The Effect Of Weld Heat Affected Zone Hot Cracks On The

"The purpose of the investigation was to study the effect of material thickness, weld heat input and post weld heat treatment on the tensile properties and microstructure of Ti-6Al-6V-2Sn Titanium, and obtain a practical weld/thermal treatment cycle. The objectives were accomplished by electron beam and gas tungsten arc welding 0.060, 0.125 and 0.250 inch thick material and then heat treating at various temperatures and times. Electron beam and gas tungsten arc welding enabled an approximate 4:1 ratio of heat inputs to be utilized. Resultant welded and heat treated material was tensile tested and metallographically examined. Heat treatments involved both air and furnace cooling from temperatures as high as 1550°F. Post weld heat treatments involving air cooling resulted in partial solution treatment and yield strengths as low as 50% of the as-received properties. Elongation values were also lower than those achieved from heat treatments involving furnace cooling. The effect was considerably increased with increasing heat treatment temperature. The most practical post weld heat treatment of 1400°F for 4 hours and furnace cool resulted in strengths that were 95-100% of the as-received properties. Elongation values varied from as low as 2% in the as-welded condition to 7-12% following this post weld heat treatment. The microstructure revealed a fusion zone with considerable alpha plate growth compared with the typical as-welded coarse transformed beta and the structures approach equilibrium quantities of the alpha and beta phases and equilibrium composition of the individual phases. Increasing material thickness and decreasing weld heat input had little effect on tensile strength, however ductility was increased by 2-3% elongation"--Abstract, pages ii-iii.

Aluminium is the third most abundant element (after oxygen and silicon), and the most abundant metal in the Earth's crust. Aluminium is remarkable for the metal's low density and for its ability to resist corrosion due to the phenomenon of passivation. Structural components made from aluminium and its alloys are vital to the aerospace industry and are important in other areas of transportation and structural materials Welding plays a crucial role or say as a back bone of manufacturing industry to join the components. Friction stir welding (FSW) is a relatively new joining process that has been demonstrated in a variety of metals such as steel, titanium, lead, copper and aluminium. The unique properties of friction stir welds make possible some completely new structural designs with significant impact to ship design and construction. Friction stir welding is especially advantageous for joining aluminium and has been exploited commercially around the world in several industries. In the present work the effects of welding speed have been investigated on the microstructural and mechanical properties of friction stir welded aluminium alloy 6063. FSW was carried out at rotational speed of 1300 rpm (constant) and transverse speeds of 35, 50 and 65 mm/min. Mechanical performance has been investigated in terms of hardness, wear resistance and tensile strength. To study the effect of post welding heat treatment on properties of friction stir welded joint, the artificial ageing was carried out at 1600 C for a soaking period of 20 hours in the muffle furnace. The study revealed that friction stir welded joint prepared at welding speed of 35 mm/min exhibited better tensile strength, hardness and wear resistance. Better mechanical properties of the joint prepared at welding speed of 35 mm/min may be attributed due to fine, homogeneous and equaxed grain structure of stir zone. Post welding heat treatment of friction stir welded joint improved the wear resistance and microhardness of the joint. However tensile properties deteriorated with the post welding heat treatment of joint.

Targeted creep strength and low-temperature toughness are required to qualify 2.25Cr- 1Mo steel welding consumables relevant to the power generation industries. Submerged arc welding of 2.25Cr-1Mo steels using the same base metal, filler, welding parameters and post weld heat treatment but different fluxes was conducted to make multipass welds. These welds exhibit a drastic variation in low temperature Charpy impact toughness in the post weld heat treated condition (114 ft-lbs to 17 ft-lbs at testing temperature of -40°F). The difference in toughness behavior was investigated using computational modeling and multi-scale microstructure characterization. The effect of flux on the recovery of alloying elements including Cr, Mo, Mn and Si into the weld metal region was analyzed using computational thermodynamic models. Single and two pass welds were made to study the microstructures as a function of thermal cycling. Another study was conducted to control and physically simulate the tempering response of the weld metal by simulating a weld cooling rate of 5 °C/s and 30 °C/s (¿t8-5 of 60 s and 10 s) on welds. Phase transformation analysis was done. Phase identification, packet size determination and precipitate characterization were done. Charpy toughness and SEM fractography was conducted to determine fracture mode. The calculated weld composition as a function of weight % ratio of filler to flux composition was found to be in good agreement with the measured composition. The predicted alloying element recovery was very sensitive to the concentration of deoxidizers in the system including Al, Si and Mn.

Almost all welding technology depends upon the use of concentrated energy sources to fuse or soften the material locally at the joint, before such energy can be diffused or dispersed elsewhere. Although comprehensive treatments of transient heat flow as a controlling influence have been developed progressively and published over the past forty years, the task of uniting the results compactly within a textbook has become increasingly formidable. With the comparative scarcity of such works, welding engineers have been denied the full use of powerful design analysis tools. During the past decade Dr Radaj has prepared to fulfil this need, working from a rich experience as pioneer researcher and teacher, co-operator with Professor Argyris at Stuttgart University in developing the finite element method for stress analysis of aircraft and power plant structures, and more recently as expert consultant on these and automotive structures at Daimler Benz. His book appeared in 1988 in the German language, and this updated English language edition will significantly increase the availability of the work.

The Effect of Weld Heat-affected Zone Hot Cracks on the Fatigue Crack Growth Behavior of As-cast Alloy 718Effect of Welding and Post-Weld Heat Treatment on QT 35 SteelThe effect of post welded heat treatment on mechanical properties and microstructure of friction stir welded Al 6063BookRix

This report is the first of a three year Army Manufacturing, Science, and Technology (MS & T) Congressionally mandated effort to investigate the weldability of a specific grade of austempered ductile iron (ADI). This specific grade of ductile iron was developed under MS & T project 5904948 and has mechanical properties after austemper heat treatment of 140,000 psi minimum yield strength and 80/c minimum elongation. This report describes the use of the Gleeble experimental technique to produce the thermal cycles experienced in welding, thus creating simulated weld heat affected zones (HAZ). Simulated HAZ were produced for two different weld energy inputs and five weld preheat temperatures. Weldability was assessed by measuring resultant hardness and through microstructural observations of the as-welded and subsequently austempered material. Results of this work provide a foundation of knowledge in the as- welded heat affected zone, determine the extent of recovery of the weld (HAZ) due to subsequent austemper heat treatment, and provide information on suitable preheat temperatures and weld energy inputs for actual weld trials. jg.

To improve the efficiency of turbine aero engines, higher operating temperatures and weight savings are being investigated. Alloys such as RR1000 are being trialled as they perform better at higher temperatures than current nickel-based superalloys. To achieve weight savings, inertia welding is being trialled for turbine discs but current post weld heat treatments reduce fatigue life. In this investigation, a number of novel post weld heat treatments were trialled aimed at improving post weld microstructure and fatigue properties. Extensive microstructural characterisation and mechanical testing were used to assess the effect of these treatments on both parent and weld materials. Post weld heat treatment (PWHT) was found to have a great effect on the size and distribution of?' and carbides, particularly when a PWHT temperature of 980?C or above was used. The effect of this microstructural change on the hardness of the weld and parent material has also been characterised. Extensive total life fatigue testing was carried out at 650?C. It was found that failure can occur in both the parent and weld material, although it is deduced that the yield stress of the weld needs to be surpassed to see weld failure (plasticity in the weld). Increasing dwell time at peak load reduced the life of these components. Two mechanisms for crack growth were observed with initiation either at the surface or at a large Hf rich particle subsurface. Oxidation was found to have a large effect on both initiation and growth of fatigue cracks. By introducing a sharp pre-fatigue crack into samples, static load testing was used to determine a threshold value of K (stress intensity factor) for growth and growth rates were plotted at different K values. It was seen in these tests that PWHT had a large effect on growth rates and threshold values of K.

Volume I reports on an assessment of a series of submerged arc welds prepared using 2 different wire-flux combinations giving weld metals alloyed with Ti-B, and Mo respectively and using different procedural variables such as heat input, post weld heat treatment, interpass temperature and joint restraint. Volume 2 explains the CVN and CTOD toughness of 4 gas metal arc welds prepared using Argon-5% carbon dioxide shielding gas and 3 consumable wires giving weld deposits alloyed with Mn-Mo, Mn-Si, and Ti-B respectively. All welds were made at 3.0 kJ/mm heat input, and the one with Ti-B weld metal was examined in the stress relieved condition also. The welds were examined for composition, strength, microstructure and inclusion distributions. Volume 3 examines a series of 14 welded assemblies prepared using the gas shielded flux cored arc welding process to examine the effect of welding procedural variables on weld metal toughness. All the welds were made using one of 3 different commercially available consumables and the Ar-25% CO2 gas shielding. Procedural variables studied included heat input, post weld heat treatment, and welding position lateral joint restraint. Their influence was assessed by microstructure characterization, deposit composition, CVN and CTOD toughness.

The corrosion behaviour of a AA2050T34-FSW was examined as a function of post weld heat treatment condition. Immersion tests in 0.1 M Nac1 and G110 intergranular tests were performed and the corrsion morphology and the depth of attacks in the different regions of the weld were investigated using FEG/SEM. Polarisation measuresments in the different regions of the weld and long term OCP for the full weld were taken and results were correlated with immersion test observations.

Post-weld heat treatment (PWHT) is carried out to improve fracture toughness and to remove residual stress in the heat-affected zone (HAZ). There are some problems, such as a toughness decrease and stress-relief cracking (SRC) in the coarse-grained HAZ subject to the effect of the tempering treatment. Therefore, in this paper, the effect of the heating rate and heat input on PWHT embrittlement under applied stresses of 0, 98, 196, and 294 MPa (0, 10, 20, and 30 kg/mm2), applied to simulate residual stress in the welded HAZ of chromium-molybdenum (Cr-Mo) steel was evaluated using the crack-opening displacement (COD) fracture toughness test and observation of the fracture surfaces. The fracture toughness of welded HAZ decreased with an increase in the heating rate under no stress, but it improved with an increase in the heating rate under stress. Applied stress in welded HAZ during PWHT assisted precipitation of oversaturated alloying elements in the structure, so grain boundary failure from the welding heat input was barely evident at a heat input of 10 kJ/cm and a heating rate of 600°C/h, but it appeared at an applied stress of 294 MPa at 30 kJ/cm and 220°C/h and of 196 MPa at 40 kJ/cm and 60°C/h.

This research is aimed at understanding the effect of thermal cycles on the metallurgical and microstructural characteristics of the heat affected zone of a multi-pass pipeline weld. Continuous Cooling Transformation (CCT) diagrams of the pipeline steel grades studied (X65, X70 and X100) were generated using a thermo mechanical simulator (Gleeble 3500) and 10 mm diameter by 100 mm length samples. The volume change during phase transformation was studied by a dilatometer, this is to understand the thermodynamics and kinetics of phase formation when subjected to such varying cooling rates. Samples were heated rapidly at a rate of 400°C/s and the cooling rates were varied between t8/5 of 5.34°C/s to 1000°C/s. The transformation lines were identified using the dilatometric data, metallographic analysis and the micro hardness of the heat treated samples. Two welding processes, submerged arc welding (SAW) and tandem Metal Inert Gas (MIG) Welding, with vastly different heat inputs were studied. An API-5L grades X65, X70 and X100 pipeline steels with a narrow groove bevel were experimented with both welding processes. The welding thermal cycles during multi-pass welding were recorded using thermocouples. The microstructural characteristics and metallurgical phase formation was studied and correlated with the fracture toughness behaviour as determined through the Crack Tip Opening Displacement (CTOD) tests on the welded specimens. It was observed that SAW process is more susceptible to generate undesirable martensite-austenite (M-A) phase which induce formation of localised brittle zones (LBZ) which can adversely affect the CTOD performance. Superimposition of the multiple thermal cycles, measured insitu from the different welding processes on the derived CCTs, helped in understanding the mechanism of formation of localised brittle zones. Charpy impact samples were machined from the two X65 and X70 grades, for use in thermal simulation experiments using thermo mechanical simulator (Gleeble). The real thermal cycles recorded from the HAZ of the SAW were used for the thermal simulations, in terms of heating and cooling rates. This is to reproduce the microstructures of the welds HAZ in bulk on a charpy impact sample which was used for impact toughness testing, hardness and metallurgical characterisation. The three materials used were showing different response in terms of the applied thermal cycles and the corresponding toughness behaviours. The X65 (a) i.e. the seamless pipe was showing a complete loss of toughness when subjected to the single, double and triple thermal cycles, while the X65 (b), which is a TMCP material was showing excellent toughness in most cases when subjected to the same thermal cycles at different test temperatures. The X70 TMCP as well was showing a loss of toughness as compared to the X65 (b). From the continuous cooling transformation diagrams and the thermally simulated samples results it could be established that different materials subjected to similar thermal cycle can produce different metallurgical phases depending on the composition, processing route and the starting microstructure.

The effect of variations in composition on the base-metal properties of ten 5Ni-Cr-Mo steels was investigated, and three of the ten steels, containing 0.5, 1.0 and 1.5% chromium, were evaluated to determine the effect of chromium on the toughness, transformation characteristics, and crack susceptibility of their simulated weld-heat-affected zones. The results showed that over the full range of practical welding conditions, the energy absorption of the various regions in the simulated weld-heat-affected zones of the three steels was high and ranged from 60 to 125 ft-lb at +80 F. In addition, the formation of fully martensitic microstructures in the simulated weld-heat-affected zones indicated that the three steels had sufficient hardenability for all practical welding conditions. (Author).

Medium carbon steel is an important engineering material used extensively where hardness, wear resistance and strength are required. A major consideration when welding medium carbon steels is the likelihood of formation of martensite in the heat affected zone (HAZ). This renders the weldment susceptible to cracking. Therefore, special precautions such as proper joint design and preparation; low hydrogen processes and consumables; and postweld heat treatment have to be taken when welding these steels to produce sound quality welds. This book discusses the result of a research conducted to investigate the effect of weld joint geometry and postweld heat treatment on the mechanical properties of weld in a medium carbon steel.

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