complicated regions bounded by curves can often be transformed into simpler regions with straightforward limits. This not only reduces computational effort but also enhances conceptual understanding of the geometric nature of integration.

The examples discussed highlight the importance of sketching the region of integration and carefully analyzing its boundaries. A clear geometric interpretation ensures correct limits and accurate results, which are essential in engineering design and analysis.

CONCLUSION

Multiple integrals and the change of order of integration are powerful tools in engineering mathematics. They provide an effective framework for evaluating areas enclosed by curves and other accumulated quantities over complex regions. A strong understanding of these concepts is essential for solving real-world engineering problems and for advanced studies in applied mathematics, numerical methods, and engineering analysis.

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A NOVEL APPROACH FOR THE SIMULATION OF FLEXIBLE COMPOSITES: EVALUATING THE STRENGTH OF POISSON'S RATIO

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Abstract
Using a wave propagation approach, the vibration properties of chiral SWCNTs are investigated using the enlarged Flügge shell theory. As the Poisson ratios decrease, the frequency increases. The frequency of chiral single walled carbon nanotubes versus Poisson's ratio is investigated for simply supported-simply supported and clamped-simply supported boundary conditions. The frequency value of the chiral tube shows the addition of the Poisson effect, which raises the effective stiffness of the single-walled carbon nanotubes. The derived conclusion for natural frequencies has a different trend with Poisson's ratios. In fact, adding Poisson's effect during vibration raises the natural frequencies and increases the effective stiffness. One clear measure of material deformation is Poisson's ratio. Significant elastic deformation in the material is indicated by a high Poisson's ratio. The frequencies of carbon nanotubes rise as a result of these deformation frequencies. It is demonstrated that the frequencies drop when the Poisson's ratio is lowered from 0.5 to 0.05.

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A STUDY ON MATRICES AND CALCULUS FOR ENGINEERING APPLICATIONS

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Abstract
The use of Mathematics is essential for performing many different types of work in all branches of Engineering and Science. Matrices and Calculus are two main areas of Mathematics that have a considerable influence on Engineering and Science. The use of matrices to solve linear Equations, perform transformations and create models to solve problems in Network Analysis, etc. is common practice in Engineering and Science today. Calculus provides tools to analyse situations where Change occurs and Optimize How you Get the Most from Your Resource(s) Related to the Issue or Event, and to understand how things Move or Respond to Changing Environments; Matrices and Calculus are examples of How Mathematics Helps in many different fields.
The goal of this research is to present introductory explanations of the fundamental concepts of matrices and differential calculus, along with examples demonstrating the practical applications within the Engineering discipline. The operations defined in matrices (e.g.: addition, multiplication and determinants) will be explained with examples of how these operations can be used to solve Linear Equation Systems. In addition, a similar explanation will be given of the basic concepts of differential calculus, along with examples relating to the rate of Change of a given function, calculating the area of a shape, and optimizing what you want to do based on your present Condition.
Through many simple examples, we hope to provide an opportunity for the reader to see how Mathematics can provide an Effective and Efficient way to deal with multiple Equations, and how Calculus is needed in understanding how Functions and Physical Systems behave.
Keywords: Matrices, Calculus, Linear equations, Differentiation, Integration

INSIGHTS INTO ENHANCED HEAT TRANSFER IN MGO+CUO HYBRID NANOFLUID DUE TO MODIFIED XUE AND MAXWELL NANOMODELS

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Abstract
Recent research emphasizes the exceptional heat transfer characteristics of nanoliquid in contrast to traditional fluids. A recent innovation in this field is the creation of mixed nanoliquids, which are produced by combining two different types of nanoparticles to enhance thermal efficiency further. These mixed fluids are increasingly being applied in various sectors, including solar energy harvesting, electronics cooling, vehicle thermal systems, nuclear power plants, and medical treatments such as cancer therapy. This research conducts a numerical analysis to investigate the heat transfer aspects of a water-based mixed nanoliquid made of *MgO* and *CuO* nanoparticles moving over an exponentially stretching sheet.
The effects of thermal radiation and spatially variable temperature generation or absorption are also taken into account in the analysis. The primary objective of this study is to investigate the enhanced energy and mass transport rates predicted by the Maxwell and Xue nanofluid models. The governing flow equations, after transformation, are solved using the MATLAB solver bvp5c. A graphic representation of the effect of pertinent constraints on the temperature profile, concentration field, and velocity distribution is provided. Additionally, the research analyzes the related differences in skin friction, Nusselt number, and Sherwood number. The results indicate that the heat transfer rate achieved under the Xue model, particularly in the company of a non-uniform heat source/sink effect, is advanced than that predicted by the Maxwell model.
Keywords: Hybrid nanofluid, MHD, non-uniform heat source/sink, Maxwell and Xue nanomodels, radiative heat flux.

SPIROAI: INNOVATION TECHNOLOGY FOR ADVANCED LUNG HEALTH MONITORING

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ABSTRACT
Smart spirometry and intelligent lung monitoring is a new area of innovation in lung health technologies, which has combined biomedical sensors, embedded computing with artificial intelligence and mobile health solutions to improve respiratory care. The new process integrates the engineering mastery with the humanistic ideals of healthcare to provide affordable, preventative, and respiratory solutions. SpiroAI is a portable smart spirometer that is developed as a high-tech item in lung health technology. The device is an indispensable device that measures breathing airflow with precision biomedical sensors and operates the signals in an embedded microcontroller and calculates the essential pulmonary parameters of Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV1), and Peak Expiratory Flow Rate (PEFR). The obtained data is sent wirelessly to a mobile application, where respiratory patterns are analyzed using artificial intelligence algorithms and abnormalities are identified as well as changes in lung functionality over time. In addition to the expansion of technological progress, this innovation will improve human, social welfare through increased access to healthcare, decreased hospitalization, decreased stress, and decreased healthcare expenses in general. The system encourages preventive care and also individual responsibility of personal health care. The proposed innovation-based lung health technology will be useful especially in patients with chronic respiratory illnesses, athletes, elderly people, and other communities with less access to medical services because the technology will provide accurate data capture, real-time analysis, and easy visualization that will eventually help in providing weak-cost, human-centered, and distant respiratory healthcare systems.
Keywords: Smart Spirometer, Artificial Intelligence, Lung Function Monitoring, Biomedical Sensors, Innovation Technology

BETON KARIŞIM TASARIMINDAKİ DEĞİŞİKLİKLERİN SÜLFAT DİRENCİ ÜZERİNDEKİ ETKİLERİNİN İNCELENMESİ

INVESTIGATION OF THE EFFECTS OF CONCRETE MIX DESIGN VARIATIONS ON SULFATE RESISTANCE

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ÖZET

Yapı sektörünün en temel malzemesi olan betonun servis ömrü ve performansı, sadece üretim kalitesine değil, aynı zamanda maruz kaldığı çevresel koşullara da bağlıdır. Özellikle sülfatlı zeminlerde veya yeraltı sularıyla temas halindeki yapılarda görülen sülfat saldırısı, betonun durabilitesini (kalıcılığını) tehdit eden en önemli kimyasal bozunma mekanizmalarından biridir. Bu çalışmanın temel amacı, farklı dayanım sınıflarında tasarlanan betonların karışım suyundaki sapmaların, malzemenin sülfat direncine olan etkisini deneysel olarak ortaya koymaktır. Deneysel çalışmada C20/25, C30/37 ve C40/50 dayanım sınıfları seçilmiştir. Karışım suyunun betonun boşluk yapısı ve geçirimliliği üzerindeki etkisini gözlemlemek adına, tasarımda belirlenen su oranları kontrollü olarak %10, %20, %40, %70 ve %100 oranlarında artırılmış; buna karşılık %10 ve %20 oranlarında azaltılmıştır.

Üretilen numunelerin kimyasal direncini belirlemek amacıyla hızlandırılmış bir yaşlandırma testi olan ıslanma-kuruma çevrimi uygulanmıştır. Bu süreçte numuneler, 105°C sıcaklıktaki etüvde 2 gün boyunca tam kurumaya tabi tutulmuş, ardından sülfat etkisini simüle etmek için kütlece %5 oranında sodyum sülfat (Na2SO4) içeren çözeltide 2 gün bekletilmiştir. Çevrimler sonucunda beton numunelerinde meydana gelen fiziksel tahribat, kütle kaybı ölçümleriyle analiz edilmiştir. Elde edilen bulgular, betonun dayanım sınıfı yükseldikçe direncin arttığını, ancak karışım suyundaki artış veya azalışların sülfat direncini belirgin şekilde değiştirdiğini göstermektedir. Sonuç olarak, doğru su/çimento oranının korunmasının, betonun sülfat ataklarına karşı uzun vadeli performansı için kritik olduğu belirlenmiştir.

Anahtar Kelimeler: Beton durabilitesi, Sülfat direnci, Karışım suyu oranı, Islanma-kuruma çevrimleri, Kütle kaybı, Na2SO4 çözeltisi.

ABSTRACT

The service life and performance of concrete, the most fundamental material in the construction industry, depend not only on production quality but also on the environmental conditions to which it is exposed. Sulfate attack, particularly observed in structures in contact with sulfate-bearing soils or groundwater, is one of the most significant chemical deterioration mechanisms threatening concrete durability. The primary objective of this study is to experimentally determine the effect of deviations in mixing water on the sulfate resistance of concrete designed in different strength classes. In the experimental study, strength classes C20/25, C30/37, and C40/50 were selected. To observe the effect of mixing water on the pore structure and permeability of concrete, the water ratios determined in the design were systematically increased by 10%, 20%, 40%, 70%, and 100%, and decreased by 10% and 20%.

A wetting-drying cycle, an accelerated aging test, was applied to determine the chemical resistance of the produced specimens. In this process, the samples were subjected to full drying in an oven at 105°C for 2 days, followed by immersion in a solution containing 5% sodium sulfate (Na2SO4) by mass for 2 days to simulate the sulfate effect. The physical deterioration occurring in the concrete samples at the end of the cycles was analyzed through mass loss measurements. The findings indicate that while resistance increases as the concrete strength class increases, increases or decreases in mixing water significantly alter sulfate resistance. Consequently, maintaining the correct water/cement ratio was determined to be critical for the long-term performance of concrete against sulfate attacks.

Keywords: Concrete durability, Sulfate resistance, Mixing water ratio, Wetting-drying cycles, Mass loss, Na2SO4 solution.

FARKLI KARIŞTIRMA SÜRELERİYLE HAZIRLANAN PMMA/Co_3O_4 NANOKOMPOZİTLERİNDE DAĞILIM KONTROLLÜ TERMAL BOZUNMA KİNETİĞİ

DISPERSION–INTERFACE INTERACTION DRIVEN THERMAL DEGRADATION KINETICS: THE CASE OF PMMA/Co_3O_4 NANOCOMPOSITES

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ÖZET

Polimerik matrisli nanokompozitlerin termal kararlılığı, inorganik dolgu fazının uzaysal dağılımına ve bu dağılımın yarattığı arayüzey etkileşimlerine sıkı sıkıya bağlıdır. Bu çalışmada, PMMA/Co_3O_4 sistemleri kontrollü ergiyik karıştırma yöntemiyle sentezlenmiş; hazırlama sürecindeki karıştırma süresinin nanoparçacık morfolojisi ve termal bozunma kinetiği üzerindeki belirleyici rolü sistematik olarak analiz edilmiştir. Örneklerin yapısal doğası XRD ve SEM teknikleriyle aydınlatılmış, bozunma süreçlerine eşlik eden kinetik parametreler ise izotermal olmayan DTA verilerinden yararlanılarak Kissinger, Ozawa ve Augis–Bennett modelleriyle hesaplanmıştır. Yapısal analizler, Co_3O_4 ilavesinin PMMA'nın karakteristik amorf matris yapısını bozmadığını teyit ederken; SEM gözlemleri, karıştırma süresinin uzatılmasının nanoparçacık yığınlaşmasını (aglomerasyon) sınırlayarak dağılım kalitesini kademeli olarak artırdığını ortaya koymuştur. Ancak kinetik veriler, termal direncin sadece dağılım homojenliğiyle açıklanamayacağını kanıtlar niteliktedir. En yüksek aktivasyon enerjisi (~285 kJ/mol) PMMA-6 numunesinde elde edilmiş olup bu değerin saf polimere göre %35, en yüksek dağılım homojenliğine sahip PMMA-12 örneğine göre ise %20 daha yüksek olduğu saptanmıştır. Elde edilen bulgular, nanokompozitlerde termal dayanımın maksimize edilmesi için en iyi dağılımın, her zaman ideal çözüm olmadığını; aksine, kısmi aglomerasyonun yarattığı arayüzeysel kısıtlamalar ve radikal yakalama mekanizmasının en verimli çalıştığı optimum dağılım durumunun kritik önem taşıdığını göstermektedir. Bu araştırma, polimerik malzemelerin termal performansının, kimyasal bir modifikasyona gerek duyulmaksızın sadece üretim parametreleriyle nasıl manipüle edilebileceğine dair yeni bir bakış açısı sunmaktadır.

Anahtar Kelimeler: Nanokompozitler, Poli(metil metakrilat), Termal analiz, Co_3O_4, Aktivasyon enerjisi

ABSTRACT

The thermal stability of polymer-based nanocomposites is strongly governed by the spatial distribution of inorganic fillers and the interfacial interactions arising from this distribution. In this study, PMMA/Co_3O_4 nanocomposites were synthesized via controlled melt processing, and the relationship between nanoparticle dispersion, interfacial constraints, and thermal degradation kinetics was systematically investigated. Structural and morphological characteristics of the composites were examined using X-ray diffraction (XRD) and scanning electron microscopy (SEM), while kinetic parameters associated with thermal degradation were evaluated from non-isothermal DTA data employing the Kissinger, Ozawa, and Augis–Bennett methods. XRD analyses confirmed that the incorporation of Co_3O_4 nanoparticles did not alter the intrinsic amorphous structure of the PMMA matrix. SEM observations revealed distinct dispersion states of Co_3O_4 nanoparticles, ranging from partially agglomerated to more uniformly distributed morphologies. Kinetic analyses demonstrated that thermal resistance cannot be solely attributed to dispersion homogeneity. The highest activation energy (~285 kJ/mol) was obtained for an intermediate dispersion state, representing an increase of approximately 35% compared to neat PMMA and about 20% relative to the most homogeneously dispersed nanocomposite. These findings indicate that maximum thermal stability is achieved not under ideal dispersion conditions, but rather at an optimum dispersion–interface balance where interfacial constraints and radical trapping mechanisms are most effective. The study highlights that the thermal performance of polymer nanocomposites can be significantly tailored through processing-induced dispersion control, without the need for chemical modification of either the polymer matrix or the filler phase.

Keywords: : Nanocomposites, Poly(methyl methacrylate), Thermal analysis, Co3O4, Activation energy

SAF ALÜMİNYUM MATRİSLİ B_4C-CeO_2 TAKVİYELİ KOMPOZİTLERİN ÜRETİMİ VE ÖZELLİKLERİ

PRODUCTION AND PROPERTIES OF PURE ALUMINIUM MATRIX B_4C-CeO_2 REINFORCED COMPOSITES

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ÖZET

Bu çalışmada saf alüminyum matrisli %10 bor karbür (B_4C) ve seryum oksit (CeO_2) takviyeli melez kompozitlerin üretimi gerçekleştirilmiş ve takviye oranlarının kompozit özelliklerine etkisi incelenmiştir. Sıcak presleme işlemi 600 ºC'de, 30 dakika presleme süresi ve 200 MPa basınç altında uygulanmıştır.

Üretilen kompozitlerde takviye oranlarının yoğunluk, mikroyapı, sertlik, ve aşınma davranışı gibi özellikleri üzerindeki etkileri araştırılmıştır. Takviye oranının artmasıyla birlikte sertlik değerlerinde artış gözlemlenmiştir. Katkısız numunede ortalama 49,12 $HV_{0,3}$ olan sertlik değeri %10 bor karbür, %10 bor karbür + %1 seryum oksit, %10 bor karbür + %3 seryum oksit, %10 bor karbür + %5 seryum oksit ilavelerinde sırayla 67,76 $HV_{0,3,}$ 67,70 $HV_{0,3,}$ 76,77 $HV_{0,3,}$ 75,88 $HV_{0,3}$ olarak ölçülmüştür.

Seryum oksitin yoğunluğunun saf alüminyuma göre daha yüksek olması nedeniyle takviye oranının artışı ile kompozit yoğunluğunda artış meydana gelmiştir. Katkısız numunenin yoğunluğu 2,7732 g/cm^3 olarak belirlenirken, bu değer %10 bor karbür, %10 bor karbür + %1 seryum oksit, %10 bor karbür + %3 seryum oksit, %10 bor karbür + %5 seryum oksit takviyeli kompozitlerde sırayla 2,7307 g/cm^3, 2,7341 g/cm^3, 2,8043 g/cm^3, 2,8728 g/cm^3, olarak belirlenmiştir. Seramik katkılar alüminyumun aşınma özelliklerine de olumlu katkı sağlamıştır. Artan takviye oranıyla aşınma direnci de gelişmiştir. B_4C ve CeO_2 katkılar hem matrise göre daha yüksek sertliğe sahip olmaları hem de CeO_2'nin yağlayıcı etkisi nedeniyle aşınma direncinin ve aşınma davranışının gelişmesini sağlamıştır.

Anahtar Kelimeler: Alüminyum matrisli kompozitler; Bor karbür; Seryum oksit; Aşınma davranışı

ABSTRACT

In this study, hybrid composites reinforced with 10 wt.% boron carbide (B_4C) and cerium oxide (CeO_2) in a pure aluminum matrix were produced, and the effects of reinforcement ratios on composite properties were investigated. The hot pressing process was conducted at 600 °C for 30 minutes under a pressure of 200 MPa.

The effects of reinforcement ratios on properties such as density, microstructure, hardness, and wear behavior of the fabricated composites were examined. An increase in hardness values was observed with increasing reinforcement content. While the average hardness of the unreinforced sample was 49.12 $HV_{0,3}$, the hardness values of the composites reinforced with 10 wt.% B_4C, 10 wt.% B_4C + 1 wt.% CeO_2, 10 wt.% B_4C + 3 wt.% CeO_2, and 10 wt.% B_4C + 5 wt.% CeO_2 were measured as 67.76 $HV_{0,3}$, 67.70 $HV_{0,3}$, 76.77 $HV_{0,3}$, and 75.88 $HV_{0,3}$, respectively.

Due to the higher density of cerium oxide compared to pure aluminum, increasing the reinforcement content led to an increase in composite density. The density of the unreinforced sample was 2.7732 g/cm³, whereas the densities of the composites reinforced with 10 wt.% B_4C, 10 wt.% B_4C + 1 wt.% CeO_2, 10 wt.% B_4C + 3 wt.% CeO_2, and 10 wt.% B_4C + 5 wt.% CeO_2 were 2.7307 g/cm³, 2.7341 g/cm³, 2.8043 g/cm³, and 2.8728 g/cm³, respectively.

The addition of ceramic reinforcements also positively influenced the wear properties of aluminum. Wear resistance improved with increasing reinforcement content. B_4C and CeO_2 additives enhanced wear resistance and wear behavior due to their higher hardness compared to the matrix, as well as the lubricating effect of CeO_2.
Keywords: Aluminum matrix composites; Boron carbide; Cerium oxide; Wear behavior

HURDA JANT KAYNAKLI ALÜMİNYUM KÜLÇELERİ KULLANILARAK LPDC YÖNTEMİYLE ÜRETİLEN A356 JANTLARIN METALURJİK VE MEKANİK ÖZELLİKLERİ

METALLURGICAL AND MECHANICAL CHARACTERISTICS OF LPDC-PRODUCED A356 WHEELS USING SCRAP WHEEL–DERIVED ALUMINUM INGOTS

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ÖZET

Tüketim sonrası alüminyum hurdasının (post-consumer) Alçak Basınçlı Döküm (LPDC) yöntemiyle A356 alaşımlı jant üretimine entegre edilmesi, otomotiv endüstrisinin düşük karbon emisyonu hedefine ulaşması ve döngüsel ekonomiye geçişi açısından kritik bir strateji olarak öne çıkmaktadır. A356 alaşımı üretiminde ergiyik temizliği büyük ölçüde gaz giderme verimliliği ile belirlenmekte olup, bu işlem çözünmüş hidrojenin ve yapısal bütünlüğü olumsuz etkileyebilecek oksitlerin uzaklaştırılmasını sağlamaktadır. Bu çalışmada, tüketim sonrası alüminyum hurdasının LPDC yöntemiyle üretilen A356 alüminyum alaşımlı jantların metalurjik bütünlüğü ve mekanik davranışları üzerindeki etkisi incelenmiştir. Jant üretimi, birincil alüminyum ve tüketim sonrası hurda içeren ikincil ergiyikler kullanılarak gerçekleştirilmiştir. Ergiyik temizliğinin etkisini değerlendirmek amacıyla, düşük ve konvansiyonel gaz seviyelerine karşılık gelecek şekilde iki farklı gaz giderme protokolü uygulanmış, diğer tüm proses parametreleri sabit tutulmuştur. Deneysel kapsamda üretilen tüm jantlar, endüstriyel koşulların homojenliğini sağlamak amacıyla tek bir üretim vardiyası içerisinde dökülmüştür. Döküm sonrası numunelere T6 ısıl işlemi uygulanmış, ardından kapsamlı talaşlı imalat ve yüzey sonlandırma işlemleri gerçekleştirilmiştir. Mekanik özellikler, jant geometrisinin kritik bölgelerinden alınan numuneler üzerinde yapılan testlerle değerlendirilmiş; sertlik ölçümleri, mikroyapı incelemeleri ve porozite miktarının belirlenmesi ile desteklenmiştir. Sonuçlar, eritme işlemleri ve süreç kontrolleri sürdürüldüğü sürece, post-consumer alüminyum hurdalarının entegrasyonunun mikro yapı veya mekanik performans üzerinde olumsuz bir sonuç vermediğini göstermektedir. Bu bulgular, uygun ergiyik kalite kontrolü koşulları altında, tüketim sonrası alüminyum hurdasının LPDC yöntemiyle üretilen A356 otomotiv jantlarında güvenle kullanılabileceğini; böylece mekanik güvenilirlik ve ürün kalitesinden ödün vermeden daha sürdürülebilir bir üretim yaklaşımının mümkün olduğunu ortaya koymaktadır.

Anahtar Kelimeler: Alüminyum, Post Consumer, Jant, Alçak Basınçlı Döküm

ABSTRACT

The integration of post-consumer aluminum scrap into the production of A356 alloy wheels via Low Pressure Die Casting (LPDC) has emerged as a critical strategy for the automotive industry to achieve lower carbon emissions and transition toward a circular economy. In A356 alloy production, melt cleanliness is largely determined by degassing efficiency, which removes dissolved hydrogen and oxides that would otherwise impair structural integrity. This research examines the influence of post-consumer aluminum scrap on the metallurgical integrity and mechanical behavior of A356 aluminum alloy wheels manufactured via the Low Pressure Die Casting (LPDC) process. Wheel production was conducted using primary aluminum and secondary melts containing post-consumer scrap. To evaluate the impact of melt cleanliness, two distinct degassing protocols were implemented to achieve low and conventional gas levels, respectively, while all other process parameters remained constant.

All experimental wheels were cast during a single production shift to maintain uniform industrial parameters. Post-casting, the specimens were processed via T6 heat treatment, followed by comprehensive machining and surface finishing. Mechanical properties were evaluated using specimens extracted from critical wheel regions, supported by hardness measurements, microstructural analysis, and porosity quantification. The results indicate that integrating post-consumer aluminum scrap has no detrimental effects on microstructure or mechanical performance, provided that melt treatments and process controls are maintained. These findings indicate that, with proper melt quality control, post-consumer aluminum scrap can be used in LPDC-produced A356 automotive wheels, enabling more sustainable manufacturing without compromising mechanical reliability or product quality
Keywords: Aluminium, Post Consumer, Wheel, Low Pressure Die Casting

CEO2 VE LA2O3 İKİLİ KATKILAMASI İLE ($Bi_{0.47}Na_{0.47}Ba_{0.06}$)$TiO_3$ (BNT-6BT) KURŞUNSUZ PİEZOELEKTRİK SERAMİKLERİN ELEKTRİKSEL PERFORMANSININ GELİŞTİRİLMESİ

IMPROVEMENT OF ELECTRICAL PERFORMANCE OF LEAD-FREE ($BI_{0.47}NA_{0.47}BA_{0.06}$)$TIO_3$ (BNT-6BT) PIEZOELECTRIC CERAMICS BY DUAL DOPING WITH CEO_2 AND LA_2O_3

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ÖZET

Bu çalışmada, kurşunsuz piezoelektrik seramikler arasında çevre dostu özellikleri ve yüksek potansiyeli nedeniyle PZT'ye güçlü bir alternatif olarak öne çıkan ($Bi_{0.47}Na_{0.47}Ba_{0.06}$)$TiO_3$ (BNT-6BT) sisteminin elektriksel ve piezoelektrik performansının geliştirilmesi amaçlanmıştır. Bu doğrultuda, BNT-6BT seramiklerine ikili donör katkılayıcı olarak CeO_2 ve La_2O_3 ilavesinin mikroyapısal özellikler, sinterleme davranışı ve piezoelektrik performans üzerindeki etkileri detaylı bir şekilde incelenmiştir.

Mevcut literatür incelendiğinde, CeO_2 ve La_2O_3 katkılarının genellikle tekil olarak veya sınırlı katkı oranlarında ele alındığı, bu iki katkılayıcının farklı mol oranlarında birlikte kullanımına yönelik sistematik ve kapsamlı çalışmaların ise oldukça sınırlı olduğu görülmektedir. Bu çalışmada, CeO_2 katkı oranı sabit tutulmuş; La_2O_3 katkı oranı ise farklı değerlerde değiştirilerek ikili katkılamanın olası sinerjik etkilerinin ortaya konması hedeflenmiştir. Böylece katkı oranlarının mikroyapı ve elektriksel özellikler üzerindeki etkilerinin daha net bir şekilde anlaşılması amaçlanmıştır.

Hazırlanan seramik numuneler katı hal reaksiyon yöntemiyle sentezlenmiş; faz yapıları X-ışını kırınımı (XRD) analizi ile incelenmiştir. Numunelerin mikroyapısal özellikleri taramalı elektron mikroskobu (SEM) kullanılarak karakterize edilmiş, yoğunluk değerleri ise Arşimet yöntemi ile belirlenmiştir. Elde edilen deneysel veriler doğrultusunda katkı oranı, mikroyapı ve elektriksel özellikler arasındaki ilişki değerlendirilmiş ve en yüksek piezoelektrik performansı sağlayan optimum katkı oranı tespit edilmiştir. Bu çalışmanın, kurşunsuz piezoelektrik seramiklerin geliştirilmesine yönelik literatüre özgün ve önemli katkılar sunması beklenmektedir. Çalışma, Çanakkale Onsekiz Mart Üniversitesi Bilimsel Araştırma Koordinasyon Birimi tarafından FLÖAP-2025-5277 Proje No. kapsamında finansal olarak desteklenmiştir.

Anahtar Kelimeler: Kurşunsuz piezoelektrik seramikler, BNT-6BT, La_2O_3 ve CeO_2 katkısı, donör katkılama, elektriksel özellikler, mikroyapı

ABSTRACT

In this study, it is aimed to improve the electrical performance of the ($Bi_{0.47}Na_{0.47}Ba_{0.06}$)$TiO_3$ (BNT-6BT) system, which has emerged as an alternative to PZT among lead-free piezoelectric ceramics. In this context, the effects of dual donor dopants CeO_2 and La_2O_3 on the microstructural, sintering, and piezoelectric properties of BNT-6BT ceramics were investigated.

In the literature, CeO_2 and La_2O_3 dopants have generally been examined individually or at limited concentrations, and systematic studies on their combined use at different molar ratios are quite limited. In this study, while the CeO_2 content was kept constant, the La_2O_3 concentration was varied to reveal the synergistic effects of dual doping.

The samples were synthesized using the solid-state reaction method; phase structures were analyzed by X-ray diffraction (XRD), microstructural characteristics were characterized using scanning electron microscopy (SEM), and density measurements were carried out using the Archimedes method. Based on the obtained data, the relationship between dopant concentration, microstructure, and electrical properties was evaluated, and the optimum doping ratio providing the highest piezoelectric performance was determined. This study is expected to make original and significant contributions to the literature on the development of lead-free piezoelectric ceramics. This study was financially supported by the Scientific Research Coordination Unit of Çanakkale Onsekiz Mart University under Project No. FLÖAP-2025-5277.
Keywords: Lead-free piezoelectric ceramics; BNT-6BT; dual doping; La_2O_3 and CeO_2 doping; electrical properties; microstructure.

COMPUTATIONAL INVESTIGATION OF VOLATILE ORGANIC COMPOUNDS (VOC) ADSORPTION TRENDS ON UiO-66 CLUSTER MODELS

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ABSTRACT
Volatile organic compounds (VOCs) are carbon-based chemicals mostly found in industrial solvents with long-term issues such as cancer and organ damage. Removing VOCs is crucial due to environmental and health concerns. Metal-organic frameworks (MOFs) are highly porous and crystalline materials which are suitable for VOC adsorption thus removal. UiO-66 is one of the mostly studied MOFs for capturing varied VOCs. UiO-66 is a zirconium-based material with a three-dimensional porous structure composed of octahedral and tetrahedral cavities. An organic zirconium cluster, where six Zr atoms form an octahedron bridged by oxygen and hydroxyl groups, is connected by terephthalic acid linkers. In this study, we focused on benzene, toluene, para-xylene, and formaldehyde since all are considered toxic to humans and animals. We employed wB97XD functional with the basis sets of LanL2DZ (for Zr and Cu) and 6–31 G(d,p) (for O, H, and C) in density functional theory (DFT) calculations to investigate the adsorption characteristics and performance of a bare and Cu-doped UiO-66 clusters for the adsorption of benzene, toluene, para-xylene and formaldehyde. Adsorption was examined at OH, O, and Zr-proximal sites with structural relaxation. Thermal correction was applied on the reported electronic and Gibbs free energy values. According to the results of the research, the adsorption of benzene, toluene, para-xylene and formaldehyde on a bare UiO-66 cluster is enthalpically favored but non-spontaneous under standard conditions, as indicated by a negative change in electronic energy ($\Delta E < 0$) and a positive change in Gibbs free energy ($\Delta G > 0$). However, presence of copper atom in the structure makes the adsorption thermodynamically favored with some exceptional cases.
Keywords: VOC, UiO-66, DFT, Adsorption.

VALORIZATION OF AGRICULTURAL WASTE IN SUSTAINABLE BIOCOMPOSITES: ENHANCING MECHANICAL PROPERTIES WITH NATURAL FIBER REINFORCEMENTS

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Abstract
In response to the rising demand for sustainable materials and the depletion of non-renewable resources, this study focuses on developing high-performance bio-composites reinforced with agricultural residues, specifically utilizing coconut fibers as a low-cost, thermally stable natural filler in polypropylene matrices to create eco-friendly materials with enhanced mechanical properties. Bio-composites, consisting of a matrix that binds the structure and transfers loads, and natural fibers that provide strength and stiffness, face a key challenge in the poor interfacial adhesion between the hydrophilic fibers and hydrophobic thermoplastic matrices. To improve fiber-matrix compatibility and overall performance, chemical treatments such as alkaline processing were employed.

This study investigates the effect of fiber length on the mechanical behavior of polypropylene reinforced with coconut fibers, using extrusion and injection molding processes. A detailed experimental analysis encompassing structural, morphological, thermo-mechanical, and moisture absorption tests was conducted to determine the optimal fiber configuration. The use of agricultural biomass as functional fillers, combined with tailored coupling agents and processing methods, resulted in composites with significantly enhanced properties, including a more than 70% increase in Young's modulus, improved thermal stability, and reduced water absorption. These results underscore the potential of valorizing agricultural waste to develop high-performance, bio-based materials, positioning such bio-composites as sustainable alternatives to petroleum-based plastics for applications in agriculture, packaging, and the processing industry.
Keywords: Biocomposites, natural fibers, agricultural residues, polypropylene, thermomechanical properties, sustainability, biomass valorization

INTEGRATED PHOTOCAPACITOR BASED ON CNT DOPED POLYMER ELECTRODE, SYNTHESIS MORPHOLOGY AND ELECTROCHEMICAL PERFORMANCE

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Abstract
The rapid advancement of smart technologies and wearable electronics has markedly increased the demand for compact, efficient, and reliable portable energy-support systems. In this regard, bifunctional photopowered energy systems (PPESs), which integrate energy harvesting, conversion, and storage within a single device, have emerged as promising solutions to address contemporary power requirements. These integrated systems generally comprise a power conversion system (PCS) coupled with an energy storage system (ESS), facilitating the direct utilization of renewable energy sources. Among these, solar energy represents the most abundant and sustainable resource, delivering an estimated 3×10^{24} J of energy annually approximately 10^4 times greater than the total global energy consumption. This immense potential has driven extensive advancements in photovoltaic (PV) technologies, particularly solar cells, as principal energy-generation devices in response to the depletion of fossil fuels. Over the past five decades, significant progress has been realized in solar-to-electric energy conversion through solid-state junction solar cells and organic photovoltaic devices. Nevertheless, a critical scientific and technological challenge persists in achieving direct storage of solar energy within a single integrated device. Although efforts to combine photovoltaic electrodes with redox-active battery materials have demonstrated promise, the recurrent redox reactions often constrain battery lifespan and stability. Conversely, capacitors offer rapid responsiveness to fluctuating light conditions, high power density, and extended operational lifetimes owing to their utilization of redox-free electrolytes. In this study, we present the development of a light-driven capacitor capable of direct solar-to-electrical energy storage with high quantum conversion efficiency. This photo-charging capacitor, termed a photocapacitor, functions by harnessing visible-light absorption in a dye-sensitized nanocrystalline semiconductor film. The proposed system effectively integrates photoelectric conversion and energy storage within a unified architecture, providing a durable and efficient alternative to conventional photovoltaic–battery configurations. Such photocapacitors exhibit considerable potential for next-generation self-powered electronics and sustainable energy technologies.
Keywords: Photopowered energy systems, Photocapacitor, Solar energy storage, Dye-sensitized nanocrystalline films, Integrated energy conversion and storage.

EFFECT OF CONSTANT AXIAL LOADS ON THE RESPONSE OF REINFORCED CONCRETE COLUMNS

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ABSTRACT
Reinforced concrete columns are vertical elements that form the load transfer path from the superstructure to the foundations and are generally subjected to compressive forces. The collapse of reinforced concrete columns can occur under externally applied loads or under additional time-dependent effects such as concrete creep. Deformations induced by external loads and those caused by creep interact with each other and should not be estimated separately. Concrete creep is defined as a gradual increase in the deformation of a concrete element under a constant load. Factors influencing concrete creep include: the size of the element, the water/cement ratio, environmental conditions, curing conditions, the type of cement, the level of applied stress, the age of the concrete at the time of loading, and the duration of the loading.
Over time, creep deformation will lead to stress relaxation in the concrete, which will be absorbed by the longitudinal steel bars. Due to this redistribution of unfavorable stresses in the concrete, the steel bars may yield before reaching their ultimate limit, particularly the compressed bars in lightly reinforced columns. Generally, reinforced concrete columns are subjected to low service stress levels (less than 30% of the compressive strength). At this stress level, creep deformation is linearly proportional to the applied stress. Therefore, the application of linear viscoelasticity theories is appropriate.
In order to continue the research carried out and to better understand the effect of concrete creep on the behavior of reinforced concrete columns under axial compression loads, this article presents a numerical analysis to study more precisely the effect of creep on the long-term behavior of concrete and longitudinal and transverse steels of compressed reinforced concrete parts.
By comparing the results of the two models, numerical and analytical, a clear convergence is observed. This will allow us to broaden our numerical contribution by introducing other parameters that may be relevant to the current problem.
Keywords: creep, concrete, time, concrete aging

THE TEMPORAL BEHAVIOR OF AXIALLY LOADED CFST COLUMNS

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ABSTRACT

In concrete-filled steel tube columns, the steel cross-section contributes to the column's axial strength and provides the confining pressure for the concrete core, while the concrete core balances the axial load and minimizes or delays local buckling of the steel tube. Furthermore, these columns reduce construction costs because they do not require formwork. However, they are subject to increased deformation due to concrete creep. Under the influence of this creep, concrete-filled steel tube columns can be subjected to longitudinal and circumferential stresses.

To date, research has focused solely on the delayed response of columns under longitudinal stress, using simple empirical expressions that can lead to unreliable results. However, long-term behavior, particularly with regard to circumferential stresses, has not yet been studied. To address this gap and improve our understanding of the overall behavior of columns, the main objective of this work is to provide researchers and designers with a new analytical tool that is both simple and sufficiently powerful to predict the temporal evolution of axial and circumferential stresses and strains in concrete-filled composite circular columns subjected to long-term compressive loads.

Therefore, the fundamental objective of our contribution is to initiate the development of an analytical formulation that allows us to calculate, at any given time t, the additional normal and circumferential stresses induced by concrete creep. This will enable us to better understand the delayed behavior of concrete-filled composite circular columns and to identify the most influential factors.

Our current approach provides a simple and accurate working tool for predicting the local redistribution of concrete creep in a concrete-filled steel tube column subjected to normal compressive forces

Keywords: creep, circumferential stress, composite columns, time.

EXPLOITATION OF RHEOROLOGY SYSTEMS IN THE STUDY OF THE DEFLEXION OF A MIXED BEAM SUBJECTED TO THE EFFECTS OF CONCRETE SHRINKAGE

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ABSTRACT
This research report examines rheological models to study the impact of concrete shrinkage on the initial state of a steel-concrete beam at rest. Given the impressive rigidity of steel profiles, these beams are most often constructed without shoring, necessitating meticulous verification of their strength. Immediately after pouring, the concrete undergoes physicochemical reactions that cause a temporal change in its volume. This volume change cannot be complete due to the artificial bond established at the contact surface (steel-concrete) to achieve a monolithic cross-section. This shrinkage is said to be restricted or partial. This situation causes the steel profile to deform, resulting in a field of elastic axial stresses. This stress field depends primarily on the concrete's capacity to shrink over time. In specialized literature, the shrinkage in question and creep are similar in their evolution and also accumulate over time. Therefore, we used all available rheological models with constant parameters to develop a theoretical approach for predicting the state of a steel profile deformed by the action of constrained concrete shortening. Predicting the stress and strain fields becomes possible after integrating a non-homogeneous second-order differential equation. This equation depends on the rheological system adopted. To achieve this, two initial conditions are proposed to integrate each equation. This theoretical approach is designed to evaluate the temporal deflection (sag) at "j" days of the composite beam in question before it is loaded. Finally, an application is developed to illustrate this theoretical aspect.
Keywords: Differential equations, shrinkage, composite beams, initial conditions,

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Bilgilerinize arz edilir,

Saygılarımla

Assoc. Prof. Dr. Mehmet Emin KALGI
Head of Organizing Committee

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İlgi : Doç. Dr. Mehmet Emin KALGI'nın 08.02.2026 tarihli dilekçesi.

İlgide kayıtlı yazıya istinaden, Fakültemiz Felsefe ve Din Bilimleri Bölümü Din Psikolojisi Ana Bilim Dalı'nda görev yapmakta olan Doç. Dr. Mehmet Emin KALGI'nın 25-26 Şubat 2026 tarihleri arasında İzmir'de düzenlenecek olan **"12. ULUSLARARASI EGE KONGRELERİ'**nin (Sosyal ve Beşeri Bilimler Kongresi, Sağlık ve Fen Bilimleri Kongresi, İnovasyon ve Mühendislik Bilimleri Kongresi) düzenleme komitesinde akademisyen temsilci olarak görev almasını olurlarınıza arz ederim.

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