Order of Magnitude Modeling May Lead to Low Cost Welding

In the automotive, aeronautical, and metals manufacturing industries, automatic welding saves millions of dollars in efficiency and manpower. The increased welding speed means that parts can be manufactured far more rapidly. However, tungsten arc welds made at high speeds often become bumpy and uneven. This "humping" effect is the sign of a bad weld, and until recently, standard modeling techniques were unable to determine what causes humping because of the large number of independent factors that affect a weld.

Materials science doctoral student Patricio Mendez may be able to explain the humping effect. Working in the Welding and Joining Group run by Prof. Thomas Eagar, Head of the Department of Materials Science and Engineering, Mendez has developed a modeling technique which determines the relative influence of the different factors. "Other members of the group and I would have long arguments about which factor was the most important," says Mendez. His order of magnitude scaling technique settled the argument. Through dimensional analysis and analysis of differential equations, Mendez was able to rate the effect of each factor on the welding process.

Sophomore Krista Niece (left) and doctoral student Patricio Mendez display welds (below) which show humping, supporting Mendez's order of magnitude welding model.

The answer? "None of us had it right," admits Mendez. Gas shear turned out to be the critical factor in high speed welding. According to Mendez's analysis, gas shear at high speeds causes uneven melting during the weld so that some of the metal being welded cools faster than the rest. This cooler metal balls up under the newly heated metal, causing the signature humping effect.

While order-of-magnitude scaling was developed to study welding processes, the modeling technique is also useful for a variety of other engineering practices. "So it's exciting in two ways," says Mendez, who hopes that his research will lead faster, less expensive automatic welding solutions. Mendez and the welding laboratory receive funding support from the Department of Energy, Office of Basic Energy Sciences.

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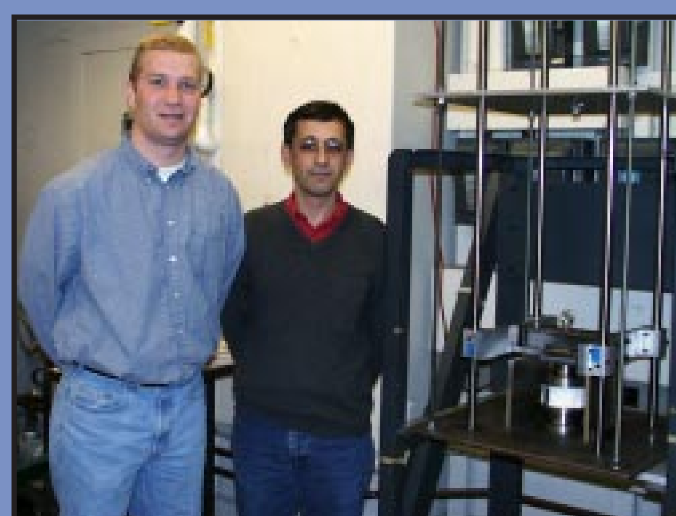
Research in Progress

New Analysis Technique for High Shear Semi-Solid Alloy Processing

"It's like a guillotine," says Professor Merton Flemings of a new analysis method being developed by doctoral student James Yurko and Dr. Anacleto deFigueredo in the MPC-sponsored Solidification Research Group. 25 years ago, Prof. Flemings led the development of the rheocasting process for low shear semi-solid alloys. Today, Yurko is turning his attention to and writing his thesis on what occurs in very high shear, or rapid deformation processes.

Modern modeling techniques break down when used to predict high shear on two-phase, semi-solid alloys. There is insufficient rheological data, and the system is too complex to be modeled. Yurko hopes to provide the much-needed data with his "guillotine" apparatus. A weight suspended above a semi-solid aluminum sample is dropped upon the sample to produce rapid deformation. The results will be recorded using a high-speed camera. Yurko and deFigueredo are still in the process of constructing the apparatus, but they expect to begin recording results in two or three months.



Graduate student James Yurko (left) and Dr. Anacleto deFigueredo are in the process of constructing a guillotine-like apparatus that may provide data on how a "skeleton" of solid particles breaks down in a two-phase, semi-solid metal.