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Electron Beam Welding of Duplexer Steels

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ABSTRACT:

Thick –walled components made of duplex stainless steels are used in the semi-finished products as well as in h machinery, apparatus and plant construction. Electron beam welding of these components may be recommended for economic and quality reason. To guarantee the necessary mechanical technological properties and the corrosion resistance. The duplexer stainless steels are welded with filler material and afterwards undergo a post-weld heat treatment. This contribution presents characteristics, metallurgy and weldability of duplex steels with using concentrated energy source. The first part of the article describes metallurgy of duplex steels and the influence of nitrogen on their solidification. The second part focuses on weldability of duplex steels with using electron beam aimed on acceptable structure and corrosion resistance performed by multiple runs of defocused beam over the penetration Weld.

KEYWORDS: duplex stainless steel, electron beam welding, heat treatment, welding without.

INTRODUCTION:

Radar is an object-detection system which uses electromagnetic waves—specifically radio waves—to determine the range, altitude, direction, or speed of both moving and fixed objects such as aircraft, ships, spacecraft, guided missiles, motor vehicles, weather formations, and terrain. Duplex stainless steels are very attractive constructional materials for service in aggressive environments. Their physical properties are between those of the austenitic and ferritic stainless steels, but tend to be closer to those of the ferritics and to carbon steel. Such steels offer several advantages over the common austenitic stainless steels. The duplex grades are highly resistant to chloride stress, corrosion cracking, have excellent pitting and crevice corrosion resistance and are about twice as strong as the common austenitic steels. The first-generation duplex stainless steels provided good performance characteristics, but had limitations in the as-welded condition. These limitations confined the use of the first-generation duplex stainless steels, usually in the unwelded condition, to a few specific applications. The heat-affected zone of welds had low toughness because of excessive ferrite and significantly lower corrosion resistance than that of the base metal. Nitrogen alloying of duplex stainless steels enhances HAZ toughness and corrosion resistance, which approaches that of the base metal in the as-welded condition. Nitrogen also reduces the rate at which detrimental intermetallic phases are formed. Normally, duplex steels are weldable using welding procedures generally used for high alloyed steels. The experience with such comparatively new welding method like electron beam welding is still limited. However, there have been a few successful applications and there is every reason to expect that procedures will be developed more fully.

Electron Beam Welding OF Duplexer Stainless Steels: Electron beam welding uses energy from a high velocity focused beam of electrons made to collide with the base material. When electrons in a focused beam hit a metal surface, the high energy density instantly vaporizes the material, generating a so-called key hole. A characteristic of this phenomenon is that it allows the unique capability for deep, narrow welds with very small heat affected zones (HAZ) and minimized thermal distortions of welded assemblies. Depth-to-width ratios of up to 40:1 have been achieved in production for many years. With high beam energy, a hole can be melted through the material and penetrating welds can be formed at speeds of the order of 20 m/min. Welds are made in vacuum, which eliminates contamination of the weld pool by gases. The vacuum not only prevents weld contamination but produces a stable beam. The concentrated nature of the heat source makes the process very suitable for stainless steels. The available power can be readily controlled and the same welding machine can be applied to single pass welding of stainless steel in thicknesses from 0.5 mm to 40 mm.

Corrosion behavior: The corrosion behavior of duplex stainless steels is strongly affected by the austenite–ferrite ratio. With regard to corrosion resistance as well as mechanical properties a balanced ratio between these two microstructural components is desired. Weld seams manufactured by electron beam welding (EBW) generally exhibit very high amounts of ferrite due to a strong loss of nitrogen during the welding process and a very high cooling rate, which can affect the corrosion behavior adversely. Significant improvements can be reached by varying the electron beam guidance and applying multi-beam technology. This paper considers the pitting corrosion as well as selective corrosion behavior of the welds as a function of the chosen process parameters during EBW. Comparisons with the corrosion performance of manual metal arc and tungsten inert gas welds are also made.

Temperatures above 1050˚C:
Duplex stainless steels solidify completely in the ferrite field for standard grades and normal cooling rates. This is followed by solid state transformation to austenite, which is naturally reversible, so that any large increase in temperature, for example from 1050˚C to 1300˚C, leads to an increase in ferrite content. Further, as he temperature increases, there is a reduction in the portioning of substantial elements between the phases. In addition, the ferrite becomes enriched in interstitial elements such as carbon and nitrogen. Heat treatment in the temperature range 1100-1200˚C can have a dramatic influence on the microstructure of

a wrought product. The grains can be made equated by prolonged treatment at high temperature or can be rendered acicular, with a Widmannstaetten type structure by cooling an intermediate rate. A dual structure, consisting of both coarse and fine austenite grains, can be obtained by step quenching, with or without simultaneous mechanical strain. These acicular structures are also encountered in weld deposits

Characteristic of a problem: Electron beam welding process is used without the addition of filler metal and is not very suitable for the welding of duplex stainless steels as the welds will be very high in ferrite. Such a weld must be quench-annealed in order to get the correct structure. Electron beam welding is especially suited to produce joints of heavy section materials in one or two passes. Unfortunately, it tends to produce rapid cooling rates and therefore highly ferrite in the melt zone, particularly in thin sections. Nevertheless, the toughness remains high which can be attributed to the very low oxygen content in the weld. Still the qualification of the procedure must be alert to the possibility of excessive ferrite in the HAZ and even in the weld when the high speed welding capabilities of these methods are considered. The cooling rate has a considerable impact on the austenite-ferrite ratio ambient temperature. This means that slow cooling causes a higher austenite content than rapid cooling, during which approx. 60 to 90 % ferrite is to be expected. In this way it is possible to influence the ferrite-austenite ratio, depending on the weld process and weld geometry.

Heat treatment: Numerous structural changes can occur in the duplex stainless steels during_isothermal and an isothermal heat treatments. Most of these transformations are concerned with the ferrite, as element diffusion rates are approximately 100 times faster than in austenite. This is principally a consequence of the less compact lattice of the BCC crystal structure. Moreover, the ferrite is enriched in Cr and Mo, which promote the formation of Intermetallic phases. Besides, element solubility in the ferrite falls with a decrease in temperature, increasing the possibility of precipitation during heat treatment. Wrought and heat-treated products are considered to be segregation free, but in case of castings and welded joints the element segregation during cooling will affect precipitation kinetics and the stability of phases formed

Parameters of post heat:

• Acceleration voltage,

• Electron beam current,

• defocusing current,

• Oscillation of electron beam by generation of sine course with 90° phase shift,

• Number of passes after welding.

ADVANTAGES: The electron beam welding technique has major advantages over conventional methods.

- Narrow fusion zone
- Vacuum environment
- Low heat energy
- Compatibility

- Conventional welding

CONCLUSION: Exceedingly low heat input may result in fusion zones and HAZ which are excessively ferritic with a corresponding loss of toughness and corrosion resistance. Exceedingly high heat input increases the danger of forming intermetallic phases. It is generally agreed that the characteristic benefits of duplex stainless steels are achieved when there is at least 35% ferrite with the balance austenite. The heat input introduced by the controlled post heat, applied after welding, enabled to affect the proportional volume of ferrite in weld metal. These results suggest that such a procedure leads to positive results.

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