



ET Foundation

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ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

Process Analysis and Optimization Workshop

Monday, May 2, 2016

8:00 a.m. – 5:00 p.m.

Hyatt Regency Chicago Hotel

Instructors: Professor Luca Tomesani, Professor Lorenzo Donati and Professor Barbara Reggiani of the Manufacturing Technologies Group at University of Bologna, Italy

Program Topics

Introduction to practical and analytical extrusion concepts (Prof. Luca Tomesani)

1. Brief review of basics concepts: strain, strain rate and flow stress;
2. Dependency of flow stress on strain and strain rate in aluminum alloys; difference between flow stress and hydrostatic pressure in the extrusion dies;
3. Friction models for light metal extrusion, influence on material flow, on press loads and on bearings efficiency;
4. Heat balance in the process, generation of heat by material deformation and friction, dissipation trough container, dies and tools and profiles;
5. Relation of profile defects like speed cracks to material damage.

Material flow and Friction in direct extrusion (Prof. Lorenzo Donati)

1. Material flow in direct/indirect extrusion through viscoplasticity experiments and FEM simulations;
2. Effect of die coatings on friction;
3. Analysis of die filling in flat and porthole dies: evolution of material flow in the die, pressure of aluminum on the die, stress distribution in the die; discussion on the most critical process stroke for die strength, supporting effect in porthole dies;
4. Extrusion of empty/filled dies: die stresses and dead metal zones, influences on profiles quality
5. Material flow corrections: use of portholes, pockets and bearings; influence of single, conical or stepped pockets.

Die failure modes and die life prediction (Dr. Barbara Reggiani)

1. Working conditions of extrusion dies; failure modes of dies: static strength, fatigue, creep and their interactions;
2. Static strength: steels propriety, influence of the heat treatment, how to distinguish between ductile and fragile failures;
3. Fatigue: how to measure steels proprieties; influence of notches and radii, influence of roughness; how to distinguish fatigue breakages;
4. Creep: are extrusion dies affected by creep?; creep stages and die lifetime; how to measure steel's creep resistance;
5. Interactions between fatigue and creep: analytical models
6. Prediction of die life through FEM simulation: which analytical models are available today?

Process Optimization and Analysis Workshop at ET '16 (continued)

Seam welds, welding criteria and profile strength (Prof. Luca Tomesani)

1. Solid state bonding in aluminum alloys; parameters affecting the seam welds quality (material speed, temperature, pressure);
2. Concepts of strength and deformability of welded zones;
3. Influence of material flow stress and hydrostatic pressure;
4. Welding criteria and their application
5. Prediction and optimization of seam weld quality through FEM simulation.

Charge welds and process performance (Dr. Barbara Reggiani)

1. Concept of seam and charge welds;
2. Charge welds in a simple profile; interaction between butt length and charge weld; profile defects related to charge welds;
3. Extent of charge welds in relation to the die design; the “stop mark”, interpretation of profile etching response, localization of material scrap from the stop mark;
4. Interaction between charge welds and seam welds;
5. Prediction and minimization of charge weld extent through FEM simulation.

Microstructure evolution and Streaks formation mechanisms (Prof. Lorenzo Donati)

1. The streaks defect in extrusion: classification and origins;
2. Basics concepts of material metallurgy for 6XXX alloys: precipitates, intermetallics and grain shape evolution from casting to ageing;
3. Grain deformation, grain recrystallization and grain growth; abnormal grain growth;
4. Interaction between streaks appearance and alloy microstructure;
5. Profile streaks and their interaction with seam and charge welds.

Panel Session with all speakers

About the Presenters

Dr. Lorenzo Donati



Since September 2014 Dr. Lorenzo Donati is Associate Professor in Manufacturing Technologies in the “Department of Engineering for Industry” in the School of Engineering (Forlì Campus) of Alma Mater Studiorum -University of Bologna. He got the Ph. D. in the course on “Engineering of manufacturing systems, of metallurgy and applied measurements” of the Polytechnic University of Marche (Ancona, IT) with a dissertation on “Seam weld formation during aluminum extrusion: FEM simulation and experimental verification of the mechanical and aesthetical proprieties”. He is responsible of the courses of Basics Manufacturing Technologies and Advanced Manufacturing Technologies. The research field concerns the analysis and optimization of forming processes with specific focus on the extrusion of light alloy: seam and charge welds quality, die life estimation, microstructure evolution during extrusion processing are some examples of the most relevant topics. He participated to several projects coordinated by Professor Luca Tomesani. A full list of publications is available at <http://www.unibo.it/docenti/l.donati>

Process Optimization and Analysis Workshop at ET '16 (continued)

Professor Luca Tomesani



Luca Tomesani is full professor of Mechanical Technology and Manufacturing Systems at the University of Bologna, Italy, where he coordinates the scientific and industrial research in the fields of extrusion and advanced manufacturing of light alloys. He is responsible of numerous research projects funded by the European Union, the Italian Ministry of Scientific Research and by private companies of the mechanical sector. He is actually head of the CIRI-MAM, the Industrial Research Centre on Advanced Mechanics and Materials at the

University of Bologna, which coordinates 130 academics and 60 full time researchers. Professor Tomesani is organizer and head of ICEB, the "International Conference on Extrusion and Benchmark", which is held in Europe every two years since 2007. In addition, he is author of more than 160 scientific papers on aluminium extrusion and advanced manufacturing technologies.

Dr. Barbara Reggiani



Dr. Barbara Reggiani is a research fellow at the Industrial Department of the Bologna University (Italy) since 2008. She is contract professor of "Non-conventional machining" at the University of Bologna for the Mechanical degree. She received her PHD degree from University of Bologna discussing a thesis on numerical models dedicated to investigate the fatigue phenomena. Since 2008 her activities have been focused on the developments and applications of numerical simulation for the optimization of the aluminum

extrusion process both in terms of die life and product quality. In the last 8 years she has been author of a number of works presented at international conferences and published in scientific journals of international relevance.