SOME STUDIES ON CIRCULAR CO_2-WELDS

by

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DEDICATED

TO

MY MOTHER

CERTIFICATE

This is to certify that the thesis entitled,"SOME STUDIES ON CIRCULAR CO_2-WELDS" being submitted by Mr. Lalit Kishore Brijkaushly to the Indian Institute of Technology, Delhi, for the award of the degree of 'Doctor of Philosophy' in Mechanical Engineering is a record of bonafide research work carried out by him. He has worked under my guidance and supervision and has fulfilled the requirements for the submission of this thesis which has reached the requisite standard.

The results contained in this thesis have not been submitted, in part or in full, to any other University or Institute for the award of any degree or diploma.

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ABSTRACT

Literature survey revealed complete lack of information about the characteristics and performance of circular welds. However, such welds are required to be made at innumerable places e.g. welding of pipes, nozzles, nipples and patches to plates. It was, therefore, decided to study indepth the behaviour of such welds made by CO_2 welding. The investigations included the study of temperature distribution, bead geometry and shape relationships, metallurgical transformations, residual stresses and distortion as well as the brittle fracture tendencies of such welds.

To have complete repeatibility of the experimental work it was decided to use mechanised means of welding and to achieve that aim a circular welding machine was fabricated which could give any desired welding speed between zero and 4 rpm. The machine was, so designed as to cover many more aspects of welding rather than making just CO_2 circular welds, so that it could be used for future research work for GMAW (gas metal arc welding), GTAW (gas tungsten arc welding) and even SMAW (shielded metal arc welding) for making straight, circular or spiral welds. Provision has also been made for projecting the arc image on a screen through a lens system so that the arc length can be measured when required. Welding parameters the arc voltage, welding current, and electrode feed rate are displayed on the front panel of the machine through respective sensing devices.

First step after fabricating the machine involved elaborate experimentation to determine the optimal size of the test-

piece. Once that was done temperature distribution studies were carried out using thermocouples and U-V recorder as well as pen recorder of high sensitivity. The study revealed that for heat input rate of about 7KJ/sec, the maximum cooling rate at the centre of the weld circle for 30 mm, 60 mm,and 90 mm diameter circle weld were 11.8°C/sec, 7.0°C/sec, and 3°C/sec respectively.

The circular welds made for the temperature distribution study were cut, polished and etched for determining weld bead geometry and shape relationships at four angular positions, using a shadowgraph and a planimeter. The detailed investigations included the determination of penetration, width, height of reinforcement, weld penetration shape factor i.e. width to penetration ratio, and the percentage dilution. The study revealed that the penetration increased as the weld proceeded towards completion along a circular path. Also, it showed that the penetration decreased with the increase in weld circle diameter but no definite effect of it was discernible on the weld width.

The welds after the weld bead geometry investigations were taken up for extensive macro-and micro-hardness survey followed by detailed investigation into the microstructure at different angular positions of the weld. It was observed that the maximum hardness was along 180° and 270° radii and that the average microhardness was highest for the smallest diameter circle weld studied (30 mm). Further, it was observed that the shape, size, and distribution of ferrite, pearlite and martensite varied from one angular position to another particularly for welds upto 60mm diameter.

For residual stresses and distortion study the welds were made on 3mm and 14 mm thick plates by bead-on-plate and single Vee butt joint techniques respectively. Using the stress relaxation technique, the residual stresses were measured with the help of electric strain gauges in conjunction with 50-way strain bridge. The investigations revealed increase in residual stresses with the increase in weld circle diameter upto 80 mm. In thin plates the residual stresses varied in nature from one angular position to another e.g. they were tensile at 90° and 270° positions and compressive at 0° and 180° positions. Distortion in 14 mm thick plates were negligible but in 3mm thick plates it varied in near sine wave pattern with maximum distortion at 45°, 135°, 225° and 315° positions and minimum at 0°, 90°, 180° and 270° positions with respect to the starting point of the weld.

The brittle fracture tendencies of welds were studied by charpy impact tests for a temperature range of -80°C to +80°C in conjunction with optical microscope and SEM (Scanning Electron Microscope) at different magnifications upto x2200. The results revealed that the highest upper shelf energy observed was in the case of 70 mm diameter circle welds. Overall, however, 60 mm diameter circle welds gave the optimal performance regarding charpy impact absorbed energy. SEM fractography revealed the different modes of failure at different impact testing temperatures used. Apart from the general trends many peculiarities were observed which are reported in detail in the main text of the write-up.

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