GLEEBLE USER GROUP MEETING

Abstracts

MONDAY, 29TH OF APRIL

9:30AM-10.00AM

WELDABILITY TESTING OF SUPPERALLOYS: LESSONS LEARNED AND FUTURE ADVENTURES

Superalloys play a crucial role in the construction of structural components within aerospace engineering, particularly in aero engines. Among these materials, Ni- and Fe-Ni-based superalloys stand out due to their exceptional performance in aerospace applications. The weldability of these superalloys is a key factor that significantly influences the reliability and longevity of aero engine components. As these materials are integral to the hot section of gas turbines, understanding and improving their weldability is essential for advancing manufacturing practices in the aerospace sector.

Cracking issues, including hot cracking and strain age cracking, pose significant challenges during the welding and additive manufacturing (AM) processes of these critical components. Such defects can arise during welding, AM, or subsequent heat treatments and are affected by various factors such as the alloy's chemical composition, the microstructure of the base and weld materials, and the specifics of the welding and AM techniques, including process parameters and post-treatment procedures. Given the importance of these materials in high-performance applications, this presentation delves into the weldability of Ni- and Fe-Ni-based superalloys. It underscores the necessity of thorough weldability testing and assessment to mitigate cracking risks and enhance the structural integrity of aero engine components.

Prof. Joel Anderson
University West
Welding Technology Division

10:00AM-10:30AM

STRIP SHEET UPSET BUTT WELDING USING GLEEBLE THERMOMECHANICAL SIMULATOR

This presentation explores the innovative application of upset butt welding for strip sheets composed of advanced high-strength materials, including multiphase steel and nickel alloys. Utilizing the Gleeble thermomechanical simulator, the study delves into nonstandard experimental procedures aimed at achieving high-quality welds despite the varying thicknesses of the materials involved. The core challenge addressed in this research is the development of specialized heating cycles and the fabrication of custom fixtures to securely hold the sheets within the copper grips of the Gleeble simulator.

By implementing modifications to standard practices and identifying welding parameters that are tailored to the geometry of the samples used, the research demonstrates the feasibility of conducting upset butt welding simulations on the Gleeble with a focus on weld quality. The findings underscore the potential of such nonstandard procedures to extend the capabilities of thermomechanical simulation in welding high-strength materials, offering insights into the critical factors influencing the success of these advanced welding processes.

Dr. Jarosław Opara
Łukasiewicz Research Network - Upper Silesian Institute of Technology

10:50AM-11:20AM

UTILIZING THE GLEEBLE 3800 THERMO-MECHANICAL SIMULATOR FOR INTERFACIAL HEAT TRANSFER COEFFICIENT (IHTC) DETERMINATION IN HOT STAMPING PROCESSES

Determining the interfacial heat transfer coefficient (IHTC) is crucial for optimizing the hot stamping process, ensuring both the mechanical strength of formed components and production efficiency. In this study, we present a novel experimental setup, named 'IHTC-Mate,' specifically designed to seamlessly interface with the Gleeble 3800 thermo-mechanical simulator. Through this setup, precise measurements of temperature changes in both specimens and tools during stamping operations were attained, enabling accurate determination of IHTC values. Comprehensive assessments were conducted for aluminum alloys, titanium alloys, and ultra-high-strength steels, in conjunction with various die materials. These assessments covered a range of contact pressures and were performed under both dry and lubricated conditions.

Dr. Liliang Wang
Imperial College London
Faculty of Engineering, Department of Mechanical Engineering

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MONDAY, 29TH OF APRIL

11:20AM-11:50AM

USING HDS-V40 TO DEVELOP SMART ALLOY MANUFACTURING.

The production of next-generation alloys, particularly focusing on steel, is poised for significant evolution in the upcoming years. There is a notable increase in the incorporation of recycled materials into production processes, with future estimations suggesting that some Electric Arc Furnace (EAF) plants could utilize up to 80% recycled material. While this trend introduces a higher degree of variability into what was previously a relatively controlled process, it also presents opportunities for advancing steel production methodologies.

This study explores the development of intelligent alloy manufacturing software designed to assess real-time grain size and transformation kinetics. Moreover, it enables feedback control mechanisms to dynamically adapt to fluctuations in incoming materials. Additionally, the Gleeble system has been employed to meticulously analyse recrystallized grain size distributions and transformation kinetics. Ultimately, the goal is to enable the Gleeble system to autonomously derive processing routes based on variable input parameters.

Asst. Prof. Carl Slater
University of Warwick
WMG

12:50PM-13:20PM

DETERMINATION OF HIGH-TEMPERATURE DEFORMATION BAHAVIOR AND PROPERTIES OF CERAMICS AND HIGH-ENTROPY MATERIALS ON GLEEBLE 3800

The research aims to understand the hot deformation behavior and microstructure evolution of ceramics and high-entropy materials for high-temperature applications in harsh environments employing Gleeble 3800. We will share the experimental setup and results on the hot deformation (1200 °C and higher) behavior of oxides, silicides, and nitrides. We will show the hot deformation behavior of refractory-based high-entropy alloys and ceramics. Furthermore, an overview of Gleeble research at the Luleå University of Technology will be presented.

Prof. Farid Akhtar
Luleå University of Technology
Department of Engineering Sciences and Mathematics

13:20PM-13:50PM

NEW TESTING FEATURES FOR ONE OF THE MOST COMMON MCU's OF GLEEBLE: OPTICALLY TRACKED TENSILE- AND 3-POINT BENDING TEST ON POCKET JAW

The purpose of this study is to demonstrate some simple and efficient solutions to extend the testing capability of Pocket Jaw MCU. These features have been combined with a synchronized optical system to capture full-field geometric images of the specimens during tests. The presented material testing procedures are the uniaxial tensile test and the 3-point bending test. The scientific objective of developing these measurement systems is to establish and advanced methodology with increased predictive capability for the structural integrity of large-scale pressurized systems. To reach our goals, several technical and measurement features should have been developed.

The biggest challenge was to construct the tools for 3-point bending test in a manner that it should have been mounted centrally onto the base plate of the load cell in Pocket Jaw MCU as well as the L-Gauge extensometer should have been integrated to measure the notch opening distance. Another key task to be accomplished was the installation and integration of those two high-resolution digital cameras which are used to create the Digital Twin (DT) of our measurements. To create a reliable DT, the synchronized triggering of cameras from Gleeble and the homogenous illumination of specimens were crucial requirements. My presentation is going to introduce these tooling, measuring and experimental related developments on our Gleeble 3800 simulator, operating at University of Dunaújváros in Hungary. There will also be presented some results from the data processing and the further modelling activities.

Dr. Peter Bereczki
University of Dunaujvaros /Arconic

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MONDAY, 29TH OF APRIL

13:50PM-14:20PM

INSIGHTS INTO GLEEBLE + LUMET APPLICATIONS FROM THE PERSPECTIVE OF A STEEL MANUFACTURER FOR SHEET METAL PRODUCTS

As a recent member of the Gleeble community, I demonstrate the motivation and expectations behind the recently acquired Gleeble system, which includes a LUMet system. Increasing modelling capabilities require high quality material data to refine, calibrate and validate these models. The focus here is on creep and hot forming or hot rolling simulation. The flexible and diverse experimental possibilities help us to investigate problems in steel production and steel processing. In the first instance, the focus here is on LME investigations. I will also discuss initial LUMet investigations and give an outlook on future applications.

Dr. Christian Hoflehner
voestalpine Stahl GmbH (Linz)

14:20PM-14:50PM

AN EXPERIMENTAL INVESTIGATION OF THE BEHAVIOUR OF MATERIALS USING GLEEBLE THERMAL-MECHANICAL SIMULATOR AT HIGH TEMPERATURE RANGE

During the presentation, research results regarding the development of high-temperature material characteristics using the Gleeble 3800-GTC thermal-mechanical simulator will be presented. These tests include the analysis of tensile strength, thermo-mechanical fatigue and creep at ultra-high temperatures (up to 1600°C). Additionally, the presentation will briefly discuss research perspectives on structure degradation in a hydrogen environment at high temperatures.

Prof. Łukasz Poloczek
Łukasiewicz Research Network
Institute for Ferrous Metallurgy (IFM) · Process Simulation Department

15:15PM-15:45PM

OPTICAL 3D MEASUREMENT TECHNOLOGY FOR STRAIN AND DISPLACEMENT DETERMINATION

Optical 3D measurement systems, such as the ARAMIS system, are increasingly being used to characterize materials and investigate complex component behavior. This presentation will show the possibilities offered by current optical measurement systems and how they can be used to determine material properties and to improve the understanding of material behavior. Individual examples are presented to show the advantages of providing areal deformation and strain distributions with high spatial resolution and high temporal resolution for dynamic and static loading processes. Due to the good reproducibility and measurement accuracy, results can be compared particularly well independent of the user and location and are an important support for many general and standardized test procedures.

Mr. Gunter Sanow
Carl Zeiss GOM Metrology GmbH

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TUESDAY 30TH OF APRIL

8:30AM-9:00AM

PHYSICAL SIMULATIONS OF BIMETALLIC SOLID/LIQUID INTERFACES

A special Gleeble bimetal bond simulation technique will be presented, where the two dissimilar metals were also at different temperatures, one in solid- and one in liquid-state. The simulation attempted to improve centrifugally cast bimetal roll quality, where improper bonding caused shell spalling in hot strip mills. Similarly good interfaces were reproduced for Electroslag Weld Cladding, where one liquid metal is deposited on a different solid substrate. The presentation will hopefully open discussions on bimetal dissimilar bond simulations where the two metals are also at different temperatures during bonding.

Prof. Yoni Adonyi
University West
Division of Mechanical engineering

9:00AM-9:30AM

SPECIAL APPLICATIONS WITH GLEEBLE 3800 TORSION MODULE AT IFU STUTTGART

Cold forging has a long and established history and is one of the most resource and energy efficient technologies for the manufacture of precise metallic components in large numbers. Increasing energy costs and more complex applications for cold forged products lead to a need for highly sophisticated processes to satisfy these requirements. In this contribution, these two aspects will be addressed in terms of current research projects at the Institute for Metal Forming Technology (IFU). One major task is to reduce the initial billet volume for components, that are nowadays mainly machined. We propose a novel process technology, where we use a process combination of forward extrusion and twisting to produce complex helical components with reduced CO2 footprint. Experiments on our Gleeble system maintaining a combination of both axial movement and twisting gave interesting insights in the process kinematics.

The manufacture of hybrid components with complex geometry is another major task in materials science. Such processes pose serious challenges regarding the interface properties between the different materials, but can yield in component properties, that extend the properties of the single parts, that make up the hybrid. We performed some first experimental studies on our Gleeble torsion module to investigate cold welding processes under simple shear with combined axial load. The analyses show, that the Gleeble torsion module is a versatile equipment, that helps us a) to gain a better process understanding for twisting process of complex cold forged components and b) to study the effects occurring during cold welding of aluminum under simple shear.

Dr. Karl Goetzinger
University of Stuttgart
Institute for Metal Forming Technology

9:30AM-10:00AM

INSTRUMENTATION OF THE DUCTILITY DIP CRACKING IN NOREM02

Norem02 is an iron based hard facing weld used in the nuclear industry as wear resistant hardfacing in replacement of Stellite. However, Norem02, as other FCC alloys, can be susceptible to hot cracking phenomena caused by solidifications defects, a ductility drop and residual stress due to the welding process. In order to study the ductility dip cracking (DDC) phenomenon, a Gleeble thermo-mechanical simulator is used. On cooling tensile tests from high temperatures are performed to simulate the effect of the welding cooling cycle. Each test is fully instrumented thanks to CMOS cameras to obtain coupled thermo - mechanical field along the specimen with high precision. A first CMOS camera uses the near infrared thermography (NIRT) to image the thermal field. The second camera acquires images for digital image correlation (i-DIC) to measure the displacement and calculate the strain field on the surface of the specimen. The challenge lies in the correct synchronization of both systems as well as to trig with the Gleeble simulator itself.

Dr. Maëlle Moor
INSA de Lyon

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TUESDAY 30TH OF APRIL

10:20AM-10:50AM

INSIGHTS INTO HOT, COLD AND REVERSE TORSION TESTING OF STEELS WITH THE GLEEBLE

We put our Gleeble Hot Torsion MCU to the test. Different steels were deformed in hot and cold conditions, either in one direction or in reverse directions. By means of data analysis, metallographic analysis, and with the help of an FEM model we tried to find out concepts what we can and cannot learn from a torsion test. Based on these concepts we will show some use cases, some limits, and some dreams.

Dr. Phillip Haslberger
voestalpine Donawitz GmbH

10:50AM-11:20AM

ADDONS FOR ISO-T COMPRESSION TESTING: CAMERA INSTALLATION FOR MEASURING THE BULGE DIAMETER AND A GLEEBLE-CONTROLLED PISTON-SETUP TO PUSH COMPRESSED SPECIMEN INTO A QUENCH-CONTAINER.

For forging applications and simulations of our scientists, customers and research partners, reliable material data such as flow curves that are as representative as possible and microstructure information of the compressed specimen are essential. To get a more precise flow curve at higher degrees of deformation, we include the diameter of the compression into the flow-curve calculation. The bulge diameter is recorded by a lab view controlled camera- and data acquisition setup using a shadow casting technique. To be able to inspect the microstructure of different stages of deformation, strain-rates or temperature-histories, we build a pressured-air driven piston, triggered by the gleeble software, to push samples after ISO-T compression into a container with quenching media. The quenched samples and their microstructure can be examined metallographically afterwards and be used as input for numerical modeling.

Dr. Martin Fuchs
Fraunhofer
Institute for Mechanics of Materials IWM

11:20AM-11:50AM

ON THE CHALLENGES OF INVESTIGATING LME UNDER RESISTANCE SPOT WELDING CONDITIONS USING A GLEEBLE 3500

Liquid metal embrittlement (LME) is a phenomenon that can occur during resistance spot welding of galvanized 3rd Generation Advanced High Strength steels. Gleeble hot tensile testing can be used to replicate the conditions that occur during resistance spot welding which lead to LME in a controlled manner. However, the search for a suitable sample geometry presents a challenge and will be the focus of this presentation.

M.Sc. Vincent Schreiber
Otto-von-Guericke-Universität Magdeburg
IWF