BRAGECRIM Newsletter

2nd Edition: December 2017

BRAGECRIM - Smart Connected Manufacturing

Dear reader,

we welcome you to the 2nd edition of the BRAGECRIM newsletter. In the following pages you will find updates about recent activities within the different BRAGECRIM projects with content ranging from current research results, kick-off and final meetings over contributions to conferences to publications.

We hope that you will enjoy reading this newsletter edition!

Best regards,

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SCoPE

Development of a concept for smart component interactions within smart assemblies

This study is part of the project "Smart Components within Smart Production Processes and Environments" (SCoPE), part of the BRAGECRIM collaborative research initiative between Brazil and German in manufacturing technology. This project associates universities research institutes from both countries to exchange knowledge, researchers and students through work missions.

The research was based on individual components as information carriers. These components comprise a digital data representation about their manufacturing states with historical, physical properties, customizations, etc. and utilize this digital data representation for real-time production planning and management. Within the project, it was developed a communication concept for smart components interactions within smart assemblies.

The assembly process is important to join a group of components (parts and sub-sets) until a final product is concluded. In order for the component to become a final product, it must communicate with other components available in the production to find its assembly pairs. These pairs interact with the environment in search of the resources capable of performing their assembly needs (assembly operations, transport from one point to other and storage over the process) as a set composed of individual parts that have the same objectives.

In the developed concept it was analysed and mapped all the interactions and information exchanged over the smart assembly process. It aims to reach a better understanding of the smart assembly processes to avoid the creation and exchange of redundant information. To validate the theoretical scenario, a case study was developed.

This research project was presented, defended and approved as a Master Thesis in the Department of Computer Integrated Design (DiK), at the TU-Darmstadt in the beginning of 2018. All the data is being compiled for a publication during this year.

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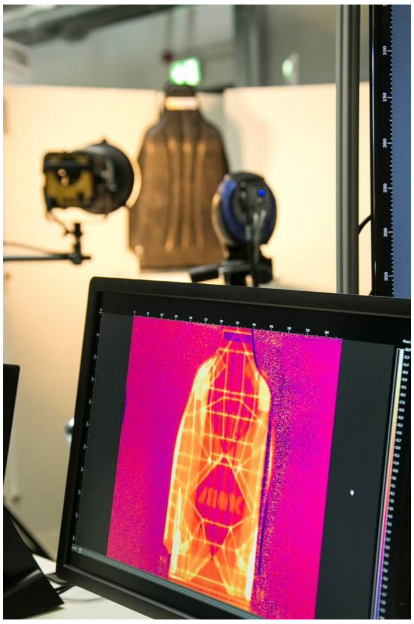
IDD-Metro

Recent outcomes and scientific publications within the research project IDD-Metro



Prof. Dr.-Ing. Robert Schmitt (Laboratory for Machine Tools and Production Engineering (WZL) of RWTH Aachen University) on the German side and Prof. Dr. Eng. Armando Albertazzi Gonçalves Jr. (LABMETRO/ Federal University of Santa Catarina - UFSC) on the Brazilian side coordinate the research project IDD-Metro "Non-Destructive Impact Damage Detection on Carbon Fiber Reinforced Plastics". The project's goal is the development of a non-destructive impact damage detection for carbon fiber reinforced plastics.

Recent outcomes of the research activities amongst others are the design of an impact tower, a measurement process based on optical lock-in thermography for the depth determination of defects and an image processing algorithm for the automated defect size determination.

The results are presented and published on various occasions. On a test bench the activities were illustrated on the "AWK Aachen Machine Tool Colloquium" with over 1,000 German and international experts from production technology and related disciplines (image). To improve the scientific impact the project outcome were additionally presented on the 7th Conference on Industrial Computed Tomography in the contribution "CT applied as a reference technique for evaluating active lock-in thermography in characterizing CFRP impact damage test samples" in Leuven (link to the publication). Furthermore, in Karlsruhe Sarah Ekanayake held a presentation on the topic "Method for quantitative 3D evaluation of defects in CFRP using active lock-in thermography" on the 1st CIRP Conference on Composite Materials Parts Manufacturing (CCMPM). The contribution is published here.

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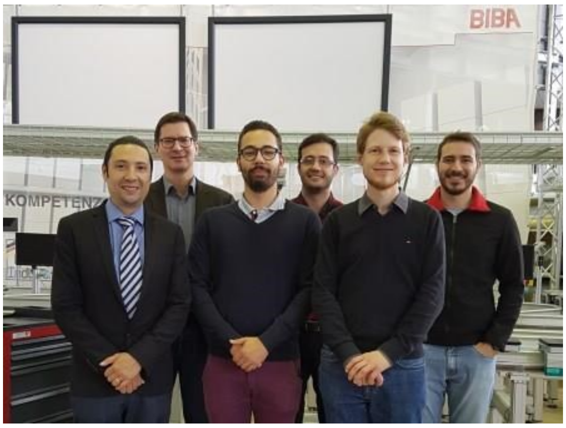
AdaptiveSBO

Intense exchange of researchers as Part of the Brazilian-German Cooperation Project AdaptiveSBO



Within the BRAGECRIM program, the project AdaptiveSBO (An adaptive simulation-based optimization approach for the scheduling and control of dynamic manufacturing systems) is headed on the German side by Prof. Dr.-Ing. Michael Freitag (BIBA/Uni-Bremen) and on the Brazilian side by Prof. Dr.-Ing. Enzo Morosini Frazzon (Federal University of Santa Catarina - UFSC). In Brazil, the project is inserted in the activities of the CNPq Research Group Production and Logistic Systems and at the Production and Logistic Intelligent Systems Laboratory (ProLogIS/UFSC). In the scope of the project, a data-driven adaptive simulation-based optimization procedure for the planning and control of dynamic production systems is being developed.

After visits of Prof. Dr.-Ing. Enzo Morosini Frazzon, Prof. Dr. Guilherme Vieira, B. Sc. Diego Evandro Mazzuco, Prof. Dr. Mauricio Uriona Maldonado, M. Sc. Ricardo Pimentel and B. Sc. Matheus Leusin, there are currently two Brazilian performing study missions at the BIBA: M. Sc. Matheus Pires and B. Sc. Ian Cavalcante. Ricardo Pimentel, Matheus Pires and Matheus Leusin worked together with BIBA employee Mirko Kück on project work packages during their stay within the cooperation project AdaptiveSBO. In the other direction Prof. Dr.-Ing. Michael Freitag and Mirko Kück recently returned from a successfull mission to UFSC / Florianopolis, in which they also took part in the 9th. BRAGECRIM Annual Meeting at CIMATEC / Salvador.

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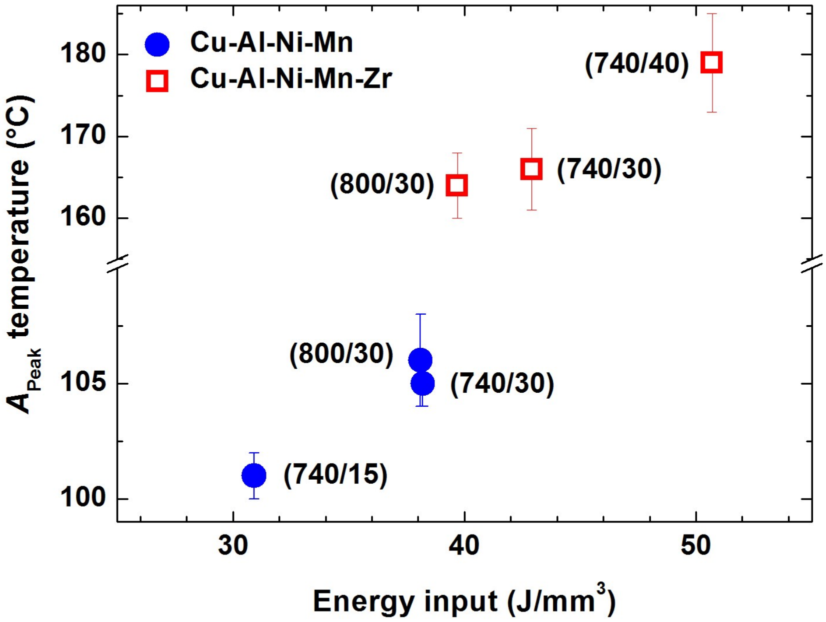
SMA-SLM

Rapid solidification and advanced manufacturing of Cu-based shape memory alloys with complex geometries



The project is based on a vibrant cooperation between the Universidade Federal de São Carlos (UFSCar) and the Leibniz Institute for Solid State and Materials Research Dresden (IFW).

Cu-based shape memory alloys generally suffer from an inherent brittleness in the coarse-grained state. Within this project rapid cooling techniques shall be employed to overcome this limitation and to make these alloys more accessible to application. An increasing cooling rate is an effective measure for reducing the grain size. Among the employed techniques is selective laser melting, which not only allows the production of intricate sample shapes but also to modify the microstructure locally. As is shown in Fig. 1, the processing parameters (i.e. scanning speed in mm/s and the track overlap in %) determine the martensite-to-austenite transformation peak- temperature. This opens an avenue for adjusting the material for a specific application without the need for post-processing. More details can be found in the journal Shape Memory and Superelasticity (Volume 3, pages 24 – 36), in which these results have been published.

Currently, our partner in São Carlos uses alternative approaches to produce refined microstructures, i.e. severe plastic deformation. The transformation properties and the mechanical properties will be explored and compared with the selectively laser-melted specimens. In this way, we hope to better understand which factors determine the transformation characteristics of Cu-based shape memory alloys.

The present findings and the next steps have been recently discussed during a visit of our partners, Prof. Dr. Claudio Kiminami and Prof. Dr. Claudemiro Bolfarini, in Dresden in November 2017.

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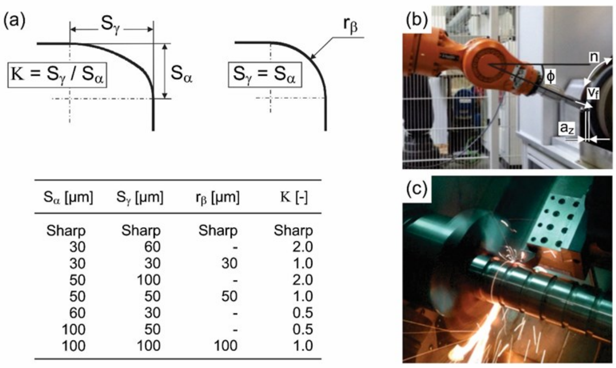
IFW UFMG

Relax

Effect of cutting edge geometry on the machinability of hardened steel



Sα [µm]	Sγ [µm]	rβ [µm]	K [-]
Sharp	Sharp	Sharp	Sharp
30	60	-	2.0
30	30	30	1.0
50	100	-	2.0
50	50	50	1.0
60	30	-	0.5
100	50	-	0.5
100	100	100	1.0

Figure 1. (a) Microgeometry parameters, (b) brushing setup and (c) turning setup for force measurement

Machining process as an important step towards a product's life cycle behavior is the motivation of this BRAGECRIM project, whose focus consists of investigating the effects of turning and deep rolling on the workpiece surface and subsurface. In turning, cutting edge geometry plays an important role due to its influence on forces, temperature and surface quality. In this regard, experiments were conducted to assess the influence of different edge geometries on the machinability of a hardened steel.

Bars of AISI 4140 hardened steel were turned with coated tungsten carbide inserts, whose microgeometries (Fig. 1a) were produced through brushing (Fig. 1b). Continuous dry turning tests (Fig. 1c) were performed at constant cutting speed and depth of cut and using two levels of feed rate. The force components were measured with a piezoelectric dynamometer and the temperature of the chip was measured with an infrared pyrometer.

Irrespectively of the microgeometry, the increment in feed rate has mainly affected the cutting force due to the larger shear area (Fig. 2a). The bluntness of the edge makes it harder to penetrate the workpiece material, causing an increase of both passive and feed forces. Higher forces are mainly obtained by employing higher values of Sα due to a more dramatic increase in the contact length compared to higher Sγ values.

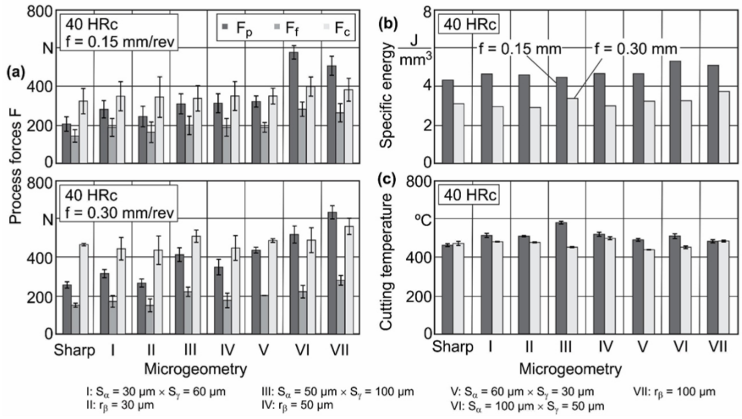


Figure 2. (a) Force components, (b) specific energy and (c) chip temperature for different edge geometries and feed rates

Specific energy was not altered by microgeometry (Fig. 2b). However, the increase in feed rate reduces the specific energy, thus elevating cutting efficiency. These results can be compared with Fig. 2c, which shows that chip temperature is also approximately constant for the different edge geometries tested and decreases with a higher feed rate.

More details about the results can be found in: Ventura, C.E.H.; Chaves, H.S.; Campos Rubio, J.C.; Abrão, A.M.; Denkena, B.; Breidenstein, B. The influence of the cutting tool microgeometry on the machinability of hardened AISI 4140 steel. International Journal of Advanced Manufacturing Technology, 2017 (link to publication).

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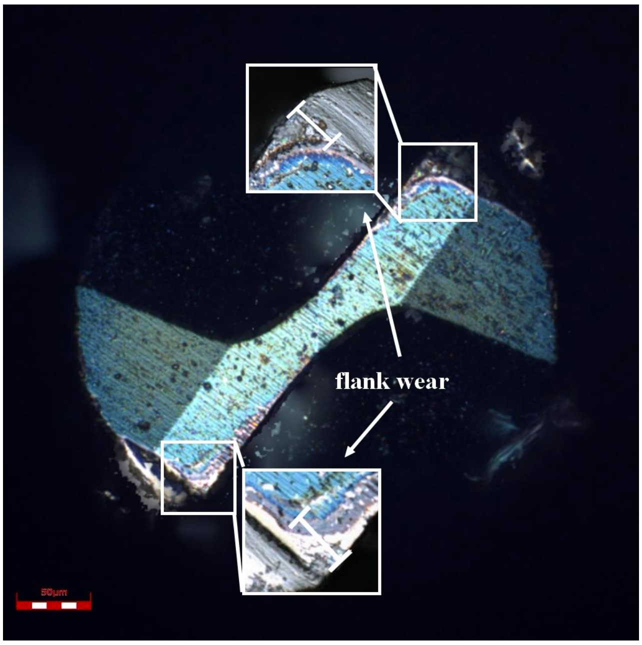
Micro-O

Micro Milling Process Optimization

This project focuses on the development of knowledge and innovating solutions for critical aspects of micro-manufacturing, concentrating on the production of molds for micro-featured products, targeting the improvement of productivity, efficiency and on the advancement of strategies for optimizing costs and quality



Modern technological devices demand high precision components and due to increasing miniaturization of these components, the industries are faced to new challenges in the manufacturing processes. Micro-machining has several advantages among these new manufacturing processes, due to its capability of producing complex, high-precision geometries with micro-features in a wide range of materials. However, it has different phenomena compared to conventional machining. In order to increase their application in industries, micro-machining processes must fit in productivity and quality standards, thus needing further research to comply with these requirements.

In this context, a current study aims to develop a tool wear predictive model in micro milling. Different methods to monitor the tool wear, such as monitoring the tool effective diameter, the cutting edge radius, and the flank wear will be combined to evaluate the tool condition and to implement it in a machine learning model to predict the tool wear. This research also aims to relate the tool wear to workpiece roughness and the tool wear impact on cutting forces and burr formation.

The described study is being carried out as an exchange of the masters student, Cinthia S. Manso, of the Brazilian partner, UFABC, at the IWF TU Berlin in Germany.

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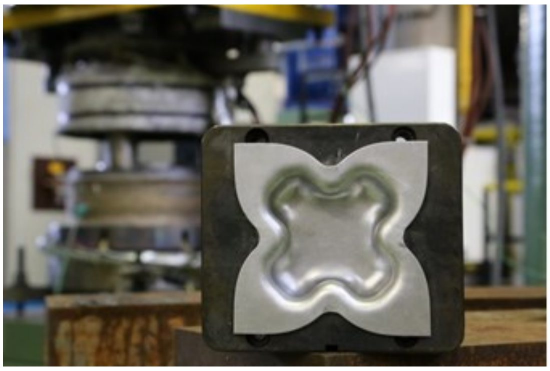
ForCover

Evaluation of sheet metal covers to improve tool life in forging



The project ForCover aims to develop an inexpensive and easy-to- exchange sheet metal die cover to improve tool life in closed-die forging. After two years of research, the second phase of this project began in last July. In the first phase of this project, the basic mechanisms of this concept and preliminary applications were investigated. The second phase aims to find more complex applications.

Based on the achieved results from the first period, three geometries were designed and evaluated. All of them are rather complex geometries, where the die cover offers a larger mechanical stability compared to the simple geometries used in the first phase of this project. After evaluating the material flow, the forging force and the stress conditions by numerical simulations, a cross geometry was selected for the first experiment. In this case, a 1.5 mm thick sheet of 22MnB5 was chosen as die cover, which was subsequently formed by deep drawing and then hardened by quenching process. The initial temperature of the forging die was 300°C. A forging cycle includes lubrication, positioning of billet, forging, taking off forged part. Under these conditions, a die cover went through ten forging cycles in experiment and no critical failure appeared. The temperature on the surface of forging die tends to reach a stable state of 350°C to 450°C. In addition, the strategies of die cover manufacturing and fixation are investigated to achieve a good accuracy and stability. Besides deep drawing, incremental forming will be also investigated to manufacture the die covers.

In the next steps, the project will aim at improving the boundary conditions, exploring other geometries and die cover materials, reaching more forging cycles and investigating applications in multistage forming process and finishing process.

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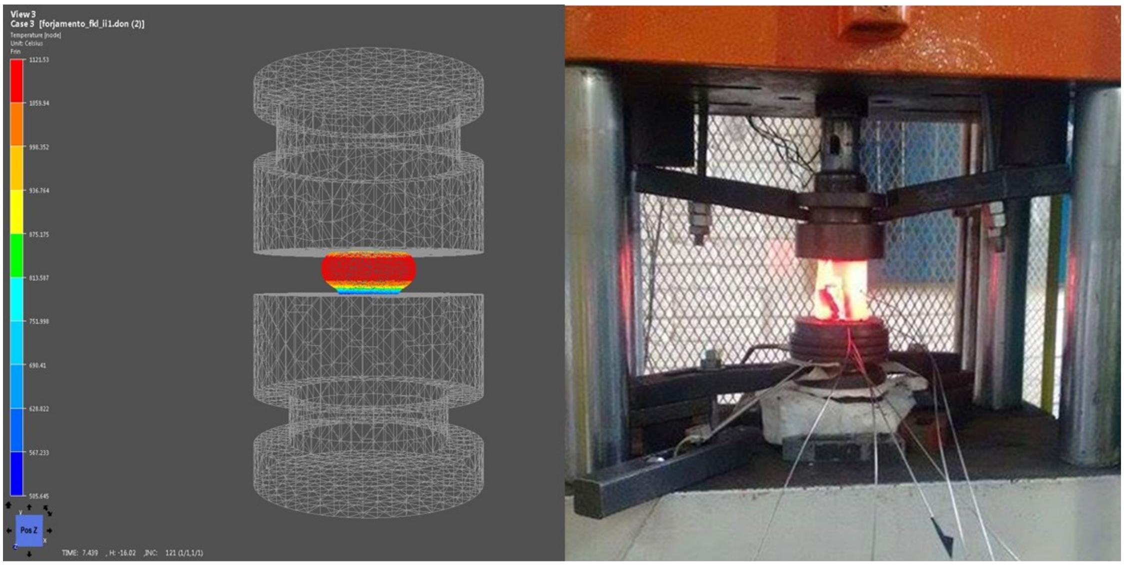
Baitinic Forging Steels

Energy efficient manufacturing chain for advanced bainitic steels based on thermomechanical processing



Comparison between finite element analysis and experimental forging.

The main objective of the project is to develop a manufacturing process of automotive components aiming at energy consumption reduction by replacing the common quenching and tempering process for a continuous cooling process shortly thereafter the hot forging. The use of advanced bainitic steels likewise the HSX 130HD allows the formation of bainitic structures through continuous cooling with superior properties when compared with conventional steels used in the automotive industry. Therefore, the processing windows for this steel will be determined, detecting the ongoing phase transformations during the cooling process, improving microstructure and consequently mechanical properties and surface-related properties enhancement by developing specific surface treatments.

The project is in its initial phase with the kickoff meeting fulfilled at the annual BRAGECRIM congress, placed in Salvador, Brazil 2017. The initial part of research is the study and elaboration of the forging procedure for the thermomechanical process, comprehending the dies project, the forging of a simple billet as a first source of data to be used in the finite element analysis and mechanical and metallurgical characterization, aiming to acquire the basic information of the material behavior.

Future steps of the project are: definition of the automotive component shape, determination of the heat transfer coefficients, characterization of the material after the thermomechanical process in different cooling rates, numerical simulation of the process and residual stress analysis of the component.

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