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Cost Analysis and Waste Reduction of Reclaimed Slag over Fresh Flux in Submerged Arc Welding

Deepanjali Nimker[1], Reeta Wattal[2]
[1, 2] Department of Mechanical Engineering, Delhi Technological University, India

Abstract: Submerged Arc Welding uses flux which generates waste known as slag. Since the flux involves high cost, slag was considered to be used instead of flux. For this, concept of recycling slag was used in recreating same quality parameter as that of fresh flux. However, it involves number of hit and trial experimentation with various error occurrence because it's hard to determine how the weld metal integrity and structure vary after mixing different ingredients with slag. Weld qualification test had been performed to investigate replenished slag. While comparing, it was observed that reclaimed slag yields better results. Cost effectiveness of reused (recycled) slag per 50 kg is premeditated and compared with original flux available in the market. It was concluded that % saving is up to the extent of 31% for reclaimed slag.
Keywords: Submerged Arc Welding, Reclaimed slag, Flux

I. INTRODUCTION

The quality of weld is prime standard in selecting any welding process but in most of the cases cost success is considered as prime factor. Submerged arc welding (SAW) is a process used to yield great quality of welds. This welding method is considered as a high quality and cost effective process. Flux is an important part of SAW. Selection of eminent flux highly increases the chances of producing superior weld. Alloy constituents in flux try to improve the crack confrontation and welding properties of the weld deposit. In SAW, flux is used to envelope electric arc and kept weld bead safe from environment effect. High temperature of electric arc melts the filler material and a portion of the parent metal and a portion of the flux makes slag. This slag prevents weld bead from atmospheric contamination and it also refines the weld metal. SAW is safe for the surrounding because processes like fusion and hardening are taking place under the molten slag in which there is no spattering, flashing, or fumes generation of metal vapour or of different gases. From literature review, it was found that flux ensured the composition as 30% (SiO2zTiO2), 55% (Al2O3zMnO), 5% CaF2, and 10% binding material. The metallurgical blending of wire and flux was same in most of recycled technique [1]. The physical properties of fresh flux are very important factor in submerged arc welding for enhancing the welding properties. The old-fashioned flux was costly and generates scrap as slag in SAW which is thrown as a waste. This waste (slag) creates the problem of storage, disposal, and environmental pollution. Christensen and Chipman [2] studied about coating of acid on arc electrodes. Few researchers [3-5] had done similar study on submerged arc welding fluxes for improvement in quality and cost reduction. Mizuochi [6] analysed the impact of working conditions on particle size of flux. Wen-hong et al. [7] investigated that high water content waste slag cannot be directly used for grinding. For cement manufacturing water content should be less than 2% .The energy utilization increases as the water content increases in slag. RN Coimbra et al. [8] used lignite coal as energy source for drying by burning. After that combustion, its emission was used to calculate environmental effect by elemental analysis. Above methodology had been well used to calculate the economic affordability of various circumstances such as passenger vehicles [9], buildings [10], hydrogen production [11], and biofuels [12]. Equally important, of great interests was the discrepancy in environmental impacts and economic cost reuse of flux. From Literature review, it was analysed that just throwing the slag is not the solution because it will be going to have adverse effect upon our environment. Moreover, recycling of slag is cost effective. In this research recycling of slag was elaborated and compared to fresh flux in cost effective range.

II. COST COMPARISON METHODOLOGY

A. Recycle slag processing

Slag was collected from the dump yard of Cheema boilers kurali, Punjab where it was thrown as a waste. It was then washed, crushed manually and then converted into powder form using ball mill rotation. This material was then assorted with few additives and binding material and sieved to form pellets which was kept to be air dried for 24 hours. These pellets were then baked at 850^{o} C for 2 hours. Fig. 1 shows the crushed recycled slag and fresh flux. Considering this slag recycling process, cost evaluation of recycled slag per 50 kg had been compared with flux commercially available. This substantiation certainly enables the company to consider the use of reclaimed slag over original flux. Certain calculations taken out by procuring market value of additives and binder with their processing and transportation cost according to the present cost existing these days. As per the standard the overhead cost and profit was considered as 10 % and 12 %, respectively. Transformation cost per 50 kg was thus acquired and correlated with fresh flux. Substantially, 31% saving had been observed. This process results in yielding slag which has negligible adverse effects on environment thus improves quality of life. Table 1. Shows the detailed cost analysis of recycled slag and original flux.

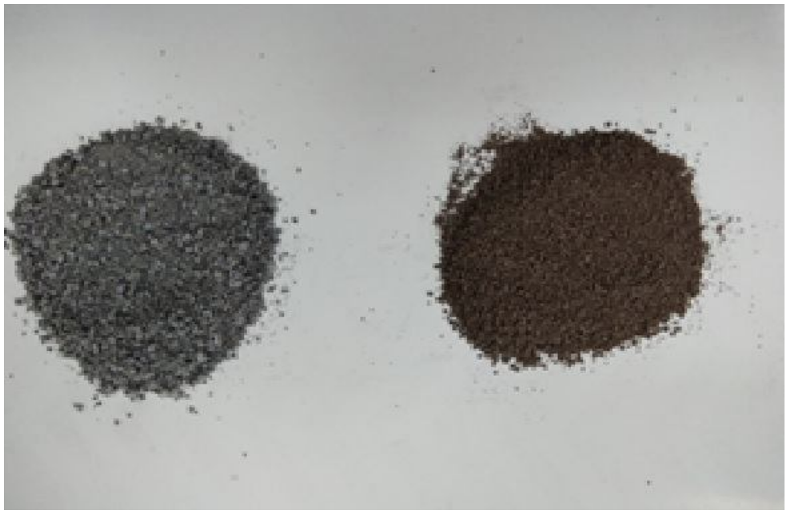

Fig 1: Crushed recycled slag and fresh flux

Table 1. Detailed cost analysis of recycled slag and fresh flux

S.No	Cost head	Material	Process	Cost (Rs.)
1.	Pure slag	slag	Slag collected includes transportation cost only	300
2.	Additives	Mn, Al, potassium titanate, $CaCO_3$	Purchase cost of additives including processing and transportation cost	1858
3.	Binder	Potassium silicate solution	Purchase cost	150
4.	Crushing and milling		Slag crushed and rotated in ball mill	300
5.	Sintering		Slag mixture heated without liquefaction	300
6.	Labour Cost		Cost of labour	150
7.	Subtotal			3058
8.	Overhead cost@10%			3364
9.	Profit@12%			3767
10.	Cost of Reclaimed Slag per 50 kg			3767
11.	Market price of fresh flux per 50 kg			5500
12.	Saving			1733
13.	%Saving			31%

B. Welding Method

Submerged arc welding machine uses flux of F7A4 grade with wire EH14.The welding wire is having 3.15 mm as its diameter. The crushed and sieved slag obtained above was used to produce a bead on mild steel plate. The dimension of the base plate as 160 x 73 x 12 mm. Fig. 2 shows submerged arc welding machine. Fig. 3 shows ball mill used to convert slag into powder form.

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Fig:2 Submerged arc welding machine

Fig. 2 Ball Mill

C. Welding Beads inspection

As observed bead on plate on a mild steel is free from oxidation after welding in both recycled slag and virgin flux. They qualify weld quality as well as mechanical properties test.

Fig 3 and 4 shows weld bead by fresh flux and recycled slag. Fig 5 shows slag removed from the weld bead.

Fig:3 Fresh flux weld bead

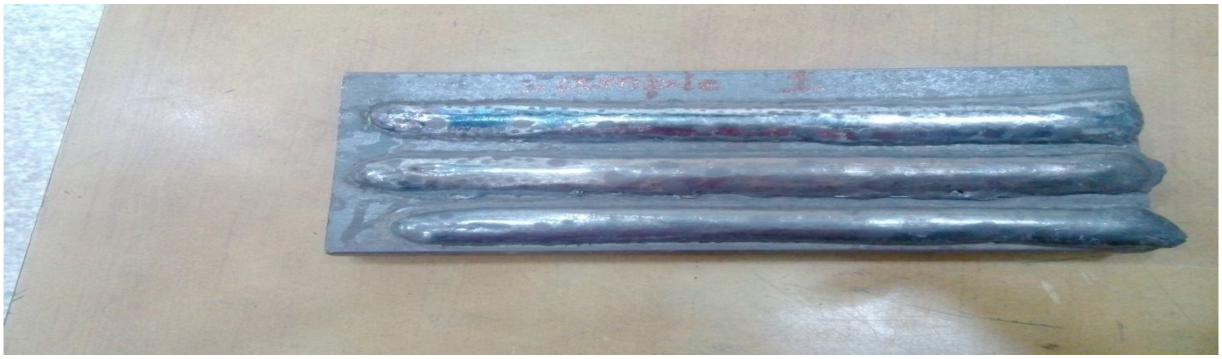

Fig 4: Recycled slag bead

Fig:5 Slag Envelope after welding

III. CONCLUSION

Following conclusions were drawn from the research:

A. Slag produced from submerged arc welding can be recycled.
B. Recycled slag used for welding does not affect the weld quality.
C. Visual Inspection of weld bead results in good appearance.
D. Slag detachability and arc stability were satisfactory when welded with submerged arc welding.
E. Recycled slag proves best alternative to original flux. It results in providing economic benefit to the company.
F. Recycled slag is proved economical by 31% as compare to fresh flux.

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