INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

Fusion welding process is complex in nature since it involves several interactive physical phenomena. An accurate knowledge of weld induced distortions and residual stress, final microstructure and mechanical properties of weld joint are greatly influenced by thermal history, cooling rate and consequently the weld dimensions. Real-time measurement of the transient growth of temperature and material flow field during welding is extremely difficult and there is uncertainty to accurately measure the residual stress of weld joint. Alternatively, the computational model of increasing complexity based on scientific principle alone is an effective route to analyze the differential influence of process parameters during fusion welding process. The major difficulty of conduction heat transfer based modeling approach is *a-priori* definition of several heat source parameters which are limited by the definition of weld dimensions only from experimental measurement. The formation of keyhole in laser welding produces deep penetration weld joint whereas proper choice of surface active elements at optimum quantity promotes high penetration weld joint in gas tungsten arc (GTA) welding process. The mechanism of material flow by surface tension gradient prevails in GTA welding process. However, the interfacial phenomena like evaporation, homogeneous boiling, and multiple reflections in laser welding brings the complexity in formation of keyhole. Moreover, the absorptivity of laser and weld joint quality is greatly affected by presence of shielding gas.

Present thesis is primarily motivated in this direction. At first, major efforts are put forward to analyze the effect of controlled atmosphere during fiber laser welding of austenitic stainless steel (SS304 and SS316) through a series of experiments. The formation of keyhole in deep penetration fiber laser welding is analyzed through semi-analytical modeling approach. Secondly, a three dimensional finite element based conduction heat transfer model is developed using novel concept of egg-configuration volumetric heat source. The proposed heat source model and the proposed methodology using double-ellipsoidal heat source model aims to reduce the heat source model parameters. A full-fledged heat transfer and fluid flow model is used to analyze the effect of surface active elements in GTA welding process. Thirdly, the numerical process model is integrated with optimization algorithm such as Differential Evolution (DE) in an organized way so that the same can identify the uncertain model parameters using sensitivity analysis of the uncertain parameters. Finally, a sequentially coupled thermo-mechanical model is developed to estimate the distortion of welded joint in deep penetration fiber laser welding and the same is validated with experimentally measured results.