Analysis on Dissimilar Metal Welding Under Cryogenic Treatment

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***Abstract*-Emerging trends in manufacturing such as light weighting, increased performance and functionality increases the use of multi- material, hybrid structures and thus the need for joining of dissimilar materials. The ability to manufacture a product using a number of different metals and alloys greatly increases flexibility in design and production. Joining of dissimilar metal combinations is, however, a challenging task owing to the large differences in physical and chemical properties which may be present. This paper describes and summarizes the state of the art research in joining dissimilar materials by TIG welding under cryogenic condition.**

Keywords—Dissimilar material welding, TIG-welding, Cryogenic treatment, mechanical properties.

INTRODUCTION:

In modern steel constructions it is extremely important, and sometimes unavoidable, to perform a durable dissimilar metal weld between low alloyed or carbon steel and stainless steel. A schematic picture of a dissimilar metal weld is presented. When welding such dissimilar metal welds the choice of filler metal plays a big role and usually has a composition differing from both of the parent metals. The composition of the weld metal will therefore be a mix of the parent metals and the filler metal at some specific ratio.

During welding of dissimilar metal welds it is important to control the composition of the weld metal. From assumptions that the weld metal consists of a mix of the parent metals and the filler metal the composition can be estimated. Narrow control of the resulting weld metal composition is important to decrease the risk of defects in the weld, such as hot cracks or sigma phase formation. The composition is also important to control so that the weld metal properties corresponds the required ones. The filler metal normally used in dissimilar metals welds. If the welds are exposed to high temperatures or an intense thermal cycle, nickel based alloys are usually used as filler metal.

In a dissimilar metal weld between carbon steel and stainless steel it is important to reduce the dilution with the carbon steel, in order to obtain a good microstructure. It is therefore common to not point the arc directly on the carbon steel side, but rather to angle the torch slightly toward the stainless steel. Another important factor to optimize during welding of a dissimilar metal weld is the inter pass temperature, i.e. the actual temperature in the already present weld bead before welding starts during multi pass welding. Welding dissimilar metal welds faces many characteristic problems caused by structural changes and several constitutional changes can occur during welding. Changes in the dilution ratio of the parent metals are possible and affected by the welding conditions. During welding a stable manufacturing and good crack resistance is important. If the dilution between the filler metal and parent metals increases, the ferrite content will decrease in the case of welding low alloyed or carbon steel to stainless steel with a filler metal of over-alloyed austenitic stainless steel. If the amount of stainless steel diluted to the weld metal increases the structure can be fully austenitic and the risk of hot cracking increases significantly. On the other hand, if the dilution with the low alloyed steel increases a structure with more martensite is created which is a hard and brittle structure. If the ferrite content becomes too high, thermal ageing during operation at elevated temperatures may lead to a transformation of the ferrite to sigma phase or as spinodal decomposition. The sigma phase is very brittle, due to this joints used in systems that operates at high temperatures should have as low ferrite content as possible.

WELDING PROCESS:

Welding is a fabrication process that joins materials by causing coalescence in which heat is supplied either electrically or by mean of a gas torch,. This is often done by melting the work pieces and adding a filler material to form a pool of molten material (the weld pool) that cools to become a strong joint, with pressure sometimes used in conjunction with heat, or by itself, to produce the weld. This is in contrast with soldering and brazing, which involve melting a lower-melting-point material between the work pieces to form a bond between them, without melting the work pieces. Welding is also the least expensive process and widely used now a days in fabrication. Welding is also called as secondary manufacturing process.

WELDING PARAMETERS:

Tungsten inert-gas arc welding

Tungsten inert-gas arc welding (TIG) is a fusion welding method that was developed in the late 1930's. The TIG-method is characterized by its high quality weld metal deposits, great precision, superior surfaces and excellent strength. TIG is the most common welding method used for pipes and tubes with a wall thickness from 0.3 mm and upward. In the TIG- method a non-consumable electrode of tungsten or tungsten alloy is used, in comparison to other common welding methods where the filler metal also is the electrode.

Filler rod (Ref-A.W.S)

E 304	Corrosion resistant
E 316, 304L, 330	High and low temperature strength
E 410, 420	Abrasion resistant

E304-16electrodes are used to weld unstabilized 18-8 stainless steels such as Types 301, 302, 304, 305, and 308. E308-16
electrodes provide corrosion resistance and physical properties equal to or greater than the steels for which they are recommended. Typical applications include dairy, distillery and restaurant equipment, and chemical tanks.

To prevent oxygen in the air from oxidizing the weld pool and the heated material, a shielding gas is used during TIG-welding. The shielding gas is also important to promote a stable metal transfer through the arc, the shielding gas commonly used for TIG-welding is argon. The root side of the weld also needs protection from oxidizing in form of a backing gas during the production of the first weld beads. The backing gas helps the weld bead to form correctly and keep the weld bead from becoming porous or crack.

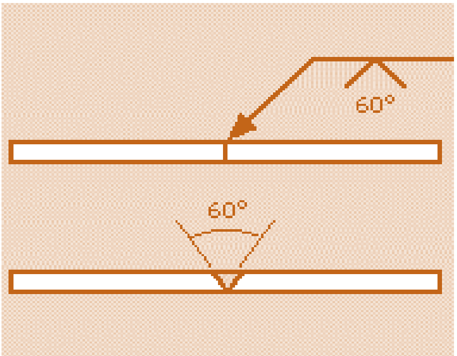

Figure 1: Schematic diagram of v- groove butt welding

CRYOGENIC TREATMENT:

In the cryogenic treatment, to optimize the metallurgical aspects by material to be treated under very cold low temperature for a predetermined period of time to obtain the metallurgical crystalline structure of the material to improve the hardness, strength, ductility, toughness, were resistance etc. and to reduction in residual stresses, which improves the stability during the machining. Cryogenic treatment (CT) is the supplementary process to conventional heat treatment process in steels, by deep–freezing materials at cryogenic temperatures to enhance the mechanical and physical properties of materials being treated.

The cryogenic treatment consists of slow cooling of conventionally hardened steel samples to a prescribed temperature, soaking for certain duration, followed by slow heating back to the room temperature for subsequent tempering. It is already patented the rate of cooling for some steels by the investigators. They proved that slow cooling (descent), soaking and heating (ascent) in a deep cryogenic treatment cycle will increase the wear resistance of steels. Liquefied gases, such as liquid nitrogen and liquid helium, are used in many cryogenic applications. Liquid nitrogen is the most commonly used element in cryogenics and is legally purchasable around the world. Liquid helium is also commonly used and allows for the lowest attainable temperatures to be reached. These gases are held in either special containers known as Dewar flasks, which are generally about six feet tall (1.8 m) and three feet (91.5 cm) in diameter, or giant tanks in larger commercial operations. Cryogenic transfer pumps are the pumps used on LNG piers to transfer Liquefied Natural Gas from LNG Carriers to LNG storage tanks.

PROCEDURE:

The liquid nitrogen as generated from the nitrogen plant is stored in storage vessels. With help of transfer lines, it is directed to a closed vacuum evacuated chamber called cryogenic freezer through a nozzle. The supply of liquid nitrogen into the cryogenic freezer is operated with the help of solenoid valves. Inside the chamber gradual cooling occurs at a rate of 2º C /min from the room temperature to a required temperature. Once the sub zero temperature is reached, specimens are transferred to the nitrogen chamber or soaking chamber where in they are stored for obtain hours with continuous supply of liquid nitrogen.

MECHANICAL PROPERTY TESTS:

TENSILE TEST

Tensile test is used to determine the tensile strength of the specimen, % elongation of length and % reduction of area. Tensile test is usually carried out in universal testing machine.

A universal testing machine is used to test tensile strength of materials. It is named after the fact that it can perform many standard tensile and compression tests on materials, components, and structures. The specimen is placed in the machine between the grips and an extensometer if required can automatically record the change in gauge length during the test. If an extensometer is not fitted, the machine itself can record the displacement between its cross heads on which the specimen is held. However, this method not only records the change in length of the specimen but also all other extending / elastic components of the testing machine and its drive systems including any slipping of the specimen in the grips. Once the machine is started it begins to apply an increasing load on specimen. Throughout the tests the control system and its associated software record the load and extension or compression of the specimen.

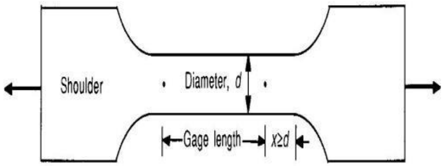

Figure 2: Schematic diagram of metal used in tensile test

HARDNESS TEST:

A simple and economical way to characterize the mechanical properties and microstructure is by performing hardness measurements. By performing hardness measurements the highest and lowest levels of hardness can be determined. In dissimilar metal welds the hardness level of parent metals and weld metal are determined. The most interesting part is where the transition from parent metal to weld metal takes place and in the root bead of the weld. A cross- section from each sample is taken transverse the weld by mechanical cutting. It is important that the preparations of the samples do not affect the surface metallurgical by hot or cold work. After the samples are cut they are grinded and polished in order to make as good preparation as possible

The numbers of indentations need to be enough to assure that hardened and softened zones are tested, i.e. that the indentations do not affect each other. This gives the metals ability to show resistance to indentation which show it's resistance to wear and abrasion. Hardness testing of welds and their Heat Affected Zones (HAZs) usually requires testing on a microscopic scale using a diamond indenter. The Vickers Hardness test is the predominant test method with testing being applied to HAZ testing in some instances. Hardness values referred to in this document will be reported in terms of Vickers Number, HV

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TOUGHNESS TEST:

It is well understood that ductile and brittle are relative, and thus interchange between these two modes of fracture is achievable with ease. The term *Ductile-to- Brittle transition* (DBT) is used in relation to the temperature dependence of the measured impact energy absorption. For a material, as the temperature is lowered, the impact energy drops suddenly over a relatively narrow temperature range, below which the energy has a considerably lower value as a representative of brittle fracture.

The principal measurement from the impact test is the energy absorbed in fracturing the specimen. Energy expended during fracture is sometimes known as *notch toughness*. The energy expended will be high for complete ductile fracture, while it is less for brittle fracture. However, it is important to note that measurement of energy expended is only a relative energy, and cannot be used directly as design consideration. Another common result from the Charpy test is by examining the fracture surface. It is useful in determining whether the fracture is fibrous (shear fracture), granular (cleavage fracture), or a mixture of both.

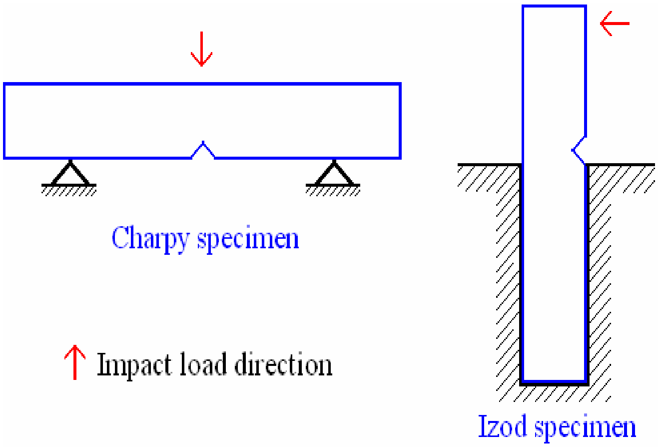

Figure 3: schematic arrangement of Charpy, Izod test specimen

CONCLUSION:

The trends of light weighting, higher performance and increased functionality are some of the drivers for multi-material, hybrid structures and the need for joining of dissimilar materials. Different material properties are utilized to achieve improvements not possible with a single material. This paper performed and analyzed dissimilar material welding by TIG welding under cryogenic condition and shows that, cryogenics of most metals and alloys reduces wear and stress to a far greater extent than untreated metals and alloys with the help of analysis of mechanical properties such as Hardness, Toughness and Tensile.

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