CONCLUSIONS AND FUTURE SCOPE

CONCLUSIONS:

Numerical methodology and techniques based on FEA for the prediction of temperature profiles and subsequent weld induced distortion patterns and residual stress fields in GTA welded thin-walled cylinders of stainless steel are developed and implemented successfully in close agreement with the experimental investigations. Detailed results and discussion pertaining to distortions, residual stress fields and there by the dynamic characteristics are presented. The following are the major conclusions from the present investigations.

- The analysis of heat source fitting revealed that the heat input of 300 J/mm results in a proper weld penetration and HAZ. For this heat input, a considerable increase in temperature distribution was observed with increase in weld speed and power.
The FE analysis of longitudinal and circumferential stresses performed on the inner and outer surfaces as well as along the radial direction revealed a considerable increase with weld speed and power. For the case of 3 mm location away from the WC, the increase in tensile stress was found to be 150 MPa on the inner surface, whereas the increase in compressive stress was 100 MPa on the outer surface. The transition from tensile to compressive and vice-versa was found to occur at 1.25 mm depth (i.e. at the mid section) through wall thickness from the outer surface.

The circumferential residual stress distribution also exhibited the similar trend with the magnitude of increase in tensile stresses as 120 MPa on the inner surface, while it was 100 MPa for compressive stresses on the outer surface. The transition from tensile to compressive and vice-versa occurred at the radial distance from the outer surface which was found to be between 0.5 and 1.0 mm.

The results of FE simulation revealed that the radial residual stresses were found to be negligible and were not influenced by the variation in weld speed and power.

The results of longitudinal, circumferential stresses, radial and longitudinal distortions from FE simulation were compared with those obtained experimentally for a typical condition of weld speed = 1 mm/s and power = 300 W i.e. heat input = 300 J/mm and revealed reasonable agreement with each other.

For a specific heat input, an increase in peak temperature was observed with the increase in weld speed and power. Similarly the distortions are found to be less with lower weld speed and power against constant heat input.
- The radial distortions adjacent to weld are ranging from 0.02 mm to 0.12 mm on the inner surface and the radial distortions varying from 0.01 mm to 0.075 mm on the outer surface as the weld speed and power increases for the condition of constant heat input.

- The longitudinal distortions are ranging from 0.1 mm to 0.18 mm on both the surfaces as the weld speed and power increases for the condition of constant heat input.

- A special experimental welding arrangement consists of special fixtures and stepper motor unit with data logging system is made available to monitor the temperature along the components during welding for different cases.

- The results of radial and longitudinal distortions from FE simulation were compared with the experimental measurements for a condition of weld speed = 1mm/s and power = 300 W, i.e. heat input = 300 J/mm and revealed good agreement with each other.

- For a particular location at 68 mm from the bottom of CE bowl the longitudinal distortions along its length of the bowl at angle 60° from the weld start position after welding is found to be maximum which is 66 microns and the numerical analysis predicted it as 50 microns.

- Distortions for different weld speeds ranging from 0.5mm/sec to 2mm/sec show a maximum value of 200 microns at 2mm/sec and 75 microns at 0.5mm/sec.

- Similarly in continuous welding it is observed a maximum distortion of 210 microns. Maximum distortion value for the case of single pass welding is about 90 microns whereas for double pass it is about 95 microns.
A relative comparison for different weld parameters directly on the distortions of rotating bowl assembly reveals that the number of passes is less significant as compared to the weld speeds and clamping conditions, as the wall thickness is less.

The effect of welding speeds on the critical speed can be easily identifiable from the modal analysis, which shows for a given operating speed, higher the welding speed implies large distortion which in turn requires high bearing stiffness.

FUTURE SCOPE:

The major concern in the welding domain is the analysis of arc welded thin walled cylindrical components for the study of weld induced imperfections. This research work has considerably contributed towards this requirement, related to the optimization of weld process parameters for welding of thin walled components using both simulation and experimental validation. It is strongly recommended to implement the presented research work for analyzing the important welding parameters and structural boundary conditions for better performance of the CE rotating bowl. The prediction of weld induced imperfections for such critical components is essential before the start of actual welding process. The selection of particular welding process may depend on several parameters in addition to the nature and requirements of the application i.e. the setting parameters, fixed parameters, geometric parameters, structural boundary conditions etc. Further, the future scope is discussed in the following.

1. It is further proposed to study the metallurgical aspects pertain to phase transformations, grain size and hardness profiles in conjunction with different weld speeds and powers with constant heat input per unit length.
2. To determine the peak cyclic stress and the non-linear through-thickness stress distributions and studying the influence of various weld parameters on the assessment of the fatigue crack initiation life of the component due to the welding induced tangential residual stresses using strain-life methodology.

3. The above methodology based on FEA can also be applied for the analysis of other steel materials like SS304L and P91 etc., mainly by incorporating the temperature dependent material properties such as Young's Modulus and thermal conductivity of model with necessary experimental validation.

4. The above studies which have been carried out for TIG welding can be further extended to other welding processes such as Submerged Arc Welding, Electron Beam Welding, and Laser beam welding etc. This is mainly to compare the nature of the HAZ and weld pool size and other heat source parameter requirements of the process.