

Undergraduate Welding Research at LeTourneau University

BY Y. ADONYI

College undergraduates bring enthusiasm, motivation, and creativity to \$1.65 million of projects over the past decade

LeTourneau University (LETU) is located in Longview, Tex., approximately 134 miles east of Dallas (www.letu.edu). Nationwide, there are few ABET-accredited institutions that teach welding engineering (WE) at the undergraduate level, and in fact, The Ohio State University holds the only WE program accredited in North America. The other ABET-accredited programs are design concentrations within a four-year BS in engineering degree such as at LeTourneau University (since 1954) and a new program that recently emerged at Montana Tech.

Several other universities, such as Weber State University in Utah and Ferris State University in Michigan, prove noteworthy because of good four-year BS programs in engineering technology. The fact is that welding engineering and topics related to WE research mostly are taught at the graduate level. Examples of institutions that offer MSc/PhDs include Ohio State, Massachusetts Institute of Technology, Rensselaer Polytechnic University, Colorado School of Mines, and others.

LeTourneau University is unique in its ABET/TAC accreditation for both a four-

year engineering program and an engineering technology program. The LETU program has also been known to emphasize a “project-based” approach to teaching WE. The founder, R. G. LeTourneau, promoted welding as advanced and economical manufacturing technology, and used it in construction of his earthmoving equipment and offshore drilling platforms. In 2005, the program was renamed Materials Joining Engineering to include polymer, ceramic, and composite joining.

Undergraduate Research

How does research performed by undergraduates differ from graduate research? In two essential ways: professional preparation and actual time spent on doing work with minimal supervision. Undergraduates are generally less prepared than graduates for research because they had not taken enough classes and typically are less mature. Undergraduates also do not typically benefit from 50% release time from their studies and can only work evenings, weekends, and during summer months. On the positive side, undergraduates are enthusiastic, highly motivated, and creative, bringing fresh approaches to solving problems.

Between 1996 and 2006, more than 83 students worked at LETU on approximately 43 applied research projects. Undergraduate pay is also lower than graduate student salaries, which combined with tuition waivers not charged to the project results in lower cost than equivalent work at graduate institutions. Average project length at LETU was six months, funded at \$25,000. Nevertheless, the total of \$1.65 million funding in ten years came from industrial sponsors and professional organizations such as the American Iron and Steel Institute and the American Institute of Steel Construction and from state and federal sources. These projects ranged

from welding process optimization to adhesive bonding and metallurgical transformations under nonequilibrium conditions in A 410 Mo stainless steel hardfacing.

Undergraduate Research Projects

Weldability Testing on High-Performance Weathering Steels

These new steels having minimum 70 and 100 ksi yield strength, respectively, (HPS 70W and 100W) represented a large amount of work in testing fusion zone and HAZ cold cracking susceptibility (Refs. 1–3). One specific contribution in this area was implementing on-site diffusible hydrogen testing, in the same environmental conditions where gapped bead-on-plate or Y-groove testing was performed.

Based on this work, preheat temperatures for avoiding hydrogen-induced cracking were established and published online under “HPS Manufacturing Guidelines” on the AISI Web site (www.steel.org).

Innovative Use of the Gleeble Thermomechanical Simulator

An example of applied research was simulating centrifugal casting of rolls for steel mills, where tool steel shells have to bond to the subsequently poured cast iron core — Fig. 1 (Refs. 4, 5).

The solid/liquid interface simulation work was also successfully applied to stainless steel-to-carbon steel transition layers, simulating electroslag weld hardfacing.

A recent example of an innovative use of the Gleeble was in simulation of a new hybrid welding process for on-line steel coil joining, sponsored by U.S. Steel in Kosice, Slovak Republic. The project’s

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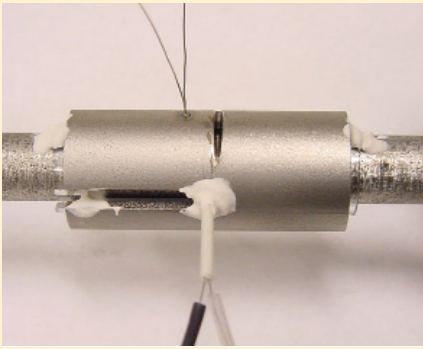


Fig. 1 — A — New Gleeble simulation sample geometry for dissimilar metal joining; solid/liquid interface between cast iron and tool steel.

aim was to improve weld quality and reliability in joining advanced high-strength steels (AHSS), which were difficult to weld with the flash welding process that was used on the pickle and galvanizing lines. A novel idea of using a combination of high-frequency induction welding and resistance welding was successfully validated using the Gleeble.

Work is underway to change specimen geometry to one better simulating the lack of symmetry in sheet metal welding, while numerical modeling and small scale prototypes are being built in Slovakia for this international cooperative project.

Adhesive Bonding vs. Welding of Steel Cabinets

Replacing unreliable and uneconomical corner gas metal arc welds in a power unit for the Defense Department was the goal of a work sponsored by the Texas Higher Education Coordinating Board, Lucent Technologies, and 3M Corp. Following welded joint redesign from corner-to-lap-joint preparation, several industrial adhesives were tested and optimum combinations found. The prototype cabinets, which were adhesively bonded, performed adequately in static testing, but were clearly superior when compared to similar welded cabinets in seismic testing — Fig. 2.

Another solution provided by the research team was finding the highest strength industrial adhesive that cured at the same temperature as the paint used for the cabinet.

These projects illustrate the applied and relevant nature of the research performed at LeTourneau University.

Future Trends

The research of the past decade resulted in nine papers, 12 technical presentations, ten reports, and seven posters.



Fig. 2 — Adhesively bonded cabinet during seismic testing at Southwest Research Institute.

Many projects performed under confidentiality agreements were never published. Most solutions provided had immediate applicability and helped in improved quality, higher productivity, and better designs. The technical value of the undergraduate research has also earned recognition through various awards from professional societies.

The LETU team has recently been challenged to approach new process simulations such as friction stir welding, as well as welding-related topics such as centrifugal casting. This illustrates this new trend of approaching materials bonding/joining in a more comprehensive fashion than before. One such example of a new trend project is working on biomedical research on leg prosthesis design, its fatigue strength (Fig. 3), and nondestructive testing. The project is led by Roger Gonzales. The LeTourneau Engineering Global Solutions (LEGS) provides a low-cost prosthesis solution to developing countries such as Kenya and Bangladesh, see www.letu.edu/legs.

Robert Warke joined the faculty at LETU in 2003 and his expertise in weld design and probabilistic assessment of



Fig. 3 — Plastic foot-to-aluminum stem joint prototype which failed during fatigue testing after two-million cycles.

welds has already been successfully used in a through-deck stud welding study funded by the American Institute for Steel Construction. We expect to work together on more materials joining design and process related research on advanced materials, ceramics, polymers and composites. This will all be taught from the improved curriculum in Materials Joining Engineering.

Conclusions

Undergraduate research presents specific challenges in the areas of student competencies, resident time and depth of understanding, limiting work to applied research and problem-solving topics. Nevertheless, several innovative solutions resulted from this work at LETU in the area of Y-groove test specimen preparation, as well as in Gleeble simulation techniques for solid-liquid interfaces and hybrid joining technologies. At the same time, the outcomes of these projects were relevant and truly needed by different industry sectors. Finally, those who hired former undergraduate researchers from LETU received the added benefit of professional competency and ability to work independently. ♦

Acknowledgments

The author would like to thank all those who supported us during this first decade of undergraduate research at LETU. Thanks go out to all those students who faithfully completed their work, to Professor Emeritus William Kielhorn who through the years helped maintain the continuity of the work in an orderly and systematic way, and all of our industry partners who have validated the relevance of our endeavors and provided in-kind funding through equipment and consumable donations. Finally, all this would not have been possible without strong institutional support from LETU Administration.