Transport Phenomena in Gas Tungsten Arc Welding of Ni to 304 Stainless Steel

Alireza Bahrami & Daryush K. Aidun
Mechanical and Aeronautical Engineering Department, Clarkson University, Potsdam, NY 13699-5725

Introduction: Study of transport phenomena in the welding process is essential in order to predict weld parameters such as weld zone and heat-affected zone size, cooling rate, thermal stress residuals and defect formation.

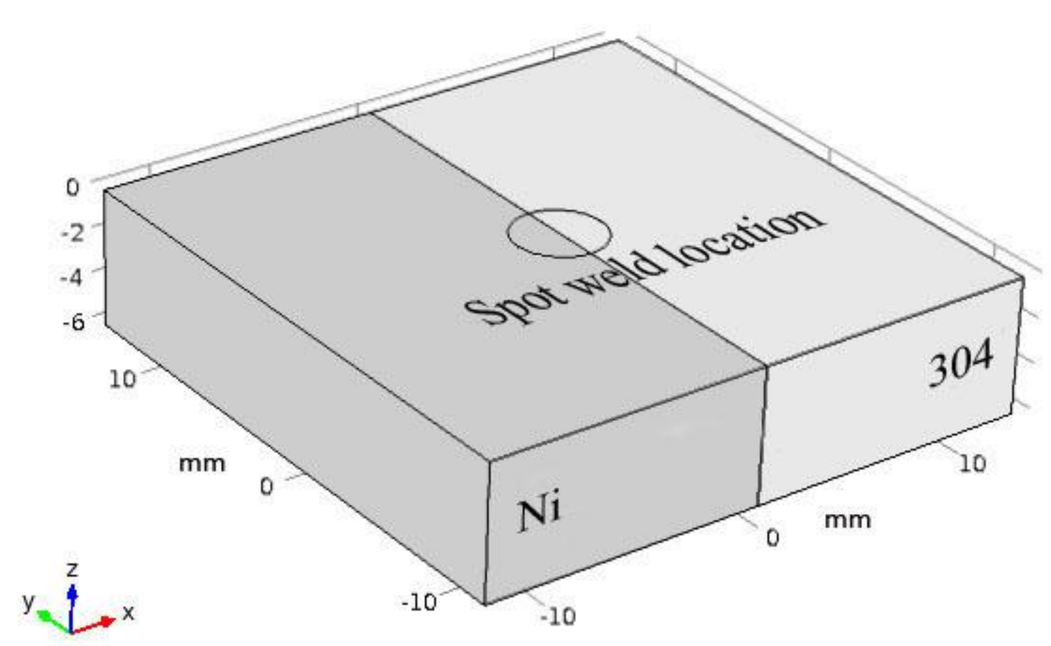

Figure 1. Schematic of Welding Model

Computational Methods: Simulation of the GTA welding process includes electro-magnetics, fluid flow and heat transfer. Volume forces applied to the model are Lorentz force and buoyancy

$$\mathbf{F_b} = \mathbf{J} \times \mathbf{B} + \rho_0\big(1 - \beta(T - T_s)\big)\mathbf{g}$$

Marangoni effect is applied to the top surface

$$\mu\frac{\partial u}{\partial z} = \frac{d\gamma}{dT}\frac{\partial T}{\partial x} \quad \& \quad \mu\frac{\partial v}{\partial z} = \frac{d\gamma}{dT}\frac{\partial T}{\partial y}$$

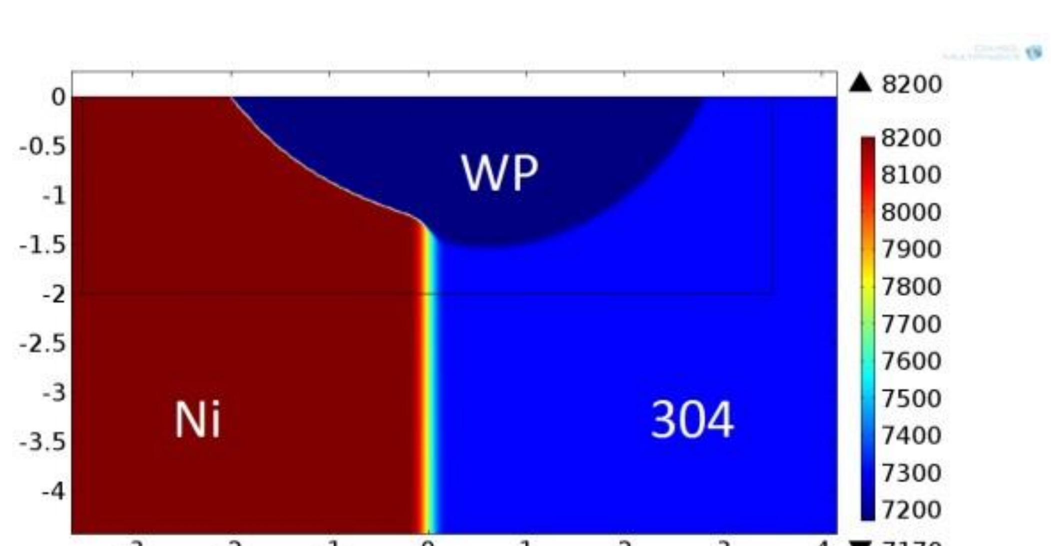

Figure 2. distribution of density

Electric Currents (ec), Magnetic Field (mf), Heat Transfer in Phase Change (ht) and Laminar Flow (spf) are used to model the welding Process.

Results: The results for welding parameters, 150A, 14V and 15s, are presented here:

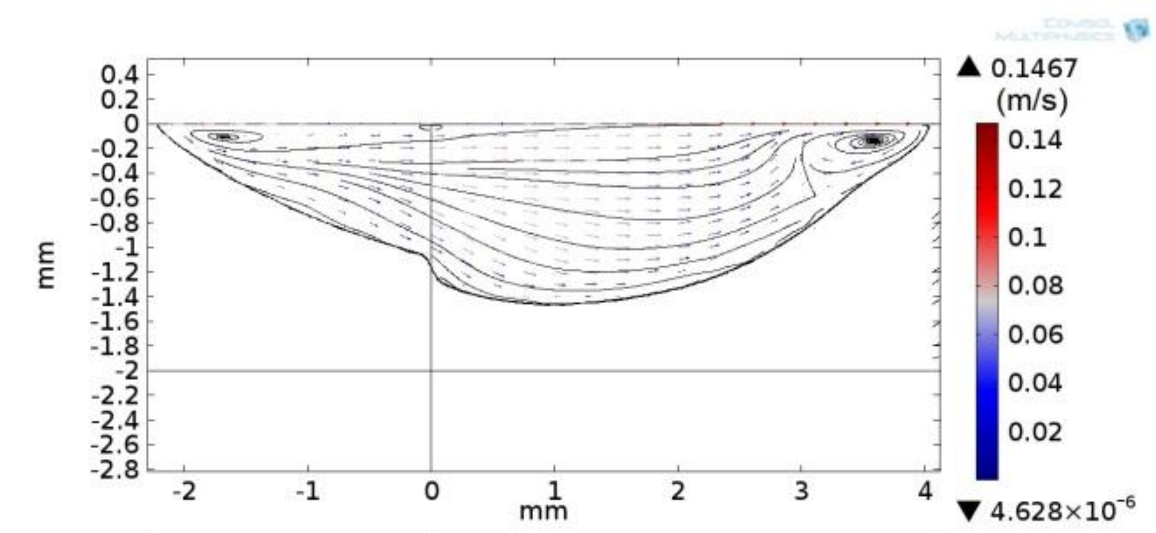

Figure 3. Velocity field in xz-plane

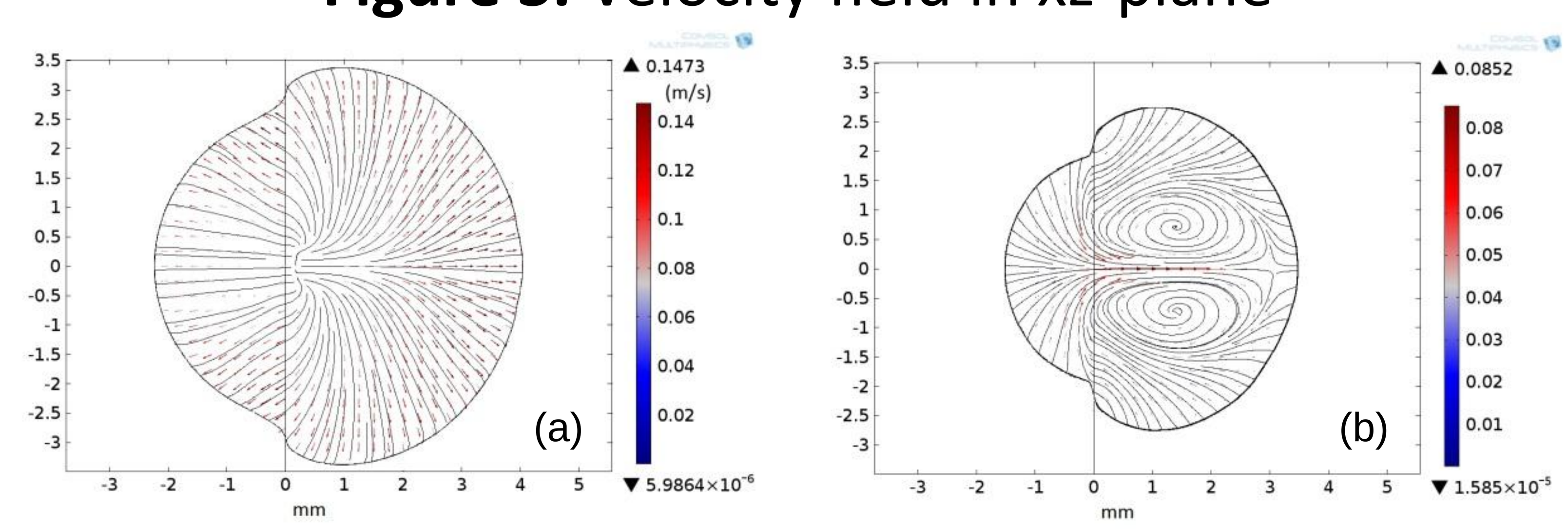

Figure 4. Velocity Field in xy-plane a)z=0 b)z=-0.5

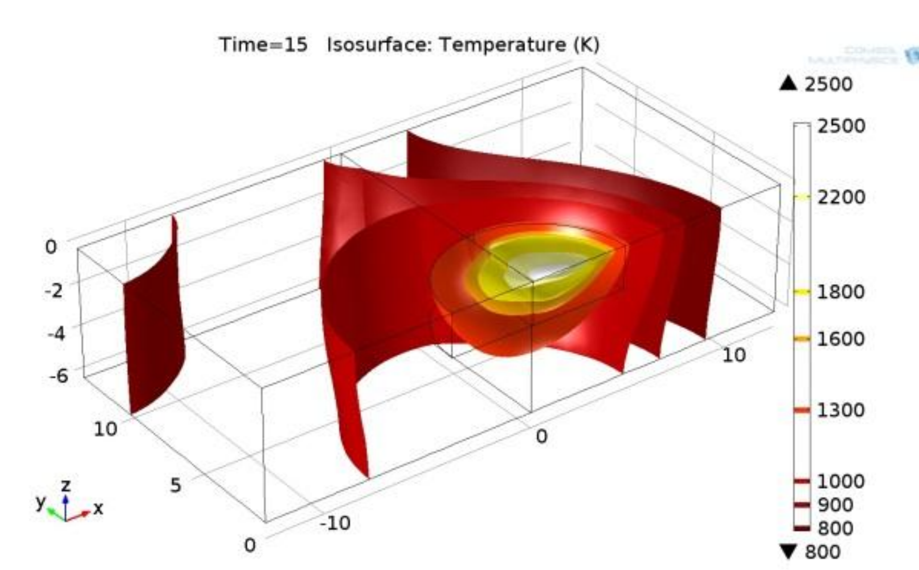

Figure 4. Isothermal Surfaces

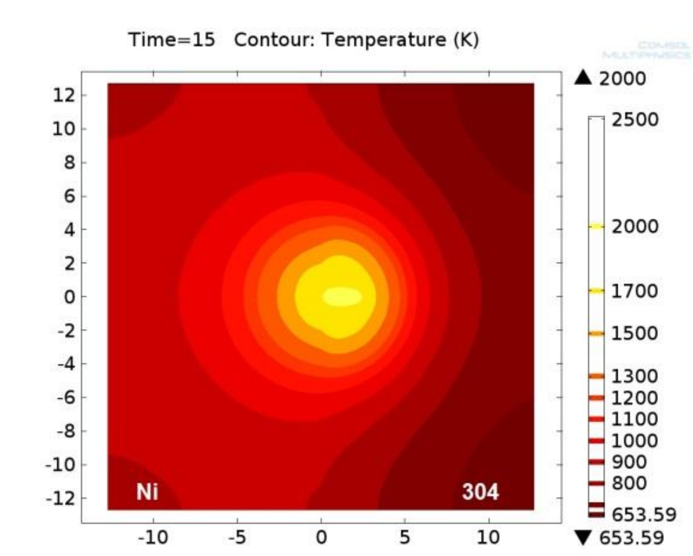

Figure 5. Temperature distribution at xy plane

Conclusions: Weld profile is asymmetric due to different melting points. Higher Lorentz force in the Ni side pushes the fluid towards the steel side. At the top surface flow is under Marangoni effect. Conductive heat transfer is higher in the Ni side; therefore its temperature grows higher.

References:

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