





Friction stir welds of aluminium alloy pipes: an investigation of defects and mechanical properties

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ABSTRACT

With the elimination of solidification defects, friction stir welding becomes the most effective process for joining flat and curved surfaces. Tool geometry (tool pin profile, shoulder diameter) and tool rotation speed mainly contribute to the overall weld quality. The study evaluates the simultaneous effect of tool geometry, rotational speed, base offset and double pass Friction Stir Welding (DP-FSW) on the defect formation and the mechanical properties. Micro-structure and macro-structure have been analysed for weld strength and hardness characterisation, and found, at high tool rotation speed maximum hardness is achieved in the Stir Zone (SZ). A small tunnel present near the middle proved to be more detrimental than the large one at the bottom. Grain refinement in the SZ was 87.2% while augmentation in hardness was 21.3 HV. Maximum tensile strength of approximately 103% with decent bead profile is obtained, using taper cylindrical tool at 710 rpm with 14 mm shoulder diameter. Fractography of the fractured surface revealed a pure ductile failure. It has been discovered that with base offset the strength of the weld is increased. However, reduction of 4.8% was obtained with DP-FSW. Better weld profile gives better strength. With DP-FSW, a significant improvement in bead surface is obtained.

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1. Introduction

The United Nations (UN) supported sustainable development goals (SDGs) put significant emphasis on weight reduction has spurred considerable interest towards aluminium alloys. The specific weight of Aluminium alloys is one-third of the steel and possess high strength-to-weight ratio, which leads to reduce the overall weight and cost [1,2]. Copper is a popular choice for heat pipes, but its high density and price renders merit on Al-alloys due to low density and high thermal conductivity making aluminium an alternate for copper in heat pipes [3]. The better corrosion resistance and ease of manufacturing are other merits of aluminium alloys due to which the use of Al-alloy pipes is more compelling for oil and gas industries [4,5]. Among other uses of Al-alloy pipes include applications in heat exchangers; food processing, pharmaceutical industries etc. are also increasing.

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