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# SAW FLUX BY RECYCLING OF WASTE SLAG WITH CHROMIUM CARBIDE AND ALUMINUM OXIDE

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## ABSTRACT

*The effect of chromium carbide and aluminum oxide by percentage of weight in SAW flux were developed by recycling of waste slag. The percentage by weight of chromium carbide (5%), aluminum oxide (5%) and binder (150 ml) added for the flux developments were used to weld sample plates measuring 100mm x 50 mm x 6 mm. The property of weld beads geometry (width, height) and hardness of the surface is measured. All Test results were satisfactory and fulfill AWS (American Welding Society) requirements.*

## 1.0. INTRODUCTION

Submerged arc welding (SAW), or sub arc as it's generally referred to , is unique welding process because there is no visible evidence that a weld is being made . The welding zone is completely shielded by a blanket of granular flux .Exposed arc eye protection is not normally used since the arc should be completely covered.

The traditional welding flux is costly and the flux used in Submerged Arc Welding (SAW) generates wastages known as Slag. It is generally thrown away as a waste after use. This poses the problem of storage, disposal, and environmental pollution and needs landfill space apart from exhaust of non-renewable resources. If by recycling the used flux can be reused in product yielding same quality parameter as the new flux, then the cost of the input will go down significantly. However, this requires extensive trial and error experimentation because it is often difficult to know how the slag ingredients interact after recycling and to determine the operational characteristics of the recycled flux and the final performance of the welded structure.

Keeping this in mind an experiment has been conducted in a manufacturing unit with small investment. As far as possible weld qualification tests were performed using recycled flux .While comparing, it was indeed revealed that the product has almost same chemical analysis, radiography, mechanical tests than as the new flux. Cost analysis of recycled slag per 1 kg was calculated and compared with the equivalent fresh flux available in the market according to the principle of market value method or reversal cost method. It is similar to the technique of by product revenue deducted from production cost. The cost analysis has revealed that of saving could be up to 30.56%.

## 2.0. LITERATURE SURVEY

Abilio Manuel et al. (2007); Introduced normalized fine grain carbon low alloy steel, P355NL1, intended for service in welded pressure vessels, where notch toughness is of high importance, has been investigated. Applications with this steel usually require the intensive use of welds. One of the most common welding processes that are used in the manufacturing of pressure vessels is the submerged arc welding. This welding process is often automated in order to perform the main seam welds of the body of the vessels. The influence of the automated submerged arc welding, in the mechanical performance, is investigated. The low and high cycle fatigue and crack propagation behaviors are compared between the base and welded materials. Several series of small and smooth specimens as well as cracked specimens made of base, welded and heat affected materials, respectively, were fatigue tested. Strain, stress and energy based relations for fatigue life assessment, until crack initiation, are evaluated based on experimental results and compared between the base and welded materials. Finally, the fatigue crack propagation behaviors are compared between the base, welded and heat affected materials.

SerdarKaraoglua et al. (2008);Observed process parameters have great influence on the quality of a welded connection. Mathematical modeling can be utilized in the optimization and control procedure of parameters. Rather than the well-known effects of main process parameters, this study focuses on the sensitivity analysis of parameters and fine tuning requirements of the parameters for optimum weld bead geometry. Changeable process parameters such as welding current, welding voltage and welding speed are used as design variables. The objective function is formed using width, height and penetration of the weld bead. Experimental part of the study is based on three level factorial designs of three process parameters. In order to investigate the effects of input (process) parameters on output parameters, which determine the weld bead geometry, a mathematical model is constructed by using multiple curvilinear regression analysis. After carrying out a sensitivity analysis using developed empirical equations, relative effects of input parameters on output parameters are obtained. Effects of all three design parameters on the bead width and bead height show that even small changes in these parameters play an important role in the quality of welding operation. The results also reveal that the penetration is almost non-sensitive to the variations in voltage and speed.

Kook-soo Bang et al. (2008); said that submerged arc welding was performed using metal cored wires and fluxes with different compositions. The effects of wire/flux combination on the chemical composition, tensile strength, and impact toughness of the weld metal were investigated and interpreted in terms of element transfer between the slag and the weld metal, i.e., quantity. Both carbon and manganese show negative quantity in most combinations, indicating the transfer of the elements from the weld metal to the slag during welding. The amount of transfer, however, is different depending on the flux composition. More basic fluxes yield less negative C and Mn through the reduction of oxygen content in the weld metal and presumably higher Mn activity in the slag, respectively. The transfer of silicon, however, is influenced by $Al_2O_3$, $TiO_2$ and $ZrO_2$ contents in the flux. Si becomes less negative and reaches a positive value of 0.044 as the oxides contents increase. This is because Al, Ti, and Zr could replace Si in the $SiO_2$ network, leaving more Si free to transfer from the slag to the weld metal.

I.C. Kuo et al. (2008);Discussed two types of martensitic stainless steel strips, PFB-132 and PFB-131S, were deposited on SS41 carbon steel substrate by a three-pass submerged arc cladding process. The effects of post-weld heat treatment (PWHT) on thermal fatigue resistance and hardness were evaluated by thermal fatigue and hardness testing, respectively. The weld metal microstructure was investigated by utilizing optical microscopy, scanning electron microscopy (SEM). Results showed that, by increasing the PWHT temperature, hardness decreased but there was a simultaneous improvement in well-meant thermal fatigue resistance. During tempering, carbide, such as (Fe, Cr) 23C6, precipitated in the weld metals and molybdenum appeared to promote (Fe, Cr, Mo) 23C6 formation. The precipitates of (Fe, Cr, Mo) 23C6 revealed a face-centered cubic (FCC) structure with fine grains distributed in the microstructure, thereby effectively increasing thermal fatigue resistance.

KulwantSingh, SunilPandey (2009);the slag generated during submerged arc welding is thrown away as a waste. Non-biodegradable nature poses problems of storage, disposal, soil pollution and also needs landfill space for dumping. It cannot be used as a filling material in building construction or elsewhere being glassy and brittle material. The non-renewable resources are also getting exhausted fast due to continuous mining for minerals required for manufacturing of fluxes. The successful development of recycling technology that allows the use of slag as a fresh flux will surely overcome the above-mentioned problems and will also prove to be very economical. Slag was processed by replenishing it with suitable alloying elements/deoxidizers by agglomeration. This replenished slag is referred to as recycled slag. Recycled slag in combination with EL-8 filler wire was used in these investigations. The properties of weld metal deposited with recycled slag were investigated. The mechanical properties were satisfactory and satisfied AWS (American Welding Society) requirements. The chemical composition of weld metal was within the acceptance range of AWS specifications. The test plates cleared the radiographic test.

SauravDatta et al. (2009);Discussed optimization problem of submerged arc welding. The target was to search an optimal process environment, capable of producing desired bead geometry parameters of the weldment. Four correlated features of bead geometry: depth of penetration, reinforcement, bead width, and percentage dilution has been selected in the study. The process environment has been assumed consisting of variables like voltage, wire feed rate, traverse speed. Multiple correlated responses have been converted into independent quality indices called principal components. Principal component analysis (PCA) has been adapted to covert multiple objectives of the optimization problem into a single objective function. This single objective function has been denoted as composite principal component. Taguchi’s robust optimization technique has been applied to determine the optimal setting, which can maximize the composite principal component. Result of this aforesaid optimization technique has been compared to that of grey- Taguchi technique; another approach which is widely used for solving multi-criteria optimization problems. A confirmatory test showed satisfactory result.

V. sahni, kulwantsingh and s. pandey (2009);Slag generated during submerged arc welding has been recycled by mixing varying percentages of crushed slag with fresh flux to use in subsequent runs. The influence of using flux-slag mixture on weld chemistry has been investigated. The results indicate that the use of such a mixture in submerged arc welding does not adversely affect the chemistry of weld metal. In addition, slag detachability and bead appearance both were found satisfactory. Arc stability observed during welding was also satisfactory.

Zhang Huaiwei, Hong Xin (2011);Significant quantities of wastes are generated as the waste materials or byproducts every day from stainless steel processes. According to the origins and characteristics, the stainless steel wastes can be mainly classified into two categories, slags and dusts. They usually contained considerable quantities of valuable metals and materials. This paper summarized and analyzed the generation, composition, characteristics and the leaching behaviors of the most of wastes obtained from the stainless steel processes. On this basis, a review of several methods for treating the various stainless steel wastes was made. It is very essential not only for recycling the valuable metals and mineral resources but also for protecting the environment.

## 3.0. PROBLEM STATEMENT

During Submerged Arc Welding process flux used is nearly 50% of the total cost of welding and after welding the slag hence formed is totally a waste. This slag if can be recycled and some ingredients (chromium, aluminum oxide) can be added to it then we on one hand reduce the cost of the process by recycling the waste slag and on the other hand getting the desired property such as for surface hardness, bead geometry, etc.

## 4.0. MOTIVATION/NEED FOR RESEARCH

In the production of machines, devices and structures various materials satisfying diverse operational requirements are used. The main requirements are: high strength, high wear and corrosion resistance, resistance to oxidation and some other specific properties. New materials for various applications are continuously developed using advance technologies. Complex properties for these materials can be given using heat and thermo-chemical treatment, plastic deformation, spray deposition, surfacing, hard facing and others.

In this research work, I have tried to analyze the effect of recycle flux on bead geometry and hardness using Submerged Arc Welding process by adding metal powder in the recycled slag. The effect of welding process parameters interaction of voltage, travel speed and the effect of alloying element present in the metal powder which is mixed with the flux in by 5% of chromium & aluminum oxide on bead geometry and hardness of the weld metal has been investigated.

## 5.0. OBJECTIVE

1. Study the Submerged Arc Welding process and parameters.
2. Development of recycled flux from waste slag by addition of metal powder.
3. Analyze the weld bead by developed flux through radiography test, bending test, and hardness test
4. Develop models for predicting the bead geometry and hardness of the weld metal within the design limits of the welding parameters.

## 6.0. METHODOLOGY

To achieve the objectives of the research, the steps to be followed are as under:

1. Select the process parameters in order to achieve bead with original flux and developed flux
2. Specify the range of the selected parameters after studying their influence on the weld characteristics.
3. Designing/ planning of experiments using Mini tab software
4. Compare the effect of weld bead geometry and hardness with original flux and developed flux by using mini tab software
5. Recycling of waste slag of SAW process and addition of metal powder in it. Performing the experiments according to design matrix prepared.
6. Cost analysis
7.

## 7.0. RESULT AND DISCUSSION

1. It was conclude from the radiography test the sample which was prepared for radiography is free from all defect like slag, porosity, crack, inclusion.
2. The brinell hardness was made on B scale having hardness 90-95 HRB for further resultsee the appendix-2 of thesis.
3. The bending test was performed face bending was done with load 14.40 N &displacement 61.0 mm while Root bending test was done with load 24.20 N &displacement 52.3mm.
4.

## 8.0. CONCLUSION

In this present work the flux developed flux & the welding bead was laid by both flux (f1, f2) one being original S.S. flux and another was Developed flux. The comparative analysis was done by comparing bead geometry and bead property. The properties were found to be similar in both cases. It is further strengthening by various tests. Following conclusion was drawn from the work.

1. The weld laid by using developed flux is found to be sound.
2. The weld was found to be radio-graphically acceptable.
3. BHN of 90-95 HRB of weld bead is obtained.
4. Weld is observed to be acceptable on the basis of root and face bending test
5. The developed flux is found to be acceptable as compare to the original flux by
6. Comparing various properties such as bead height, bead width and hardness.
7. 30.56% saving in cost is obtained.
8.

## 9.0. FUTURE SCOPE OF WORK

1. Process parameters used in this study were arc voltage, current, welding speed. Study can be done by selecting more parameters such as multiple wire electrode, electrode wire size, flux type etc.
2. Response surface methodology and other techniques can be used.
3. Microstructure of the welds may also be studied.
4. Other alloying elements may also be added to improve the mechanical properties of the weld.

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