

## Arcing up for Better Welds

An AutoCRC research team has created the first industrial grade computer model of weld quality for use in robotic arc welders on the assembly line. Using the model to guide welding robots promises to significantly improve the quality and consistency of joints in tomorrow's cars.

Supported by GM Holden and AutoCRC, the team led by Dr Tony Murphy, a CSIRO senior researcher and modelling specialist, has succeeded in developing a digital model of gas-metal arc welding, commonly known as MIG welding. The model takes into account all critical production weld quality factors such as arc and weld pool formation, transfer of metal from the rod, and creation of the weld joint. MIG welding is used extensively by automakers to assemble lightweight components.



Robotic welding of a component

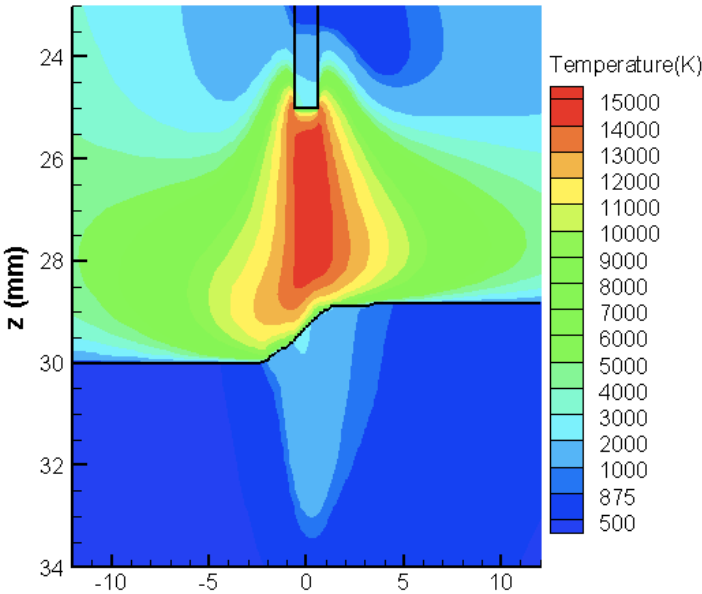
Modern automobile bodies are assembled automatically on production lines, using resistance (spot) welding, laser and arc welding to create permanent joints between the stamped steel parts. With the recent focus on weight reduction for fuel economy, and increased use of high strength steels and aluminium parts, other joining processes are now increasingly used, especially MIG welding. MIG welding has the ability to weld where spot welders can't get access, and is ideal for welding aluminium components. However, the time and cost of arc weld quality control is much greater than spot welding.

Automobile assembly has developed over decades to a sophisticated practice, especially in the case of spot welding, where each aspect of the process has been optimised for quality and repeatability. Production lines include sensors and controls to maintain spot weld quality and alert line operators when maintenance is needed. The introduction of MIG welding in high volume robotic production has been achieved using practical experience and experiment, and there are opportunities for great improvements.

Because current applications of arc welding in production are based on practical experience, any variations in weld wire size and composition, arc current and temperature, and weld speed can cause quality issues that must be fixed after the weld is completed. These issues can be unmelted pieces of weld wire, uneven weld depth and size, or even gaps in the weld joint. While all these faults are easily rectified, it takes time and money. In an attempt to predict and prevent these problems, scientists have developed models of parts of the process, but Dr Murphy says “.. no comprehensive treatment of MIG welding that addresses all the difficulties has yet been developed.” So GM Holden looked for a better way.

The CSIRO team has pioneered world developments in the modelling of the arc, the electrode and the weld pool. With the aid of modern computing power, years of research in arc welding, and a considerable amount of creativity in science and computer programming, Dr Murphy and the team were able to integrate models of many separate aspects of the production MIG welding process into a complete model. Dr Murphy says, "Our aim is to visualize weld profiles and key parameters throughout the length of the weld."

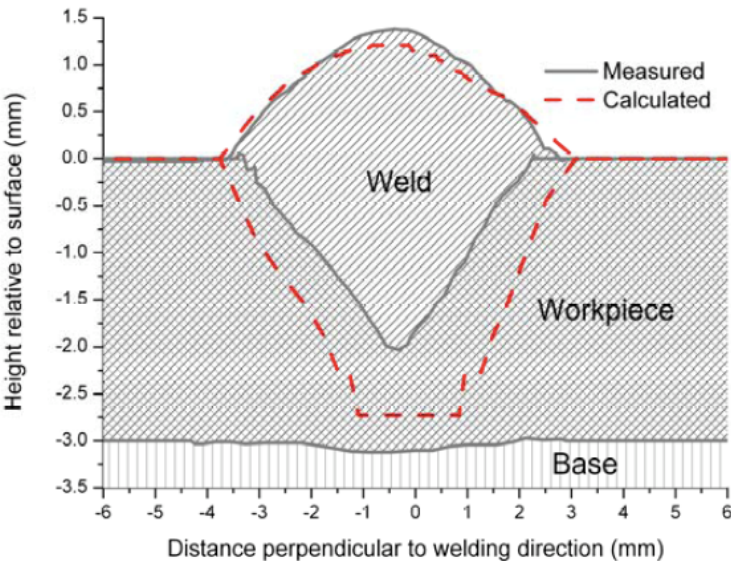
The team's 3-D model of MIG welding takes into account all the important effects. The model treats the wire, arc and workpiece self-consistently, and this allows the geometry of the weld to be predicted. A key feature is the integration of the arc in the model, which allows engineers to predict the influence of weld pool surface shape on arc position, and the transfer of metal droplets to the weld pool. The model also predicts temperatures, current densities and velocity distributions in the arc and weld pool.



The model predicts temperatures and current densities and velocities in the arc and weld pool

*"Complete computational models of arc welding will improve understanding of typical weld quality problems, and allow automation for consistent high quality welds in production." -Dr Murphy, Project Leader.*

AutoCRC's Research Manager, Dr Gary White, is enthusiastic about the potential for the model. "Car makers look for every opportunity for waste reduction, and the welding process has significant potential. Time and money can be saved in the production of tomorrow's fuel efficient cars when the model is fully utilised by a production welding system."



Calculated weld compares well with experiment

As each metal has unique characteristics, the parameter ranges for good weld quality will vary. MIG welding is often performed at unusual positions and orientations. In future the weld model could be tuned to other metals, to eventually predict weld quality for a wide range of metals and welding conditions.

AutoCRC's strategy is to encourage local and international collaboration to optimise the research outcomes from its projects. The weld research team has active links with researchers in Canada and China, collaborating to further improve the model's performance.

### **Publications**

Murphy, A. "A self-consistent three-dimensional model of the arc, electrode and weld pool in gas-metal arc welding." Journal of Physics D: Applied Physics, Institute of Physics Publishing, 2011.

Murphy, A. "Three-dimensional computational modelling of MIG welding." The International Symposium on Visualization in Joining & Welding Science through Advanced Measurements and Simulation, 11 Nov 2010.

### **Contact details**

Contact:

Dr Matthew Cuthbertson, CEO

Mr Ian Christensen, General Manager

Dr Gary White Research Manager

Dr Thomas Ting, Commercial Manager

Email: [info@autocrc.com](mailto:info@autocrc.com)

Web: [www.autocrc.com/research](http://www.autocrc.com/research)