



MATEDAS 2026



20th International Conference on

Materials and Technologies for Defence and Security

Department of Mechanical Engineering
Faculty of Military Technology
University of Defence

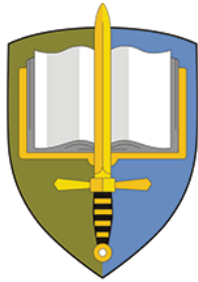
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Preface

Ladies and gentlemen, dear fans of materials and technologies!

It is our great pleasure to welcome you to the *20th International Conference on Materials and Technologies for Defence and Security (MaTeDaS 2026)*, held from **May 13–15, 2026**, in the distinguished settings of **Brno and Lednice, Czech Republic**.

This anniversary edition marks two decades of continuous dialogue, collaboration, and advancement in the field of materials science and engineering for defence and security applications. Over the years, the MaTeDaS conference series has established itself as a respected international forum where researchers, industry professionals, and representatives of defence institutions come together to exchange knowledge, present cutting-edge innovations, and discuss emerging technological challenges.

The rapidly evolving security landscape continues to drive the need for advanced materials and technologies that ensure resilience, protection, and operational effectiveness. From nanostructured materials and smart composites to advanced manufacturing techniques, energy systems, and sensor technologies, this conference provides a multidisciplinary platform for exploring solutions that address current and future defence requirements.

The 20th edition of MaTeDaS highlights not only scientific excellence but also the importance of international cooperation. We are proud to host participants from academia, research organizations, industry, and governmental institutions, fostering a collaborative environment that bridges theoretical research with practical applications.

The choice of venues—Brno, a vibrant center of science and technology, and Lednice, a UNESCO World Heritage site known for its cultural and historical significance—offers a unique combination of intellectual stimulation and inspiring surroundings. We believe that this setting will further encourage fruitful discussions and lasting professional connections.

We would like to express our sincere gratitude to all authors, reviewers, and members of the organizing and scientific committees for their dedication and hard work. Our thanks also go to our partners and sponsors for their valuable support in making this conference possible.

We hope that MaTeDaS 2026 will be both scientifically enriching and personally rewarding, and that it will continue to strengthen the global community working towards safer and more secure societies.

We wish you a productive conference and a pleasant stay in the Czech Republic.

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Influence of Heat Treatment Parameters on the Microstructure and Mechanical properties of maraging steel 18Ni-300

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This article investigates the influence of heat treatment parameters of 18Ni-300 maraging steel on the resulting microstructure and mechanical properties. The hardening of maraging steels consists of solution annealing, rapid cooling to prevent segregation of dissolved phases at grain boundaries, and subsequent aging to precipitate nano-sized intermetallic phases as finely dispersed precipitates within the martensitic matrix. The presented research includes three different heat treatment regimes. The solution annealing temperature is constant in all cases at 820 °C. The aging was carried out in three combinations of temperature and holding time: 480 °C / 3 h, 490 °C / 6 h, and 460 °C / 6 h. The objective of the research is to study the microstructure and selected mechanical properties under these three regimes to determine the optimal heat treatment providing the most favorable combination of mechanical properties and wear resistance. In principle, the structure consists of low-carbon nickel martensite, reverted austenite, and intermetallic precipitates. Confocal microscopy, which achieves significantly higher magnifications than conventional light microscopy, was utilized for the microstructural investigation. Furthermore, Vickers microhardness measurements and quasi-static nanoindentation were employed, allowing for the determination of the nanohardness and Young's modulus of the present phases.

Keywords: Maraging Steel, Aging Temperature, Holding Time, Microstructure, Nanoindentation

Effect of Vacuum Carburizing Temperature on the Properties of Selected Automotive Steels

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Gears and shafts are critical components that play an essential role in the automotive industry. During the production of precision gears and shafts, specific heat treatment processes must be applied to achieve the required surface hardness and core toughness, with the aim of maximizing component reliability and service life. This work is focused on the evaluation of the influence of vacuum carburizing temperature on selected steels widely used for the manufacture of automotive components. The vacuum carburizing process was carried out using an ALD ModulTherm device, while the effect of carburizing temperature and carburizing time on the resulting properties of the carburized layer was investigated. Basic parameters such as austenitic grain size, microstructure, and hardness profiles were evaluated. Attention was also paid to the tribological properties of the carburized layer, namely the coefficient of friction and the volume of removed material. These properties are crucial in transmission systems for reliable power transfer, reduction of energy losses, and extension of the service life of these critical machine components.

Keywords: Vacuum, Carburization, Evaluation, Shaft

Experimental Analysis of Tribological Behaviour and Wear Mechanisms of Tool Steels under Intensive Contact Loading

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The present work focuses on the experimental analysis of the tribological behavior and wear mechanisms of tool steels under conditions of intense contact stress in dry friction. The materials investigated were tool steels 1.2842 and 1.2379, which were heat treated by the quenching and tempering process. Tribological tests were performed using the ball-on-flat method with reciprocating motion at a normal load of 20 N, a speed of 10 mm s⁻¹ and test times of 20, 30 and 40 minutes. A hardened steel ball of material 1.7225 with a diameter of 4.76 mm, manufactured in accuracy class G40 according to ISO 3290, was used as the counterpart. Steel 1.2379 achieved a higher hardness of ~666 HV10 and a lower surface roughness of Sa ≈ 0.13 μm compared to steel 1.2842, which showed a hardness of ~622 HV10 and a roughness of Sa ≈ 0.25 μm. The friction coefficient for steel 1.2379 ranged from 0.58–0.61, while for steel 1.2842 it reached values of 0.64–0.65, which represents an approximately 7% reduction in friction. The most significant difference in wear was recorded after 20 minutes of testing, when the wear volume of steel 1.2379 reached approximately 0.003 mm³, while for steel 1.2842 it reached 0.046 mm³, which corresponds to a wear reduction of approximately 93%. At longer test times, the difference in wear volume remained in the range of 14–24% in favor of steel 1.2379. Analysis of the worn surfaces demonstrated dominant adhesive-abrasive wear mechanisms for steel 1.2842, while for steel 1.2379 adhesive-oxidative mechanisms associated with local plastic deformation of the surface and the presence of chromium carbides were more pronounced.

Keywords: Tribology, Tool Steels, Wear Mechanisms, Dry Friction, Surface Roughness

Real-time Temperature Measurement Challenges under Split Hopkinson Pressure Bar loading

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The Taylor–Quinney coefficient (TQC) quantifies the fraction of external work converted into heat during the plastic deformation of metals and is essential for accurate thermomechanical modelling. Literature shows that TQC strongly depends on microstructural features such as crystal structure, grain size, stacking fault energy, and whether the material is single- or polycrystalline. Loading conditions, particularly strain rate, and temperature also play a decisive role, with high strain rates and elevated temperatures promoting greater heat generation. Despite this complexity, many researchers assume TQC to be constant and close to 0.9, whereas experimental evidence shows that it can vary widely, ranging from about 0.2 to values exceeding unity, depending on material and deformation conditions.

TQC is typically determined using calorimetric methods or infrared thermography during mechanical testing, although such measurements remain challenging due to heat losses, non-uniform temperature fields, and uncertainties in separating stored and dissipated energy. These challenges become even more pronounced under dynamic loading, where the time available for temperature measurement is extremely short - often on the order of several tens of microseconds - making accurate determination of the TQC particularly difficult. To determine the influence of dynamic loading on the evolution of the TQC, the Split Hopkinson Pressure Bar (SHPB) technique is typically employed, as it is the standard method for investigating the mechanical response of materials under very high strain-rate conditions. Fig. 1 presents a schematic of the newly developed experimental setup, which enables the determination of TQC evolution as a function of strain magnitude and strain rate.

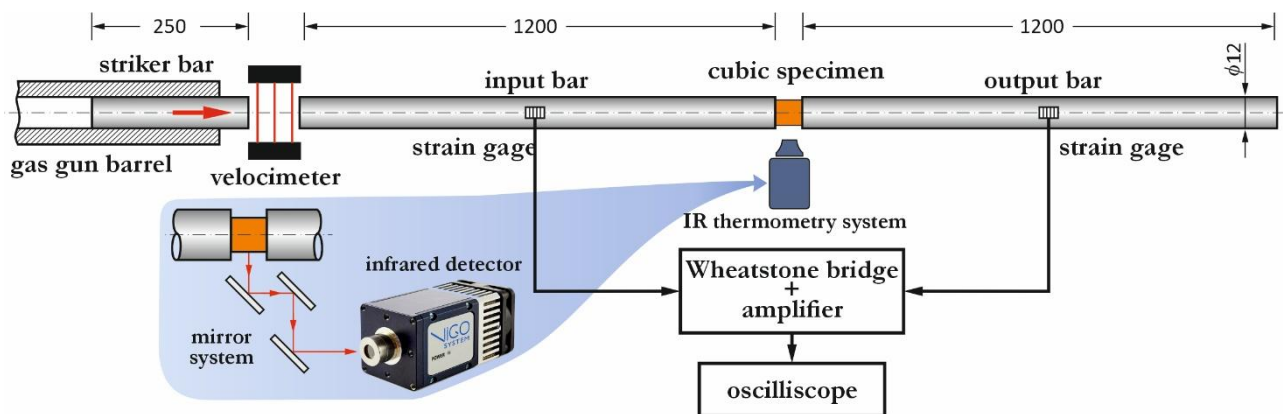


Fig. 1. Schematic representation of the SHPB-based test stand designed for determining the evolution of the Taylor–Quinney coefficient under high strain-rate loading, incorporating a single-element high-speed infrared detector for temperature measurements.

A key component of this setup - in addition to the SHPB system - is a temperature-measurement module based on a single-element infrared detector with a very high sampling frequency, enabling the capture of rapid temperature changes during dynamic deformation. Preliminary experimental investigations confirm the high measurement capabilities of the developed setup, and the obtained results demonstrate high repeatability and excellent measurement sensitivity. Moreover, tests performed using the developed temperature-measurement system revealed that both the amplitude of the temperature signal and the signal-to-noise ratio are highly sensitive to the surface condition

of the material specimen. For material specimens made of a 7000-series aluminium alloy and manufactured by machining, coating the lateral surfaces with a dedicated graphite paint provides the highest-quality temperature signal.

Keywords: Taylor-Quinney Coefficient, Thermal-Mechanical Coupling Effect, Split Hopkinson Pressure Bar

Monitoring the Efficiency of the Abrasive Blasting Process Using Strain Gauge Force Measurement

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The abrasive blasting process is designed for blasting structurally complex components or structures. The target of blasting is to achieve an optimal surface finish on structures, for example, prior to the application of an anti-corrosion coating. The effectiveness of abrasive blasting technology is highly sensitive to the settings of key operating conditions, which include air pressure and volume, the amount and type of abrasive material, and the size of the nozzle. The objective of this research project is to determine the maximum efficiency of abrasive blasting based on strain gauge force measurements on the nozzle holder and on the platform of the structure being blasted. Brown corundum abrasive material in various particle size distribution was used for the experimental verification. The results demonstrated the applicability of this method for automating the adjustment of operating conditions in the blasting process to ensure continuous operation with maximum efficiency.

Keywords: Abrasive Blasting, Operating Parameters, Strain Gauge Measurements, Efficiency Optimization

Chip Morphology as a Non-invasive Indicator of Cutting Edge Degradation in High-Feed Milling of Tool Steel

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This study examines the correlation between progressive flank wear and chip formation mechanics during high-feed milling (HFM) of DIN 1.2343 tool steel. The research compares length-based and weight-based methods for determining the chip compression ratio and shear plane angle ϕ , evaluating their sensitivity to tool degradation. Reaching the tool life limit is associated with a decreased angle ϕ , increased chip evacuation resistance, transformations in chip morphology and discoloration. Discrepancies between analytical methods are attributed to the side flow phenomenon and specific HFM tool geometries. The identified correlations enable non-invasive identification of the cutting edge condition via quantitative chip parameters, essential for eliminating micro-cracks in machined materials. In the context of manufacturing ballistic protection and structural military components, subsequent chip analysis allows for verifying process stability and preventing fatal component failure under extreme operating conditions in strategic applications.

Keywords: High-feed Milling (HFM), Tool Wear, Chip Morphology, Chip Compression Ratio, Shear Plane Angle, Hardened Tool Steel, Plastic Deformation

Predictive Modelling of Magnetron Sputtering: Bridging Computational and Experimental Approaches for Metallic Glass Thin Films

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Advanced thin film coatings are key enabling technologies for defence and dual-use systems, where components must withstand extreme mechanical loads, thermal shocks, corrosive environments, and prolonged operational stress. Thin film metallic glasses (TFMGs) represent a promising class of materials, combining high hardness, strength, wear resistance, and chemical stability. However, translating these materials from laboratory concepts to industrial-scale production with controlled composition remains a major challenge.

Here, we present a simulation-driven framework for the optimisation of magnetron sputtering processes in industrial batch coaters. By coupling SDTrimSP and SIMTRA simulations, we capture sputtering, particle transport, and system-scale effects, including complex chamber geometries and substrate motion.

The validated model enables predictive design of multi-component coatings and segmented cathodes, reducing costly trial-and-error experimentation. This approach supports scalable manufacturing of advanced coatings for critical defence, security, and high-reliability industrial applications.

Keywords: Thin Films, Metallic Glasses, Magnetron Sputtering, Simulation

Modelling the Geometry of Fusions in the Laser Cladding Process

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This study focuses on the simulation and experimental validation of the laser cladding process of 1.0038 steel with respect to the prediction of clad bead geometry. The experiments were conducted using the TRU LASER ROBOT 5020 system by TRUMPF, equipped with a 30 kg payload robotic arm and a diode-pumped disk laser with a beam quality of 8 mm·mrad and a minimum output power of 4000 W at the workpiece. The samples were mounted in a fixture attached to an integrated rotary table, and a series of trials was carried out for different levels of surface preparation accuracy and varying laser beam parameters, such as power and head linear speed.

The experimental campaign covered a wide range of process parameters. The laser power ranged from 1000 W to 3000 W, as detailed in Table 1.

Tab. 1 Laser cladding parameters from experiment

Sample no.	P [W]	Vs [mm/min]	E [kJ/cm]	Powder amount [g/min]	gas amount[l/min]	laser dia[mm]	Vs [m/s]	Laser power [W/mm ²]
T1.1	1000	240	2,50	10,46	16	6,4	0,004	31,10
T1.2	1500	240	3,75	10,46	16	6,4	0,004	46,65
T1.3	2000	240	5,00	10,46	16	6,4	0,004	62,20
T1.4	2500	240	6,25	10,46	16	6,4	0,004	77,75
T1.5	3000	240	7,50	10,46	16	6,4	0,004	93,30
T2.1	1000	360	1,67	10,46	16	6,4	0,006	31,10
T2.2	1500	360	2,50	10,46	16	6,4	0,006	46,65
T2.3	2000	360	3,33	10,46	16	6,4	0,006	62,20
T2.4	2500	360	4,17	10,46	16	6,4	0,006	77,75
T2.5	3000	360	5,00	10,46	16	6,4	0,006	93,30
T3.1	1000	240	2,50	10,46	16	4,81	0,004	55,06
T3.2	1500	240	3,75	10,46	16	4,81	0,004	82,59
T3.3	2000	240	5,00	10,46	16	4,81	0,004	110,12
T3.4	2500	240	6,25	10,46	16	4,81	0,004	137,65
T3.5	3000	240	7,50	10,46	16	4,81	0,004	165,18
T4.1	1000	360	1,67	10,46	16	4,81	0,006	55,06
T4.2	1500	360	2,50	10,46	16	4,81	0,006	82,59
T4.3	2000	360	3,33	10,46	16	4,81	0,006	110,12
T4.4	2500	360	4,17	10,46	16	4,81	0,006	137,65
T4.5	3000	360	5,00	10,46	16	4,81	0,006	165,18

T5.1	1000	240	2,50	13,94	16	6,4	0,004	31,10
T5.2	1500	240	3,75	13,94	16	6,4	0,004	46,65
T5.3	2000	240	5,00	13,94	16	6,4	0,004	62,20
T5.4	2500	240	6,25	13,94	16	6,4	0,004	77,75
T5.5	3000	240	7,50	13,94	16	6,4	0,004	93,30
T6.1	1000	360	1,67	13,94	16	6,4	0,006	31,10
T6.2	1500	360	2,50	13,94	16	6,4	0,006	46,65
T6.3	2000	360	3,33	13,94	16	6,4	0,006	62,20
T6.4	2500	360	4,17	13,94	16	6,4	0,006	77,75
T6.5	3000	360	5,00	13,94	16	6,4	0,006	93,30
T7.1	1000	240	2,50	13,94	16	4,81	0,004	55,06
T7.2	1500	240	3,75	13,94	16	4,81	0,004	82,59
T7.3	2000	240	5,00	13,94	16	4,81	0,004	110,12
T7.4	2500	240	6,25	13,94	16	4,81	0,004	137,65
T7.5	3000	240	7,50	13,94	16	4,81	0,004	165,18
T8.1	1000	360	1,67	13,94	16	4,81	0,006	55,06
T8.2	1500	360	2,50	13,94	16	4,81	0,006	82,59
T8.3	2000	360	3,33	13,94	16	4,81	0,006	110,12
T8.4	2500	360	4,17	13,94	16	4,81	0,006	137,65
T8.5	3000	360	5,00	13,94	16	4,81	0,006	165,18

The cladding speed varied between 240 mm/min and 360 mm/min (0.004–0.006 m/s). The corresponding linear energy input ranged from 1.67 kJ/cm to 7.5 kJ/cm. Two powder feeding rates were applied: 3 and 4 rpm, corresponding to 10.46 g/min and 13.94 g/min, respectively. The shielding gas flow rate was kept constant at 16 l/min. The experiments were performed for two laser beam diameters: 6.4 mm and 4.81 mm. View of samples from experiment are presented on Fig. 1.

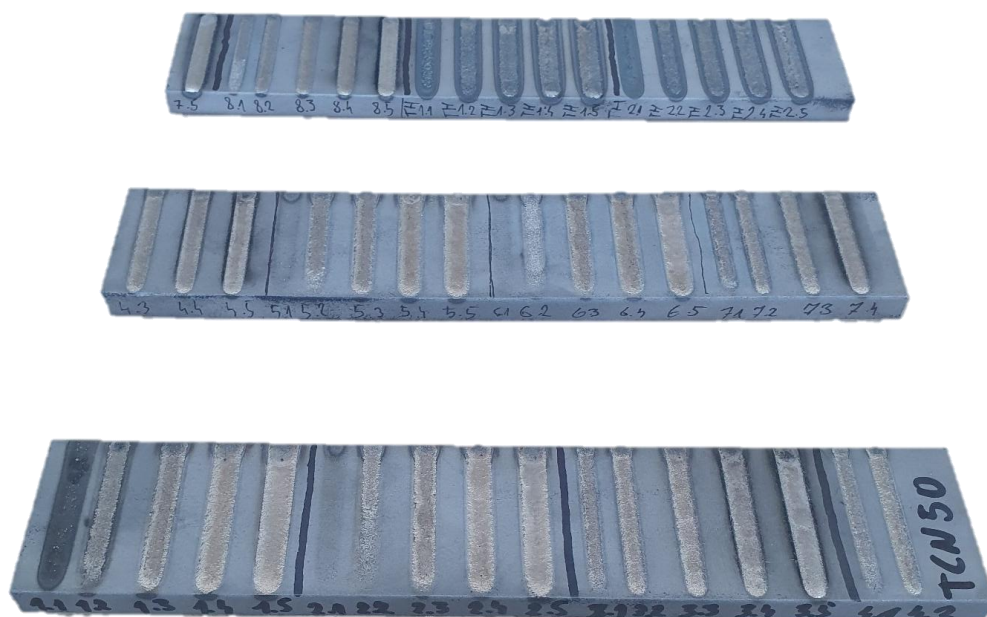


Fig. 1. View of laser cladding samples from conducted experiment

To accurately reproduce the geometry of the clad beads, a FARO measuring arm was used, enabling precise acquisition of bead geometry. The obtained geometric data were used for the calibration and optimization of the numerical model.

The simulation of clad bead geometry was carried out in the Ansys Mechanical environment using the Goldak heat source model.

The combination of experimental and numerical studies on clad geometry prediction constitutes the first stage of laser cladding process optimization. The next stage of research will include, in addition to bead geometry, the temperature field distribution and the heat-affected zone (HAZ). The acquired experimental and geometrical data serve as input for the development and optimization of simulation models in the Ansys environment, enabling the reduction of costly experimental trials through virtual analysis of a wide range of process parameters.

Keywords: Simulation, Heat-affected Zone, Laser Parameters, Laser Cladding.

Experimental Investigation of Mechanical Behaviour in 316L Lattice Structures Produced by SLM

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Additive manufacturing technologies enable the production of complex geometries that are unattainable using conventional manufacturing methods, with lattice structures representing one of the most promising applications of this approach. Selective Laser Melting (SLM) allows precise fabrication of metallic lattice structures with controlled geometry, porosity, and mechanical response. This study focuses on the mechanical characterisation and tensile and bending behaviour of lattice structures manufactured from austenitic stainless steel 316L using SLM technology. Three different lattice topologies—Gyroid, X-cell, and Schwarz D—were designed with a relative density of 50 % and fabricated using an Xact Metal XM200G SLM system under predefined processing parameters. Experimental testing included uniaxial tensile tests performed according to ISO 6892-1 and three-point bending tests in accordance with ASTM E290. The results demonstrate a significant reduction in tensile strength, yield strength, and Young's modulus for lattice structures compared to solid infill samples, with mechanical properties decreasing by up to five times depending on the parameter evaluated. However, only minor differences were observed between individual lattice topologies, indicating that relative density has a more pronounced influence on mechanical behaviour than lattice geometry or orientation under the applied loading conditions. These findings highlight both the potential and current limitations of lattice structures for engineering and biomedical applications and underline the need for further systematic research focused on structure–property relationships in additively manufactured lattices.

Keywords: Additive Manufacturing, Selective Laser Melting (SLM), Lattice Structures, Mechanical Properties, Stainless Steel

Application of High-Strength M300 Steel in Metal Additive Manufacturing for Defense Industry with Emphasis on Field Deployment in Firearms, Rocket Weapons and Combat Systems

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The presented study focuses on the application of high-strength M300 maraging steel in the field of metal additive manufacturing (AM), specifically using the Laser Powder Bed Fusion (L-PBF / SLM) process, with emphasis on defense industry applications — including firearms, rocket weapon systems, and rapidly deployable field components. Maraging steel M300 (18Ni300, EN 1.2709) represents a premium class of ultra-low-carbon martensitic steel, achieving tensile strengths in the range of 1,000–2,100 MPa after standard age-hardening treatment. Its exceptional weldability, dimensional stability, and compatibility with PVD/CVD surface coatings make it particularly suitable for high-performance weapon components manufactured via field-deployable additive manufacturing units. This paper reviews the current state of research into the structural, mechanical, and tribological properties of L-PBF-processed M300 steel, evaluates the effects of various heat treatment regimes, and discusses the strategic potential for forward-deployed metal 3D printing in defense operations. Key findings indicate that post-process age-hardening at 490 °C for 6 hours yields optimal mechanical performance, with hardness values reaching 640–660 HV and ultimate tensile strength exceeding 1,960 MPa. Surface enhancement using HiPIMS-deposited CrN/MoN multilayer coatings further improves tribological resistance, extending component service life in demanding operational environments

Keywords: M300 Maraging Steel, Metal Additive Manufacturing, Defense Industry, Weapon Systems, Field Deployment

Optimization of Cold Spray Deposition for WIP-C1 in Defense Applications

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This study investigates the Cold Spray deposition of WIP-C1 (Chromium Carbide in Ni matrix), a material showing significant potential for the repair and maintenance of military hardware. Given the evolving global security landscape, the demand for rapid, high-performance additive restoration technologies is increasing. This research focuses on evaluating the deposition efficiency (DE) alongside the mechanical and functional properties of the resulting coatings, specifically hardness, porosity, and shear strength. Microstructural evolution is analysed using Electron Backscatter Diffraction (EBSD) to understand the bonding mechanisms and grain deformation. The primary objective is to optimize deposition parameters to establish an ideal balance between process efficiency and material performance. The findings demonstrate that WIP-C1, deposited using Cold Spray technology, provides a robust solution for critical component recovery, aligning with the strategic needs of modern defense logistics and advanced manufacturing.

Keywords: Cold Spray, Repair, Optimization, Mechanical Properties

Laser-Assisted Joining Technology for Modular Gear Systems

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This study presents a manufacturing approach for modular gears based on interference-fit joints reinforced by laser hardening. The concept combines additively manufactured hubs with conventionally produced gear rims made of 21NiCrMo2 steel. The applied laser-assisted joining technology leads to significant improvement in load-carrying capacity compared to conventional press-fit connections. The research focuses on the relationship between processing conditions, microstructure evolution, and mechanical performance of the joint. Investigations included porosity analysis, EBSD characterization, and microhardness measurements in both hardened and non-hardened regions. The results show that additively manufactured components exhibit a finer and more homogeneous microstructure, which remains stable under destructive loading. Laser-hardened zones reveal martensitic structures with increased hardness, while adjacent areas are also affected by strengthening mechanisms. The developed technology demonstrates high potential for lightweight and high-performance gear systems.

Keywords: Modular Gears, Laser Hardening, Interference Fit, Additive Manufacturing, Microstructure

Structural and Material Considerations in the Integration of Mission Modules on an Optionally Manned TAERO Vehicle

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The integration of mission-specific modules into optionally manned unmanned ground vehicle platforms introduces significant structural and material challenges during operation in unstructured terrain conditions. This study focuses on the TAERO platform as a case study, with emphasis on the mechanical and material implications of integrating a scaterable mine-laying system. Operational data obtained during field experiments in manned and unmanned modes were analysed to identify load characteristics, vibration profiles, and their influence on structural components. The results indicate that payload integration significantly affects load distribution, dynamic response, and potential fatigue of key structural elements. Based on the experimental observations, critical design parameters for mounting interfaces and material selection are identified. The findings contribute to the development of improved manufacturing and integration strategies for mission-adaptable UGV platforms, ensuring higher reliability and operational effectiveness in defence applications.

Keywords: Unmanned Ground Vehicle, Structural Analysis, Material Engineering, Payload Integration, Mission Modules

Ballistic Efficiency of Titanium-based Monolithic and Layered Structures Manufactured with Different Techniques – Review and Own Results

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This paper presents a review of the results of the estimation of the terminal ballistic efficiency of protective structures based on titanium alloys. Due to its excellent strength-to-density ratio, titanium is a promising material for designing protective structures. Ti6Al4V, one of the most popular alloys, is one of the materials included in the military protection standards due to its potential use in armouring vehicles and airplanes. Unfortunately, the main drawback of this material is its tendency to generate adiabatic shear bands, which promote the plugging failure mode of the target. Taking this effect into account, specific manufacturing steps are taken to produce layered structures for ballistic protection. The paper analyses the effects and potential of applying metal matrix composites (MMCs), additive manufacturing techniques (especially the EBM technique) and some novel hybrid alloying methods in the design of impact-resistant structures. Particular attention was given to recent test results from the Military University of Technology, which focused on numerical simulations and experimental tests of the interaction between armour-piercing bullets and ceramic-faced structures containing Ti6Al4V. Results so far have shown the potential to shape the properties of the considered structures – from porous titanium-based materials for shock attenuation to hard tungsten- and TiC/TiB-based materials

Keywords: Terminal Ballistics, Layered Structures, Titanium-based Materials, Impact Toughness

Ballistic Response of Twaron CT 737 Aramid Fabric under 9×19 mm Luger Impact: Experimental and Fractographic Analysis

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This study focuses on the experimental evaluation of Twaron CT 737 aramid fabric in terms of its response to ballistic loading by 9×19 mm Luger ammunition. The experimental program included comprehensive characterization of mechanical properties, with hardness reaching 80.2 Shore D, tensile strength of 491.8 ± 12.3 MPa, and flexural strength of 137.6 ± 5.1 MPa. Microstructural analysis was performed to identify morphological features governing deformation and failure mechanisms of the material. Ballistic testing demonstrated the material's ability to effectively dissipate the kinetic energy of the projectile without complete penetration under defined loading conditions. Fractographic analysis of post-impact fracture surfaces revealed that failure is governed by a combination of fiber fibrillation, local delamination, and progressive pull-out from the woven structure. The results indicate that the ballistic response is governed by stress redistribution within the yarn architecture and inter-fiber load transfer mechanisms.

Keywords: Aramid Fabric, Twaron CT 737, Ballistic Resistance, 9×19 mm Luger, Mechanical Properties

WoGaWe's Advanced Hybrid Welding Technology and Its Application

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The newly designed Laser-MIG hybrid technology, described by the acronym WoGaWe, differs in principle from "classic" Laser-MIG hybrid welding, which has been used in industry for about 15 years. Existing hybrid technology for butt joints relies on the fact that the laser can create a narrow and deep weld pool, while MIG arc technology supplies sufficient material to the weld pool to achieve the required weld height. WoGaWe technology utilizes an oscillating laser beam (wobble) that performs two functions: first, during its oscillation, it preheats a narrow gap intentionally created between the parts being welded (here, the increase in temperature improves the surface wettability by the molten metal, and as the metal transitions to a liquid state, it ensures a high-quality metallurgical joint).

Keywords: Hybrid Welding, Laser Welding, Wobble Techniques

Welding of Lap Joints in Various Structural Steels with Different Configurations of Welded Thicknesses, Validated by Numerical Simulations

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The integration of standard structural steels (S235, S355) with high-strength fine-grained steels (S355MC, S550MC) offers a versatile solution for the automotive, military, and agricultural industries, particularly in cases where low heat input and minimal deformation of thin sheets are critical. This study presents a comprehensive analysis of lap welds in various configurations, thicknesses, and material combinations. Quasi-static tensile tests of the welds revealed significant differences between individual material configurations of lap welded joints, both in terms of the combination of different material types and their thicknesses. Different welding parameters also had a significant influence, as they have a fundamental impact on the geometry and structure of the weld. Furthermore, based on experimental data, an analysis of the welding process was performed using the finite element method (FEM), which approximately confirmed the experimental results. These conclusions were verified by macroscopic and microscopic structural examinations, as well as microhardness profiling, which demonstrated a good correlation between the experimental results and the numerical simulations.

Keywords: Structural Steels, Fine-grained Steels, Welding, Lap Joints, Numerical Simulations

Non-Metallic Polymer Heat Exchangers

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Polymer exchangers use hollow polymer fibers as a heat transfer surface. Hollow fibers typically have an outer diameter of one millimeter and a wall thickness of 0.1 mm and are produced by extrusion. The very thin wall compensates for the disadvantage of the polymer's low thermal conductivity. Extruded hollow fibers can withstand an internal pressure of 50 bar for common materials and up to 200 bar for special materials. Depending on the selected material, the heat exchangers can be used up to temperatures of 250°C (see Fig. 1). The developed exchangers were tested in liquid-liquid and liquid-gas applications. The examples given are for automotive radiators, oil cooling, air conditioning, exhaust gas condensation and battery cooling. In these applications, they can fully replace classic metal exchangers.

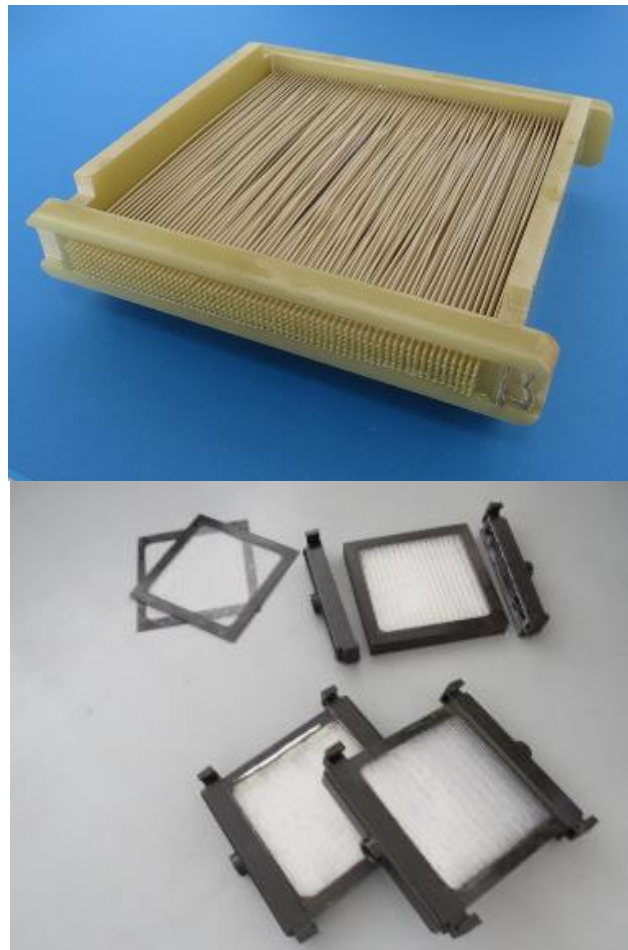


Fig. 1 Heat exchangers for liquid-gas applications, on the left an exchanger made of PEEK fibers for temperatures up to 230°C, on the right an exchanger made of PA fibers up to 120°C

The car radiator consists of 12,240 fibers, which are arranged in 34 layers. It is made of polyamide 612 and the fibers have an outer diameter of 0.8 mm. The total heat exchange area is 13 square meters. The radiator is shown in Fig. 2. A comparison of the performance parameters of a classic

aluminum radiator and a radiator made of polymer hollow fibers is shown in Fig. 3. The automotive radiator was tested in laboratory conditions and during vehicle testing, according to the methodology used at VW.

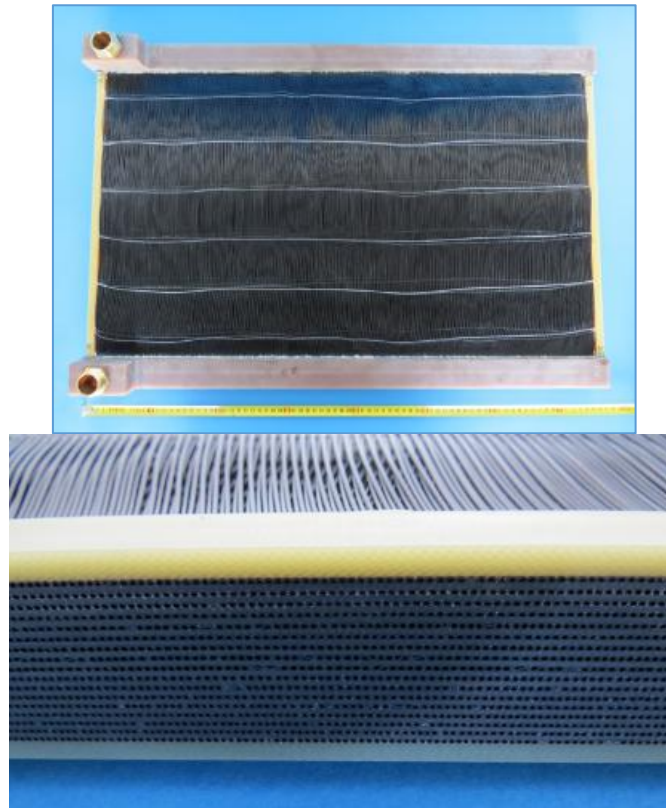


Fig. 2 Car radiator for Škoda Octavia, right view of the entrance to the hollow heat exchange fibers

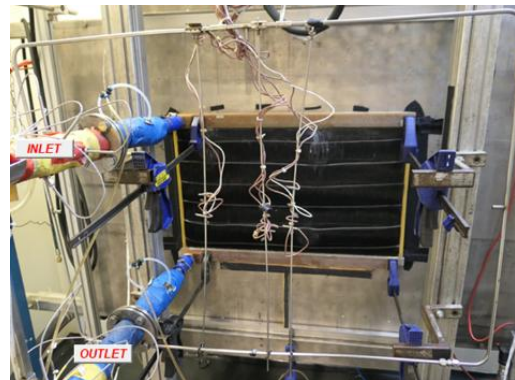
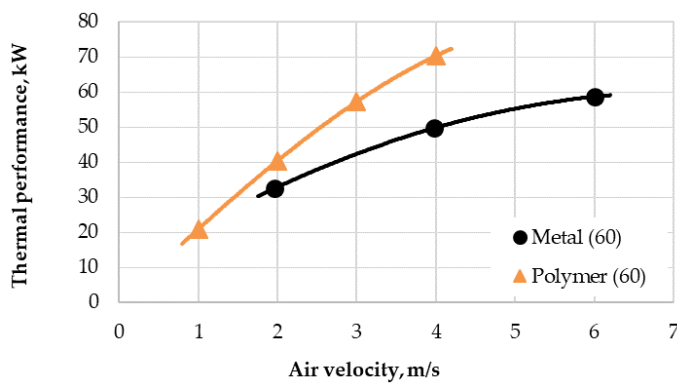


Fig. 3 Comparison of performance parameters of a classic and polymer radiator from Skoda Octavia, on the right is a test image

Heat exchangers designed for natural convection have larger heat exchange fiber spacings. An example of such an exchanger made of polypropylene fibers and its testing in the laboratories of BUT in Brno is shown in Fig. 4.



Fig. 4 Heat exchanger for natural convection and its testing (right)

Bundled heat exchangers utilize separation of heat transfer fibers by chaotization as seen in Fig. 5. These exchangers are used mainly for liquid-liquid applications. Their advantage is very cheap production.

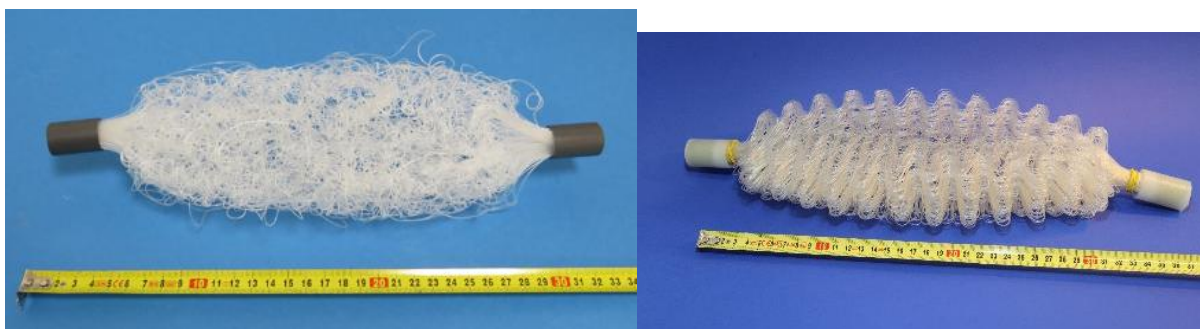


Fig. 5. Bundle heat transfer surfaces

Heat exchange surfaces made of hollow polymer fibers can be used in battery cooling. Their advantage is the use of electrically non-conductive material. Examples of battery cooling are shown in Fig. 6.



Fig. 6 Cooling of cylindrical electrical cells, on the right is the block for the cell set

The advantage for the defense industry is a lightweight product that contains no metal parts.

Keywords: Heat exchanger, Hollow Polymeric Fibers, Non-metallic Heat Exchangers

Detection of Foreign Metallic Contaminants in Critical Engine Components Using Polar Transformation and Deep Learning Enhanced by Anomaly Detection

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The presence of foreign metallic contaminants on the surface of critical engine components constitutes a significant threat to system reliability, potentially leading to accelerated wear, degradation of operational performance, and premature failure, particularly under high-load conditions and in mission-critical applications. Conventional visual inspection methods are often insufficient due to variability in surface conditions and the small size of contaminants. This study proposes a hybrid approach for the detection of foreign metallic contaminants on rotationally symmetric engine components, combining the transformation of image data from Cartesian to polar coordinates with deep learning techniques. The transformation to the polar domain enables a more effective representation of circumferential surface features, significantly improving the detectability of localized surface irregularities and anomalies. Additionally, to enhance the robustness of the inspection system against previously unseen defect types, an anomaly detection mechanism based on the analysis of feature representations in latent space is incorporated. This approach enables the identification of deviations from the reference surface pattern without requiring prior definition of all possible contamination types. The proposed method was validated using a real industrial dataset consisting of images of steel engine components containing both defect-free samples and samples contaminated with foreign metallic particles. Experimental results demonstrate a significant improvement in detection performance compared to conventional convolutional neural network approaches operating directly in the Cartesian image domain. The developed solution shows strong potential for deployment in automated industrial quality inspection systems, particularly in applications requiring high reliability, repeatability, and the capability to detect previously unknown defect types.

Keywords: Foreign Metallic Contaminants, Polar Image Transformation, Rotationally Symmetric Components, Deep Learning, Anomaly Detection

The Influence of the Type of Ground on the Stress Distribution on the Base Plate

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The work presents an innovative methodology for conducting numerical tests on the model of the M98 mortar base plate, which involved controlling the stiffness of the ground and the plate support area in order to obtain stress values close to the actual ones recorded during shooting tests. Field experimental tests defined the stress values occurring in individual areas of the base plate when firing from earthy, sandy and stony ground at an angle of elevation of the mortar barrel of 45°.

The input data for numerical simulations were determined based on measuring the pressure of the gunpowder gases in the mortar barrel with a piezoelectric sensor and on the basis of measuring the deformations of the base plate with strain gauge rosettes.

Very high prices of ammunition and shooting tests in scientific and research centers result in the increasingly frequent use of FEM simulations on numerical models, the costs of which are limited only to the purchase of computer software.

Taking into account the variable ground stiffness, so far omitted in scientific publications, allowed for achieving high convergence of the simulation results in relation to the results from strain gauge measurements. This proves the validity of the proposed stress analysis approach and confirms the correctness of the adopted research methodology, which can be used to develop or change the design of

a series of types of mortar retaining plates.

Keywords: Stress Distribution, Base Plate, Numerical Simulations

Poka-yoke in the Automotive Industry: Symmetry as a Tool for Eliminating Assembly Errors

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Poka-yoke is a design philosophy focused on preventing human errors through physical, visual, or functional constraints that inherently guide correct actions. In the automotive industry—where assembly mistakes can directly impact vehicle safety, durability, and overall quality—this approach plays a particularly critical role. One of the most effective, yet frequently underestimated, poka-yoke strategies is the use of symmetry in structural components. The example of seat rails illustrates that a symmetrical part design eliminates the possibility of incorrect assembly not by relying on additional control mechanisms, but by removing orientation ambiguity altogether. Unlike asymmetric components that require colour coding, electronic sensors, specialized tools, or extensive worker training, a symmetrical part ensures correct assembly in any orientation without requiring extra effort or oversight. This leads to fewer customer complaints, reduced assembly time, and simplified logistics and inventory management, as the need to store multiple part variants is eliminated. Symmetric design therefore represents a straightforward yet highly efficient poka-yoke solution within modern manufacturing.

Keywords: Poka-yoke, Rails, Symmetry, Asymmetry, Design

Study on Ballistic Performance of Twaron/epoxy Composite Laminates Subjected to Ballistic Impact of 7.62 mm Projectiles

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A numerical model based on the macro-homogeneous approach is developed to predict the ballistic performance of Twaron/epoxy composite laminates subjected to normal impact of 7.62×39 mm M43 projectiles with various impact velocities. Numerical simulations are performed using the finite element method within the LS-DYNA software environment. To ensure accuracy, the numerical model is validated by experimental data obtained from ballistic impact tests conducted on Twaron/epoxy composite laminates. The model predictions for the residual velocity of the projectile, ballistic limit and damage patterns of the composite laminates are in good agreement with the experimental observations, demonstrating the robustness and reliability of the present model.

Keywords: Fiber-reinforced Composite, Ballistic Impact, Numerical Modelling

Impact of the Annealing Process on Selected Properties of PETG Prints Produced by FDM

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The present study investigates the impact of the annealing process on selected mechanical properties and dimensional stability of PETG specimens manufactured using Fused Deposition Modeling (FDM). Additive manufacturing, particularly FDM, is widely used due to its accessibility, material versatility, and ability to produce complex geometries. However, parts produced by this method often exhibit anisotropy and internal stresses caused by the layer-by-layer deposition and rapid cooling cycles.

The main objective of this research was to determine whether controlled thermal post-processing (annealing) can improve the mechanical performance of PETG prints by enhancing interlayer bonding and reducing residual stresses. The study included both theoretical analysis and experimental investigations.

In the experimental part, standardized tensile test specimens were designed, manufactured using FDM technology, and subsequently subjected to annealing at three different temperatures: 90°C, 100°C, and 110°C. Two cooling strategies were applied: slow cooling inside the furnace and cooling at ambient conditions. The mechanical properties were evaluated through static tensile testing, focusing on tensile strength, elongation, and fracture behavior.

The results indicate that annealing has a measurable influence on the mechanical properties of PETG specimens, although its effectiveness strongly depends on process parameters and internal structure (infill density). For reference (non-annealed) samples, tensile strength ranged from approximately 37 to 41.5 MPa.

The most significant improvements were observed for specimens with medium infill (50%), where tensile strength increased up to 41.19 MPa after annealing at 100°C. This temperature corresponds closely to the glass transition temperature of PETG, which facilitates increased molecular mobility, stress relaxation, and improved interlayer diffusion. The effect of annealing temperature on tensile strength is illustrated in Figure X, showing a peak performance at 100°C and stabilization or slight decrease at higher temperatures (Fig. 1).

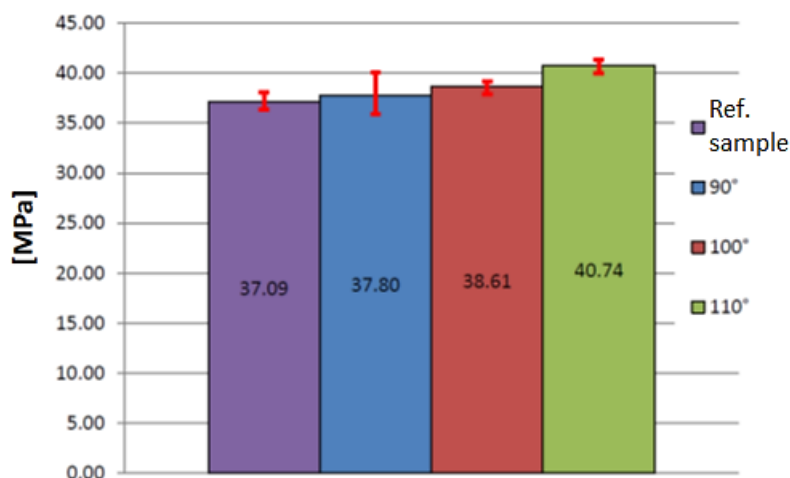


Fig. 1. Average tensile strength vs. annealing temperature (for 100% infill)

In contrast, samples with low infill (25%) showed minimal or no improvement, with tensile strength remaining in the range of 38–40 MPa. This behavior is attributed to the lack of structural continuity,

which limits the effectiveness of molecular reorganization during annealing. For higher infill levels (75% and 100%), the results were more stable, with tensile strength typically remaining between 37 and 41 MPa, although improvements were less pronounced than in the 50% infill case.

The cooling method also played a significant role. Furnace cooling resulted in more uniform properties and improved structural stability, while ambient cooling led to greater variability due to uneven thermal gradients.

Additionally, annealing was found to reduce internal stresses and improve material homogeneity, but at the cost of dimensional changes. Shrinkage and geometric deformation were observed, which must be considered in engineering applications requiring high dimensional accuracy.

Overall, the study confirms that annealing can enhance the performance of FDM-printed PETG components, but its effectiveness depends on a combination of factors, including temperature, cooling rate, and internal geometry. The optimal conditions identified in this work suggest that annealing at approximately 100°C provides the best balance between improved mechanical properties and acceptable dimensional stability.

Keywords: 3D Printing, PETG, Annealing, Additive Manufacturing (AM), Plastics

Effects of Gas Pressure During Firing on Barrel Material Degradation

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Firing a firearm, especially from weapon systems equipped with a rifled barrel, significantly stresses the complex surface of steel components. They represent one of the most demanding parts of the weapon's production and often determine its overall service life and readiness for full combat deployment. The number of shots that can be fired while maintaining effectiveness also fundamentally affects the operating costs of the weapon. Modern artillery systems operate in intensive and rapid firing modes, which are characterized by a sharp increase in internal pressure and temperature in the barrel in short time intervals. Such extreme and cyclically recurring loads lead to the emergence of complex thermo-mechanical stress-strain states. Their consequence can be a gradual degradation of material properties, the initiation of plastic deformations and, in the final stage, the emergence of local failures and even critical damage to the barrel structure.

Keywords: Erosion, Degradation, Material Fatigue, Cyclic Loading

IoT-Based Multi-Node System for Predictive Vibration-Based Machine Diagnostics

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Paper presents a custom-designed, distributed IoT system for remote vibroacoustic diagnostics of industrial machinery. The solution is based on proprietary measurement nodes equipped with a microcontroller and two 3-axis accelerometers. To achieve maximum sampling performance, additional sample memory and a circular buffer were implemented. As a result, the device transmits data files to a central server characterized by very low jitter (10–14 μ s). The transmitted data undergoes automatic conversion, database indexing, and predictive analysis on the server side. Experimental results confirmed the system's effectiveness in detecting mechanical anomalies while maintaining low implementation costs. This architecture serves as a scalable alternative to industrial monitoring systems, enabling the construction of extensive vibroacoustic datasets for predictive maintenance algorithms in distributed machinery fleets.

Keywords: Vibroacoustic Diagnostics, Internet of Things (IoT), Predictive Maintenance, Anomaly Detection, Distributed Monitoring Systems

Application of Trainable WEKA Algorithms for Automated Segmentation and Analysis of Optical and Electron Microscopy Images of Micro-Structures

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The aim of this study is to develop a method for an automated segmentation of metallographic micro-structures using machine learning algorithms implemented in the Fiji/ImageJ software environment. Images obtained from optical and electron microscopy were analysed and the influence of imaging conditions on classification accuracy was evaluated. The results demonstrate that the proposed method is effective and repeatable, provided the consistency of imaging conditions and appropriate classifier training are ensured.

Keywords: Optical microscopy, SEM, Image Processing, Machine Learning

Effect of Motor Oil Degradation and Metallic Surfaces' Treatment on Their Wettability

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This work examined and showcases the change in wettability of motor oils in relation to their degradation and treatment of the surface they wet. Wettability is a complex scientific discipline which focuses on the interplay of a liquid placed upon a surface, their surrounding atmosphere, their affinity and their properties. Over 500 measurements were done with various liquids and surfaces, using the sessile drop method, to further showcase various aspects of wettability. Various graphs using geometric mean to showcase the effect of degradation in motor oils are presented and talked about in detail. This credibly demonstrates the effect of degradation and impurities on wettability.

Keywords: Oil, Degradation, Wettability, Surface Treatment

Safety Research and Survivability Analysis for Next-Generation Vehicle Platforms: From Numerical Modelling to Field Testing

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The article discusses the latest safety research and survivability assessment methodologies developed at the Military Institute of Armoured and Automotive Technology (WITPiS) for next-generation vehicle platforms. As modern battlefield threats evolve, including advanced IEDs and high-kinetic energy projectiles, the demand for integrated protection systems becomes critical. The paper focuses on a hybrid research approach that combines advanced numerical simulations (FEM) with experimental validation conducted at specialized testing facilities

Keywords: Vehicle Survivability, Blast Protection, Next-generation Vehicles, WITPiS, Autonomous Systems, Crew Safety

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