Ultrasonic metal welding

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Presentation Outline

- Objectives
- Experimental
- Results
- Conclusions
- Impacts

Objectives

- To improve the weld quality in terms of strength and appearance by using amplitude profiling
- To minimize the tool/part adhesion and improve the weld quality in terms of appearance and possibly weld strength by using buffer sheets, such as zinc and/or copper
- To compare the three control modes: energy, post height, and time and determine which one resulted in a higher weld consistency of strength

Background –Ultrasonic metal welding

- Consists of joining two metals by applying ultrasonic vibrations under moderate pressure
- The overlap zone - softened between the parts to be welded – solid-state weld by shearing and plastic deformation
- The oxide –removed by the high frequency vibration – metal/metal contact between parts – metallic bonds

Background –Ultrasonic metal welding system

Equipment:

- System components: transducer (converter), booster, horn

Resonates at a particular frequency to maximize the overall efficiency

- **Power supply: - converts line voltage electrical power into high frequency electrical energy**
- **Converter: - changes electrical energy into low-amplitude mechanical vibrations of the same frequency**
- **Booster: - increases or decreases the amplitude of the vibrations**
- **Horn: - transmits the vibrational energy from the booster into the workpieces**

Background – Ultrasonic metal welding

Amplitude and amplitude profiling:

Amplitude:

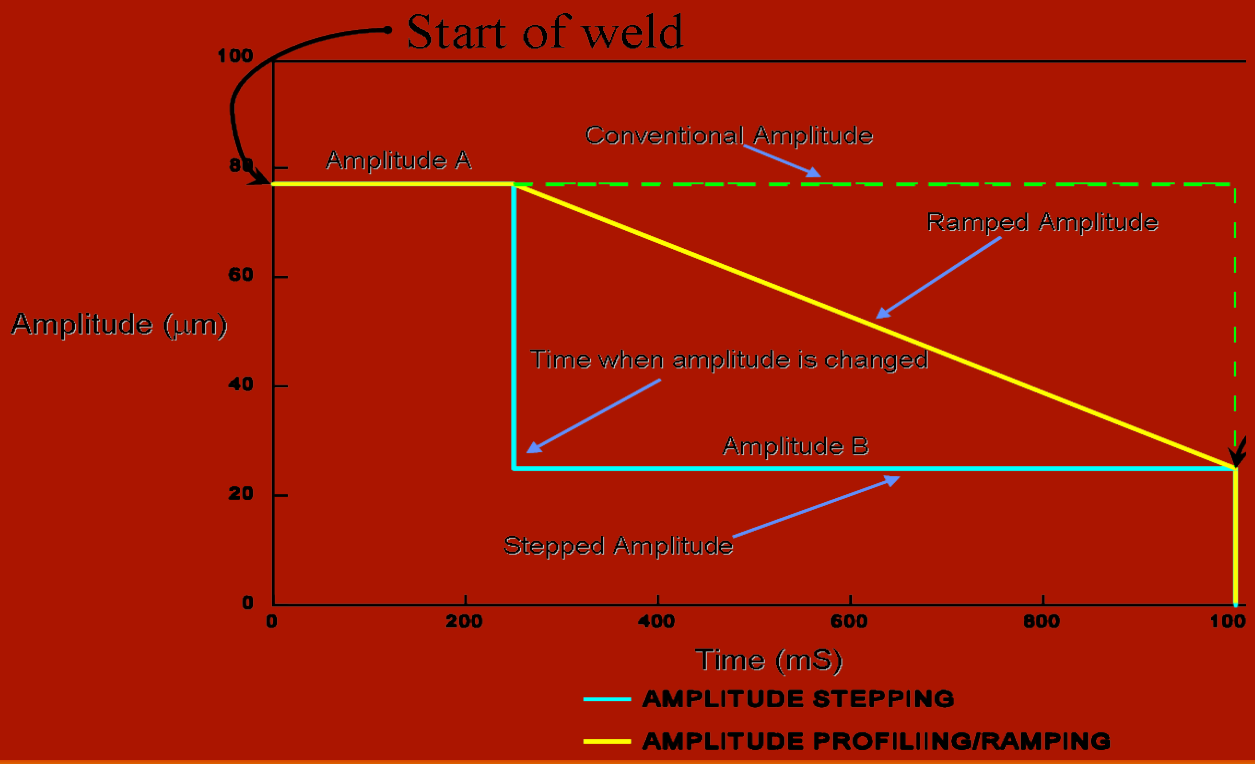
- **Peak-to-peak displacement of the horn at its work face in μm or in**
- **Controlled electrically by adjusting the voltage into the converter**

Amplitude profiling:

- **Performs a weld using two different amplitude settings**
- **The trigger point for the A to B transition during the weld - time method**

Background – Ultrasonic metal welding

Constant amplitude and amplitude profiling:



Background – Ultrasonic metal welding

- **Welding modes:**

  Energy:

  - A preset energy dissipated - the power supply discontinues the ultrasonic energy, independent of the time

  Postheight:

  - Power supply monitors an encoder on the actuator and applies sonics to the parts until the preset postheight occurs

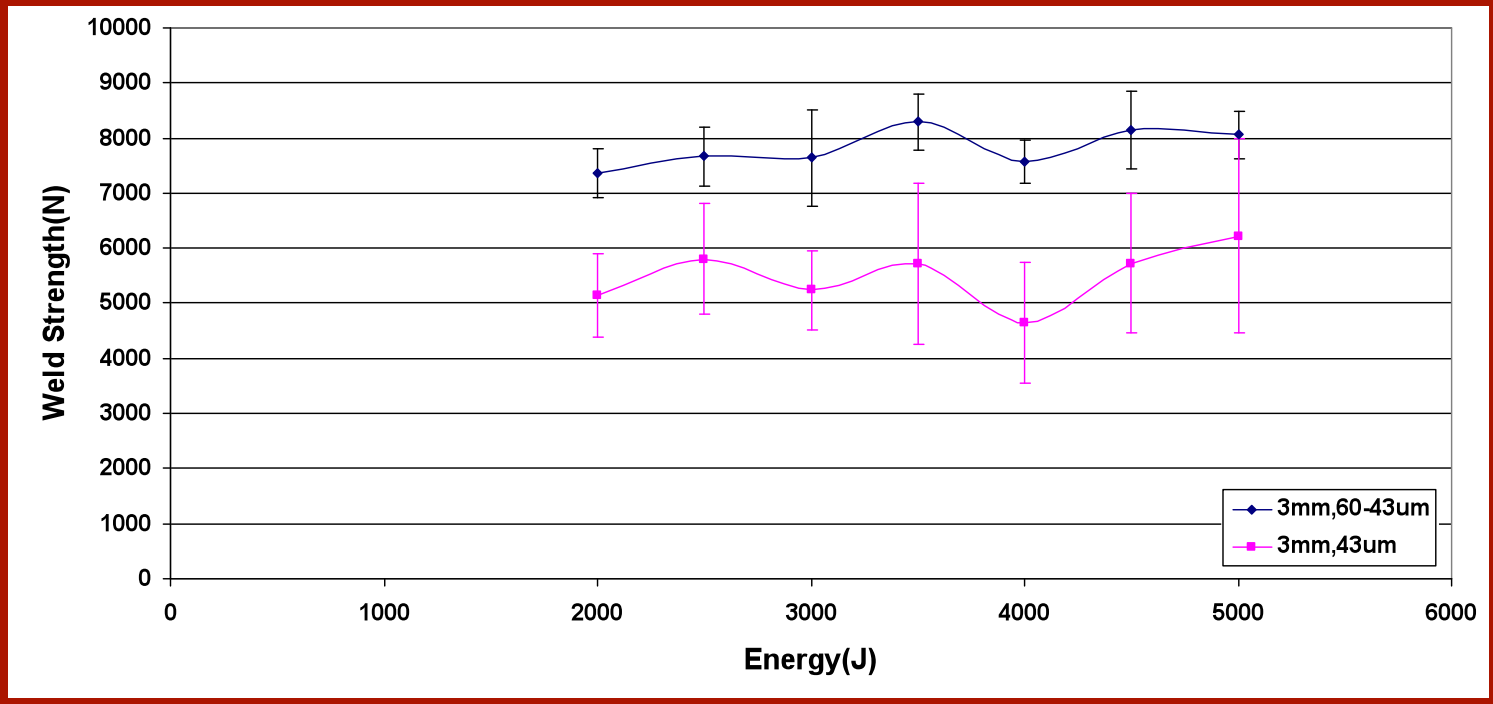
  Time: - Sonics remain on for a preset length of time

Experiment – ultrasonic metal welding process

- Amplitude profiling was studied to reduce part marking and improve weld strength
- The use of buffer sheets were studied to reduce part marking
- Three modes were studied and compared for consistency
  - Energy
  - Postheight
  - Time

Results – Ultrasonic metal welding using amplitude profiling

Comparison of weld strength values when welding in the energy mode with amplitude profiling (60-43 µm) and constant amplitude (43 µm)



Results - *Evaluation of zinc buffer sheets in ultrasonic welding of aluminum*

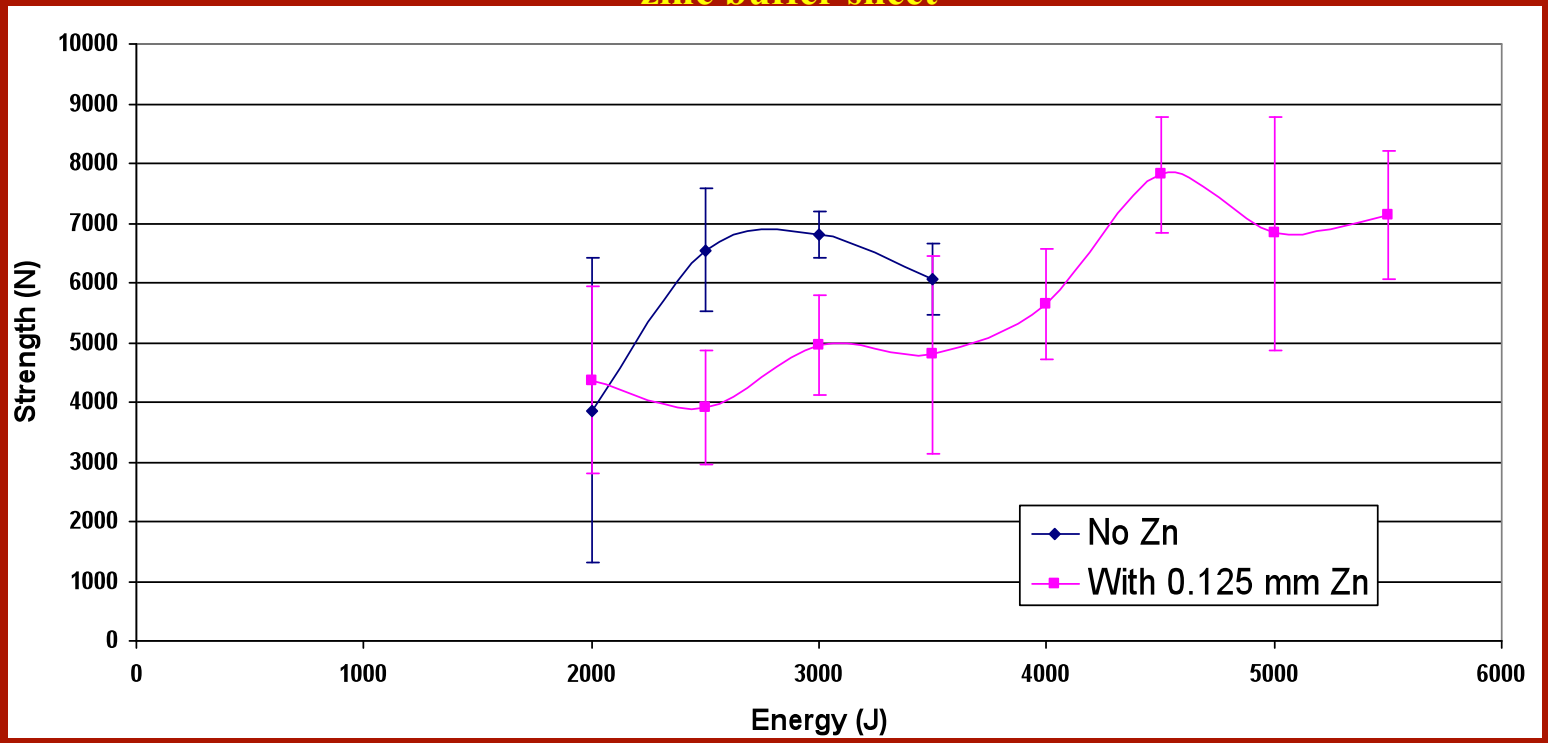
Part marking –zinc study

Without zinc

With 0.125 mm zinc

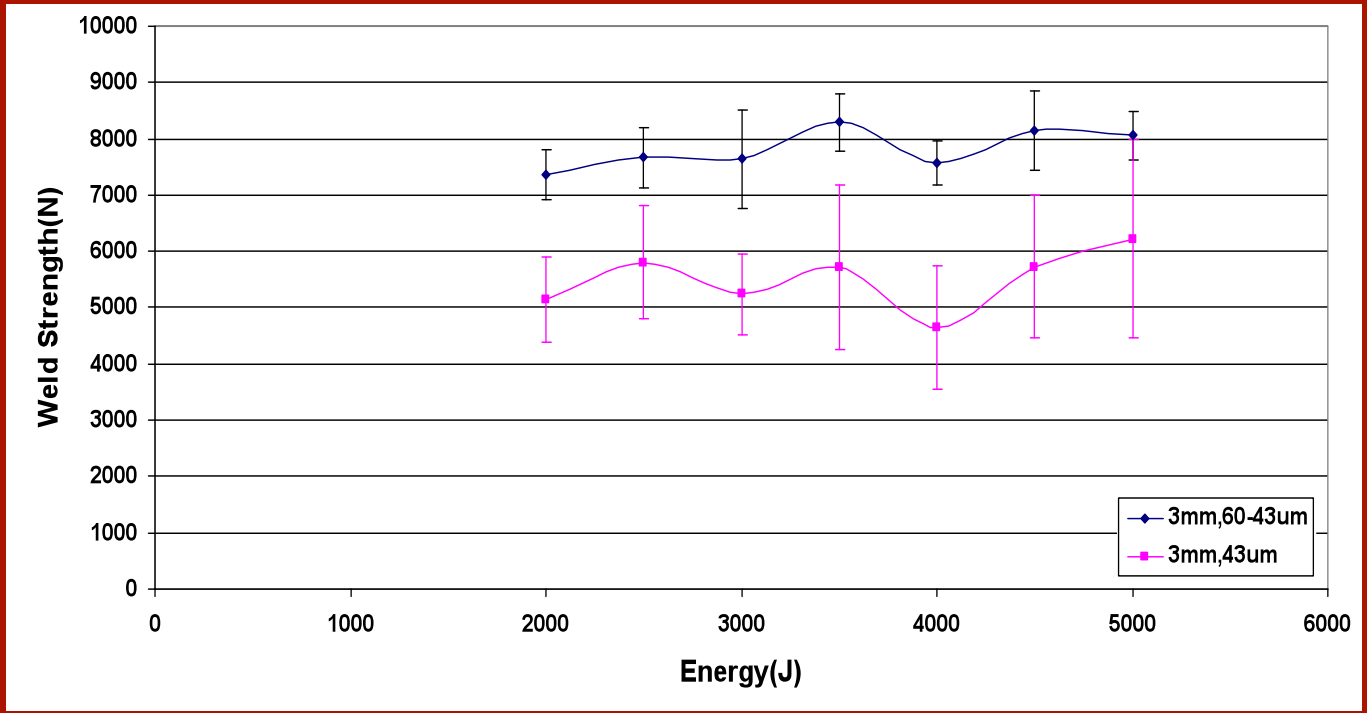
Results - *Evaluation of zinc buffer sheets in ultrasonic welding of aluminum*

Weld strength values when welding in the energy mode with amplitude profiling without and with zinc buffer sheet



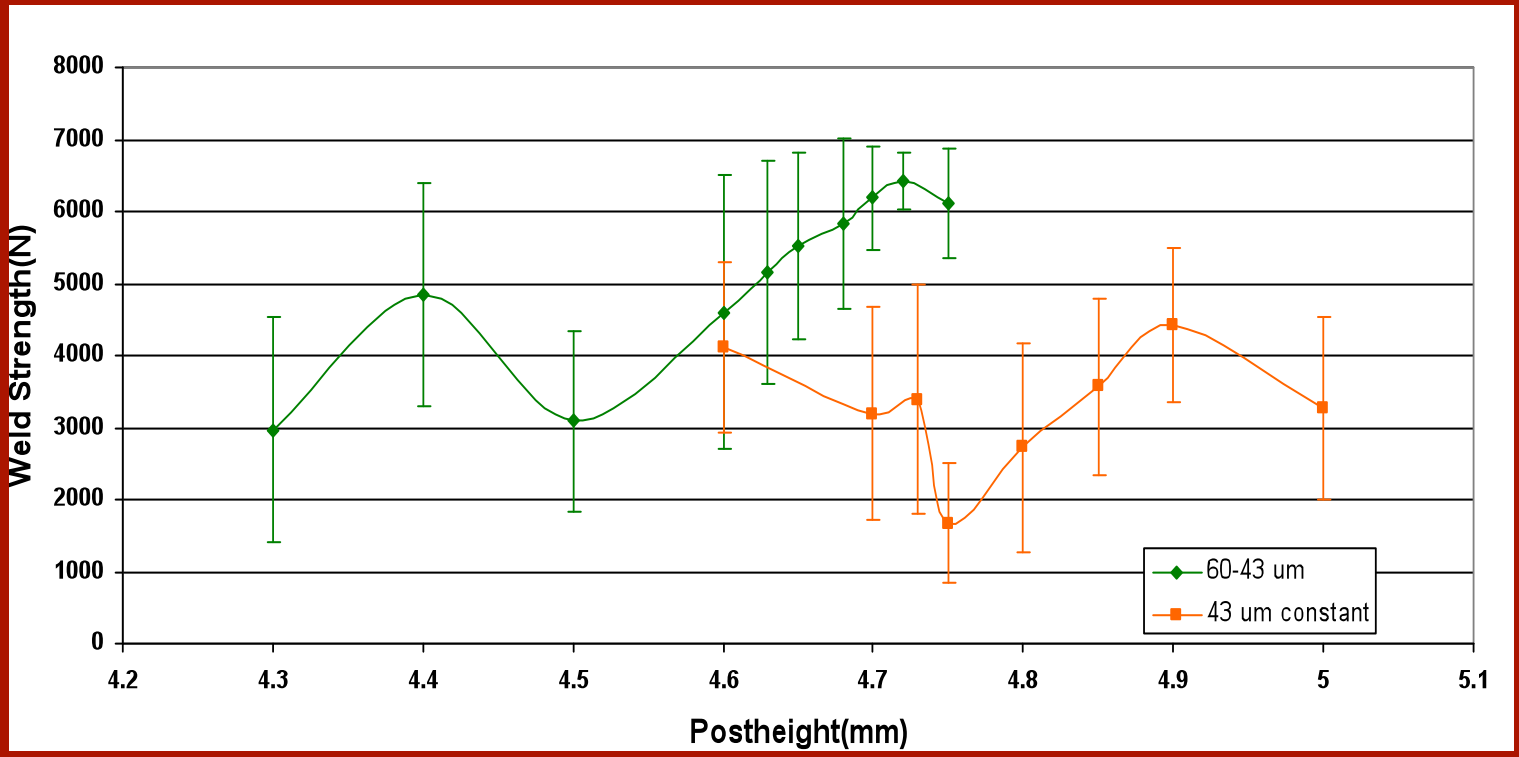
Results – Comparison of the three welding modes

Energy mode optimization



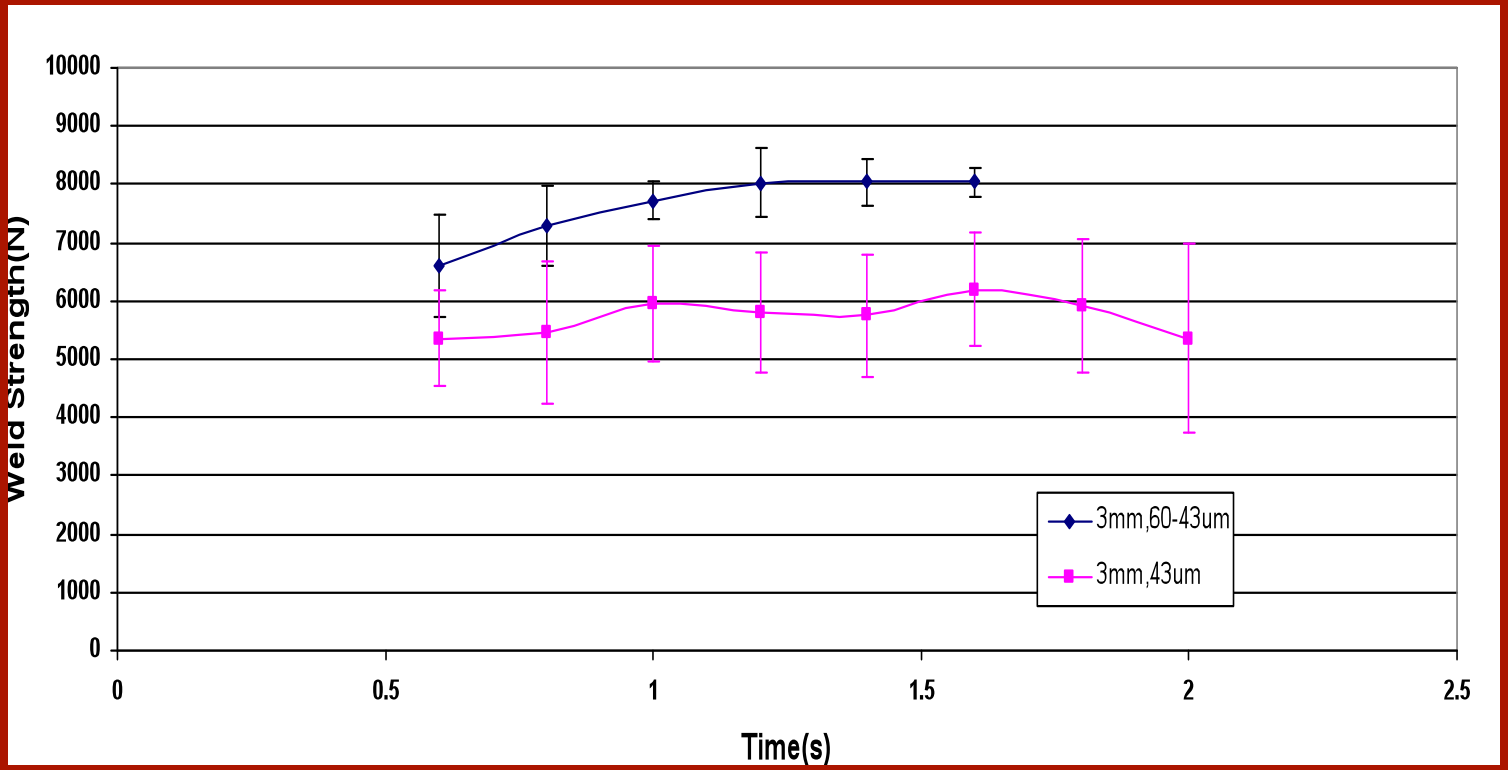
Results – Comparison of the three welding modes

Post-height mode optimization



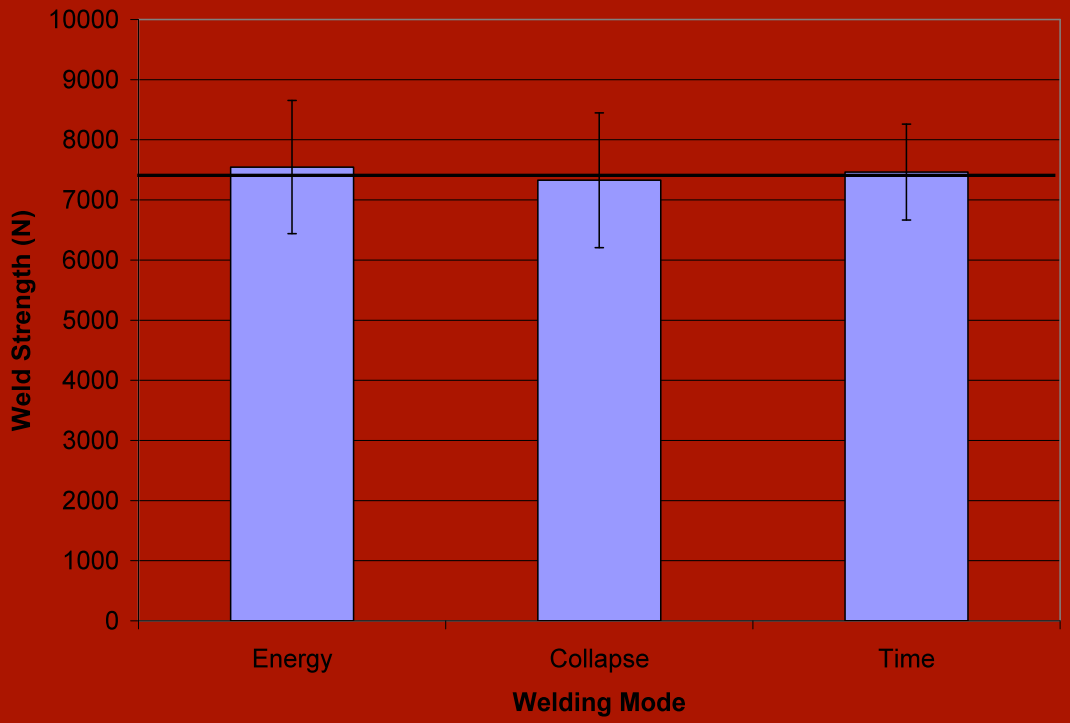
Results – Comparison of the three welding modes

Time mode optimization



Results – Comparison of the three welding modes

Statistical comparison:



Conclusions

- Amplitude profiling increases weld strength and reduces weld time
- Buffer sheets significantly reduced part marking and part/tool adhesion
- The weld strength variance for the time mode smaller compared to the other two modes

Impacts

- Welding of larger samples and actual automotive applications at extremely high speed and high efficiency

- Alternative tooling design, buffer sheet composition, tip coating