NUMERICAL PREDICTION OF WELD BEAD GEOMETRY IN PLASMA ARC WELDING OF TITANIUM SHEETS USING COMSOL®

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Introduction: Numerical simulation of Plasma Arc Welding (PAW) of Ti-6Al-4V is performed using Modified Three Dimensional Conical heat source and newly developed three dimensional heat source models. Temperature dependent material properties are considered for performing the simulation to predict the weld bead geometry of PAW of 2 mm thick Ti-6Al-4V sheet.

Figure 1. Plasma arc welded Ti-6Al-4V sheet

Computational Methods: The transient nonlinear thermal heat conduction equation available in Finite Element code COMSOL® is utilized for simulating the temperature distribution.

$$\rho C_p \frac{\delta T}{\delta t} + \rho C_p (-v) \frac{\delta T}{\delta x} = \nabla.(k \nabla T) + Q$$

$$Q(r,z) = \frac{3\eta UIe^3}{A_v \pi (e^3 - 1)} \exp\left(-\frac{3r^2}{r_0^2} \right)$$

$$A_v = a^2 \left[(H + z_i) \ln^2 (H + z_i) - z_i \ln^2 z_i \right]$$

$$-2a(a-b)\left[H + z_i) \ln(H + z_i) - z_i \ln z_i - H \right] + b^2 H$$

$$A_v = (a^2 / 5)\left[(H + z_i)^5 - z_i^5 \right] \ (New\ Heat\ Source)$$

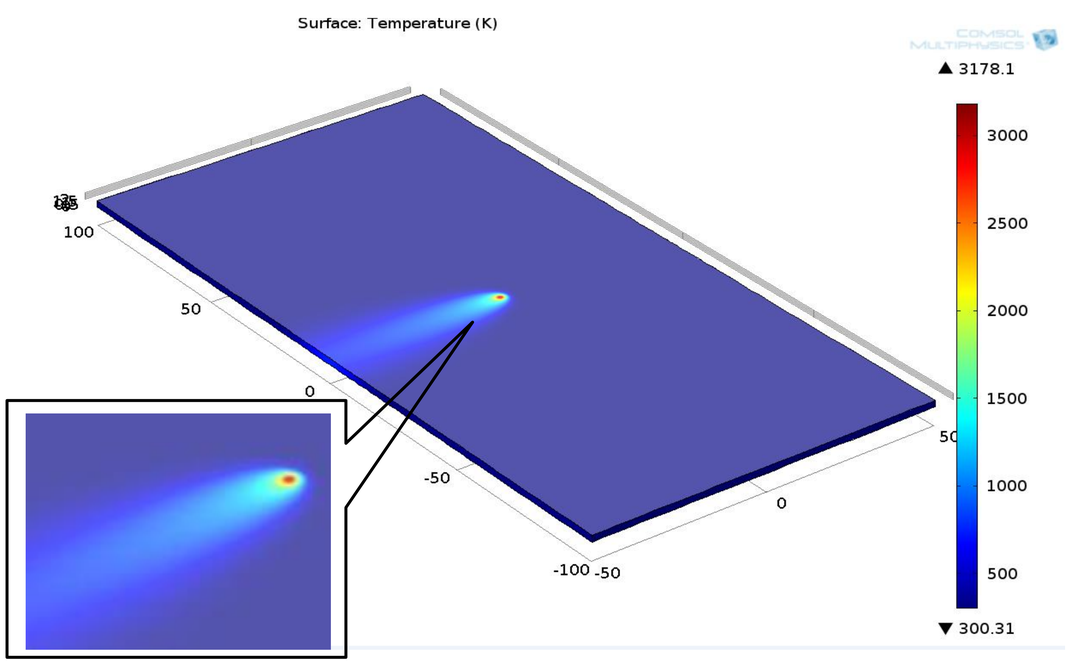

Figure 2. Temperature Distribution at middle of the plate

Results: The weld bead geometry i.e. bead width and depth of penetration are predicted from the temperature distribution plot using two different heat source models. For validation, the predicted weld bead geometry for two different heat source models is compared with the experimental results.

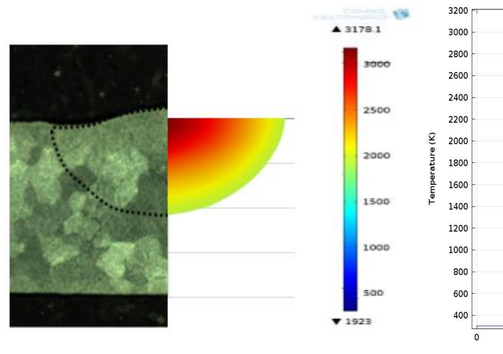

Figure 3. Macrograph comparison

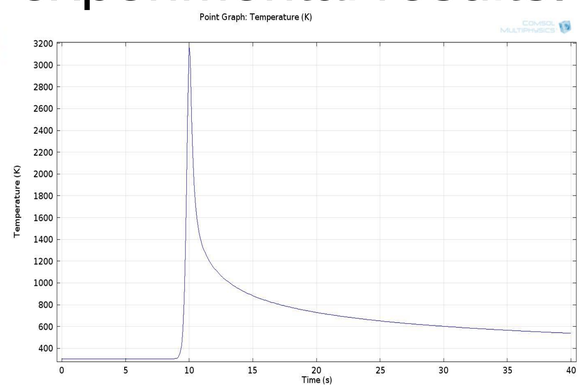

Figure 4. Temp. Vs. time

Current	60	A
Voltage	20.8	V
Speed	5	mm/sec
TGFR	12	LPM
SGFR	20	LPM

Table 1. Welding Parameters

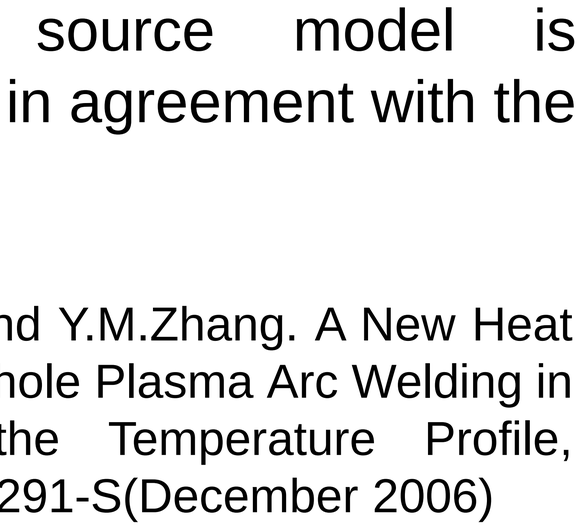

Figure 5. Temp Vs. Depth

Conclusions: Based on the investigation, it is inferred that the predicted weld bead geometry using newly developed three dimensional heat source model is observed to be good in agreement with the experiment result.

References:

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2. Aditya A Deshpande, Andrew B Short,Wei Sun, D Graham McCartney, Lei Xu and Thomas H Hyde, Finite element-based analysis of experimentally identified parametric envelopes for stable keyhole plasma arc welding of a titanium alloy, The Journal of Strain Analysis for Engineering Design, vol. 47 no. 5 266-275(July2012)