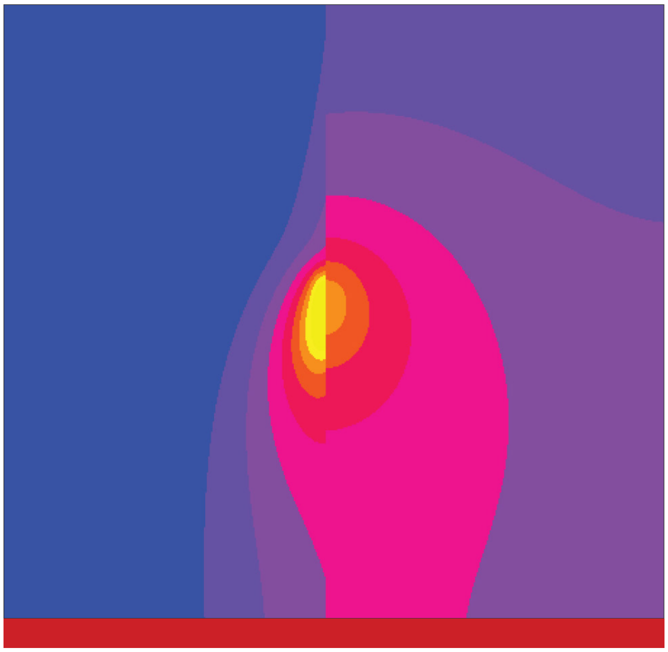
Case Study: **Sant Longowal Institute of Engineering & Technology**

Marc Helps Solve Complex Welding Problem to Improve Life of Heat Exchangers

Overview

Welding is a common practice in the automotive, aerospace, railways, ship building, and machinery industries. It allows for the joining of components by subjecting them to intense localized heat which melts and coalesces the material in the welded region, forming a permanent joint.

Multiple process parameters influence the effectiveness of the welding, which include energy source, shape and size of the melt zone, heat affected zone, and speed. Understanding and improving this challenging process through physical iteration can be time consuming and expensive. MSC's Marc, a nonlinear finite element analysis tool, can provide the required insights needed to solve these parameters in a cost-effective manner.



“We found Marc to be very good in simulating the complex physics of the welding problems. Matching results with experimental data demonstrated that this approach can be used to significant costs by reducing material waste and improving life of the welded parts.”

Gurdeep Singh, Sant Longowal Institute of Engineering & Technology

Challenges

Multiple materials are used in heat exchangers in different temperature zones for better efficiency and cost reduction. This requires welding of dissimilar materials with different properties like conductivity, coefficient of thermal expansion, and strength. These differences increase the chances of failure due to differential expansion and contraction. In addition the joining of metals with different melting temperatures or thermal conductivities is made even more difficult as one metal melts before the other, with uneven temperature partitioning, and distribution around the weld surface.

Solution/Validation

Copper and steel are commonly used in heat exchangers in different zones and need to be joined at the transition region. High conductivity of copper makes it difficult to reach the melting temperature of copper, which makes it harder to achieve a good weld between steel and copper. “This is a common problem experienced by a railway manufacturer in India, which also leads to higher welding and material costs, and risk of early failures,” notes Gurdeep Singh of Sant Longowal Institute of Engineering & Technology. Singh decided to employ MSC Software’s Marc after reviewing multiple FEA software products. He chose Marc for its robust welding specific technology and the thermal analysis capabilities to address this complex problem.

As peak temperatures and temperature distribution dictate the effectiveness of the weld, the study focused on thermal analysis to investigate the problem and potential solutions. A 3-D thermal finite element model is created with two plates, each of dimensions 50 mm x 100 mm x 1 mm, one made of Copper and the other made of AISI304 stainless steel (Figure 1). A higher mesh density is defined at and around the interface region. The mesh density is gradually reduced further from the interface as the thermal gradient is not expected to be high far from the weld zone.

The model is used to perform nonlinear, transient thermal analysis to predict the temperature distribution and heat affected zone during butt welding. The goal of the study is to find the effect of offsetting of the welding arc from the weld interface during gas tungsten arc welding (GTAW). To that extent, all the welding parameters are kept constant, except for the offset distance of the weld from the weld line.

The heat generated by the welding arc is modeled using double ellipsoidal heat source model, as shown in Figure 2. The specific parameters used in this model are determined through experimental study of the weld pool and are adjusted to create desired melted zone geometry for the prescribed welding conditions. Transient thermal analysis is then performed by translating the weld arc along the interface, but with different offsets with respect to the

Key Highlights:

Product: Marc

Industry: Manufacturing/ Research

Benefits:

- Easily try alternative approaches without having to invest in physical experimentation
- Gain greater insight into temperature gradients with simulation, which are harder to measure in physical tests

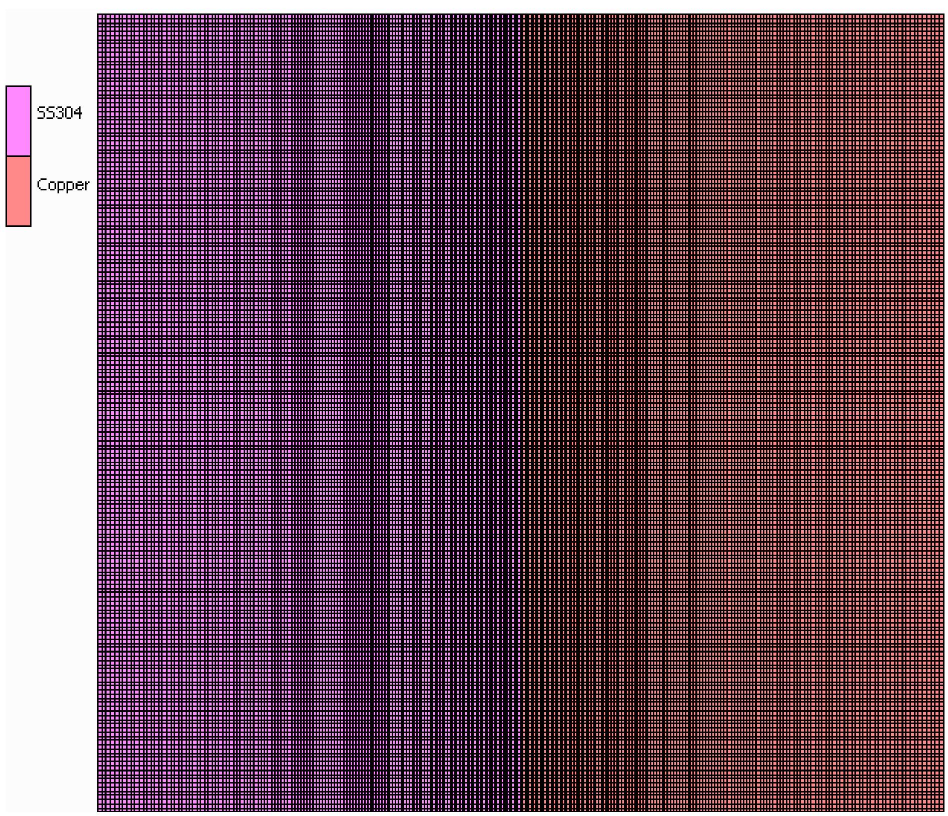


Figure 1: Finite element mesh used for analysis

interface. Results obtained and reviewed include the temperature distribution in both the plates to identify peak temperature and heat affected zone for each case (Figure 3 shows a temperature distribution for one case) and temperature distribution along transverse direction (Figure 4).

The investigation provided key insights into the welding of dissimilar materials:

- Heat affected zone (HAZ) is larger in copper weld pads than in stainless steel.
- Heat dissipation rate in copper weld pad is higher than in stainless steel
- When the welding arc is positioned along the weld line, the peak temperature attained is not along the weld line, but at some distance away in stainless steel plate
- Off-setting the arc towards copper plate helps shift the peak temperature towards the plate interface or the weld line.

Conclusion

The model demonstrated the effects of thermal contact at the joint interface during GTAW welding of the dissimilar materials, and the influence of transverse offsetting of the arc away from the weld line. "We found Marc to be very good in simulating the complex physics of the welding problems. Matching results with experimental data demonstrated that this approach can be used to significant costs by reducing material waste and improving life of the welded parts," says Singh.

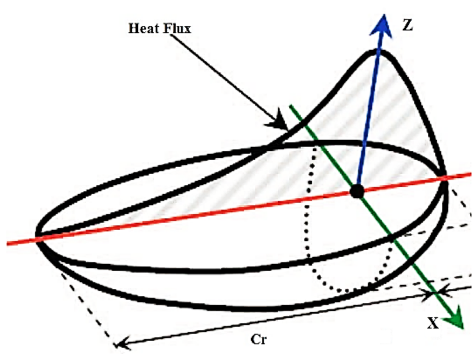


Figure 2: Double ellipsoidal heat source model

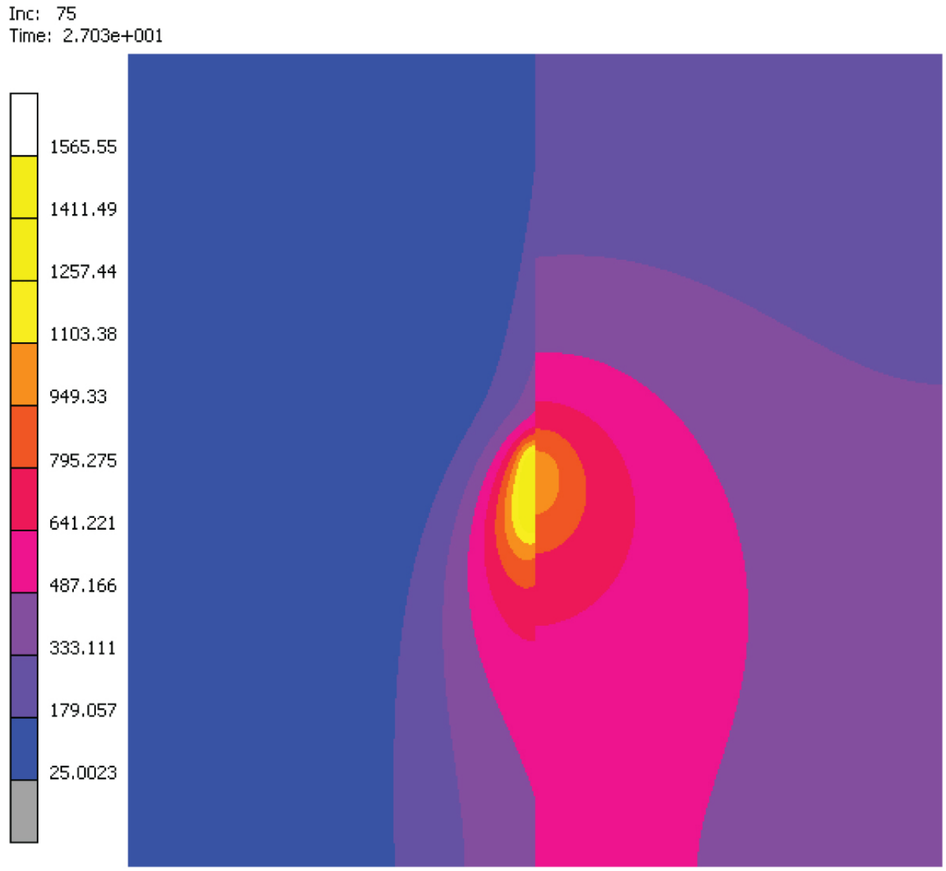


Figure 3: Heat affected zone of stainless steel and copper

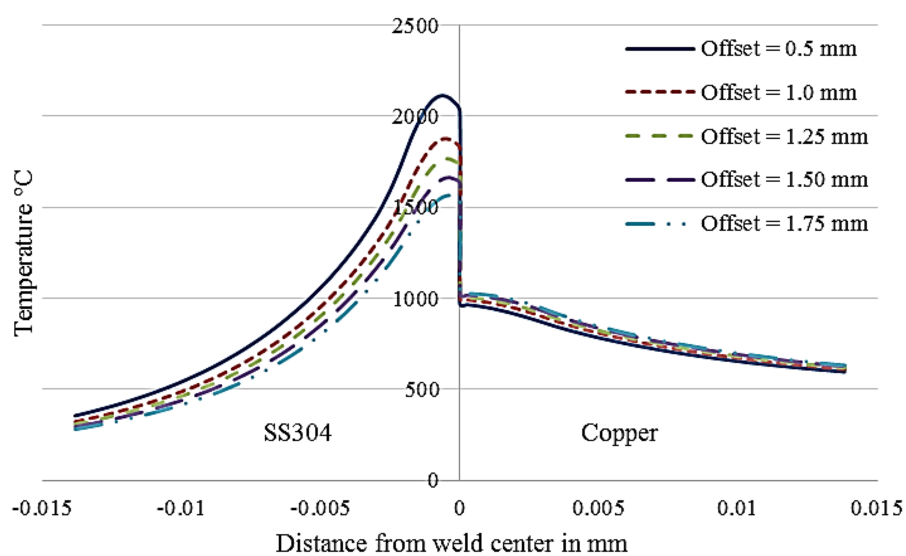


Figure 4: Temperature distribution along transverse direction with offset

For more information on Marc and for additional Case Studies, please visit **www.mscsoftware.com/marc**

Corporate
MSC Software Corporation
4675 MacArthur Court
Suite 900
Newport Beach, CA 92660
Telephone 714.540.8900
www.mscsoftware.com

Europe, Middle East, Africa
MSC Software GmbH
Am Moosfeld 13
81829 Munich, Germany
Telephone 49.89.21093224
Ext.4950

Desktop Engineering Ltd
6-7 Bankside, Hanborough Business Park
Witney Oxfordshire OX29 8LJ UK
www.dte.co.uk | enquiries@dte.co.uk
+44 (0) 1993 883 555
dte DESKTOP ENGINEERING

MSC Software

The MSC Software corporate logo, MSC, and the names of the MSC Software products and services referenced herein are trademarks or registered trademarks of the MSC Software Corporation in the United States and/or other countries. All other trademarks belong to their respective owners. © 2016 MSC Software Corporation. All rights reserved.

SL*2016SEPT*CS