# THE EFFECT OF PREHEATING OF ELECTRODE IN SUBMERGED ARC WELDING OF STAINLESS STEEL

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**ABSTRACT:**

Where thick plates are to be welded (like ship building industries) submerged arc welding is very useful process. The deep penetration will get due to the use of high currents in the process. The deep penetration welds may not be suitable when SAW process is to be used for surfacing applications. Low penetration and consequently less dilution are desired. In this study we achieved low penetration (and lower dilution) by varying the process parameters.

The process of laying metal over another Material to improve its mechanical properties such as resistance to abrasion and corrosion resistance is known as Metal Surfacing. Dilution plays important role in metal surfacing. The lower the dilution better will be the metal surfacing results. The process of Advanced Submerged Arc Welding (ASAW) is developed at welding research laboratory, IIT Delhi. The process controls the dilution break the fixed relationship between the welding current (I) and wire feed rate (W). 308L Stainless steel was used as electrode wire on mild steel substrate. The results indicate that ASAW process controls and significantly reduces the percentage dilution. The mechanical and metallurgical properties were also improved significantly.

***Key Words:*** *Advanced Submerged Arc Welding (ASAW), Dilution control, welding parameters*

## INTRODUCTION

In saw process the arc produces between electrode and workpiece and the heat of the arc melts the surface of the base metal and electrode. The melted metal is transferred through the arc to the work piece, where it becomes the deposited weld metal. Shielding is obtained from granular flux, which is directly sprayed over the weld area. The flux near to the arc melts and mix with the molten weld metal. The flux forms a slag which is floats on the surface to protect weld pool. The weld pool is covered by this layer of flux and slag, hence the name submerged arc welding. The arc will be covered by flux and slag so that it is not visible. SAW normally uses constant-voltage power supply and is self-regulating, so it can be used with a constant speed wire feeder. The current is controlled by the wire-feed speed, the electrical stick-out, and the wire diameter, while the voltage is controlled by the power supply. Direct current supply is used for the high-speed welding of comparative thin steel plates.

Dilution is defined as the chemical composition change in of the filler material caused by the mixing with the base material. The degree of dilution depends upon the difference in chemical composition between the weld and the base metal. It also, influences the strength, ductility, heat treatment, corrosion resistance, the welding process and the technique used.

## LITRATURE

[1] Study done to find the effect of process parameters on output features of submerged arc weld by using Taguchi method. The relationship between control factors and performance outputs was stablished by means of nonlinear regression analysis, resulting in a valid mathematical model. [2]. He studied the effect of Nd-YAG laser welding parameters on the ultimate tensile stress. Their result indicated that the pulse shape and energy of the laser contributed most to thin plate butt-welding. [3] They analyze the effect of each welding process parameter (arc gap, flow rate, welding current and speed) on the weld pool geometry. It was experimentally reported that, the four smaller-the-better quality characteristics, four responses‟ of the weld pool in the TIG welding of S304 stainless steel of 1.5 mm in thickness are greatly improved by using this approach .Laser butt-welding of a thin plate of magnesium alloy using the Taguchi method has been optimized by Pan et al.[4] He used the applied Response Surface Methodology (RSM) for prediction and optimization of weld bead geometry. [5] The study of welding procedures generation for the submerged arc welding process. Several research works have already been carried out in the field of submerged arc welding for parametric optimization. [6] They studied the effect of process parameters on output features of submerged arc weld by using Taguchi method. [7] In this paper he

developed statistical models for predicting bead volume of submerged arc butt-weld. [8] Studied the effect of the laser welding parameters mentioned above on the impact strength of the same joint at room temperature using the same optimizing technique. The results indicated that the laser power has the most significant effect on the impact strength. [9] They have used the Taguchi method and regression analysis in order to optimize Nd-YAG laser welding parameters (nozzle type, rotating speed, title angle, focal position, pumping voltage, pulse frequency and pulse width) to seal an iodine-125 radioisotope seed into a titanium capsule. The accurate control of the melted length of the tube end was the most important to obtain a sound sealed state. [10] Used Non-dominated Sorting Genetic Algorithms (NSGA) to optimize the contradicting combination of strength and toughness of steel welds.

## ADVANCED SUBMERGED ARC WELDING

The Advance Submerged Arc Welding technology by adopting a very simple and innovative welding setup design at Research Laboratory at the Indian Institute of Technology, Delhi .This process break the fixed relationship existing between the welding current and the deposition rate by preheats a certain section of the filler wire ($I^2R$ heating) before it came out from the welding contact tip. The new process allows independent and balanced control of metal deposition rate, weld bead penetration and arc force, resulting in an extremely versatile and flexible system. The purpose of preheating one auxiliary power source was utilized for controlling the varying current, dielectric gap and mass flow rate of the welding filler wire. The power source supplies the required welding current for joining process. The welding mechanism had two contact tubes with a dielectric gap between them.

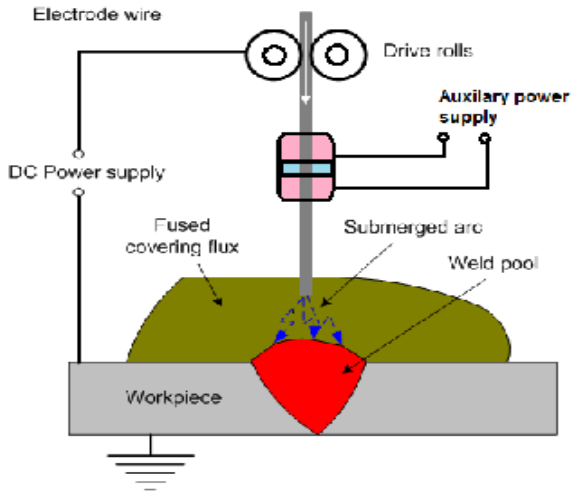



Figure-1: Advanced Submerged Arc Welding setup

The process has an advantage that the welding current, the electrode stick-out, and the deposition rate can be individually varied thus making the process particularly useful in surfacing operation, thin sheet welding and weld brazing where low level of penetration and dilution is required made possible.

The Setup for Advanced submerged arc welding process is shown in Figure-1, it has two contact tubes. Contact tube 'A' and 'B' with a suitable dielectric medium is used for the pre heating purpose, which is connected to a auxiliary power source and the contact tube 'B' is connected to the power supply from the source responsible for welding.

## EXPERIMENT AND ANALYSIS

The experiments were conducted according to Bead on plate technique. It is very important to select right welding parameters for designed experimental runs. Wire feed rate (F), Open circuit voltage (V), current polarity (P) and welding speed (S) were selected as welding parameters since they can be varied independently. The ranges of selected parameters were finalized after performing extensive trial runs. The effect of independent parameters on weld dilution behaviour was analysed. The values of the parameters were taken as two levels for the each parameter.

The weld beads were deposited using 'Bead-on-plate' technique on 250 x 70 x 10 mm mild steel flat, using 3.15 mm diameter mild steel and stainless steel wire with agglomerated flux. Constant potential transformer-rectifier type power source with a current capacity of 600 A at 60% duty cycle and an open circuit voltage ranges from 0-56 volts was used. The actual values of parameters corresponding to the coded values are given in **Table 1 and Table 2.**

**Table-1: Welding parameters and limits <u>without</u> preheating**

| Parameter | Units | Symbol | Limits | |
|---|---|---|---|---|
| | | | Low (-1) | High (+1) |
| Wire feed rate | m/min | W | 0.9 | 1.08 |
| Voltage | Volts | V | 20.0 | 26.0 |
| Welding speed | cm/min | S | 30 | 60 |
| Preheat Current | ampere | A | 0 | 0 |

**Table-2: Welding parameters and limits with preheating**

| Parameter | Units | Symbol | Limits | |
|---|---|---|---|---|
| | | | Low (-1) | High (+1) |
| Welding wire feed rate | m/min | W | 1.0 | 1.26 |
| Arc voltage | Volts | V | 26.0 | 32.0 |
| Welding speed | cm/min | S | 45 | 90 |
| Preheat Current | ampere | A | 200 | 250 |

## RESULTS

There was a significant reduction in the weld bead penetration. The dilution was calculated mathematically by dividing the area of penetration by the total bead area.

The results of percentage dilution level due to preheat are shown in figure-3 through bar charts. It is observed from the data that with the preheating of the electrode the penetration into the parent material is reduced. The percent dilution was calculated by the relationship.

$$\%D = \frac{A_P}{A_P + A_R} * 100$$

Where

$A_P$ = Area of penetration,

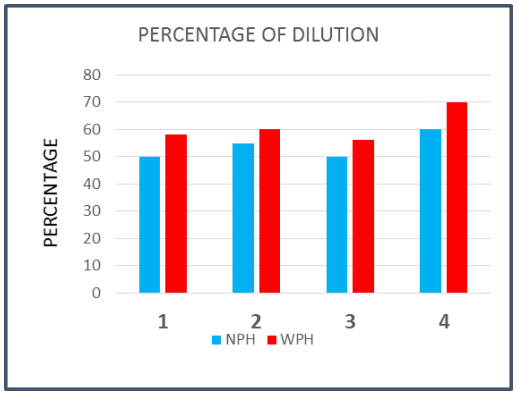
$A_R$ = Area of reinforcement,

$A_T$ = Total area of Bead,

As $A_T = A_P + A_R$

| Comparison | | | |
|---|---|---|---|
| Parameter | Symbol | SAW Process | ASAW Process |
| Wire feed rate, m/min | W | 1.08 | 1.26 |
| Arc voltage, volts | V | 26.0 | 32.0 |
| Contact tip to plate distance, mm | N | 20 | 25 |
| Travel speed, cm/min | S | 60 | 90 |
| Pre-heat current, ampere | A | 0 | 250 |
| Bead Profile | |  |  |

Figure-2: Comparison of Dilution level in both processes.



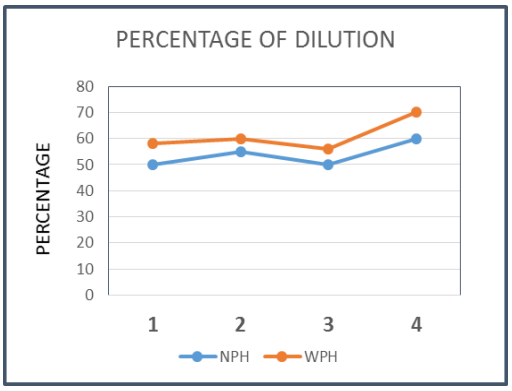




Figure-3: Comparison of % dilution through chart

The results shows that an increase in wire diameter and voltage results in increase in the level of dilution %age. But with increase in Preheat current, welding speed and contact tip to plate distance the % age dilution decreases. It was also observed from the micrographs that the width of heat affected zone is smaller in size as compared to the size obtained from the welded specimens without preheating of the filler wire.

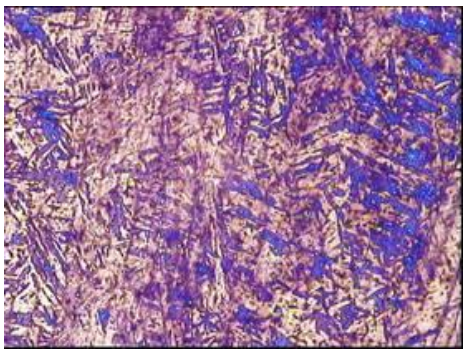


Figure 4: Microstructure of stainless steel 308L with SAW

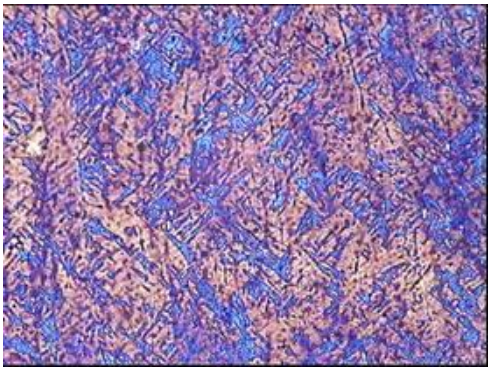


Figure 5: Microstructure of stainless steel 308L with ASAW

## CONCLUSION

The results shown by the experiment that the Advanced submerged arc welding process for the controlled dilution level useful for the cladding process. The heat input can be controlled easily irrespective of the process parameters. The dilution was calculated mathematically by dividing the area of penetration by the total bead area. Around 34% reduction in the dilution was recorded by the use of Advanced submerged arc welding process.

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