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ANALELE UNIVERSITĂŢII „DUNĂREA DE JOS” DIN GALAŢI

Fascicula V

TEHNOLOGII ÎN CONSTRUCŢIA DE MAŞINI

ANUL XL (XLV) 2022

MINISTRY OF EDUCATION

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Fascicle V

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NEWTECH 2022 BOOKLET

The 7th International Conference on *Advanced Manufacturing Engineering and Technologies*

September 08-10, 2022
Rennes, FRANCE

CONTENT

PREFACE

The 7th International Scientific Conference: NEWTECH 2022 – Advanced Manufacturing Engineering and Technologies was organized by National Institute of Applied Sciences of Rennes – INSA Rennes, France. It was held between 8th-10th of September 2022 in Rennes, France and was supported by the French Mechanical Association, Manufacturing'21 and ITCM Center of UDGJ Galati, Romania.

The situation with COVID-19 imposed restrictions on holding mass events and travelling. The health of the participants is key and so, the organizing committee, encouraged by the eagerness of the participants to share their scientific work despite the circumstances, decided to hold the conference both in life and online version.

The 7th International Scientific Conference: NEWTECH 2022 – Advanced Manufacturing Engineering and Technologies provides a forum where recent advances and future directions in the manufacturing processes and forming are discussed by scientists and engineers from academia and industry worldwide. The topics covered are of great interest for academics and for professionals (engineers and researchers) from industry involved in traditional and novel forming and manufacturing technologies for conventional and emerging materials.

The 7th International Scientific Conference: NEWTECH 2022 – Advanced Manufacturing Engineering and Technologies takes place in the year in which the France celebrates Mechanics Year during 2021-2022 academic period.

A total of 20 oral and 6 online presentations and from 10 worldwide countries, Czech Republic, France, Greece, Portugal, Serbia, Spain, Bulgaria, Romania are registered including:

- 4 plenary lectures given by renowned experts from academia;
- 30 submitted abstracts and 20 oral presentations organized in 8 general sessions.

The all oral and online presentations are composed around of 20 peer-reviewed full papers (between 6 and 14 pages each one).

All the papers have been reviewed by two expert referees in their relevant fields. The papers selected for the volume depended on their quality and relevancy to the conference.

Free access to all the conference papers will be granted to all the registered attendees. However, the peer-reviewed full papers and a part of the plenary lectures will be published after the conference, in the open access proceedings by EDP Sciences on MATEC Web of Conferences ISI Conf. Journal Series.

In the proceedings, the first section contains a part of the plenary lectures papers delivered by the renowned scientists. These experts were invited to highlight various topics of the conference so as to provide a perspective on the future of scientific and industrial challenges within the scope of the conference. The second section consists of oral presentations which cover Cutting, Milling, Metrology, Bulk Forming, Hydroforming, Mechanical behaviour, Process Control, Welding... The authors report advances in aspects such as numerical techniques, including artificial intelligence.

The main goal of NEWTECH 2022, under the given conditions, was successfully achieved - to bring together researchers from academia and industry, scientists and experts in engineering and technology to address new challenges, share solutions and discuss future research directions.

We would like to thank all those researchers who have trusted the conference and who recognized NEWTECH 2022 as an appropriate forum to share their recent developments and learn about the new trends in the field of technical sciences and engineering.

We thank all the authors for their contribution to this valuable volume. We must also thank all the reviewers for their effort, which ensured not only excellent feedbacks for the authors but also a high-quality scientific research.

Last but not least, we sincerely thank the whole team involved in organizing the NEWTECH 2022 conference.

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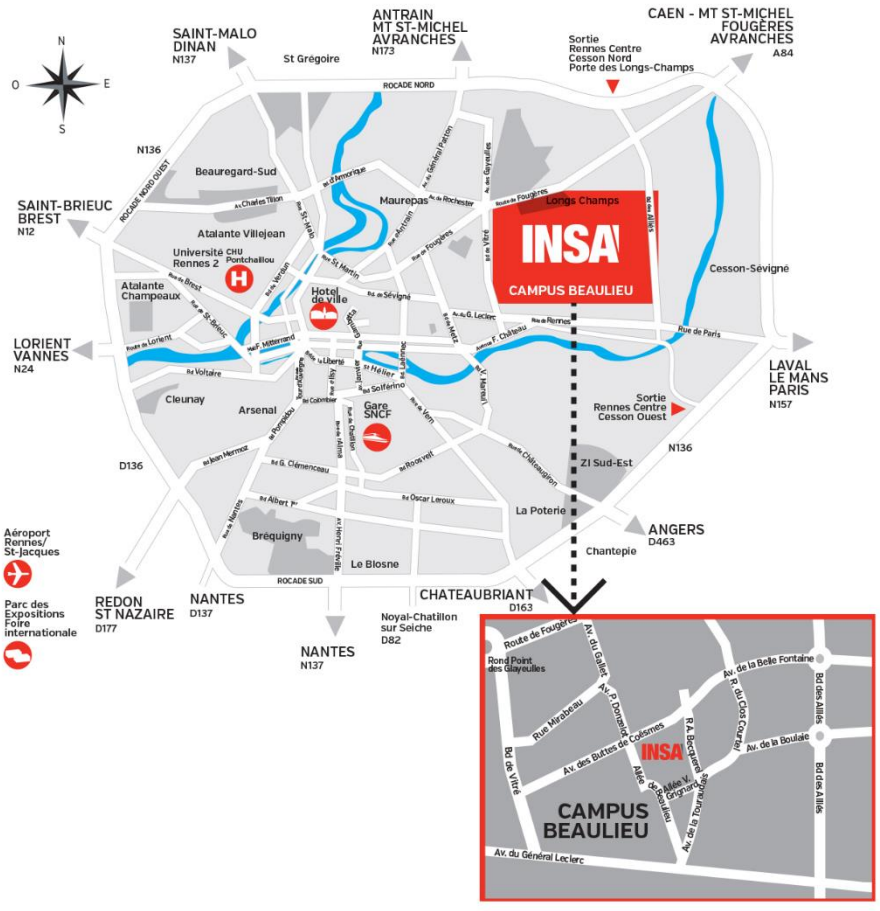

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PLENARY LECTURES

Thursday, September 08, 2022

Prof. Dr. Mohamed EL MANSORI,

Arts et Métiers Paris Tech, ENSAM Aix-en-Provence,
Director AM2 Transatlantic Partnership, Director Mechanics, Surfaces and Material Processing Laboratory (MSMP-EA7350), Head Engineering and Multi-physics of Multiscale Manufacturing Research Group, France

Convergent manufacturing to leverage sustainability and digitalisation of industrial production

Prof. Dr. Miroslav PÍŠKA
Brno University of Technology, CZECH REPUBLIC

The new technologies for advanced joint implants

Friday, September 09, 2022

Prof. Dr. Dumitru NEDELCU
Gheorghe Asachi Technical University of Iasi, ROMANIA

Coated Biodegradable Polymers

Prof. Dr. Vidosav D. MAJSTOROVIC
University of Belgrade, SERBIA

Management of tools in digital manufacturing. A case study

INSTRUCTIONS FOR THE CHAIRPERSONS

Chairpersons should be present in the computer desk at least 10 min before the beginning of the session. Please check the e-program (e-Program Booklet) to confirm the schedule of your session.

A technical staff will help to solve technical problems occurring during the session and hand out the microphones in the audience during the discussions.

Please check the presence of all the speakers scheduled for your session before the beginning of the session.

You are in charge of animating the discussion following each lecture. If necessary you can skip or shorten the discussion.

If a speaker is absent, please do not advance the following talk. You must make the audience wait until the next presentation, as defined in the initial program, by suggesting a discussion of earlier presentations.

Please note that presentation time is depending in the type of the oral presentation according to:

	Lecture time	**Discussion time**	**Total time**
Plenary lectures	30 min	10 min	40 min
Full papers presentation	15 min	5 min	20 min

To leave the required time for discussion, you are adviced to interrupt the oral presentation of any speaker who exceeds his allowed time.

All presentations are registred by organizators.

INSTRUCTIONS FOR ORAL PRESENTATIONS

Please check the e-Program Booklet to confirm the schedule of your presentation.

On the e-booklet or on the website (Program Tab), you may refer to the List of Oral Presentations ordered by IDs.

Try to be in your presentation computer desk 10 minutes prior to the starting time. Please indicate your presence to the chairperson of your session. You are expected to be present for the entire time of each session.

Please note that presentation time is depending in the type of your oral presentation according to:

	Lecture time	**Discussion time**	**Total time**
Plenary lectures	30 min	10 min	40 min
Full papers presentation	15 min	5 min	20 min

A simple rule is to consider 1 slide equals 1 minute of presentation. For example: a full paper presentation will have around 15 slides (15min of lecture) and for plenary lecture is around 30 slides maximum (30 min of lecture).

Please respect your presentation time. If not, the chairperson is asked to interrupt your presentation at the prescribed time to leave the required time for discussion.

All presentations are registred by organizators.

CONFERENCE PROGRAM

FINAL PROGRAM INTERNATIONAL CONFERENCE NEWTECH2022
8 – 10 September 2022
Amphitheater André BONNIN – Bat. 5 INSA Rennes, Rennes, FRANCE

THURSDAY 8 SEPTEMBER 2022

8h30 – 9h30 : **PARTICIPANTS REGISTRATION** – Front of Amphitheater André BONNIN – Bat. 5 INSA Rennes, Rennes, FRANCE

9h30 -10h00 : **OPEN CEREMONY**

- Prof. Hervé FOLLIOT Research Director of INSA Rennes
- Assoc. Prof. Habil. Dr. Adinel GAVRUS – Chairman of NEWTECH 2022
- Prof. Dr. Viorel PAUNOIU – Vice-President of NEWTECH 2022

10h00-10h30 : Coffee Break

10h30 – 11h10 : FRENCH MECHANICAL YEAR 2021-2022 - **Introduction by President Representing of French Mechanical Association – AFM and by Mandatory Deputy of Manufacturing'21**

- Prof. Tanguy ROUXEL Responsible of "MecaScience" Seminaries or UR1/INSA Rennes/ENS Cachan – Mechanics Year 2021-2022/Prof. Valérie BOTTON representing the President of AFM (France) – visio-conférence
- Prof. Guenael GERMAIN – Manufacturing'21

11h10 – 11h50 : **PLENARY LECTURER - Convergent manufacturing to leverage sustainability and digitalisation of industrial production**

- Prof. Mohamed EL MANSORI, Arts et Métiers Paris Tech, ENSAM Aix-en-Provence, Director AM2 Transatlantic Partnership, Director Mechanics, Surfaces and Material Processing Laboratory (MSMP-EA7350), Head Engineering and Multi-physics of Multi-scale Manufacturing Research Group, France

11h50-12h30 : **ONLINE SCIENTIFIC SESSION** (2 speakers x 20' – online presentations) – Session Chairman: Assoc. Prof. Adinel GAVRUS

https://zoom.us/j/93457457343?pwd=djdad3M3T2IzTHovWitmYmxuTUdaZz09

Bernd Peukert, Adithya Rangaraju, Andreas Archenti, In-situ prediction of the spatial surface roughness profile during slot milling

Nikolaos Vaxevanidis, Laser cutting of FFF PLA/wood *and* Machinability optimization of dry CNC turning of UNIMAX® tool steel under annealed and hardened states by implementing swarm intelligence algorithms

12h30-12h40: Group Photo – in the front of INSA Rennes Administrative Building (Bat. 2)

12h40 – 14h00 : LUNCH – Staff Cafeteria

14h00 – 14h40 : **PLENARY LECTURER - The new technologies for advanced joint implants**

- Prof. M. PISKA, Brno University of Technology, Faculty of Mechanical Engineering, Department of Manufacturing, Cehia

14h40-15h40 : **SCIENTIFIC SESSION** (3 speakers x 20') – Session Chairman: Prof. Viorel PAUNOIU

Philippe SEITIER, Patrick GILLES, Valérie BOUDIER, Michel GALAUP and Pierre LAGARRIGUE, Getting started procedure of a NC machine simplified by the use of a mixed-reality training scenario

Gabriela-Petruța RUSU, Valentin Ștefan OLEKSIK, Radu Eugen BREAZ, Dan DOBROTĂ, Ilie Octavian POPP, Analysis of the metal sheets formability at single point incremental forming process

Mihai-Octavian POPP, Sever-Gabriel RACZ, Mihaela OLEKSIK, Claudia GÎRJOB, Cristina BIRIȘ, Analysis of forming forces at SPIF using Taguchi method

15h40 – 16h00 : Coffee Break

16h00 – 17h20 : **HYBRID SCIENTIFIC SESSION** (4 speakers x 20') – Session Chairman: Prof. Mohammed EL MANSORI

Vasile Ermolai, Alexandru Sover, Marius Andrei Boca, Adelina Hrițuc, Laurențiu Slătineanu, Gheorghe Nagîț and Răzvan Cosmin Stavarache, Mechanical Behaviour of Macroscopic Interfaces for 3D Printed Multi-material Samples

Miroslav Piska and Katerina Urbancova, On the Machining of Joint Implant UHMWPE Inserts

https://zoom.us/j/95314766050?pwd=UTlUNW1Cd3E3SHljUFkzNFVOVW9aQT09

Teodor Costinel Popescu, Alexandru-Polifron Chiriță, Ana-Maria Carla Popescu, Andrei Vlad, Gheorghe Alexandru Trăneci, Alina Iolanda Popescu, Optimization of Manufacturing Processes by Reducing the Costs of Tools and Equipment on Hydraulically Operated High-Pressure Technological Lines

Cătălin Dumitrescu, Adinel Gavrus, Radu Rădoi, Ștefan Șefu, Alexandru-Polifron Chiriță, Ana-Maria Popescu and Dragoș Preda, Modern Techniques for Remanufacturing Hydraulic Equipment in the Context of Circular Economy and Energy Efficiency

19h00 – 22h30 : **OFFICIAL DINNER – RESTAURANT « LA TAVERNE »**, Place de Colombier/Charles de Gaulle, 2 Rue d'Alma, Rennes

FRIDAY 9 SEPTEMBER 2022

9h00 – 9H40 : **PLENARY LECTURER - Coated Biodegradable Polymers**

- Prof. D. NEDELCU, Technical Univ. « Gheorhe Asachi » Iasi, Romania, Manager of Fine Mechanics and Nanotechnology Laboratory, Romania

9h40 – 10h40 : **SCIENTIFIC SESSION** (3 speakers x 20') – Session Chairamn: Prof. Dumitru NEDELCU

Vidosav Majstorovic, Vladimir Simeunovic, Radivoje Mitrovic, Dragan Stosic, Sonja Dimitrijevic and Zarko Miskovic, How to apply the ERP model for Smart Mining?

Enora LEVREL, Siti Nursyafinaz Binti Mohd Safie, Pierrick Malécot, VirgileLambert, Michael Fontaine, Loic Hallez, Séverine Lallemand, Functional correlation surface texture / grip of a deposit : case of NiP

Vojin Vukadinović, Jovan Živković, Dragan Đurđanović, Vidosav Majstorović, Management of tools in digital manufacturing - A case study

10h40 – 11h00 : Coffee Break

11h00 – 12h00 : **Scientific Session** (3 speakers x 20') – Session Chairman Prof. Vidosav MAJSTOROVIC

Gheorghe Nagîț, Laurențiu Slătineanu, Oana Dodun, Viorel Păunoiu, Marius-Andrei Mihai, Marius-Ionuț Rîpanu, Adelina Hrițuc, Ioan Surugiu, The Influence of Lubrication on the Roughness of the Vibroburnished Surface

Vytautas Ostasevicius, Sandra Mikuckyte, Rimvydas Gaidys, Vytautas Jurenas, Vytautas Daniulaitis, Digital Twins for Micro Machining

Alina Marguta, Simona-Nicoleta Mazurchevici, Constantin Carausu and Dumitru Nedelcu, Biodegradable polymer properties through ceramic coatings

12h00 – 13h40 : LUNCH – Staff Cafeteria

13h40-14h20 : **PLENARY LECTURER - Management of tools in digital manufacturing. A case study**

- Prof. V. MAJSTOROVIC, University of Belgrade, Faculty of Mechanical Engineering, Serbia

14h20 – 15h40 : **Online Scientific Session** (3 speakers x 20') – Session Chairman: Assoc. Prof. Adinel GAVRUS

https://zoom.us/j/94108154964?pwd=US9wSXh1TWIrUG5jZW52L0ViQ21PZz09

N. Baroiu, V.G. Teodor, V. Paunoiu, G.A. Morosanu and R.S. Craciun, Study of the enwrapping of the front profiles of the active elements of a three-screw compressor

G.A. Morosanu, V.G. Teodor, V. Paunoiu, R.S. Craciun and N. Baroiu, Quality characteristics analysis for the assembly of the elements from the construction of a mechanism for adjusting the seats in the automotive industry

Cezarina Afteni, Mitica Afteni and Gabriel-Radu Frumusanu, Study on the Application of the Holistic Optimization Method of the Manufacturing Process in the Case of a Reduced Instances Database

Viorel PAUNOIU, Virgil TEODOR, Nicusor BAROIU, Georgiana-Alexandra MOROSANU, and Alexandru EPUREANU, Contribution to a new method for deep drawing with kinetic control

15h40 – 16h00 : Coffee Break

16h00 – 17h00 : Meeting of Steering International Committee

SATURDAY 10 SEPTEMBER 2022

Excursion to Mont Saint-Michel, Normandie (France)

9h30 Departure to Mont Saint-Michel – in the front of INSA Rennes Administrative Building (Bat. 2)

17h00 Arrival from Mont Saint-Michel – in the front of INSA Rennes Administrative Building (Bat. 2)

ABSTRACTS

VIBRATION TRANSMISSIBILITY OF ALUMINUM FOAM FOR DESIGN AS A BEARING DAMPER

Fettah Bilal, Zahloul Hamou

Laboratory of Rheology and Mechanic, Hassiba Benbouali University of Chlef, Algeria, BP. 151 Hay Es Salem 02000 Chlef, Algeria

Abstract. Metal foams materials energy absorption, thermal insulation, and damping resistance will make it a special item for new development in rotor vibration control. The vibration of a shaft supported by ball bearings is analyzed based on metallic foams. Modern gas turbine engines typically utilize squeeze film dampers as flexible damped support to attenuate vibration amplitude and to reduce transmitted forces. The mechanical and damping properties of metal foams will be used as a damper absorber to reduce the vibration of a simple Jeffcott rotor system. This paper's aim is to explore the characterization of met-al foam as a source of dampening in a simple Jeffcott rotor system. also, to reduce the detrimental vibration effect on rotor dynamics supported especially by ball bearing with squeeze film metal foam damper. The adapter covering the outer rings of the ball bearings will be modified to obtain a vibratory analysis with or without the use of a porous metal foam damper. The vibration transmissibility through the metallic foam sample will be presented to figure out the damping coefficient and vibration isolation efficiency.

Keywords: vibration, metal foam, transmissibility, damping, shaft, SFD

STUDY ON THE APPLICATION OF THE HOLISTIC OPTIMIZATION METHOD OF THE MANUFACTURING PROCESS IN THE CASE OF A REDUCED EXTENSION INSTANCES DATABASE

Cezarina Afteni[1], Mitica Afteni[1,2], Gabriel-Radu Frumusanu[1]

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Abstract. The optimal management of the manufacturing processes is achieved through a set of optimal decisions, which must be made for choosing the best way to follow, every time we find ourselves in a point from which several potential manufacturing paths start. A dedicated method, namely the Holistic Optimization Method has been already developed in this purpose, and validated in a number of studies based on artificial and real instances databases.

In the current papers, which approach the optimal management of the manufacturing processes, in order to estimate the consequences of a decision, are used known methods, such as: NN methods, big data analysis, statistical methods, etc. In all these cases, the database size plays an essential role in terms of estimation quality. The present study aims to prove the feasibility of applying the Holistic Optimization Method when the decision-maker does not dispose of a consistent database. This can be a significant advantage relative to the other methods. The study is performed using an artificially generated instances database in the case of a turning process, and the results obtained are promising.

Keywords: decision making, holistic optimization method, instances database, comparative assessment, turning process

THE INFLUENCE OF LUBRICATION ON THE ROUGHNESS OF THE VIBROBURNISHED SURFACE

Gheorghe Nagîț[1], Laurențiu Slătineanu[1], Oana Dodun[1], Viorel Păunoiu[2], Marius-Andrei Mihalache[1], Marius-Ionuț Rîpanu[1], Adelina Hrițuc[1], Ioan Surugiu[1]

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Abstract. One of the processes by which a hardening of the surface layer and a diminishing of the heights of the surface roughness take place in the case of steel parts is vibroburnishing. In principle, vibroburnishing involves a vibratory motion and a rolling of a small diameter ball on the surface to be subjected to a vibroburnishing process. There are a large number of factors that can influence the values of roughness parameters in vibroburnishing. These factors take into account the physical-mechanical properties of the workpiece material, the surface roughness before applying vibroburnihsing, the ball dimensions, the sizes that characterize the movement of the ball in relation to the workpiece surface, the pressure of the ball on the surface being pro-cessed, etc. The analysis of the conditions of use of the vibroburnishing process of some cylindrical surfaces showed that the heights of the asperities resulting from the pro-cessing can be influenced by the use of lubrication during the process. As such, the problem of conducting experimental research was formulated to highlight the intensity of the influence exerted by some input factors in the vibroburnishing process on the roughness of the processed surfaces, evaluated by using the roughness parameter Ra. An experimental program was designed aiming to use different values of ball diameter, ball pressing force, initial roughness, in conditions of dry processing and use of a lubricating oil. The experimental results were processed using a software based on the least squares method. The determined empirical mathematical models highlighted the possibilities of reducing by at least 10% the height of the surface roughness when lubricating liquids were used, compared to vibroburnishing without lubrication. It was considered that the presence of oil decreases the

friction forces between the ball and the surface asperities and causes a wider deformation of the test sample material under the action of pressing the ball.

Keywords: vibroburnishing, lubrication influence, surface roughness, empirical mathematical model

STUDY OF THE ENWRAPPING OF THE FRONT PROFILES OF THE ACTIVE ELEMENTS OF A THREE-SCREW COMPRESSOR

Nicușor Baroiu, Virgil Gabriel Teodor, Viorel Păunoiu, Georgiana Alexandra Moroșanu, Răzvan Sebastian Crăciun

„Dunărea de Jos" University of Galați, Galați, România
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Abstract. Fluid transport requires specific equipment, such as pumps and compressors. Currently, the emphasis is on the ease of transport of liquids and gases so that their handling can be done with the highest possible efficiency and safety. One way to increase efficiency is to change the front profile of the active elements of compressors and pumps. But, a side effect of this change is the difficulty of securing the necessary spare parts in case one of these items is damaged. The usual solution, to completely change the pump or compressor, is not always possible or effective. The paper proposes a method for identifying the front profile of a snail-type active element, consisting of a three-screw compressor. The purpose of this identification is to study the frontal enwrapping between the profiles of the driver and the driven element, in order to produce a possible replacement element. As is it well known, the two profiles are mutually enwrapping profiles, which means that the problem can be treated as a plane enwrapping problem. The identification of the profiles was performed by specific reverse engineering methods, the parts being scanned on an ATHOS 500 scanning system. Subsequently, the analytical shape of the driven screw was identified and, applying the "virtual pole" method, the corresponding shape of the guide screw profile was deduced. The obtained profile was compared with the real profile, obtained by 3D scanning. The obtained results demonstrated not only the good match between the theoretical and the real profile but also the simplicity and robustness of the method applied for the study of the enwrapping, namely the "virtual pole" method.

Keywords: reverse engineering, enwrapping profiles, „virtual pole" method

MECHANICAL BEHAVIOUR OF MACROSCOPIC INTERFACES FOR 3D PRINTED MULTI-MATERIAL SAMPLES

Vasile Ermolai[1,2], Alexandru Sover[2], Marius Andrei Boca[1,2], Adelina Hriţuc[1], Laurenţiu Slătineanu[1], Gheorghe Nagîţ[1], Răzvan Cosmin Stavarache[1]

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Abstract. The development of Additive Manufacturing technologies introduced new possibilities regarding multi-material part production. Fused Filament Fabrication (FFF) is one of those technologies suitable for multi-material 3D printing. Usually, multi-material parts are manufactured from different blends of the same material, also known as multi-color 3D printing, or from materials with good chemical compatibility. However, the mechanical performance of multi-material parts is frequently based on a simple face-to-face contact interface be-tween parts bodies and a physical bond between thermoplastics. In this regard, the paper aimed to investigate the performance of the contact interface of multi-material components using a geometrical approach. Therefore, multiple inter-locking interfaces were investigated, such as Ω-shape, T-shape, dovetail, and others. For a broader understanding of the interlocking interfaces, the experimental runs consisted of a group of compatible thermoplastic materials, acrylonitrile styrene acrylate (ASA) and thermoplastic polyurethane (TPU), and low-compatible, i.e., polyethylene terephthalate glycol (PETG) and polyamide (PA). The results showed that macroscopic interlocking interfaces could enhance the mechanical properties.

Keywords: fused filament fabrication, multi-material, interlocking mechanism, contact interface

INFLUENCE OF BOND INTERFACE OVER THE LAP-SHEAR PERFORMANCE OF 3D PRINTED MULTI-MATERIAL SAMPLES

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Abstract. Multi-material 3D printing offers new possibilities regarding product development, allowing design freedom and multiple materials choices in terms of colour and polymer type.

Material extrusion technologies are among the most popular options for multi-material printing due to their low equipment cost and various thermoplastic materials. However, polymers' compatibility and bond interface must be considered for multi-material components. Material Extrusion creates the parts layer by layer, and each layer is characterised by multiple lines of extruded thermoplastic at a defined width. Therefore, regardless of the 3D model's surfaces, they are composed of numerous lines of material and voids. Depending on the 3D Printing process setup, the bonding mechanism between materials can be influenced due to the different characteristics of horizontal and vertical contact interfaces. For this reason, this paper aims to study the influence of process parameters over horizontal interface through lap-shear tests for multi-materials samples made of acrylonitrile butadiene styrene (ABS), acrylonitrile styrene acrylate (ASA), and polycarbonate (PC). The results show that bond interface strength can be improved by creating ways for the mechanical interlock of the materials.

Keywords: fused filament fabrication, multi-material, bond interface, pro-cess parameters, lap shear

ANALYSIS OF THE METAL SHEETS FORMABILITY AT SINGLE POINT INCREMENTAL FORMING PROCESS

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Abstract. Although research on incremental forming process began a few decades ago, it is still a process in development phase. Single point incremental forming is a simple process and the deformation of the sheet blank is done with the help of a punch that follows a known toolpath.
In the case of this process, one important aspect is the prediction of material failure. To achieve this with the help of a finite element analysis, a series of experiments were performed to determine the forming limit diagram. In this paper, an attempt has been made to determine the forming limit diagram for the AA1050 aluminium alloy and DC01 steel sheets. The experiments were performed with the help of an industrial robot, KUKA KR 210-2, thus the part can be measured with an optical measuring instrument obtaining the major and minor strain from forming limit diagram.

Keywords: single point incremental forming, deformability, aluminium alloy, steel

A CAD-CAE-CAM APPROACH TO MANUFACTURE THE CAR DOOR HANDLE THROUGH SPIF

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Abstract: The car industry is looking for less expensive ways to produce various car body components. One of those processes is the single point incremental forming process which doesn't require a mold or die for each component, but only a good knowledge of the process to obtain a good accuracy of the components.
The purpose of this paper is to present the stages necessary to manufacture a portion of a car body. Thus, a CAE and CAM model is proposed for an existing model of door handle CAD to be produced through SPIF. After running the finite element method analysis it is shown that certain car body parts can be produced successfully through SPIF for which the process was developed in the first place.

Keywords: single point incremental forming, deformability, steel.

ANALYSIS OF FORMING FORCES AT SPIF USING TAGUCHI METHOD

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Abstract. Incremental sheet metal forming process has seen one of the highest increases in diversity in the last years. Single point incremental forming (SPIF) has become more attractive due to multiple benefits it possesses over other conventional cold forming processes such as deep-drawing. However, the process has yet to arise in the large-scale industrial implementation because of its drawbacks such as high production time and low accuracy, which lead to prototype production.
A very important aspect for this manufacturing process is the analysis of the forming forces in terms of process energy especially when using industrial robots.
The aim of this paper is to investigate the influence of material and vertical step over the forming forces. Thus, aluminium and steel sheets with a thickness of 0,8 mm were incrementally deformed as a truncated cone with an angle of 50°, respectively 60° at a depth of 30 mm and 40 mm. Experiments were performed using a KUKA KR 210-2 robot which allows to measure the forces using a piezoresistive sensor.

After performing the analysis of the forming forces using the Taguchi method, it can be observed that the material has the highest influence.

Keywords: single point incremental forming, forming forces, Taguchi Method

OPTIMIZATION OF MANUFACTURING PROCESSES BY REDUCING THE COSTS OF TOOLS AND EQUIPMENT ON HYDRAULICALLY OPERATED HIGH-PRESSURE TECHNOLOGICAL LINES

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Abstract. Most technological manufacturing lines include hydraulically operated stationary tools, devices and equipment. During a manufacturing cycle, there are phases, usually short, in which part of the hydraulic cylinders of the drive systems concerned, with small gauges and displacement speeds, have to generate / maintain high clamping or pressing forces, which implies functioning at high working pressures.
The solution for such cylinders is to use modular hydraulic pumping units comprising: oil tank; low-pressure electric pump; hydraulic directional valve for starting, stopping and changing the direction of movement of the cylinder; electric pump pressure control valve; pressure filter; return filter; oscillating hydraulic pressure intensifier (minibooster mounted directly on the cylinder).
Such pumping modules, which consume low pressure (in the primary side of the minibooster) to generate high pressures (in the secondary side of the minibooster), are cost-effective when it comes to the purchase of components, installing them, the space required for installation, and their maintenance, too.
The classic applications of using them are for achieving and maintaining high pressure values, either in volumes of closed spaces (endurance tests for pipes and tanks), or at the active stroke end of hydraulic cylinders (hydraulic presses).
The authors demonstrate, on an experimental laboratory bench, the following:
- The range of applications of such pumping modules can be extended in a third direction, namely for actuation of hydraulic cylinders with low gauge / speeds and constant high load (high working pressure) over the entire stroke;
- Uniformity of movement of these cylinders with load over the entire stroke that are fed and operated by such pumping modules is weakly affected by the pulsating operating mode of the hydraulic pressure intensifier.

Keywords: low pressure; pumping module; oscillating hydraulic pressure intensifier; high pressure; hydraulic cylinder

MODERN TECHNIQUES FOR REMANUFACTURING HYDRAULIC EQUIPMENT IN THE CONTEXT OF CIRCULAR ECONOMY AND ENERGY EFFICIENCY

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Abstract. The article presents several current methods of remanufacturing hydraulic components, a trend that is encouraged, on the one hand, by concerns about reducing material consumption in the context of the circular economy - some of these materials being expensive or in short supply. On the other hand, remanufacturing by modern methods can lead to a decrease in energy consumption in the devices concerned, due to obtaining shapes that are difficult to achieve by classical procedures. Among the remanufacturing processes considered there are additive manufacturing, metal coating, reverse engineering, etc.
An important step in the remanufacturing process is testing of components, which certifies the achievement of performances at least equivalent to those of the original products. To this end, the article presents a test bench solution with the help of which tests can be carried out on hydraulic devices such as hydraulic pumps and (linear or rotary) motors, hydraulic directional control valves or other types of valves.

Keywords: remanufacturing, additive manufacturing, reverse engineering, circular economy, energy efficiency, test bench

INFILL PARAMETERS INFLUENCE OVER STRENGTH OF 3D PRINTED SAMPLES BY FUSED FILAMENT FABRICATION

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Abstract. Fused Filament Fabrication (FFF) is an extrusion-based technology that uses molten thermoplastic material to build 3D models additively. Each part is built in a layer-wise fashion and is composed of walls, bottom/top layers, and internal structure. Regarding the internal structure, also known as infill, many studies adopted 100 percent infill density for the tested samples, which logically, is the strongest. However, there are still other infill parameters that were not thoroughly studied. Thus, this research aimed to investigate the influence of nine infill parameters and two travel parameters over the tensile properties of 3D printed samples. The experiment was designed using a mixed Taguchi L36 matrix. All samples were printed with gyroid infill without bottom and top layers using a polylactic-acid-based (PLA) material. The results show that the strength of samples can be increased by multiplying the infill line along with an increased overlap between the infill line and the inner wall.

Keywords: Fused Filament Fabrication, infill, infill parameters, tensile strength

CONTRIBUTION TO A NEW METHOD FOR DEEP DRAWING WITH KINETIC CONTROL

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Abstract. The paper presents a new deep drawing sheet metal method in which, due to the complex geometric shape of the part, there are significant variations in the level of deformation in different areas of the piece. The method aims to improve the quality in the deep drawing process by reducing the variation of the wall thickness of the part, caused by the different degree of stretching of the sheet in different areas of it. In the proposed method the vertical movement of the punch is completed by two vertical rotational movements of it which will have the effect the increasing the flexibility of the deformation process, the active elements occupying the most favourable position dictated by the material flow in the die. It

results an improved material deformability and a higher degree of deformation. Also, the new method offers a relatively simple constructive solution of the press and does not require long auxiliary times for assembly-disassembly.

Keywords: deep drawing, deformability, hydraulic presses, kinetic control

NEURAL NETWORKS FOR PREDICTING KERF CHARACTERISTICS OF CO2 LASER-MACHINED FFF PLA/WF PLATES

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Abstract: Wood flour (WF) mixed with poly-lactic acid (PLA) is an eco-friendly composite material used in the fused filament fabrication (FFF) process. Laser beam machining (LBM) is a non-conventional process that can achieve high dimensional accuracy, surface quality, and process efficiency [1]. This work investigates the effect of CO2 laser cutting (LC) with variable cutting parameters of thin 3D printed PLA/WF plates on kerf angle (KA) and mean surface roughness (Ra) of the resulted slot. This research work is a follow-up of previous reports related to the field [2-3].
The experimental design follows the response surface methodology (RSM) in order to formulate a continuous experimental domain. All twenty-four experiments were repeated three times for the three PLA/WF plates (deposition angle/DA: 0o, 45o, and 90o from X-axis, respectively). Table 1 summarizes the parameters and the levels corresponding to the full factorial experimental design.

Table 1. Parameters and levels
Full factorial design of experiments

Parameter	Symbol	Level 1	2	3	4	Unit
Stand-off Distance	SoD	7	8	-	-	rpm
Traverse Speed	TS	8	13	18	-	mm/rev
Beam Power	BP	82.5	90.0	97.5	105	Mm
Cutting Direction	CD	0	45	90	-	(deg.)

The results were statistically processed using Analysis of Variance (ANOVA), to study the significance of independent parameters to the responses of kerf angle and surface roughness. To allow for rigorous investigation in terms of independent parameters, contour plots were created to interpret interaction effects. The physical meaning of the influence of each parameter on the laser cut attributes has also been discussed.

A number of Artificial Neural Network (ANN) architectures were tested for predicting the responses of kerf angle (KA) and mean surface roughness (Ra) as two of the most critical quality objectives. The results have shown that the ANN architecture finally implemented can adequately predict KA and Ra responses while during experimentation it was observed that a cutting path parallel to the filament beads produced the best results for surface roughness Ra.

Keywords: hybrid manufacturing, CO2 laser cutting, 3D printing, PLA/wood flour composite, optimization

MACHINABILITY OPTIMIZATION OF DRY CNC TURNING OF UNIMAX® TOOL STEEL IN ANNEALED AND HARDENED STATES BY IMPLEMENTING SWARM INTELLIGENCE ALGORITHMS

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Abstract: In this research work, the machinability of a special tool steel (UNIMAX® by Uddeholm, Sweden) under dry CNC turning is investigated. The working material was investigated under two states; annealed and hardened. As major machinability indicators, main cutting force Fz (N) and mean surface roughness Ra (μm) were selected and examined under different values for the cutting conditions; cutting speed, feed rate, and depth of cut [1-2]. A systematic design of experiments was established as per the Response Surface Methodology (RSM) [3]. The experimental design involved twenty base runs with eight cube points, four center points in the cube, six axial points and two center points in axial direction. The experimental design is summarized in Table 1.

Table 1. Cutting parameters and corresponding experimental levels

Central composite design of experiments

Parameter	Symbol	Level			Unit
		Low (-1)	Center (0)	High (1)	
Spindle speed	n	1500	1750	2000	rpm
Feed rate	f	0.050	0.125	0.200	mm/rev
Depth of cut	a	0.500	1.000	1.500	mm

Statistical analysis to examine the effect of cutting conditions on the responses of main cutting force and surface roughness included analysis of variance (ANOVA) and contour plots under the scope of studying the interaction effects among process parameters and

generating a full quadratic model for predicting the two responses. To assess the significance of models in predicting the responses of main cutting force and surface roughness standard statistical indices were examined such as *F* and *P* values, whilst *Anderson–Darling* normality test was conducted to verify the suitability of the models corresponding to the main cutting force and surface roughness, for practical applications.

The two regression models served as the fitness functions and were iteratively evaluated by three swarm-based intelligent algorithms namely Grey-wolf optimization algorithm, Multiverse optimization algorithm and Ant-lion optimization algorithm, for optimizing main cutting force and surface roughness.

The results obtained have shown that all algorithms were capable of producing robust Pare-to fronts of non-dominated optimal solutions, yet with some differences in their quality from the perspective of coverage of the solution domain.

Keywords UNIMAX® tool steel, dry CNC turning, main cutting force, mean surface roughness, optimization

QUALITY CHARACTERISTICS ANALYSIS FOR THE ASSEMBLY OF THE ELEMENTS FROM THE CONSTRUCTION OF A MECHANISM FOR ADJUSTING THE SEATS IN THE AUTOMOTIVE INDUSTRY

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Abstract. Statistical control of a technological process is a method that is based on a series of tools that allow documentation, understanding, monitoring and supervising of the entire process, in order to ensure quality finished products. When the technological process is complex, statistical methods contribute to an early identification of systematic deviations, so that the quality characteristics are within the allowable tolerance limits. Thus, statistical control is a preventive method of quality management. The analysis of the capability of a production process is mainly used to determine the capability of the process to ensure compliant products, by analyzing certain monitored data that are representative of that process. The paper presents a study on the statistical control of some pieces from the construction of electric motors used to adjust the seats of vehicles. For each piece, 8 measurements were made, the volume of each measurement having 50 elements and the results were interpreted through a software application developed for this purpose and made in the Java language. The software analyzes a database consisting of the values of the dimensions of the measured pieces and identifies whether these values have a statistically normal distribution and falls within the permissible tolerance limits.

Keywords: statistical control, capability, automotive industry

ON THE MACHINING OF JOINT IMPLANT UHMWPE INSERTS

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Abstract. The modern orthopaedic implants for applications in hips, knees, shoulders, and spines are composed of hard metal alloys or ceramics. The tribological sub-component is composed of soft materials with good tribological properties – e.g. UHMWPE (Ultra High Molecule Weight Polyethylene). The UHMWPE implants need to be machined into their final shape after the polymerization and consolidation into a blank profile or near-net shaped implant.
So machining is a crucial technology that can generate an accurate and precise shape of the implant that should comply with the joints' function. However, the machining technology can affect the topography and integrity of the surface, and its resistance to wear. The technology, cutting tools, and cutting conditions can impact the physical and mechanical properties of the entire implant, limiting its life span and creating a need to be replaced.
The basic machining technologies are turning and milling (each can be used as roughing or finishing). There are many ways to machine these surfaces. Many problems such as low rigidity of the product, poor thermal properties of the material, high melt viscosities, and sticking of the material to the cutting edge (production of built-up edges) have been solved. UHMWPE can be damaged by excessive heat, feed rate, cutting force, and tool micro-geometry. The shapes and dimensions for the customized implants vary broadly for the humans this complicates the machining technology. No standard programs can be used repeatedly so each joint must be designed and produced individually. However, it results in the longer implant life and a better comfort of patients.

Keywords: machining, UHMWPE, implant, surface integrity, tribology

DIGITAL TWINS FOR MICRO MACHINING

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Abstract. The digital twin is a virtual mirror of the physical world throughout its life cycle. A cutting process controlled by digital twins can be a modern solution for manufacturing. Continuous data collection using virtual twin simulation and physical twin experimentation is related to modified vibration micro drilling processes, improving the quality of operations.

The main research question is how to quickly create a virtual model, and the mechanism for deploying the connection between the physical world production system and the virtual model it reflects. Over the last two decades, the demands of drilling small holes (Ø 0.5 mm) at high rotational speed (80.0÷180.0 rpm) are increasing due to the trend towards higher density circuits of computer parts and microelectronic packaging products. Compared to various micro machining methods, the main advantages of mechanical micro drilling are: less complicated equipment is necessary, the process is cheaper, the electrical properties of the workpiece do not influence the process, and machining time can be controlled easily. Buckling stiffness of micro drill bit is essential factor in order to secure the quality of micro drilling process, most of micro drill bit failures happen because of buckling. The aim of this study is to investigate the possibilities to increase micro drill stiffness by buckling it on a higher mode of the tool. This would allow to use higher cutting parameters and to increase efficiency of the micro drilling process.

Keywords: data collection, vibration drilling, buckling stiffness, higher mode, process efficiency

MANAGEMENT OF TOOLS IN DIGITAL MANUFACTURING - A CASE STUDY

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Abstract: Rapid changes in the market, with additional requirements for personalization of products, create new needs for great flexibility in manufacturing management, but on a new basis. The answer to all these challenges is the Industry 4.0 model. Digital manufacturing is the basis for Industry 4.0, and it has the following dimensions: (i) is based on the application of advanced digitally oriented technologies, (ii) smart products are increasingly being developed and marketed, the characteristics of which meet unexpected customer requirements, and (iii) smart supply chain (procurement of raw materials and delivery of finished products). In this concept, there is a two-way exchange of information in collaborative manufacturing, and their exchange through digital platforms for smart manufacturing. Tool management in this model is part of this platform and this concept, and is extremely important for manufacturing organizations. Therefore, this paper presents a developed model of a digital factory with a detailed presentation of the model for management tools in workshop, as part of the ERP and MES modules.

Keywords: digital manufacturing, tools management, ERP, MES

HOW TO APPLY THE ERP MODEL FOR SMART MINING?

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Abstract. For a long time, and especially today, the energy crisis has been a limiting factor for the growth and development of the world economy. On the other hand, improving the reliability and readiness of energy production systems is becoming a first class priority for research and development institutions around the world. Therefore, the process of production, transport, distribution and usage of energy is increasingly becoming a very important part of smart systems, whose basic framework is Industry 4.0. Thus, starting from the analogies between industrial manufacturing and mining (i.e. "ore production"), the concept of smart mining is developed. This model has three dimensions: (i) application of advanced digital technologies (Cloud Computing and Internet of Things) with automated Cyber-Physical Systems (CPS), Adaptive Manufacturing Processes (depending on working conditions) and Control of Manufacturing Processes (with optimal resource usage); (ii) Smart Maintenance of CPS (for machinery and equipment); and (iii) Smart Supply Chains (procurement of materials and spare parts / delivery of final products). Deeper analyses have shown that most of the Industry 4.0 elements could be applied with some modifications in mining (there are 45 in total, and analyses have shown that 32 of them can be successfully applied in smart mining) – which was the starting point for the ERP model presented in this paper. The developed ERP model has three main parts: a virtual part based on the Cloud Computing model (SaaS model) and us-age of Internet of Things to connect different business processes (procurement, sales, management, finance, warehousing, downtime monitoring etc.), the manufacturing part (coal production in open-pit mine) and the technology process part (monitoring and maintenance of auxiliary machinery). This paper presents the developed and partially implemented ERP model for Industry 4.0 in smart mining at one surface coal mine in the Republic of Serbia.

Keywords: industry 4.0, mining, ERP

ADVANCED PRODUCTION OF ALUMINUM AND STEEL CANS

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Abstract. Production of thin walled products in the shape of aerosol cans presents a booming technology, esp. in the time of pandemics when many disinfectants are urgently needed. Several materials for the aerosol cans be used, however, the chemical means are basically stored in metallic containers made of aluminum alloy or steel. Both these materials can be fully recycled, but the carbon track for steel is four times lower compared to the carbon track for aluminum alloys. Moreover, the tensile strength of steels for such purposes is three times higher, what can result in applications of thinner can walls, lighter products, their higher endurance or a better safety of the products. Back extrusion is typically performed technology with the aluminum can. A pellet is placed in an open top cylinder, and a piston with a diameter smaller than the cylinder, is forced down into the blank. The result is that the product flows back between the space created by the piston and the cylinder. However, this technology can´t be used at steels directly due to its limited plasticity, higher mechanical properties and material hardening so welding and other technologies should be taken into consideration, but new problems like corrosion can be invoked. The paper deals with selected problems of the technologies and highlights their pros and cons in today´s time, when the material resources are limited and demands on efficient material processing are rising due to many factors.

Keywords: thin walls, forming, steel cans, surface integrity, corrosion

FUNCTIONAL CORRELATION SURFACE TEXTURE / GRIP OF A DEPOSIT: CASE OF NIP

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Abstract. This work studies a functional correlation between different texture parameters and the adherence of NiP coating on a metal substrate. Multiple surfaces with different milling feed rate and coated with NiP went through a pulloff adhesion test. This study determined through texture analysis functional correlation between characterization of surface

topographies and the strength measured during the test. In order to study if a multi-scale approach improve the correlation, a "conventional" method based on ISO 25178 procedure and a multiscale method based on wavelet filtering are compared.

Keywords: surface metrology, multiscale, wavelet, surface analysis, coating adhesion, ISO 4287-4288, ISO 25178

BIODEGRADABLE POLYMER PROPERTIES THROUGH CERAMIC COATINGS

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Abstract. Coating of bio-based polymers with ceramic layer has attracted interest recently, the research topic raising difficulties regarding the technology of obtaining layers that involve very high working temperatures. The study aims to analyses the mechanical, tribological and structural characteristics of the Arboblend V2 Nature biodegradable polymer after the deposition of ceramic microlayers. The micro powders used were Amdry 6420 (Cr2O3), Metco 143 (ZrO2 18TiO2 10Y2O3) and Metco 136F (Cr2O3-xSiO2-yTiO2). The coated samples were obtained by injection molding and the deposition was achieved by using Atmospheric Plasma Spray (APS) method. The results of the related analyses showed that, in general, the deposits of ceramic micro particles increased the material surface characteristics (hardness, scratch resistance, apparent friction coefficient), due to the uniformity of the ceramic coating on the polymeric substrate. Based on these, it was possible to recommend the use of coated bio-based polymer - Arboblend V2 Nature in harsh operating conditions, such as the automotive industry.

Keywords: lignin-based polymer, coating, micro powders, wear, adhesion

GETTING STARTED PROCEDURE OF A NC MACHINE SIMPLIFIED BY THE USE OF A MIXED-REALITY TRAINING SCENARIO

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Abstract. To allow increased manufacturing quality and integration in Industry 4.0, machines have become increasingly complex, resulting in increasingly difficult operating procedures and therefore a longer and more expensive operator-training period. Moreover, to be competitive in a global market where competition is sometimes distorted by local aid, European companies must be innovative and flexible. They must therefore be able to count on competent and responsive staff capable of adapting to the various workstations. The initial and continuous training of personnel is therefore a crucial need today. The arrival on the market of AR and VR technologies makes it possible to imagine new training models generally taking into account the technical possibilities, without rethinking the educational scenarios. The work carried out in this study consists of offering novice users a set of educational scenarios and an augmented reality device for handling a 3D printer. A first work carried out on a small group of students tests the autonomy of the users with this new material. A second experiment carried out on 80 first-year engineering school students made it possible to quantify usability using a standardized SUS questionnaire. The results show that the level of usability varies from good to excellent, regardless of whether the user has used a VR headset before. They also validate the transmission of technical skills. To obtain this result, the observed criterion is the effective printing of a part in an autonomous manner. The global work in progress aims at providing relevant training scenarios for the use of machine tools.

Keywords: mixed-reality training, NC machine, technical skills

FEASIBILITY AND PARAMETRICAL STUDY OF AN INCREMENTAL SHEET BENDING PROCESS USING A FINITE ELEMENT MODEL

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Abstract. Metal sheet air-bending is a well-established forming process heavily used in different industrial sectors. It relies basically on a punch and a die with a v-opening that a have a specific depth for each bending angle and radius. Which induces a high-cost tooling,

reduces the process's flexibility and make it suitable only for mass production. For medium or low quantity production more flexible forming processes are needed. In this work we evaluate the feasibility of incremental sheet bending. Where a hemispherical tool follows a trajectory to bend the sheet. Will the bending angle be uniform? How is this uniformity affected by the sheet's width and the trajectory parameters? To answer these questions, we conduct a parametrical study using a finite element model of bending of simply supported sheet and the tool follows a sinusoidal trajectory. We develop a procedure to measure the resulting bending angle and its uniformity. We increase the sheet's width and for each value we change the trajectory's spatial period. We obtain a good uniformity for small spatial periods and it decreases for larger values. We quantify springback variation with these two parameters. These results give a good evaluation of the feasibility of the process, shows the effect of the sheet's width and the trajectory's spatial period on the bending angle and its uniformity. This process is an alternative flexible bending process for low and medium productions. The results help the designer in choosing the right parameters to have a uniform bending angle.

Keywords: incremental sheet bending, air-bending alternative, bending angle control

IN-SITU PREDICTION OF THE SPATIAL SURFACE ROUGHNESS PROFILE DURING SLOT MILLING

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Abstract. Quality inspection is traditionally considered non-productive. That is why the manufacturing industries aim to decrease inspection times to a bare minimum without sacrificing part quality. Alongside the implementation of the Industry 4.0 paradigm, data-driven in-situ quality control is a potential enabler for minimizing inspection times. In that, the surface roughness parameter prediction is the subject of a large body of research, but studies on the spatial surface roughness profile prediction are limited. This research contributes to this field by using vibration signals and physics-informed machine learning models for the in-situ prediction of the surface roughness profile. A tri-axial accelerometer mounted on the machine tool spindle is used to capture the vibrations during a slot milling process. For one tool revolution during a stable cut, the observed acceleration in the three axes and the surface roughness profile are periodic. A model is constructed to establish the correlation between the input signals and the spatial surface roughness profile by utilizing a physics-based model of the tool trajectory together with a two-layer feed-forward neural network. Furthermore, the feature engineering of denoised velocities and displacements derived by the numerical integration of the acceleration signals improves the prediction performance with overfitting. The results show a good correlation between the spatial surface roughness and the accelerometer signals.

Keywords: surface roughness, data-driven modeling, physics-informed machine learning.

AN INVERSE ANALYSIS METHOD APPLIED TO OPTIMIZATION OF SPECIMEN'S SHAPE FOR PERFORMING HOT RAPID CRUSHING TESTS FROM HOMOGENEOUS INITIAL TEMPERATURE FIELD

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Abstract. Specific experimental tests with loadings conditions close to those of industrial fast forming processes as rapid forging, rapid stamping or high speed machining, characterized by large plastic strains, localized deformations and important gradients of strain rates, strain and temperature, requires to analyses material flow behavior at different initial temperatures. One of the more important conditions to obtain intrinsic rheological constitutive equations is to have a quasi-homogenous initial temperature distribution and especially to keep constant the material microstructure during the specimens heating. The rapid induction heating seems to be one of the most reliable processes. This scientific study proposes an inverse analysis technique based on numerical finite element modelling to define on the thermal point of view, optimal specimen shapes for performing hot rapid crushing tests from homogenous initial temperature field.

Keywords: hot SHPB pressing, thermal cooling, FEM, inverse analysis

AN ENERGY APPROACH APPLIED TO DEFINE ELASTO-PLASTIC CONSTITUTIVE MODELS DESCRIBING THERMOMECHANICAL METALLIC MATERIALS BEHAVIOR DURING FORMING PROCESSES

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Abstract. A new formalism for the definition of metallic materials constitutive laws expressing the stress as a function of the plastic deformation energy it is proposed. This new approach, called energy approach, can integrate physical mechanisms governing the microstructure changes during a plastic deformation. It is also important to emphasize that the proposed energy formulation is more relevant since it can describe physical phenomena taking place in a material forming process characterizing at the different scales the material properties evolution. This formulation remains valid for a large field of deformation, the whole spectrum of loading conditions and remains able to predict rigorously the material response for all types of stresses states: static, transient or dynamic.

Keywords: energy approach, differential equation's constitutive models, plastic deformation energy, work hardening and dynamic softening