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The Gleeble® NEWSLETTER

Summer 2005

Gleeble Application Story

The Gleeble at the University of Manitoba

A major program on the joining and forming of aerospace materials is underway using a Gleeble at the University of Manitoba, Department of Mechanical and Manufacturing Engineering. There, Dr. Mahesh Chaturvedi, Ph.D., FASM, Canada Research Chair in Aerospace Materials, six graduate students, four post-doctoral fellows, and four technologists are exploring welding, brazing, diffusion bonding, superplastic forming and the mechanical properties of joints.

"Our main thrust is on the micro-structural aspects," Dr. Chaturvedi says. "We're looking at hot ductility parameters, such as nil ductility temperature on heating, ductility recovery temperature cooling, nil strength temperature, and brittle temperature parameters."

A major project involves nickel-based superalloys Inconel 738, Inconel 718 and Inconel 718 plus. When these and other similar alloys have been used in aircraft engines and power generation turbines for some time, they crack. New parts are very expensive, so engine repairers and overhaulers want to repair these parts by grinding the cracks then cladding with new materials and reshaping them to the original shapes, or by sealing the cracks by welding. However, these materials are very susceptible to cracking in the heat affected zones, and repair welding or cladding induces micro-cracks in the repaired parts, thus reducing the useful life of the repaired component.

Dr. Chaturvedi says, "We're trying to

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Two members of Professor Chaturvedi's research team include Gleeble technologist Mike Boskwick (left) and graduate student Lanre Ojo.

See Us at the Shows

ICTP2005 Set for October 9–13, Verona, Italy

The 8th International Conference on Technology of Plasticity will be held October 9–13, 2005, in Verona, Italy. The Conference will be held at Palazzo della Gran Guardia in Verona.

Technical sessions will include: Forging Simulation, Incremental Sheet Forming, Blanking, Materials Testing, Surfaces, Cold Forging, Microforming, Damage and Fracture, CAE and Knowledge Engineering, Forming Simulation, Thyxoforming, Sheet Forming Operations, Materials Modeling, Machines, Warm Forming, Hot Forging, Dies and Tools, Sheet Hydroforming, Incremental Bulk Forming, Rolling, Sheet Metal Formability, Tube Hydroforming, Tribology, Extrusion, Powder Forming, Deep Drawing, Joining by Forming, Extrusion, ICEM Special Session, Superplastic Forming and Bending.

For more information about ICTP2005, visit www.ictp2005.sistemacongressi.com.

THERMEC' 2006, July 4–8, 2006, Vancouver, Canada

THERMEC' 2006, International Conference on processing and manufacturing of advanced materials will be held July 4–8, 2006, at the Fairmont Hotel, Vancouver, British Columbia. The Conference will cover all aspects of processing, fabrication, structure/property evaluation and applications of both ferrous and non-ferrous materials, including hydrogen

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Recent Gleeble Papers

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Physical Modelling and Processing of Ti-6Al-4V ELI

by C.P. Chou, S.C. Wang, C.C. Chang, and W.R. Wang

Titanium has been widely used as the implant materials of joint prostheses. This paper simulates the microstructures of the hot forged titanium knee joint component by physical modeling. Ti-6Al-4V ELI were deformed by Gleeble 2000 hot deformation simulator in compression mode to determine the hot workability, in the range of 900 to 1100°C, with the strain rates between 0.05 to 5 s^{-1}. Test results derived from specimens processed by on-cooling test and on-heating test were compared, thereby estimating the effect due to thermal history. The forging process of Ti-6Al-4V ELI tibial base plate of knee joint prostheses was designed based on the workability data obtained.

425

Effect of the Controlled Rolling and Controlled Cooling on the Strength and Ductility of the Bainite Micro Alloyed Eng. Steel

by Z. Li, G. Wang, X. Liu, and C. Ma

The continuous cooling transformation of hot deformation austenite of test steel and the effect of different processing schedules of controlled rolling and controlled cooling on the strength and ductility have been studied. The theory and the experiment base are presented for controlled rolling and controlled cooling of the SBL micro alloyed engineering steel.

431

Optimizing Hot Forging Processes of Difficult-To-Forge Materials

by W. Chen, D. Ferguson, and H. Ferguson

Many difficult-to-handle steels and non-ferrous alloys have narrow processing windows, which create forging problems. How to forge new alloys, and especially those difficult alloys, becomes essential in obtaining better products and higher yields. For example, some stainless steels must be heated and soaked very carefully to avoid thermal shock and cracking, while in other alloys, heat loss must be minimized during forging to prevent steep thermal gradients on the surface due to die chilling. Physical simulation of both heating and forging processes in a laboratory can overcome difficulties in industrial trials and can tell the forging shop exactly how to heat and forge difficult alloys. The authors will draw upon their 40-year experience in process physical simulation to present methodology on how to optimize forging processes to prevent problems and achieve better product properties. New techniques, such as the SICOTM procedure, simulated forging, and hot ductility testing for development of forging process maps and thermal-mechanical forging process simulation are presented. Thermal mechanical process simulation of a crank shaft forging is studied with a microalloyed steel. The results have been successfully applied in an automotive crank shaft forging process and proved that drop forging with controlled cooling using a microalloyed steel provides better final mechanical properties than those from a five-sequence forging process using a medium carbon quench and tempered steel. In addition, development of a forge processing map using the SICOTM procedure to prevent cracking of 17-4PH stainless steel ingots is presented.

430

A Neural Network-Based Model for Prediction of Hot-Rolled Austenite Grain Size and Flow Stress in Microalloy Steel

by J. Niu, L. Sun, and P. Karjalainen

For the great significance of the prediction of control parameters selected for hot-rolling and the evaluation of hot-rolling quality for the analysis of production problems and production management, the selection of hot-rolling control parameters was studied for microalloy steel by following the neural network principle. An experimental scheme was first worked out for acquisition of sample data, in which a Gleeble 1500 thermal-simulator was used to obtain rolling temperature, strain, strain rate, and stress-strain curves. Consequently the austenite grain sizes were obtained through microscopic observation. The experimental data were then processed through regression. By using the training network of BP algorithm, the mapping relationship between the hot-rolling control parameters (rolling, temperature, strain and strain rate) and the microstructural parameters (austenite grain size and flow stress) of microalloy steel was function approached for the establishment of a neural network-based model of the austenite grain size and flow stress of microalloy steel. From the results of estimation made with the neural network based model, the hot-rolling control parameters can be effectively predicted.

435

Experimental–Numerical and Microstructural Control of Hot Strip Rolling

by R. Turk, M. Knap, and R. Robic

On a local level, thermomechanical states during the passing of hot metallic material through the deformation volume in a process of plane rolling with smooth rolls were analyzed by an experimental–numerical method. These states, which are markedly inhomogeneous in the length as well as in the height of the deformation zone, were taken as the basis for physical simulation of rolling the material at a certain level (i.e., stream line) of the deformation zone. Their influences on local yield stresses and on the development of the microstructure were checked. The efficiency of physical simulation of rolling with the Gleeble 1500 simulating equipment was examined. The states at which the transport of metallic materials through the deformation zone between smooth rolls takes place were analyzed by a visioplastic method, while physical simulation of rolling was made by thermomechanically controlled cylindrical compression tests. The tests were made with industrially manufactured X5CrNi8.9 austenitic stainless steel.

Gleeble at the University of Manitoba

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devise ways to pre-heat treat these alloys to improve hot ductility and to raise nil ductility and nil strength temperatures so that the weldability will be better. Most of our research is being done in collaboration with engine repairers and overhaulers, and some of the original manufacturers are getting into it as well."

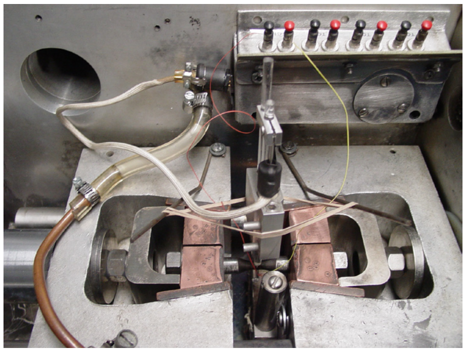
He adds, "Standard Aerospace Limited and Bristol Aerospace Limited, both engine overhaulers, are helping to fund this research, and so is the Natural Sciences and Engineering Research Council of Canada."

Another area of research at the University is diffusion bonding.

"Titanium aluminides are 'hot' aerospace materials," Dr. Chaturvedi says. "They are conventionally made by investment casting, but we are trying to make Ti-TiAl composites by taking micro-thin sheets, heating them to about 600°C in the Gleeble and compressing them so that they bond to each other."

He adds, "We're also doing work with magnesium, which is a very attractive material because it is very light, lighter than aluminum. But it is difficult to join because it forms an oxide layer. We're using the Gleeble to see if we can get a rod of magnesium and a rod of aluminum to bond together. We're trying to pioneer new ways of putting things together."

The group is also investigating thermal and mechanical fatigue. Dr. Chaturvedi says, "Fatigue occurs when you are cycling the load on a material. When you are varying both the load and the temperature, the material fails even more rapidly. Unfortunately, the effects are invisible until the failure happens."



A thermo-mechanical fatigue experiment is set up in the Gleeble.

The Gleeble research lab at U. Manitoba.

From the standpoint of thermal and mechanical fatigue, an aircraft engine can be quite a complicated system. For example, when an aircraft is taking off, load is being applied to the engine and the temperature is rising. As the aircraft reaches cruising altitude the engine thrust is reduced, but the engine turbine's blades etc., are still very hot, so the load can be out of sync with the temperature.

Dr. Chaturvedi says, "We want to understand what the fundamental causes for thermo-mechanical fatigue are, so we use the Gleeble to apply load and temperature, sometimes in sync and sometimes out of sync. The Gleeble can keep going for days, executing the same program again and again. It can drive our people crazy, but it gives us excellent reproducibility."

He adds, "We don't do too much research that is proprietary. We're trying to get at the fundamental issues underneath the problem. In one case, we found that the weldability of Inconel 718 can be improved if, after pre-weld solution heat treatment, you don't cool the material within certain cooling rates."

The team at the University of Manitoba also uses the Gleeble as a screening tool. Many aircraft components have thermal barrier coatings because temperatures inside an engine can reach 1,450°C. Unfortunately, the coefficient of expansion for the base material and the coating are usually different, and there is a need to subject the combination to thermal cycling to see what will happen. So the Manitoba group uses the Gleeble to pre-screen combinations to see which ones are good candidates for more expensive burner-rig tests.

Dr. Chaturvedi says, "The Gleeble is an essential tool in our research at the University of Manitoba."

See Us at the Shows

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and fuel cell technologies, metallic glasses, thin films, ecomaterials, nanocrystalline materials, biomaterials and other advanced materials.

THERMEC' 2006 is built upon the proven concept and continues the tradition of its four predecessors, Japan (1988), Australia (1997), USA (2000) and THERMEC' 2003 in Spain. This conference series provides a forum for researchers from around the globe to present papers on recent advances in the overall field of science and technology of processing and manufacturing of advanced materials.

Topics will include: Al Alloys, Mg Alloys, Aerospace Structural Metallic Materials, Automotive Alloys, Steels (including HSLA/IF/TRIP/Stainless, High Nitrogen and UHCS), Superalloys/Heat Resistant Steels, Composites, Hydrogen and Fuel Cell Technologies, Metallic Foams, Intermetallics, Nanocrystalline Materials, Metallic Glasses/Bulk Metallic, Amorphous Materials, Biomaterials, Severe Plastic Deformation, Friction Stir Welding/Processing, Smart/Intelligent Materials, Surface Engineering/Coatings, Advanced Thin Films and Nanomaterials, 3-D Microstructures, Characterization and Modeling Evolution, Powder Metallurgy, Ecomaterials, Textures, Modelling, and Welding and Joining.

For further information, visit http://thermec.uow.edu.au or contact:

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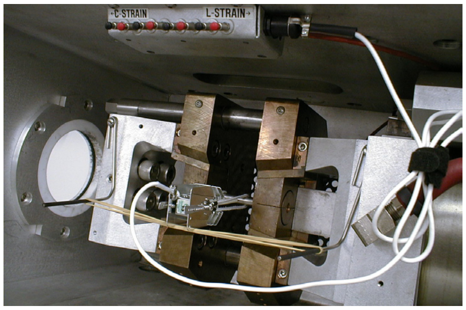
The Gleeble®
eNEWSLETTER

Unique Hot Zone L-Strain Fixtures



Fixtures are equipped with alumina rods.

The 39070 series of Hot Zone L-Strain Fixtures are based on a unique design that offers special advantages. These fixtures are equipped with alumina rods to contact the specimen for lengthwise measurement of the strain in the hot zone. The units are held on by light, flexible ceramic cords. These make the extensometer almost self-supporting and eliminate the need for bulky mounting brackets. The light weight of the sensor, combined with the self-supporting design, virtually eliminates side loading on the sample. The combination of radiant heating shields and auxiliary cooling allow use of the transducer at temperatures up to 1200°. A calibrated signal conditioner is included.

Several models are available based on initial gage length and total travel required. For additional information, contact Dynamic Systems Inc., P.O. Box 1234, Route 355, Poestenkill, NY 12140 USA, tel. 518 283-5350, fax 518 283-3160, or email info@gleeble.com.

Specifications for transducer only on Models 39070, 39071, and 39072

Model	*Parameter*	*Specification*
39070	Gage length	1.0 inch (25.4 mm)
39071	Gage length	10 mm (0.39 inch)
39072	Gage length	25 mm (0.984 inch)
39070	Travel	0.5 inch tension, 0.2 inch compression
39071	Travel	5 mm tension, 2 mm compression
39072	Travel	12.5 mm tension, 5 mm compression
All models	Linearity	±0.15% of full scale
All models	Resolution	±2.0 μm (0.00008 inch) This resolution is based on the electronic signal conditioning used.
All models	Transducer type	Full bridge strain gaged design
All models	Stroke rate	Maximum usable stroke rate is 10 mm/sec
All models	Operating temperature	Quartz contact tips rated for continuous operation from –0°C to 1200°C (0°F to 2200°F) and limited time operation up to 1300°C (2372°F). Heat shields required at all times. Heat shields are provided for protection of the measuring unit section of the transducer.