XV CONVEGNO AITEM

ASSOCIAZIONE ITALIANA
DELLE TECNOLOGIE MANIFATTURIERE

Milano 17-19 gennaio 2022

PROGRAMMA con ABSTRACT

POLITECNICO
MILANO 1863

mecc
DIPARTIMENTO DI ECCELLENZA
MIUR 2018-2022

PROGRAMMA SINTETICO

Lunedì 17/01/2022

09:00 Apertura XV Convegno AITeM

10:50 Pausa Caffè

11:00 Sessione Giovani Ricercatori – Premio "Edoardo Capello"

13:05 Pausa Pranzo

14:00 Sessione Giovani Ricercatori – Premio "Edoardo Capello"

16:05 Pausa Caffè

16:30 Riunione PAA

Martedì 18/01/2022

09:00 Sessione "*Additive Manufacturing*"
09:00 Sessione "*Non-Metallic Materials Processing*"

11:00 Pausa Caffè

11:15 Sessione "*Additive Manufacturing and Quality*"
11:15 Sessione "*Non-Metallic Materials Processing*"

13:15 Pausa Pranzo

14:00 Sessione di Discussione "*Manifatturiero per la mobilità sostenibile*"

15:30 Sessione "*L'AITeM e l'Open Innovation: il progetto OIMAN*"

16:15 Pausa Caffè

16:30 Assemblea AITeM

Mercoledì 19/01/2022

09:00 Sessione "*Advanced Metal Forming and Joining*"
09:00 Sessione "*Work in progress and Laboratories*"

11:30 Pausa Caffè

11:45 Sessione "*Advanced Machining and Processing*"
11:45 Sessione "*Manufacturing Systems*"

13:05 Pausa Pranzo

14:00 Sessione "*Advanced Machining and Processing*"
14:00 Sessione "*Manufacturing Systems and Quality*"

15:30 Sessione Speaker's Corner

16:00 Chiusura XV Convegno AITeM

Lunedì 17/01/2022

Apertura XV Convegno AITeM

Presiede: Bianca Maria Colosimo – Politecnico di Milano

09:00 Saluti di Apertura

Donatella Sciuto – Prorettore Vicario del Politecnico di Milano

Marco Francesco Bocciolone – Direttore del Dipartimento di Meccanica, Politecnico di Milano

Barbara Colombo – Presidente di UCIMU-Sistemi per Produrre e Fondazione UCIMU

Tullio Tolio – Presidente AITeM

09:30 The role of science-tech universities in a knowledge intensive world: Results from Polimi2040 assessment study

Carolina Pacchi e Stefano Ronchi – Politecnico di Milano

In the actual context of knowledge-based economies and societies, universities are assessing their crucial role as driving forces involved in all knowledge-based processes: knowledge transfer through education and life-long learning, and knowledge creation through research and innovation. Starting from the final decades of the 20th century, the knowledge society is more and more often driven by research-intensive and high-technology sectors, reinforcing the role of science-tech universities as crucial actors to contribute to designing the future of a sustainable society, in the face of unprecedented global challenges. This contribution summarizes results of the study carried out by Polimi2040, a team of seven Faculty members established in 2017 with the aim of performing a critical analysis of current trends, identify possible future scenarios to support strategic decision making for science-tech universities in Europe.
The contribution starts from the analysis of past and current trends that have been shaping the current landscape of universities in Europe and beyond, then it depicts possible paths towards the future, along the main dimensions characterizing internal and external strategic areas: education, knowledge creation, entrepreneurial innovation, societal outreach. The future development paths of technical universities are thus discussed as a set of strategic interrelated decisions, which are clearly connected to local economic and societal contexts.

10:10 Advanced manufacturing for space applications: the new frontiers of the space economy

Tommaso Ghidini – Head of ESA's Structures, Mechanisms and Materials Division

Europe has been the cradle of the Industrial Revolution and is hosting a manufacturing infrastructure, which builds its strength on a solid engineering tradition, a prestigious research and development and academic network and a responsive industry (fast adapting to technological developments). However, the role of the manufacturing industry has declined in the recent years with 3.8 million jobs lost in Europe, creating high governmental concern. In some cases, entire industrial sectors have been exported overseas. On the other hand, game changing materials and manufacturing processes are readily available in the current European industrial landscape and ESA's Advanced Manufacturing Cross-Cutting Initiative has the main objective to map them, mature them and spin them in the space business. This will create new industrial capabilities, in terms of design freedom, streamlined and optimized production lead-times and reduced costs, along with enhanced performances of the final product. The opportunity is there to change the way space industry works while also regaining lost manufacturing competences. This shall continue to remain a priority, opening to digitalization. Advances in manufacturing will likely become increasingly networked and manufacturing is expected to advance to new frontiers, resulting in a more and more automated and data-intensive manufacturing sector that will replace traditional production. An advanced workforce will be needed to develop and maintain these innovations, revitalizing and consolidating the European leadership in advanced manufacturing for space applications, with a great return of investment in many non-space large and highly profitable industrial sectors. The present keynote presents an overview of the main achievements obtained in Europe by the Advanced Manufacturing Cross-Cutting Initiative, covering not only the physical but also the digital manufacturing as well as the on-orbit and on-planet production and assembly capabilities.

Lunedì 17/01/2022

Sessione Giovani Ricercatori – Premio "Edoardo Capello"

Presiede: Luigi Carrino – Università di Napoli "Federico II"

11:00 Assessing the effect of a novel production control policy on a two-product, failure-prone manufacturing/distribution scenario

Roberto Rosario Corsini, Sergio Fichera and Antonio Costa

This research deals with a production control policy for an unreliable manufacturing system handling two different types of product. Since the production line cannot produce both product families at the same time, setup operations are required to change the production mode. The decision on product changeover is guided by the production control policy, coping with capacity and inventory shortages due to long setup times and failure events. Usually, the literature adopts the Hedging Corridor Policy, which is optimal in a one-machine two-product reliable manufacturing system for minimizing the total backlog and inventory costs. However, the complexity of the problem increases whenever companies have to satisfy orders with high variability coming from a distribution chain. To address this problem, an analytical model based on discrete time difference equations and an extended experimental analysis have been accomplished to demonstrate the effectiveness of a new production control strategy, named Adaptive Hedging Corridor Policy.

11:25 Systematic repeatability analysis of nanosecond pulsed laser texturing

Gianmarco Lazzini, Adrian Hugh Alexander Lutey and Luca Romoli

The fabrication of specific surface features requires an adequate level of repeatability to be applied in industrial production environments. Although reference is frequently made to repeatability as a strength of many micro-machining techniques, few works in the literature have been dedicated to systematic and quantitative study of this parameter. The purpose of this work was therefore to quantitatively analyze the repeatability of textured surfaces with an original approach. Aluminum alloy substrates were textured with nanosecond laser pulses to produce micro-dimple arrays. Such features are widely employed to enhance wettability and tribological behavior, for which analysis was performed in terms of interfacial area and void volume. To give the work a more general character, two other parameters based on the definition of the Pearson's Correlation Coefficient were also tested and compared to find the most suitable parameter for assessing repeatability for a given application. Finally, a study of the point-to-point repeatability of single surface features was conducted to detect variations in process repeatability in different portions of the same processed area. For the specific laser texturing process considered, it was found that an increase in total energy dose led to improved process repeatability.

11:50 Scheduling remanufacturing activities for the repair of turbine blades: a branch and bound approach to minimize a risk measure

Lei Liu and Marcello Urgo

Refurbished products are gaining importance in many industrial sectors, specifically high-value products whose residual value is relevant and guarantee the economic viability of the remanufacturing at an industrial level, e.g., turbine blades for power generation. In this paper we address the scheduling of re-manufacturing activities for turbine blades. Parts entering the process may have very different wear state or presence of defects. Thus, the repair process is affected by a significant degree of uncertainty.
To cope with this, the proposed approach pursues robust schedules minimizing the risk associated to a timely completion time. An approximate branch and bound algorithm is developed grounding on the estimation of the lower bound of the makespan. The viability and efficiency of the approach is assessed through computational experiments grounding on the industrial case under study and a comparison is operated among alternative scheduling approaches.

12:15 Robust improvement planning of automated multi-stage manufacturing systems

Maria Chiara Magnanini and Tullio Tolio

Automated multi-stage manufacturing systems serve as the backbone of mass industrial production. Increasing the efficiency of these systems represents a key challenge for manufacturing companies, which continuously cope with planning the sequence of optimal improvement actions according to budget and implementation time constraints. Improvement actions related to different areas, as quality, maintenance, logistics, are usually evaluated independently among each other. Recent developments in data gathering support the evaluation of the effect of improvement actions at local level, i.e. single machine, without accounting for the interactions at system-level among machines. This work presents an optimization method for the sequencing of improvement actions in automated multi-stage manufacturing systems. It combines dynamic programming with a stochastic analytical model for the performance evaluation of manufacturing systems. Results from a real industrial case in the furniture sector prove the usefulness of this novel methodology, compared to traditional bottleneck identification and improvement.

12:40 Characterization of the chemical finishing process with a cold acetone bath of ABS parts fabricated by FFF

Leonardo Riva, Antonio Fiorentino and Elisabetta Ceretti

Additive Manufacturing (AM) is going through an impressive growth from 15 years to today. Its main strength is the capability to fabricate complex parts for a wide range of applications. In contrast, its typical layer-by-layer building method can cause a low surface finishing of the parts. Post-processes as chemical treatments can be used to enhance the finishing but few studies are published on the topic.
This work focuses on the surface prost-treating of ABS parts made by FFF. During the treatment, the part is immersed in a cold acetone bath to chemically dissolve and smooth its surface. The process is characterized by varying the duration of treatment, the orientation of the surface with respect to gravity and using samples covering the full range of initial roughness. The results are statistically analyzed showing the robustness of the process. Moreover, the effectiveness of the treatment is proven by an overall reduction of the roughness which is 97% on average within 1 minute of treatment.

Lunedì 17/01/2022

Sessione Giovani Ricercatori – Premio "Edoardo Capello"

Presiede: Quirico Semeraro – Politecnico di Milano

14:00 Comparison between micro machining of additively manufactured and conventionally formed samples of Ti6Al4V alloy

Andrea Abeni, Paola Serena Ginestra and Aldo Attanasio

The paper deals with micro mechanical machining process of Ti6Al4V alloy. A comparison between additively manufactured samples and conventionally fabricated samples with mill annealed structure was performed. Powder Bed Fusion Laser Based (PBF-LB) and Beam Based (PBF-BB) processes were used to produce samples with a building direction of 0° and 30° in relation to the plate. The Minimum Uncut Chip Thickness (MUCT) was determined to investigate the removal behavior during slot machining with rounded-edges micro-tools. The cutting forces were measured, and the loads were utilized to calculate Specific Cutting Force (SCF). It was reported as a function of the feed per tooth (fz) to investigate when the transition between shearing and ploughing occurs. Once the MUCT was identified, further micro machining tests were performed by changing the feed rate and speed rate. The surface roughness and cutting force of the machined samples were measured to deeply investigate the effects of ploughing regime. The dependence of roughness on the sample fabrication technique and on the process parameters of micro milling was highlighted.

14:25 Development of single point exposure strategy to suppress vapour formation during the Laser Powder Bed Fusion of Zinc and its alloys

Leonardo Caprio, Fabio Guaglione and Ali Gökhan Demir

The conventional scanning strategies based on linear trajectories in Laser Powder Bed Fusion (LPBF) are highly limited for processing novel materials. In order to manage the energy input and exploit a higher feature resolution, novel scan strategies are required, capable of exploiting the flexibility enabled by the fast modulation capabilities of contemporary fiber laser sources. Zinc and its alloys are among these challenging materials for LPBF aimed to be used in customized biodegradable implants. LPBF of Zn is notoriously difficult to process due to excessive vaporisation which generates high porosity. Accordingly, in this study an innovative LPBF processing strategy based on Single Point Exposure (SPE) was developed. The control over the energy input via single spot exposure allowed to suppress excessive vapour and spark formation typical to Zn alloys. The dynamics of the novel process and its parameters were investigated employing open LPBF platforms and high-speed imaging. Fully dense struts with diameters lower than 300µm were achieved to produce Zn alloy lattice structures, confirming the effectiveness of the innovative SPE strategy for high precision deposition of challenging materials.

14:50 An experimental-numerical analysis of innovative aluminum foam-based sandwich constructions under compression loads

Antonio Viscusi, Massimo Durante and Antonio Formisano

Recent studies have highlighted the effectiveness of using closed-cells aluminum foams as core of sandwich constructions, making them attractive for industrial applications. In previous studies, the authors proved the possibility of developing innovative sandwiches by using aluminum foams as core and stainless-steel grid as reinforcing skin, through a one-single foaming step and without using any molds. In line with this topic, the present work investigates the possibility of improving the compression strength of these constructions by integrating the same grid, used as skin, inside the core as corrugated skeleton. For this purpose, sandwiches with different geometries were manufactured and characterized mechanically. An original numerical FEM model was developed in support of the experimental campaign to thoroughly investigate the foam/grid interaction, as well as the failure mechanisms, in order to study the effects of the skeleton shape on the compression behavior of the sandwiches.

15:15 Wire arc additive manufacturing monitoring system with optical cameras

Giuseppe Venturini, Francesco Baffa and Gianni Campatelli

Wire Arc Additive Manufacturing (WAAM) is an emerging technology to produce metallic components thanks to its high deposition rate and low cost compared to other technologies. One step to make the WAAM technology reliable is to achieve a stable process control that can avoid collapse of the part during deposition caused by an excessive thermal input that may bring to a collapse of the part. To avoid that, dwells must be introduced in the production phase that slow down the productivity and introduce start-and-stop operations that often are sources of defects. This paper presents an easy-to-use and cost-effective monitoring system for WAAM as a first step to overcome this issue. The proposed technique uses an optical camera to acquire images of the deposited bead that are analysed to determine the condition of the bead itself to control the process. The general idea is to create the data background to support the implementation of a future closed loop control of WAAM, able to keep constant the deposition conditions and make the process stable. An experimental test case is presented to demonstrate that the proposed system is effectively able to monitor the process, extracting significative data form the acquired pictures that can be used to modify the process parameters to keep the deposition stable.

15:40 Reuse of composite prepreg scraps as a sustainable alternative for producing car components

Alessio Vita, Archimede Forcellese and Michela Simoncini

In the present paper, an innovative process for the reuse of carbon fiber prepreg scraps, based on a zero-waste approach, was proposed in order to recovery scraps produced during cutting operations of virgin prepreg rolls. Unfortunately, during the prepreg transformation, about 75% of the materials is discarded due to the inefficiency of the cutting phase. Nevertheless, this prepreg can be reused, in a closed loop system, to produce second life products. In this research, the environmental and economic benefits of implementing a recovery system for prepreg scraps were investigated exploiting Life Cycle Assessment (LCA) and Life Cycle Costing (LCC) techniques. The LCA technique was used to compare the environmental impact of the innovative reclaiming process with the one obtained by the manufacturing process based on the use of virgin prepreg. Typical compression molding process was modeled for both the scenarios and the environmental performances were evaluated exploiting the Cumulative Energy Demand indicators. Moreover, the LCC analysis of the two alternatives was performed for evaluating the economic sustainability of the recycling process.

Martedì 18/01/2022

Sessione “Additive Manufacturing”

Presiede: Barbara Previtali – Politecnico di Milano

09:00 Keyhole prediction in selective laser melting

Emanuele Vaglio, Giovanni Totis and Marco Sortino

Selective Laser Melting can provide high quality products only if critical operating conditions such as balling, preballing and keyhole are avoided. To this aim, optimal material-specific process parameters should be identified, and this usually requires a considerable effort. Indeed, accurate analytical models enabling to effectively predict process instabilities have not yet been developed, forcing to resort to expensive and complex empirical or numerical methods.

In this work a physics-based semi-analytical method aimed at predicting the formation of keyhole-related porosity was developed. The theory was tested by processing Ti6Al4V single tracks according to a full factorial DoE involving laser power and scanning speed. Produced samples were cross-sectioned and analyzed by light microscope to evaluate porosity formation. Results proved the effectiveness of the developed method and an improvement in the achievable accuracy compared to other analytical models.

09:20 Additive manufacturing of nanocomposite parts by nano-coating fragmentation

Leandro Iorio, Alice Proietti, Daniele Santoro, Fabrizio Quadrini, Loredana Santo and Denise Bellisario

Nano-coating fragmentation is an innovative technique for nanocomposite molding which is able to manufacture functional parts with very small amounts of nano-fillers. The idea is coating polymer pellets by nano-films of the filler substance before their use in injection molding or extrusion. Shear forces by the plastification screw break the continuity of the nano-film which is diffused into the polymer matrix in the shape of nano-platelets. This technology was already validated for PP injection molding and it has been evaluated in this study also for additive manufacturing. For this aim, ABS and PLA wires for fused deposition modeling has been coated by physical vapor deposition with a thin silver film. The thickness of the Ag coating ranged between 130 nm and 470 nm for a nominal filler content between 0.07% and 0.3%. The coated wire has been used to produce dog-bone samples (ASTM D-638) for tensile testing with fused deposition modeling (FDM) process. Microscopic observations were used to evaluate filler presence on composite surface. A small increase of the tensile strength (about 5-8%) was measured. The film fragmentation is not optimal as in the case of injection molding, but it is sufficient to have a local distribution of the functional filler. The filler had a detectable influence on the ABS glass transition temperature and on the melting heat of PLA. Therefore, a first confirmation about the effect of the Ag particles interaction with the polymer mobility has been found. Consequently, this study is a first confirmation about the presence of the micro-filler platelets into the polymeric matrix due only to the fragmentation caused by passing through the extrusion head of the FDM process.

09:40 Ageing of PA12 powder in selective laser sintering

Achille Gazzerro, Wilma Polini and Luca Sorrentino

Selective laser sintering is an additive manufacturing technology widely used thanks to its high print resolution and its ability to obtain microscale geometries without any additional support. However, despite the many advantages of SLS, there are still today some limitations connected with the materials to be printed. A limit critical from an industrial point of view is the aging of PA12 powder, that is the degradation of its physical and chemical performances, due to the high temperatures and the long printing cycles, of the powder that is not directly sintered into the final part, but that supports the part under construction. This powder is lately used to manufacture another part to reduce manufacturing costs. The reused powder involves a decrease in the mechanical properties of the printed parts. The present work aims to characterize the powder aging through experimental tests, that involve Differential Scanning Calorimetry, Dynamic Mechanical Analysis, and Thermogravimetric Analysis, to define the physical and chemical parameters of the powder to be used inside a simulation software to optimize the process.

10:00 Fuzzy logic for process optimization: a case study for metal additive manufacturing

Gennaro Salvatore Ponticelli, Simone Venettacci, Flaviana Tagliaferri, Oliviero Giannini and Stefano Guarino

Making decisions and deducing control actions in manufacturing environments require considering many uncertainties. The inherent attitude of fuzzy logic to incorporate imperfect information into a decision model has made it suitable for manufacturing optimization purposes, i.e. for the evaluation of the optimal processing window in order to meet the productivity and the final quality requirements. In metal additive manufacturing, in fact, these aspects are governed by a complex interaction of many process parameters, ranging from those connected with the energy source, to those concerning the properties of the processed material. The proposed fuzzy-based decision approach overcomes this difficulty by taking into account both the random error associated with the process variability and the systematic error due to the inability to describe accurately the physics of the process and propagating such sources of uncertainties at the input level to the output one.

10:20 On the effect of building direction on microstructural heterogeneity evolution and mechanical performances during selective laser melting of Ti6Al4V titanium alloy

Rosa Di Lorenzo, Livan Fratini, Gianluca Buffa, Dina Palmeri, Davide Emmolo and Gaetano Pollara

During the last few years, additive manufacturing has been more and more extensively used by several industries, especially in the aerospace and medical device fields, to produce Ti6Al4V titanium alloy parts. During the Selective Laser Melting (SLM) process, the heterogeneity of finished product is strictly connected to the scan strategies and the building direction. An optimal managing of the latter parameters allows to better control and define the final mechanical and metallurgical properties of parts. Acting on the building direction it is also possible to optimize the critical support structure. To study the effects of build direction on microstructure heterogeneity evolution and mechanical performances of selective laser melted Ti6Al4V parts, two build direction samples (0° - 90°) were manufactured and analyzed using optical metallographic microscope (OM). The influencing factors for the heterogeneity in the microstructure, as grain morphology, defects, phase transformation, and
microstructural coarsening were investigated by isometric microstructure reconstruction in the three orthogonal planes for each sample. The correlation between mechanical performances of the SLM samples and microstructure was investigated by microhardness tests. The obtained results indicate that the build direction has to be considered a key geometrical parameter affecting the overall quality of the obtained products.

10:40 Process parameters influence on structural performances of SLM and EBM lattice structures

Teresa Primo, Alessia Begher and Antonio Del Prete

Additive manufacturing (AM) is an enabling technology that allows the production of highly complex shapes and lightweight design, such as lattice structures, that cannot be built using conventional manufacturing process. This paper presents an analysis of process parameters influence on structural performances of lattice structures obtainable by Selective Laser Melting (SLM) and Electron Beam Melting (EBM). A census of different properly designed lattice structures, depending on cell type, cell size and beam diameter, using the nTopology Platform has been proposed. In particular, for SLM and EBM technology numerical simulations have been carried out with AlSi10Mg and Ti6Al4V respectively. The stiffness / weight ratio for the two different materials has been compared. Through the Design Of Experiments (DOE) the sensitivity of considered response to evaluated factors was investigated, in order to select the number of samples to be printed for future compression tests.

Martedì 18/01/2022

Sessione "Non-Metallic Materials Processing"

Presiede: Pierpaolo Carlone – Università di Salerno

09:00 A combined numerical and experimental methodology for improving the thermoforming process of thermoplastic composite parts

Antonios Stamopoulos and Antoniomaria Di Ilio

Among the existing fabrication processes of thermoplastic composite parts, thermoforming appears to be very promising, especially since it can be implemented in a production line quite easily, making the production of these components sustainable and cost effective. Nevertheless, there have been reported some series of defects (wrinkles, residual stresses, textile shear deformation), introduced while these parts are being thermoformed, that are affecting the final product both structurally and aesthetically. These defects are strongly related to the process parameters as well as to the geometry of stamping tools and the component itself. In the present work, presented is an extensive numerical simulation, based on experimental data, of the thermoforming process applied to several types of automotive composite components. The results indicate a strong dependency of the quality of the produced part on the process parameters such as the temperature and the geometry of the stamping tools while, in parallel, a strategy is presented for optimizing the dies and, consequently, the quality of the produced component.

09:20 Mechanical performances of orbital riveted composite/aluminum joints for marine applications

Tiziana Alderucci, Chiara Borsellino and Guido Di Bella

In an innovative vision of manufacturing, orbital riveting is a joining technique characterized by high efficiency, energy saving, low cost and low noise. It is a cold forming process where a tool rotates at a fixed angle (i.e. typically 3° to 6°) to create a sweeping line of pressure around a rivet. This movement progressively promotes, with each rotation, the collapse of the rivet shank down onto the upper substrate of a joint, permanently forming a rivet head.

The aim of this research, funded by the Italian Ministry of University and Research on the National Operational Programme "Research and Innovation" 2014-2020 as part of the THALASSA project, is to make and test hybrid joints between a glass fiber reinforced composite and an aluminum AA5083 H111. In particular, nine configurations of single lap joints were studied by investigating the effect of the thickness (2.5, 3.0 and 4.0 mm for the aluminum and 2.5, 3.0 and 4.0 mm for the composite laminate) both on the mechanical characteristics and on the failure modes.

09:40 Replication of sub-micrometric surface features on large polymeric components with laser-textured molds

Adrian H.A. Lutey, Gianmarco Lazzini, Francesco Fuso and Luca Romoli

Injection-molded polypropylene specimens have been produced with laser-textured molds characterized by sub-micrometric ridge, hole and cone arrays with the aim of producing antibacterial surfaces. Replication effectiveness was evaluated in terms of surface roughness parameters and the Power Spectral Density (PSD), after which detailed comparison of topography in the same region on plastic samples and molds was performed. Greatest replication effectiveness was observed with ridges parallel to the injection direction, where the arithmetic mean height of plastic samples was 97% of the corresponding value of the mold. Replication of ridge arrays was then performed on 570 mm × 280 mm surfaces to demonstrate process feasibility in an industrial setting. The investigation demonstrated that micro and nanoscale morphology can effectively be transferred via injection molding over large areas relevant to industrial applications.

10:00 Drilling process analysis of Al/GFRP hybrid laminates

Gianluca Parodo, Luca Sorrentino and Sandro Turchetta

Mechanical fastening is widely used for assembly components in polymeric composite materials. However, the drilling of FRP parts to be assembled represents a critical step. In fact, the abrasive nature of the reinforcement combined with the low thermal conductivity of matrix can generate delaminations and thermal damages into the machined part. These aspects become more important in case cutting in dry conditions and for hybrid laminate like the fibre metal laminates (FML). An analysis of the temperature and optimization of cutting parameters during the drilling process can avoid these phenomena. The purpose of this work is to monitor the cutting force and temperature measured on the tool and workpiece during dry drilling of AL/GFRP hybrid laminates. In particular, the trend of the thrust force and temperature according to the main process parameters have been analysed. Moreover, a first numerical model for analyse the process temperature trend during drilling has been developed.

10:20 Resin flow enhancement by microwave preheating in resin infusion processes

Felice Rubino, Fausto Tucci, Vitantonio Esperto, Massimo Durante and Pierpaolo Carlone

The impregnation of dry preforms is one of the key steps to manufacture sound components by liquid composite molding. The resin flow is mainly influenced by pressure gradient, geometrical features of the reinforcement, and resin viscosity. The first parameters are dictated by the requirements of the component and other constraints; therefore, they are hardly modifiable during the process. Conversely, the resin viscosity can be controlled to a certain extent. Resin preheating increases its fluency, thus enhancing the impregnation and saturation flow,

reducing the mold filling time. In the present work, a microwave heating system has been integrated within a vacuum bag resin infusion process, to analyze the effect of the online preheating on the fiber impregnation. An appositely designed dielectric sensor system is used to monitor the resin flow. Results from resin infusion tests conducted with and without the resin pre-heating were compared: the outcomes indicated an advance of approximately 190 s of the flow front when microwave heating is applied with respect to the unheated tests.

10:40 Flow-induced crystallization of PET in injection molding

Leonardo Piccolo, Marco Sorgato and Giovanni Lucchetta

In injection molding, during the filling phase, the polymer in contact with the wall solidifies developing the so-called skin layer. Although the skin layer formation mechanism can be interpreted by exploiting the no-flow temperature for amorphous polymers, there is still a low understanding of what happens for the semi-crystalline. In fact, for these polymers, the high shear stresses combined with the thermal gradient at the polymer-mold interface, cause the so-called flow-induced crystallization. This work aims to experimentally investigate the flow-induced crystallization at the typical non-isothermal shearing flow conditions of the injection molding process. The thermal and mechanical boundary conditions at the polymer-wall interface are varied using insulating coatings and different injection speeds and mold setups. The results show that the insulating mold coating succeeds in delaying the skin crystallization during mold filling, leading to a lower pressure gradient inside the cavity.

Martedì 18/01/2022
Sessione "Additive Manufacturing and Quality"
Presiede: Enrico Savio – Università di Padova

11:15 Quality and sustainability benchmarking of decentralized additive manufacturing processes

Domenico Maisano, Elisa Verna, Paolo Minetola, Vincenzo Lunetto and Paolo Priarone

Current trends show that companies are increasingly adopting decentralized-manufacturing strategies. Additive manufacturing is one of the technologies that allow for enhanced production flexibility and customization, without significantly increasing per-unit cost. In this context, a company often has to manage multiple geographically scattered manufacturing centers, characterized by similar equipment and working methods, performing similar productions, although with variable mix and volumes. Hence, there is the need to (i) monitor the absolute performance of individual centers in a structured way and (ii) make practical comparisons between "competing" centers. This article analyzes the suitability of each manufacturing center from two viewpoints: (i) the quality of the products, intended as compliance with the geometric specifications, and (ii) the sustainability of the production, in terms of energy consumption and manufacturing time. While quality is assessed through a multivariate statistical analysis of data concerning several geometric features, sustainability is assessed through linear regression models concerning energy and time consumption data. The proposed methodology can be adopted during regular production, without requiring the execution of ad hoc experimental tests. The description is supported by a real-world case study.

11:35 Preliminary application of convolutional neural network to the classification of metallurgical defects in AM parts

Alberto Boschetto, Luana Bottini, Luciano Macera, Somayeh Vatanparast and Francesco Veniali

The Selective Laser Melting (SLM) is an additive manufacturing technology able to directly produce full density metal part from a digital model. The geometrical degree of freedom allows fabricating part shape which is difficult or impossible to produce by traditional methods. However, the process limitations imply some compromises on surface finishing and metallurgical defects. The process parameters optimization requires a metallographic analysis which is a work usually carried out by human operators and the goodness of the results is linked to their experience and level of attention. This study presents a convolutional neural network (CNN) based approach for the classification of metallurgical defects to obtain a reliable and robust identification system. It tries reproducing the skilled ability of the operator to selectively find defects within metallographic photos characterized by a variety of information related to the microstructure.

11:55 Monitoring of powder bed through digital image processing in selective laser melting

Alberto Boschetto, Luana Bottini, Luciano Macera, Somayeh Vatanparast and Francesco Veniali

Selective Laser Melting is an Additive Manufacturing technology that allows fabricating end-use metal parts with complex geometry. The process requires the formation of a powder bed before the laser consolidation: this operation is affected by several factors which are critical to control and many flaws can occur. As a consequence, the final parts show poor quality and internal defects which are difficult and expensive to find. This work proposes a new methodology to layerwise control the powder bed development based on digital image processing. No alteration of the original system is necessary since the method is based on the system built-in camera which is calibrated through a design for the purpose procedure. Photos of each layer are analyzed by the combined use of different morphological operators which allow generating a hierarchical data of the internal defects.

12:15 Big data handling and dimensionality reduction for in-situ process monitoring in additive manufacturing

Bianca Maria Colosimo, Marco Grasso and Luca Pagani

In-situ sensing and monitoring in metal Additive Manufacturing (AM) has attracted a wide interest in the literature and a continuously increasing adoption in industry to support part and process qualification. Despite the several advantages enabled by a quick and in-line detection of errors and anomalies, various challenges still have to be faced. One of them regards the capability of making sense, through automated and real-time algorithms, of actual "big data" acquired on a layer-by-layer basis, where the term "big" refers to the volume of data, but also to their sampling frequency and variety. Indeed, high spatial and/or temporal resolution image and video image data are needed to capture the complex physical phenomena involved in the process and to characterize local and transient anomalies that may indicate the presence of defects in the part. This imposes the need for novel methods suitable to extract the relevant information content from big and fast data streams in an efficient and effective way. This study investigates the use of the Ripley's K-function as a tool for dimensionality reduction of video image data acquired in Laser Powder Bed Fusion (L-PBF). The aim is to synthesize the spatial pattern of process by-products in L-PBF by passing from a high-speed stream of 2-D images to a data representation in the form of 1-D curves. K-functions are here proposed to describe the spatial spread of spatters generated by the laser-material interaction, and to analyze the influence of process parameters on the spatter behavior. Indeed, spatters can be used as driver of information about the process stability but also the quality of the manufactured part. A real case study is presented to demonstrate the effectiveness of the proposed approach in identifying how the spatter behavior is affected by process parameters and linked to the final quality of the part.

12:35 Accuracy of X-ray computed tomography dimensional measurements of additively manufactured metal lattice structures

Filippo Zanini, Marco Sorgato, Enrico Savio and Simone Carmignato

Metal additive manufacturing (AM) technologies are capable of producing highly complex and customizable lattice structures with advantageous strength-to-weight properties, which are of growing interest in several industrial sectors, including aerospace and biomedical. However, the geometrical and dimensional quality of AM lattice structures – which often needs improvements to meet specific industrial requirements – needs to be assessed by adequate measurement techniques. Differently from conventional contact and optical coordinate metrology, X-ray computed tomography (CT) enables non-destructive measurements of both external and difficult-to-access struts, as well as of internal defects and features. The accuracy of CT measurements – fundamental to effectively improve the AM process – is investigated in this work using a metrological CT system to scan Ti6Al4V lattice structures fabricated by laser powder bed fusion. In particular, methods for the determination of measurement errors and uncertainty are studied, with the aid of a new reference object specifically designed and produced for the purpose.

Martedì 18/01/2022

Sessione "Non-Metallic Materials Processing"

Presiede: Vincenzo Tagliaferri – Università di Roma "Tor Vergata"

11:15 Influence of fabric areal weight on the mechanical properties of composite laminates in carbon fiber reinforced polymers

Archimede Forcellese, Michela Simoncini, Luciano Greco, Tommaso Mancia, Massimiliano Pieralisi, Serena Gentili, Alessio Vita, Vincenzo Castorani and Alessia Nardinocchi

The present work aims at studying the effect of the reinforcing fabric areal weight on the mechanical properties of composite laminates in carbon fiber reinforced polymers. Two different pre-impregnated 2x2 twill weaves, characterized by different areal weight values of 380 g/m2 and 630 g/m2 respectively, were used to produce laminates by means of the hand lay-up technique followed by an autoclave cycle curing. The final thickness of the laminates was obtained by laying-up a different ply number, employed as a function of the areal weight of each fabric. Uniaxial tensile and in-plane shear response tests were performed on samples obtained from laminates after curing. It was demonstrated that the fabric areal weight affects the mechanical performances of the composite laminates; specifically, the decrease in the areal weight of the twill weave leads to an increase in tensile strength, elastic modulus, and in-plane shear stress.

11:35 Polyamide 6,6 self-reinforced composites

Ilaria Papa, Antonio Langella, Valentina Lopresto and Pietro Russo

In the last decades, a new class of polymer composites has attracted the research activities' attention for the development of new materials with potentials in many industrial fields. The concept using oriented polyethylene filaments and polyethylene powder with different melting points, gives rise to so-called self reinforced polymer composites (SRPCs). These materials' success is mainly based on the fact that their main constituents, matrix and reinforcement, are composed of the same polymer or constituted by the same polymer and, consequently, ensure, among other, perfect adhesion at the interface as well as recyclability. In this work, self reinforced laminated samples based on a high performance and high tenacity technical fabric, 100% polyamide 6.6, were manufactured by hot-compaction technique and compared with plaques based on commercial polyamide 6,6, neat and filled with 30 wt% of glass fibres, taken as the

reference materials. Preliminary calorimetric and morphological analyses highlighted influences of processing conditions on the ultimate performances of the investigated systems.

11:55 Structural adhesive bonding of continuous-carbon-fibre composites made via additive manufacturing

Marco Pizzorni, Enrico Lertora, Chiara Mandolfino, Mirko Prato and Alberto Parmiggiani

Lately, additive manufacturing technologies have seen an ongoing development to face the wide diffusion of the use of composite materials in several industrial fields. Indeed, the fabrication of continuous-fibre reinforced polymer parts via 3D-printing has been recognised as a promising method to practically combine the advantages of composite materials with the simplicity of such a manufacturing technology. However, the latter is still at an embryonic stage, and many aspects related to process control or performance and applicability of products have not been fully investigated. One of these aspects is related to the small size of printers which, limiting the dimension of the built components, implies design criteria based on a 'building-block' approach. It follows that assembly via adhesive bonding becomes an inherent part of the fabrication process. In this experimental work, the mechanical performance is critically evaluated of adhesive bonded joints made of a continuous carbon-fibre composite built via Fused Filament Fabrication technology. Notably, attention is paid to the influence of the base-material non-homogeneity on the response of adhesive joints for structural applications.

12:15 A response surface designed experiment to improve adhesive bonding in pulsed laser surface treatment of CFRP composites

Chiara Mandolfino, Lucia Cassettari, Enrico Lertora, Marco Pizzorni and Stefano Saccaro

In this work, a response surface designed experiment approach was used to determine the optimal settings of laser treatment as a method of surface preparation for CFRP prior to bonding. A source of Ytterbium-doped fiber laser was used in combination with a scanning system. Two Central Composite Designs were used to model the tensile shear strength (TSS) of adhesive bonded joints and to investigate the effects of varying three parameters, namely, power, pitch and lateral overlap. The analysis was carried out considering different focal distances. For each set of joints, shear strength values were modeled using Response Surface Methodology (RSM), in order to identify the set-up parameters that gave the best performance, considering any equivalent conditions from a statistical point of view. A regression model was also generated in order to predict the behavior of the joints for not experimentally tested parameter settings. This aspect is particularly important in consideration of process optimization of the manufacturing cycle; indeed, it allows the maximization of the joint efficiency by limiting the energy cost for treatment.

12:35 Injection molding of compostable coffee capsule: criticality of the manufacturing process

Massimiliano Barletta, Clizia Aversa, Annamaria Gisario and Francesco Veniali

The present work deals with the critical aspects of the manufacturing by injection molding of bioplastic capsules. Bioplastics often display difficult processability in the injection molding process due to inadequate viscosity, in particular during the injection phase of the molten polymer and during the ejection phase of the molded item. Moreover, many capsules made with commercially available bioplastics do not fulfill functional requirements such us leakage tightness and thermal resistance. In order to overcome these issues, some formulations of compostable bioplastic material are studied which differ mainly in the molecular weight of the polymeric grades and in the mineral phase content. These formulations were initially processed using the reactive extrusion technique with a co- rotating twin-screw extruder. Subsequently, the compounds thus obtained were reprocessed by injection molding in a 32-cavity mold, to obtain prototype capsules with a low environmental footprint. The compounds were tested for main thermo-mechanical and physical properties. The capsules were, instead, tested through functionality tests in Essenza Mini instant machine for the coffee brewing. The experimental results showed that it is possible to improve the manufacturing process for injection molding by working on the characteristics of the formulation of compostable bioplastic materials. Furthermore, it emerged that the parameters controlling the prototype quality are the viscosity of the bioplastic compound (in particular, the Melt Flow Index (MFI)) and the mineral content. The capsules produced through an optimized molding process also show excellent thermal resistance during the extraction phase. These capsules also guarantee the best performance during the brewing phase of the infusion in the machine, guaranteeing excellent tightness and the almost total absence of leaks.

12:55 Design and manufacturing of disposable tablewares in home compostable bioplastics

Massimiliano Barletta, Clizia Aversa, Annamaria Gisario, Silvia Vesco and Giulia Cappiello

The disposal of plastic containers suitable for hot food is a challenge for the recycling and waste chain, as these items require post-use washing to be recycled. The most beneficial solution would be to design a single compostable material for home composting, which would allow the container or dish to be disposed of in the organic fraction without being prewashed of food residues. Unlike traditional petroleum-based polymers, which are often used in this type of application, compostable materials are known to have poorer mechanical properties. This characteristic does not allow the material to withstand loads applied at temperatures of 70-85 °C. The aim of this paper is to realize and engineer new formulations that manage to combine the home-compost characteristic of the materials used with good thermo-mechanical resistance, even at temperatures higher than 70°C.In this study, two PLA-based formulations were compounded by co-rotating twin-screw extruder with polybutylene succinate adipate (PBSA) and polycaprolactone (PCL), respectively. The selected materials are home compost certified and have characteristics that match the demands of food packaging. Compatibilising agents were added to the blends to promote better dispersion and distribution and to achieve better mechanical and thermal behaviour. The blends were then reprocessed by melt extrusion and finally by thermoforming moulding. This resulted in a final product that is easy to process, easy to compost and has high market potential in the food industry. The produced articles were characterized through thermo-chemical and functional tests.

Martedì 18/01/2022

Sessione di Discussione "*Manifatturiero per la mobilità sostenibile*"

Presiede: Andrea Matta – Politecnico di Milano

Modera: Mariangela Pira – Sky Italia

14:00 Enio GRITTI, Componente Consiglio di Amministrazione, Officine Meccaniche Rezzatesi

Mattia ANDOLFATTO, Responsabile R&D, Divisione Tecnologie Manifatturiere – Costruzione Impianti per la Produzione di Componenti, Cannon

Mauro MOLLO, Industrial Strategies Powertrain, Stellantis

Gian Carlo TRONZANO, Head of E-Motor and Battery Cell Global Competence Centers, Comau

Martedì 18/01/2022

Sessione "*L'AITeM e l'Open Innovation: il progetto OIMAN*"

Presiede: Luigino Filice – Università della Calabria

15:30 Giuseppe SARAGÒ, Director Manufacturing Excellence, Wartsila

Maria Francesca MARINO, Vibo Valentia Plant Leader, Baker Hughes

Beatrice MAESTRI, Open Innovation Manager, Electrolux Group

Mauro VISCARDI, Project & Innovation Manager, Cosberg

Mercoledì 19/01/2022

Sessione "Advanced Metal Forming and Joining"

Presiede: Antonino Squillace – Università di Napoli "Federico II"

09:00 Ultrafine grained AA6082 tubes by backward tube flowforming

Tommaso Magro, Andrea Ghiotti, Enrico Simonetto and Stefania Bruschi

Several innovative applications in the automotive, biomedical, or aerospace sectors have tailored-designed properties as their prerogative. These requires not only customized mechanical properties over the components, but also enhanced fatigue-life and corrosion resistance behavior. In this work, the formation of tailored AA6082 tubes processed via backward tube flowforming was investigated. Different amount of deformation have been applied, changing the process parameters, to study the evolution of the microstructure and the mechanical properties. The results show how the process may open new possibilities to manufacture components characterized by a controlled microstructure.

09:20 Virtual shape and process optimization of nitrogen cooling in extrusion industry

Riccardo Pelaccia, Marco Negozio, Lorenzo Donati, Barbara Reggiani and Luca Tomesani

Cooling of the die with liquid nitrogen is an efficient solution to limit the temperature developed during the process allowing increasing the productivity while preserving the profile quality and/or die life. However, many parameters are involved in the setting-up of an efficient system that necessary demand for the use of numerical models and comprehensive methodologies to be properly managed. In this context, a 3D FE model of the extrusion process, coupled with a 1D model of the cooling channel, previously proposed by the authors, has been validated against an industrial complex-shaped AA6060
profile. In addition, to further reduce the required computational time, an equivalent thermal model of the die was successfully developed. The FE model has been then integrated in an optimization platform in order to iteratively, and automatically, adjusts the channel geometry and the process variables gaining to a final optimal solution in terms of thermal balance, cooling efficiency and nitrogen consumption.

09:40 Single point incremental forming assisted by magnetic field: a preliminary study

Marco Gucciardi and Gianluca Buffa

The Single Point Incremental Forming (SPIF) allows to overcome material formability threshold in sheet metal manufacturing through a localized deformation approach. One geometrical limitation in SPIF can be attributed to the pin tool mounted on spindle, which represents a physical interference in terms of attainable shapes with the conventional process, especially in vertical direction. The aim of the following work is to increase the variety of achievable geometries with SPIF through in-process magnetic field assistance and to test its feasibility. A new configuration controlling SPIF tool movement using magnetic force is introduced. Speaking of which, a suited configuration of magnets was designed to produce a vertical load able to plastically deform a 0.5 mm thick AA1100 aluminum sheet. Experiments were carried out to prove the concept by manufacturing a truncated cone, then comparing the new procedure with traditional one; the results established the feasibility of this new configuration.

10:00 Understanding formability and accuracy performance of SPIF based reshaping strategy

Omer Zaheer and Giuseppe Ingarao

Putting in place Circular Economy strategies is an urgent action to be undertaken. Manufacturing processes play a relevant role as efficient material reuse enablers. Scientists have to make an effort either to find new processes or to rethink old ones to reprocess End-of-life (EoL) components to recover both material and functions. In this paper Single Point Incremental Forming (SPIF) process is used for Reshaping sheet metal EoL components. The authors have already proved the technical feasibility of such an approach, some aspects still need to be studied, though. In this paper two main issues are discussed: 1/the possible change in formability performances of SPIF when used as Reshaping process and 2/the effect of uniaxial pre-straining on the accuracy of the reshaped component. Specifically, an experimental campaign is developed with different pre-straining levels. Maximum forming angle as well as 3D shape acquisitions of the reshaped components were also developed.

10:20 Modification of the thickness distribution through the laser heat pre-treatment of Mg superplastically formed sheets

Pasquale Guglielmi, Angela Cusanno, Donato Sorgente and Gianfranco Palumbo

The growing need for high-performance components in terms of shape and mechanical properties encourages the adoption of integrated manufacturing methods. In this regard, the present work aims at evaluating the manufacturing of components via superplastic forming using a Mg AZ31B alloy sheet locally pretreated by a laser beam. Different durations and temperatures for the pretreatment were investigated. The preheated sheet was deformed into a closed die at 450°C with an appropriate gas pressure profile. The experimental conditions were numerically reproduced in a Finite Element model. A material constitutive equation, capable to predict the microstructural evolution, was implemented. Thickness distribution and grain evolution were considered to evaluate the effectiveness of

the proposed approach. Results showed the capability of the preliminary laser treatment to locally modify the microstructure and to effectively affect the characteristics of the formed part.

10:40 The effect of the heat generated during friction stir welding process on different aluminum alloys

Sara Bocchi, Mariangela Quarto, Gianluca D'Urso, Claudio Giardini and Giancarlo Maccarini

Aim of this paper is the study of the effect of the heat generated, in both temporal and spatial terms, during the friction stir welding process on precipitation-hardening and work-hardening alloys. In order to analyze the thermal distribution within the joints, the temperatures reached during the traditional air-cooled process and with an external water-cooling system were measured at the nugget, the thermo-mechanically affected zone and the heat affected zone. After performing tensile and Rockwell tests, a clear dependence of the thermal gradient on all the mechanical properties of the joints was observed. In particular, it was noticed that the change in the water-cooled joints properties of the precipitation-hardening alloys depends on both the distribution of the hardening precipitates and the grains size. Moreover, a virtual model was set up to predict the temperatures reached locally by the joint and consequently the overall mechanical properties.

11:00 On the role of specific thermal contribution in friction stir welding of different morphological configuration joints

Davide Campanella, Giulia Marcon and Francesco Giunta

Friction Stir Welding (FSW) is a solid-state welding process, developed initially for welding aluminum alloys. In this process, joints are formed using the heat generated by friction between the tool and the workpiece. The amount of heat conducted into the workpiece determines the quality of the weld. In the present paper, the authors report the results of an experimental campaign, developed on FSW of AA2024 aluminum alloy, aimed at the investigation of the possibility to enhance the joint performances through two different configurations, Lap and Butt joints. The joints are characterized by an increasing Specific Thermal Contribution (STC) imparted to the weld. Both mechanical and metallurgical investigations were developed on the welded joints highlighting improvements of mechanical performances of the joints.

Mercoledì 19/01/2022

Sessione "Work in progress and Laboratories"

Presiede: Fabrizio Micari – Università di Palermo

09:00 Machine learning applications for process optimization in laser manufacturing and grinding

Antonio Candido, Alessandro Fortunato and Luca Tomesani

In recent years, Machine Learning (ML) has gained increasing attention in mechanical processing as laser hardening, grinding and additive manufacturing (AM) due to its unprecedented performance in data tasks such as classification, regression, and clustering. This paper provides a comprehensive review on ML applications (neural networks, support vector machine, regression trees) in activities of University of Bologna technology research group in order to develop a fast and accurate process simulator. In laser hardening, ML can be leveraged for laser process variables prediction according to the desired hardness and extension of the treated area (depth and width). In grinding processing, ML algorithm is proposed to predict the specific cutting forces and it can be useful for optimizing process parameters in quality control manufactured parts. In AM processing, ML algorithms can help to optimize process parameters, automatically detect faults, and conduct examination of powder.

09:15 Precision laser welding of Li-ion battery cells for custom battery module production

Matteo Moroni, Leonardo Caprio, Ali Gökhan Demir and Barbara Previtali

Laser welding has several applications in electric vehicle manufacturing as a digital, non-contact tool. One of the critical joining processes is the welding of connector plates to the battery cells, where remote laser welding with a scanner provides ease of accessibility to the weld region, flexible weld trajectories manipulation, and reduced downtime between weld seams. Such features are highly desirable for custom-built Li-ion battery modules as well as small series productions found in motorsports. However, the welding configuration is characterized by several issues concerning the very limited thicknesses of the connector (0.3 mm) and the battery casing (0.25 mm) made of different materials, gap formation, and maintaining contact in highly deformable foils. The process requires high precision in penetration depth to avoid the lack of adherence (<0.3 mm) and excessive penetration (>0.55 mm) leading to the puncture of the cell. Hence, this work describes the initial studies on the remote laser welding of battery cells, highlighting system configuration, process parameter selection, and fixture design.

09:30 BIONIC: Surface functionalization to improve triBo-corrosIOn performaNces of metal Implants through advanCed machining operations

Rachele Bertolini, Maria Rosaria Saffioti, Stefania Bruschi, Andrea Ghiotti and Domenico Umbrello

BIONIC project is an ongoing research activity, funded by the Italian Ministry for research, which aims at manufacturing permanent and bioabsorbable prostheses, characterized by high performances and reliability in terms of corrosion and wear resistance. Innovative processes, based on advanced finishing machining operations are being applied on titanium and magnesium alloys to investigate how these techniques lead to improve the surface integrity and the mechanical behaviour. Among others, two main activities are taking place, with the common objective to pursue implants with enhanced characteristics: (i) machining and burnishing operations using MQL lubri-cooling conditions to functionalize surfaces of titanium alloys for permanent prostheses; (ii) Large Strain Extrusion Machining (LSEM) to increase magnesium alloys surface integrity and corrosion resistance for bioabsorbable prostheses.

09:45 Production of hemp/carbon hybrid composites in both sandwich and laminate configuration

Luca Boccarusso, Massimo Durante, Antonio Langella and Fabrizio Memola Capece Minutolo

It is a well-known challenge that the new generation of composites have to minimize the environmental impact with a more efficient use of energy resources, materials and waste management. To employ new technologies with less impact on the environment and, where possible, replace synthetic or petroleum materials with more sustainable components is the aim of several academic and industrial research projects. According to this research line, carbon/vegetable fibre hybrid composites can have some role especially for the possible combination of properties since vegetable fibre composites might allow different mechanisms of damage propagation and energy dissipation and possibly even have some mitigating effect on the inherent brittleness (limited toughness) of carbon fibre composites. It was pointed out from the authors that the use of hemp fabrics coupled with carbon ones represents an interesting challenge for the production of both hybrid laminates and sandwich structures requiring different manufacturing techniques and starting materials. In this paper the authors would focus the attention on some in-progress works aimed on the possibility to produce hemp/carbon hybrid composites overcoming what the literature offers in order to further extend the use of hemp fibres for different applications.

10:00 SPIF performed by a controlled temperature room for polymer-based materials

Francesco Gagliardi, Romina Conte, Giuseppe Serratore, Giuseppina Ambrogio and Luigino Filice

Polymer-based blanks with or without reinforcements have been widely proposed in part design, meeting the increasing demand of lightweight bodies. Herein, a specific equipment was proposed to the aim of shaping thermoplastic sheets by single point incremental forming (SPIF) technique. The idea aims to prove the feasibility of this manufacturing solution to exploit the SPIF flexibility in processing sheet composites, too. The SPIF equipment has been designed according to the peculiarities owing to polymer sheet forming. A heating room has been employed to achieve a controlled temperature, considering the polymer glass transition phase and melting point of the polymeric matrix. The feasibility of the process dynamics was analysed by FE simulations. Indeed, a numerical model was built considering the process peculiarities and boundary conditions. By doing so, the deformation of a polymer matrix composite (PMC) plate was simulated showing the process difficulties and how promising could be the proposed solution for specific plastic materials, if set properly.

10:15 Laser-based directed energy deposition for industrial applications

Fabrizia Caiazzo, Vittorio Alfieri, Annalaura Fabbricatore, Donato di Lonardo and Francesco Verrastro

In some automotive applications, the improvement of the mechanical properties of car body is required to prevent deformations. Namely, local reinforcement of structural elements allows to reduce the weight and improve the stiffness. Therefore, this paper is aimed at assessing the feasibility of laser-based Directed Energy Deposition of steel powder on homologous substrate. A 3-factor, 2-level plan is designed to discuss the effects of the main parameters. Geometrical responses, porosity, microstructure, and Vickers microhardness have been discussed. The most suitable condition has been found through an optimization function and statistical tools, resulting in no porosity and reduced HAZ extension.

10:30 Towards lattice structures produced by bound metal deposition: printability study of surface-based unit cells

Paolo Parenti, Dario Puccio, Quirico Semeraro and Bianca Maria Colosimo

As an innovative Additive Manufacturing technique, Bound Metal Deposition (BMD) can produce at low costs, highly complex AM components in Steel, Copper and other functional materials by applying both extrusion of feedstock rods, debinding and furnace sintering operations. However, the complexity that BMD parts can reach are limited with respect to those produced by traditional laser or Electron Beam AM techniques. This work is aimed at studying the BMD printability of complex Surface-based Lattice structures, such as those based on triply periodic minimal surface (TPMS), made on 17-4 PH steel. Starting from an in-depth geometrical analysis and the process's constraints and limitations, feasible solutions and printing quality assessments are presented for the successful manufacturing of Schoen-Gyroid unit cells. The presented results lay the foundation of a comprehensive printability assessment of lattice-like structures with BMD technique.

10:45 A statistical approach to the CMM performance verification

Stefano Petrò and Giovanni Moroni

Performance verification of coordinate measuring machines (CMMs) guarantees they keep working at their optimal condition. To guarantee coherence all over the world, the ISO 10360 series of standards defines the tests required to verify CMMs performance. The tests were initially developed in the nineties to be easy to understand and perform and are a good compromise between test accuracy and

required effort. However, in their current structure, the tests completely neglect their intrinsic statistical nature. Tests are statistical experiments and should be considered like that. Multiple measurements are involved in them, and this can lead to unexpected system non-conformance declarations. We are therefore working on the statistical model of the ISO 10360 tests to prove that their simple application can lead to misleading results and improper performance statements. The final aim is the proposal of test decision rules that correctly handle the customer's and producer's risks.

11:00 Investigation on the effect of the test object material on the metrological performances of X-ray computed tomography systems

Elia Sbettega, Marco Sorgato and Simone Carmignato

X-ray computed tomography (XCT) plays a significant role in industrial metrology, supporting the evolution of manufacturing technologies and the developments of advanced application. Indeed, it enables the measurement of a wide range of complex parts, characterized by internal and non-accessible features, micrometric details or free-form surfaces. However, the effect of a number of quantities, which affect the measurement results, limit the diffusion of the technology and need to be investigated. In this work, the effect of the material of the inspected object is analysed. A reference standard, consisting of a hole plate with a specific distribution of the holes, was designed in order to evaluate the influence of the material of the test object on the metrological performances of an industrial XCT system. The indications provided by the current draft of the ISO 10360-11 standard were followed to metrologically characterize the system, testing two hole-plates of different material, manufactured and calibrated for the study, separately and in combination with a ball plate.

11:15 Using virtual reality for serious games in manufacturing engineering education

Marcello Urgo, Walter Terkaj, Marta Mondellini and Giorgio Colombo

Digital tools are becoming a prominent aspect in the education of young engineers. VLFT is an Erasmus+ project focused on the development and integration of digital tools to support advanced engineering education in manufacturing. Within the activities of the VLFT project, a dynamic 3D virtual reality environment has been developed to enable serious games aimed to enhance teaching and learning in manufacturing engineering. This paper reports the results of a pilot set of experiments on the use of the serious game paradigm addressing the analysis of a manufacturing system.

Mercoledì 19/01/2022

Sessione "Advanced Machining and Processing"

Presiede: Luigino Filice – Università della Calabria

11:45 Indirect estimation of thin-walled workpiece vibrations from dynamometer signals during milling operations

Giovanni Totis, Marco Sortino and Alessandra Bordon

Measuring thin-walled workpiece vibrations is a crucial task for studying milling dynamics, developing more effective systems for chatter avoidance, designing innovative cutting tools, indirectly estimating surface quality and form errors. For this purpose, non-contact displacement probes are generally placed close to the workpiece. Alternatively, contact accelerometers may be attached on it. All these approaches are very invasive, since they do strongly interfere with the available working space. Thus, they are problematic for research activities and not compatible with most industrial applications. In this work an indirect, non-parametric technique for estimating workpiece vibrations from cutting force signals is proposed and validated on a thin-walled blade-like benchmark workpiece. A simple relation of proportionality was found between the main principal components of the transverse workpiece vibrations and the principal components of the cutting force signals derived from the load cells composing a special dynamometer. The method was then successfully applied for studying and classifying the milling process instabilities that were found in a former work.

12:05 Effects of hybrid machining on the AZ31 magnesium alloy surface integrity

Rachele Bertolini, Andrea Ghiotti and Stefania Bruschi

Magnesium alloys are more and more used in several fields thanks to their low strength-to-weight ratio and biocompatibility characteristics. However, poor corrosion and wear resistance makes their applications still limited. Machining processes can be used as a mean to increase their surface integrity, and, as a consequence, the components in-service properties. To this aim, a hybrid machining technology, namely ultrasonic vibration-assisted turning coupled with cryogenic cooling, was here applied to machine the AZ31 magnesium alloy. Results showed that the liquid nitrogen application had the primary effect on the surface integrity, leading to the formation of harder surfaces thanks to an increment of the severe plastic deformation layer thickness compared to dry ultrasonic vibration turning. On the other hand, the application of ultrasonic vibration to the cutting tool path contributed to form unique textures, whose morphology was function of the adopted process parameters.

12:25 Analysis of tool wear evolution and component surface changes during turning by condition monitoring systems

Rodolfo Franchi, Giovanna Rotella, Alessia Begher and Antonio Del Prete

Phenomena taking place during turning significantly influence the final state of the components being machined. In particular, it is useful to monitor the changes of the process variables in order to better relate their evolution to the component quality and performance. In this work, a complex system of condition monitoring has been set up and used to track the tool wear progress during turning by means of customized sensors measuring different process conditions such as vibrations and acoustic emissions in order to relate them to the wear evolution and, consequently, the surface roughness. Thus, an extensive experimental campaign based on Design of Experiments has been conducted on turning a Nickel superalloy, at varying the process conditions, namely the cutting speed, depth of cut and feed rate. The overall results demonstrate how the selected system can offer the possibility to successfully track the tool and roughness conditions with a significant impact on the industrial applications of the proposed methodology.

12:45 Static and dynamic prediction of surface errors in 3-axis milling

Lorenzo Morelli, Niccolò Grossi and Antonio Scippa

In the manufacturing field, machining operations represents an essential solution to guarantee both surface accuracy and surface finishing on mechanical components. In this context, 3-axis milling is well known for its flexibility and repeatability. However, both static and dynamic issues cause geometric errors (i.e., surface errors) and poor finishing, limiting the productivity of this process. For this reason, the analysis of surface errors is important to increase the productivity of the milling process. In detail, in 3-axis milling the tool helix angle ensures that the surface error varies along the axial depth of cut. Moreover, the surface error axial distribution is not unique, and it changes according to the tool geometry and the cutting conditions. This paper presents a comprehensive method to predict the surface error in 3-axis milling considering static and dynamic aspects. Finally, the proposed approach has been experimentally validated.

Mercoledì 19/01/2022

Sessione “Manufacturing Systems”

Presiede: Arianna Alfieri – Politecnico di Torino

11:45 The open shop scheduling problem with sequence-dependent setup time: a matheuristic approach

Arianna Alfieri, Erica Pastore and Fabio Salassa

This paper studies open shop problems with sequence-dependent setup times. Open shops are typical of contexts where each job has a set of operations to be performed by a set of machines, but the processing route (i.e., the sequence of machines) can be any. For example, they are used in maintenance facilities (e.g., maintenance operations on an aircraft) or in healthcare sector (e.g., patients needing multiple medical tests in hospitals). In these contexts, the only restriction is to avoid overlapping for the same job (e.g., the aircraft or the patient), and for the same machine (e.g., a maintenance resource or the resource performing the medical test). Open shop problems are generally difficult to solve, as the lack of given processing routes increase the number of feasible solutions, and thus the solution complexity. For this reason, usually meta-heuristic algorithms are used to solve such problem. In this paper, a matheuristic algorithm based on variable fixing of the continuous relaxation of the mixed integer model is developed to minimize the total completion time.

12:05 Enhancing ergonomics in assembly lines by a genetic approach

Michela Dalle Mura and Gino Dini

Ergonomics represents nowadays a key feature to be considered while designing manual assembly lines, as it may affect both productivity and human factor issues. Repetitive movements and handling of high weight components are frequent during assembly processes and may result in operator’s overload. To enhance ergonomics on manual stations, assembly tasks should be distributed on the line so as to smooth the workload among the different workers, based on their physiological limits given by individual characteristics. The aim of this work is to present and validate a software tool that uses a genetic algorithm for solving a multi-objective version of the assembly line balancing problem, in which one of the objectives is the optimization of ergonomic aspects. In the developed system, the assignment of workers available in a company to the stations of an assembly line considers physical capabilities and limits of workers, from an energy expenditure point of view. The other objectives of the problem are the minimization of the number of stations and the distribution of assembly tasks to stations according to worker technical skills. To demonstrate the efficacy of the system, tests for different case studies are presented and discussed.

12:25 Automated simulation model generation for manufacturing systems with assembly operations

Giovanni Lugaresi and Andrea Matta

Industry 4.0 determined the emergence of technologies that allow for data-based production planning and control approaches. Digital twins of production systems can be used to take decisions based on the current system state, and their performance strictly depends on the capability to correctly represent the physical counterparts at any time. Automated simulation model generation techniques can significantly accelerate the development of digital twins for manufacturing systems. However, complex manufacturing systems suffer from

data with multiple part identifiers, resulting in the wrong finding of the system structure with traditional mining techniques. In this paper, we describe the problem of discovering manufacturing systems with assembly operations. Then, we present an approach for the proper simulation model generation, exploiting the new concept of object-centric process mining. The proposed approach has been applied to a test case and a real manufacturing system, in both cases proving its applicability to realistic settings.

12:45 Cyber-physical system for the control of size-reduction processes in demanufacturing to unlock demand-driven circular value-chains

Marco Diani and Marcello Colledani

Size-reduction processes are fundamental components of demanufacturing systems supporting the recovery and re-use of materials from post-consumer products, under a circular economy perspective. These technologies enable to obtain high liberation degree and suitable size of the material mixture prior to separation and re-use. However, their poor adaptability affects the capability to meet required material properties, thus preventing the systematic re-use of materials in high-added value applications. This paper presents a methodology to control size-reduction processes to meet desired demand-driven particle requirements, customized to the specific re-use application. The industrial benefits are validated in a real demanufacturing system for composite materials.

Mercoledì 19/01/2022

Sessione "Advanced Machining and Processing"

Presiede: Luigi Maria Galantucci – Politecnico di Bari

14:00 Modeling of orthogonal cutting forces in metallic feedstock machining

Paolo Parenti, Andrea Cazzani and Massimiliano Annoni

Metallic feedstock is adopted in Powder Metallurgy and binder-based Additive Manufacturing. It combines micro metallic particles with a multi-component polymeric binder. Machining feedstock at soft state, i.e., before sintering, shows improved machinability enabling the creation of microfeatures on the green parts and an increased surface finish quality. This paper proposes an innovative orthogonal cutting analytical model for predicting the cutting force in steel spheroidal feedstock. The model considers the tool shape, including the cutting edge radius, and computes the force from the viscous-interactions between the tool and the feedstock material. Experiments are performed to validate the model. Once tuned, the model is capable to predict forces with different feedstock granulometry and composition.

14:20 FEM modelling of the incipient chip formation for the generation of micro features

Armin Gharibi, Amar Hajj-Ahmad, Andrea Rossi, Mark Cutkosky and Michele Lanzetta

This paper preliminarily explores the modeling of incipient cutting by (LS-Dyna) FEM software comparing the results on different material classes, including common aluminum and steel alloys and an acetal polymer. The target application is micromachining of a durable mold for mass manufacturing gecko adhesives, with challenging requirements, including undercuts and sharp tips; other cases of industrial interest are briefly reviewed. The FEM configuration is discussed and compared with experimental chip characterization experiments.

14:40 A new kinematic architecture for modular machine tools: towards real time reconfigurability

Alessandro Bruzzone

A new kinematic architecture that enables a new class of dynamically Reconfigurable Machine Tools whose modular and scalable structure permits to dynamically host and integrate different processing technologies is presented. The real time reconfigurability enables new manufacturing business models that could provide resiliency to face market volatility and improve sustainability.

15:00 Surface functionalization of substrates for biomedical applications

Michela Sanguedolce, Giovanna Rotella and Luigino Filice

Surface properties and, as a consequence, surface modification processes have a key role in defining overall behaviour of components. A wide literature can be recognized concerning surface functionalization for several fields of application such as aerospace, environmental and biomedical. As far as the latter is concerned, while a deep medical analysis has been carried out, a lack of information concerning mechanical characterization of the components has been detected, although its relevance for their reliability. This issue represents the subject of this work. An overview of the current state of the art in terms of functionalization of implants and prostheses for different biomedical applications (e.g. drug delivery and bone repair) will be provided. Various substrate and coating combinations will be presented and, as a case study, two of them will be characterized in order to assess mechanical performance with regard to strength and adhesion. The main purpose is to make a contribution in filling the gap between biological and mechanical characterization, promoting a comprehensive evaluation of these devices.

Mercoledì 19/01/2022

Sessione "Manufacturing Systems and Quality"

Presiede: Sergio Fichera – Università di Catania

14:00 A structured methodology to support human-robot collaboration configuration choice

Riccardo Gervasi, Luca Mastrogiacomo, Domenico Augusto Maisano, Dario Antonelli and Fiorenzo Franceschini

Among the cornerstones of Industry 4.0, Human-Robot Collaboration (HRC) combines human and robotic skills to make manufacturing more flexible. Since the effective implementation of HRC requires a careful analysis of different aspects, related both to robots and humans, there is a real need for a structured methodology to support it. A multi-dimensional framework to analyze several HRC aspects of a collaborative task was proposed in a previous work. However, identifying the configuration that better exploits the HRC potential is not always straightforward.The goal of this paper is to expand the previous methodology to support a structured comparison of alternative HRC configurations, incorporating a Multiple-Criteria Decision Analysis (MCDA) method for generating a preference ranking. The description is supported by a real industrial application in the automotive field, in which four alternative HRC configurations are analyzed by a team of experts.

14:20 Environmental impact and economic analysis of an innovative fluidized bed technology for industrial dry washing: A case study of metal degreasing

Erica Menna, Silvio Genna, Gianluca Rubino, Gabriele Baiocco, Nadia Ucciardello and Vincenzo Tagliaferri

Industrial washing is essential in manufacturing and many other technological fields. Nowadays, steam washing is definitely the most common technique. However, it involves chemical solvents which are noxious and difficult to be disposed of. Therefore, there is a growing demand for an alternative washing technique that would ensure low operating costs, great productivity, high efficiency, environmental sustainability, good compatibility with different materials and, safe operating conditions. The fluidized bed (FB) represents a promising alternative to satisfy market requirements. In this study, a prototype of an FB machine for the degreasing of pressure vessels was designed, built, and compared to the current solvent washing machine. The analysis of variance (ANOVA) was carried out to detect the process parameters that influence the cleaning. Optimal process parameters were identified based on the experimental results. Life Cycle Assessment (LCA) and Life Cycle Cost (LCC) were additionally performed in order to evaluate the economic impact and resource consumption. The results confirmed the validity of FB technology as an alternative to current washing techniques thanks to superior cleanness, minor environmental impact, and comparable productivity.

14:40 KA-Map: Classifying product key-attributes for customer (dis)satisfaction from user- generated contents

Federico Barravecchia, Luca Mastrogiacomo and Fiorenzo Franceschini

Manufacturers need new tools to leverage the value of User-Generated Contents (UGC). These unstructured and disorganised data need ad-hoc approaches for their analysis and interpretation. In this view, this article proposes an innovative methodology aiming at classifying the Key-Attributes (KA) of products and services that may influence customer (dis)satisfaction. The proposed methodology relies on the analysis of User-Generated Contents to extract relevant information for classifying key-attributes. A novel graphical tool called KA-Map is at the basis of the proposed classification. The KA-Map combines two dimensions of analysis: the extent and the way a key-attribute is discussed. The methodology classifies KAs into six categories: obstacles, frictions, indifferent, sleeping beauties, promises, and delights. For each category, the most appropriate management strategy is also suggested. Finally, an empirical study is given to illustrate the effectiveness of the proposed method.

15:00 A composite approach based on an effective model for measuring the quality of the service provided by the campus restaurant

Toni Lupo

In the present work a service quality measurement model suitable for the Campus Dining Services is to develop. Such a new measurement model is based on the ServQual discrepancy paradigm, thus it allows to link service quality inadequacies perceived by users (external gaps) with the internal service shortcomings (internal gaps), so supporting focused and effective quality improvement policies.

Mercoledì 19/01/2022

Sessione Speaker's Corner

Presiede: Giovanni Moroni – Politecnico di Milano

15:30 In-process monitoring of fused filament fabrication via computer vision and the use of digital twins

Michele Moretti, Nicola Senin and Arianna Rossi

We illustrate ongoing research work on the development of an open and modular machine for fused filament fabrication (FFF), where multiple heterogeneous sensors and machine learning are used to implement in-process monitoring. Here we focus on the use of computer vision to monitor the current layer, exploring the use of additional, real-time sensor data streams to aid scene understanding. Information is extracted from the part program and from additional sensors recording selected process variables and used to create digital twins, simulation models that replicate what the camera would be expected to see, based on the current progress in fabrication. Computer vision therefore operates from a digital expectation of what the scene should look like, which aids in the identification of anomalies, as well as in the identification of the boundaries of the actual geometric elements of interest. Contour stacking allows a reconstruction of the side surfaces of the part and comparison to nominal for detection of geometric error.

15:45 A new learning platform exploiting LEGO for teaching manufacturing systems integration and discrete event simulation

Giovanni Lugaresi and Andrea Matta

Involving students through intensive work in computer laboratories and simulation projects might be a challenging task, often due to the lack of a real manufacturing system that must be modeled and improved. This poster presents an education platform developed in Politecnico di Milano from 2018. The proposed environment is based on miniaturized production systems made by LEGO® MINDSTORMS® and industrial IoT devices. The goal is to exploit learning-by-playing principles to offer scholars the possibility to understand the most common issues in the design and management of manufacturing systems, with a focus on system integration. Several course modes have been designed, for instance involving the active participation in the laboratory and building physical models. Students are asked to build and improve a manufacturing system model. In the future, the laboratory can also be exploited to deliver professional training courses about digital technologies and smart manufacturing systems.

16:00 CHIUSURA XV CONVEGNO AITEM