ABSTRACT

Ferritic stainless steel is employed in place of austenitic stainless steel since it has minimal production cost, high-pitched ductility, excellent corrosion resistance as well as extreme temperature oxidation. Ferritic stainless steel (FSS) is a member of the stainless steel, possessing body centered cubic (BCC) arrangement. FSS is observed for stress corrosion cracking as well as pitting corrosion while it is employed in chemical surroundings. SS409M is a tailored form of SS409 of ferritic grade with 0.08% carbon content and 10.90% of Chromium. SS409M swaps carbon steels and low alloy steels where superior strength, abrasive resistance (because of having 1.5% of Nickel and 0.004% of Titanium), weld-ability and slide-ability are necessities. SS409M possesses great scaling and oxidation at prominent temperatures. The material is chiefly employed in petrochemical, transport wagons, fishing, agriculture, quarrying, sewage plants and mining. Welding is an enduring joint category fabrication process that is extremely inexpensive and quicker when evaluated with provisional fabrication processes.

Gas metal arc welding process is that which melts and joins metals by heating them with an arc established between a continuously fed filler wire electrode and the metals. The process is employed with exteriorly provided shielding gas devoid of putting on pressure. It is a flexible welding procedure employed in a diversity of metals and alloys even small and medium scale industries because of less cost and versatile applications. In this study the electrode employed is 308L consumable wire of 1.2 mm diameter wound on a spool that is provided for by the weld from the welding torch nozzle. The shielding gas employed is argon to guard the weld.
collection from the contaminants existing in the air. If oxygen, nitrogen gases go into the welding ambiance it could produce porosity in the weld. This procedure is appropriate for turning out high quality welds even in high speed welding condition, and also this process reduce spattering and minimize the porosities in the weld.

In welding process the quality and joint strength is based on the bead geometry. The bead geometry mainly depends on the input process parameters. Welding speed, wire feed and torch angle were selected as the input process parameter. In analog welding machines the current readings are always fluctuating. If the wire feed rate is selected as the one of the process parameter, the accurate value of current supplied was easily measured and also it is the indirect way of measuring the actual current supplied while welding. Productivity factor is mainly based on welding speed of the process. Based on the position of the weld torch the amount of shielding gas applied is varied, and it will reflect in bead dimension and the weld strength. So these are the reasons for selecting wire feed, welding speed and torch angle as the input process parameters.

The direct and interactive effects of the process parameters on bead geometry help to select the apt process parameters. By studying the various literatures it is found that very little work is found out on regression modeling and in ANN modelling of GMAW process. So it is useful to study GMAW of SS409M and model GMAW process for comparing the process parameter to bead geometry. To achieve the desired quality and strength these models will help by selecting the required parameter.

In the present study, SS409M base metal was welded by GMAW process by using 308L filler wire. As per the Box Behnken design
matrix required experiments were conducted. To find the influence of GMAW process parameters such as wire feed, welding speed and torch angle on bead dimensions, regression equations were developed to associate GMAW process parameters with weld bead dimensions such as weld bead width, reinforcement, penetration and weld bead area.

By using multiple regressions, the models were developed. By using ANOVA technique validation and capability of the regression models are checked. To find the model accuracy conformity test was conducted. The error of the models is found to be less than 4%. The developed regression equation can be used to predict the weld geometry. The direct effect and the interactive effect of the process parameters were studied and presented graphically. By using the regression models and by understanding the interdependence of various weld parameters, the weld bead area was minimized, without affecting the strength of the weld. Design expert software was used for optimizing the weld bead area.

For developing ANN models to predict weld bead geometry, multilayer feed forward neural network with back propagation algorithm was used. By comparing regression model with ANN model it was found that ANN models are more accurate.

The quality of the welded joint is governed by the heat input. With the help of the measured welding current, voltage and welding speed the heat input for all trials was calculated. Tensile strength of welded joints at various heat input conditions was measured.

Tensile test results prove that failure has occurred in the base material except the sample no.11, where maximum heat is applied. From the
tensile test results it was founded that, the maximum tensile strength of 529.58 N/mm$^2$ was occurred at low the heat input of 54.79kJ/mm.

Impact test is concerned the maximum impact value 304 joules has occurred at heat input of 92.71kJ/mm. It is concluded that if the heat input value increases the impact strength is also increased.

Face bend test and root bend test was carried out to know the ductile property of the welded joint. The result proves the weld was ductile without any defects.

Using the ferritescope the ferrite content was measured. The effect of GMAW process parameter and heat input on ferrite content was obtained with the help of developed regression models. The direct and interactive effect of process parameter on percentage of ferrite was investigated. It was observed that ferrite content was decreased with increase in wire feed rate and decrease in welding speed. The microhardness study was carried out at various zones like BM, HAZ, FZ and weld metal of the weldment at various heat input conditions. Higher heat input in GMAW results in reduced amount of ferrite % thus increasing the microhardness of the weld zone. The microhardness value along the fusion line was around 275.4 VHN to 325.7 VHN and for the base material micro hardness value is 145.3 VHN to 171.6 VHN.

Microstructures were observed to be different for varying heat input levels. In the microstructure of the base metal shows the broken network of titanium carbides in black colour at the grain boundaries with finer grain structures.
At a low heat input of 51.13 kJ/mm the bead is comparatively lesser than the medium and high heat input samples. Since the heat input is less so the volume of base metal melted is low. The fusion line and heat affected zone shows that finer ferritic grains are observed near the fusion line without any defects. The weldment joined at lower heat input samples has fine dendritic ferritic grains due to faster cooling rate. This is attributed to an increase in both solidification and cooling rates due to low heat input resulted from high welding speed.

At high heat input of 92.71 kJ/mm it is observed that the heat input increases; the size of the bead also increases. Since the heat input is high the volume of base metal melted is also high. The fusion line and heat affected zone found that coarse ferritic grains are observed near the fusion boundary line. The weldment joined at high heat input has coarser ferritic grains and dendritic arms in the weld zone.