PREFACE

Welding is a process of joining two or more pieces of the same or dissimilar materials, which are melted together by the application of heat or pressure or both and with or without adding a filler material to obtain monolithic structures (Connor 1987). Often a filler material is added to facilitate coalescence. Welding is primarily used in metal parts and their alloys. Recent technologies behind welding have enormously created opportunities to add more value to welded structures and products. A few typical examples are automobiles, aircraft, ships, locomotives, space shuttles, and offshore platforms, to name but a few. Metals predominate the structures, and the quest for the use of metals in manufacturing innovative products by utilizing welding as the main joining process is highly indispensable. To meet the stringent requirements and demanding service conditions of aircraft, missiles, aerospace, automobiles, and commercial structural fields, it is not only necessary to develop new materials but also methods to fabricate them into useful components repeatedly. One such fabrication technique is the arc welding process.

A572 and 316L stainless steel possess some unique properties like strength and corrosion resistance, making it versatile for hazardous environments. A572 micro-alloyed /high strength low alloy steel is becoming the most popularly used as a replacement for mild steel with the added advantage of slightly more protection from corrosion. At the same time, stainless steel is a preferred choice for hazardous environment applications like the food and chemical processing industry. With the increased use of these steels in industries, a reliable joining technique and finding the variables compromising the joint integrity needs to be developed for time and cost-effectiveness. Gas Metal Arc Welding (GMAW) is the most extensive gas shielded arc welding process used in the joining of structural applications due to its preferable flexibility and economy. But there are a few problems like catastrophic failure in heat affected zone, low welding speed, partial penetration, and lack of the deposited metal that occurred during this process. Due to uneven heating and cooling cycles during welding, excessive heat and stress are experienced. Its microstructure and mechanical properties become different from the base material and create heterogeneity in metallurgical structure. HAZ is often an area where failures can occur as it is a highly stressed region. The need for optimum welding parameters in terms of metallurgical uniformity is always required.

Hence in this research, an attempt has been made to find optimum welding parameters, parameters with reduced HAZ size and maximize the mechanical properties of the GMAW welded joints by the different welding parameters. In this investigation, the emphasis was to observe the HAZ and weld bead variations, morphology and microstructure with respect to different current and travel speed combinations under a shielding gas mixture of Argon (Ar) and Carbon dioxide (CO_2).

Butt joint welding in a single pass is performed on A572 gr. 50 and 316L SS steel plates at different combinations of input parameters like Welding Current (A), Weld speed(mm/sec), and Gas flow rate (l/min). MIG joints were fabricated using an inert gas with the help of automated welding machines. The joints were evaluated by conducting tensile tests using the universal testing machine, and interface hardness was found using Vickers hardness testing equipment. Microscopic examinations and characterizations of the joints have been done using Optical Microscopy (OM), X-ray radiography and Scanning Electron Microscopy (SEM).

The present investigation aimed to study the heat-affected zone and the effect of Gas Metal Arc Welding parameter on microstructural and mechanical properties. The characteristics of the fusion zone are typical coarse columnar grains structure because of the prevailing thermal conditions during weld metal solidification. HAZ contained the soft zone, which is the result of the grain coarsening effect for higher heat input parameters, particularly in CGHAZ, resulting in the reduction of strength levels. In this work, plates of 5mm thickness have been used as the base material for preparing single pass butt welded joints at different current, gas flow rate and weld speed values. The filler wire used for joining the plates has a matching composition or is slightly over alloyed to counter the loss of alloying elements during welding. From this investigation, it was found that the hardness of the CGHAZ zone was degraded significantly due to the high heat input. Optimum parameters for both welded materials were found by Taguchi analysis and ANOVA, indicating current as the most dominating parameter, followed by weld speed and gas flow rate affecting the strength properties.

Organization of the thesis-: The thesis is classified into five chapters.

Chapter 1 gives a brief introduction to the various types of welding processes, their classifications, materials and its applications. It also describes the GMAW welding Process, Heat Affected Zone generation and its components in brief. The material chosen for this investigation, the problems encountered in the welding of steels and the HAZ of a welded joint are briefly discussed. The motivation of the research work and objectives of the research work is also presented in this chapter. The chapter concludes with a detailed investigation of Gas Metal Arc Welding (GMAW) and Heat Affected Zone (HAZ) as a critical area prone to defects and discontinuities.

Chapter 2 reviews the various literature on GMAW pertaining to the present investigation. A brief survey is carried out on the welding and HAZ effect on the mechanical behaviour of A572 gr. 50 and 316L SS joint. Based on the available literature effect of process parameters on bead profile characteristics has been reviewed. Further, the formation of heat affected zone and metallurgical aspects of welding low carbon steel and austenitic stainless steel are discussed. Literature related to the variation of process parameters and optimization techniques for better strength and microstructural characteristics has been reviewed and presented. The chapter concludes with a discussion of conclusions from the literature and the objectives of the present investigation.

Chapter 3 discusses the details of materials and experimental procedures adopted for the weld properties investigation. The entire workflow chart and its various tests are also presented in this chapter. It also deals with the chemical and mechanical properties of the base material and filler wire selection. A detailed description of the experimental setup, Taguchi's approach, different levels of shielding gas and its flow rate, welding procedure and testing methods are also presented. The chapter concludes with the details of L_{16} orthogonal array used and characterization techniques involved for the present investigation.

Chapter 4 enumerates the effect of welding parameters such as current, gas flow rate, weld speed and heat input on the mechanical and metallurgical properties of GMAW joints. This chapter focuses on the analysis of fabricated A572 gr. 50 and 316L SS welded joints under premixed shielding gas of Ar and CO_2. Taguchi's experimental design was used for optimization, and the effect of input variables was analyzed, followed by validation. The performance of joints was addressed in terms of macrostructure, microstructural features, and mechanical behaviour for maximum strength. Heat affected zone of joints were thoroughly analyzed for their contribution.

Chapter 5 summarizes the results obtained and the findings of the present investigation along with concluding remarks and scope for future work.