International Journal of Advanced Multidisciplinary Research (IJAMR)
ISSN: 2393-8870
www.ijarm.com
Volume 3, Issue 6 -2016

Research Article

SOI: http://s-o-i.org/1.15/ijarm-2016-3-6-7

Influence of heat input variation using cold wire on performance of inverted type submerged arc welding process – IS 2062 carbon steel

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Keywords

Cold wire addition technique – Cold wire feeder – Bead geometry – Deposition Rate – Dilution - Heat input – Mechanical Properties – IS 2062 Carbon Steel

Abstract

Submerged Arc Welding is most widely used method for welding thick section in down hand position being a highly economical method for fabrication. As products must meet more stringent requirements of quality, requiring more flexible processes to reduce cost, further improvements is studied. Quality control aspects are also becoming more important to meet regulations and monitoring and control of welding process, and the standardized testing of joints will meet all the requirements This paper describes the experimental work carried out to study the influence of heat input variation using cold wire on performance of inverted type submerged arc welding process – IS 2062 carbon steel. Improved results in mechanical and metallurgical properties obtained in this studied are reported.

1. Introduction

There is a great interest to increase the welding productivity through process, equipment, and consumable development. One such development studied is Inverted type submerged arc welding with cold wire addition. This cold wire addition technique using high amperage gives higher productivity. The focus of this project is the testing, evaluation and qualification of submerged arc welding with cold wire addition technique for IS 2062 Carbon steel welding applicable for boiler fabrication. Cold wire addition provides an increase in deposition rate without accompanying increase in heat input. It also provides a finer Heat – Affected Zone (HAZ) grain structure and narrow Heat-Affected Zone compared to conventional submerged arc welding. Cold Wire addition has produced quality welds with lower heat inputs per gram of deposited weld with substantial reduction in arcing time. In this project, a test weldments of IS 2062 carbon steel has been fabricated.

2. Review of literature

M. Ramakrishnan, V. Muthupandi, [1] has experimentally investigated on for welding of thick section in down hand position being a highly economical method for fabrication. As products must meet more stringent requirement of quality, requiring more flexible processes to reduce cost, further improvements is studied. Quality control aspects are also becoming more important to meet regulation and monitoring and control of welding processes, and the standardized testing of joints will meet all the requirements. This paper describes the experimental work carried out to study the effect of process parameters and weld metal property of thick section welds in SA 299 material using cold wire addition technology in tandem submerged arc welding for boiler drum shell fabrication. Improved results of mechanical and metallurgical properties obtained in this study are reported. M.A. Moradpour, S.H. Hashemi, K.Khalili [2] had experimentally investigated on submerged arc welding Based on Fuzzy logic and NSGA-II (Non-dominated Sorting Genetic Algorithm-II) algorithm, a new approach was proposed for weld bead geometry prediction and for process parameters optimization. First, different welding parameters including welding voltage, current and speed were set to perform SAW under different conditions on API X65 steel plates. Next, the designed Fuzzy model was used for predicting the weld bead geometry and modeling of the process. The obtained mean percentage error of penetration depth, weld bead width and height from the proposed Fuzzy model was 6. 06%, 6. 40% and 5. 82%, respectively. The process parameters were then optimized to achieve the desired values of convexity and penetration indexes simultaneously using NSGA-ll algorithm. As a result, a set of optimum vectors (each vector contains current, voltage and speed within their selected experimental domains) was presented for desirable values of convexity and penetration indexes in the ranges of (0. 106, 0. 168) and (0. 354, 0. 561) respectively, which was more applicable in real conditions. Hirosisa Tanabe, Hiroyuki Hirata, Kzuhiro Ogawa, Masahiko Hamada. [3] conducted experiment on Fixed welding tests were performed to investigate deoxidization during submerged arc welding and to develop a model for it. For all the chemical compositions of the fluxes used, the oxygen content of the weld metal decreased with increasing arcing time in the initial stage of welding. The oxygen content of the weld metal eventually became constant; this is assumed to be a quasi-equilibrium state. Both the rate of reduction of the weld metal oxygen content and the oxygen content of the quasi-equilibrium condition depend on the chemical composition of flux. The weld metal oxygen content in the quasi-equilibrium condition can be estimated thermodynamically Tadahisa Tsuyama, Kiyomichi Nakai, Takumi Tsuji,[4], in the present investigation. An electrically heated filler wire, hereafter referred to as hot wire, was inserted into the rear part of weld pool made with leading SAW electrode. By using the hot wire without arc, increase in heat input could be suppressed but the amount of weld deposit could be greatly increased. In the present study, mechanical properties of the weld metal formed with F-SAW were clarified. Mechanical properties of the weld metal formed with F-SAW could be improved, compared with those with SAW. Moreover, those with F-SAW was greatly improved by selecting the hot wire and cut wire. The microstructure formed with F-SAW was so fine.

DegalaVenkataKiran, Dae-Won Cho, Woo-Hyun Song, Suck-Joo Na,[5] A three-dimensional numerical heat transfer and fluid flow model is developed to understand the temperature distribution and molten pool behavior in a three wire submerged arc welding process. The model solves the equations of the conservation of mass, momentum, and energy along with the volume of fluid method. The volume of fluid method is used to track the shape of the free surface. Further, a physical model is developed to estimate the arc center displacement. For a given welding condition, connecting the leading electrode with direct current electrode positive polarity, the middle and trailing electrodes with trapezoidal alternating current waveform displayed deeper weld pools when compared to the sine waveforms. Within the range of welding conditions considered in the present work, weld width is significantly influenced by the leading arc whereas the penetration by the middle and trailing arcs. The computed weld width and penetration are in fair agreement with the corresponding experimental results. D.V.Kiran, D.W.Cho, W.H.Song, S.J.Na [6] experiments the behavior of leading and trailing arc root dimensions and arc interaction in the two-wire tandem submerged arc welding process was studied using real-time recorded current and voltage waveforms, and CCD arc images for a wide range of experimental conditions. Physical and regression equations were developed to predict the arc interaction and dimensions as a function of the welding condition. The influence of the arc interaction on the molten droplet transfer direction was studied. The arc center displacements (arc interaction) under different welding conditions were fairly well predicted by the corresponding physical models. The arc root dimensions were unsymmetrical and increased with an increase in the welding current and voltage while the same decreased with the increase in the arc center displacements. This variation was reasonably envisaged by the developed regression models. The detached molten electrode droplet followed the arc axis at the time of detachment and deposited into the weld poolM.R.Forouzan, S.M. MirfalahNasiri, A.Mokhtari, A.Heidari, S.J.Golestaneh [7], In this paper, three-dimensional finite element (FE) simulations of double SAW and hydrostatic test processes of spirally welded pipes are carried out in two simulation steps using the ANSYS commercial software. In the first step, i.e., welding, a new method, namely, unfurl-mapping (UM) is introduced to overcome the geometrical difficulties of defining the Goldak double ellipsoidal heat source of the welding process. In the second step, the hydrostatic test is easily simulated by defining a ramped internal pressure. The method is validated using hole drilling measurements performed before and after hydrostatic test for this research. It is observed that obtained results from the FE simulations are in good agreement with the experimental measurements.U.Resigen, U.Dilthey, i. Aretov [8] studied the experiments and investigation carried on austenitic CrNi-steels and nickel-based alloys are increasingly applied in power station construction, crude oil and petrochemistry and, moreover, in industrial furnace and turbine construction. Besides the good mechanical properties of these materials also a good process ability is required. This applies particularly to welding. Due to their low heat input, TIG and MIG (pulsed) welding are the most frequently used welding methods in the case of heat-resistant nickel-base super alloys and also in the case of stainless CrNi-steels. Due to the high heat input, submerged-arc welding is, as a rule, not applied for the welding of these steels. Submerged arc welding could, however, be used as efficient alternative if process modifications are available, which ensure higher hot cracking resistance by reduced heat input. Apart from the high weld quality which is a result of submerged-arc welding, the economic efficiency which is particularly marked by the high deposition rates is also interesting. M.Ramakrishnan, K.Padmanaban, V.Muthupandi [9], Due to the faster joint completion rates coupled with good mechanical properties, narrow gap submerged arc welding (NGSAW) is widely used for fabrication of thick-walled pressure vessels. Several researchers are working on further increase in productivity in NGSAW. In this paper, we propose to increase the quality and productivity in NGSAW through cold wire addition without addition of heat input. Further toughness at sub-zero temperature is also enhanced. The improvement in toughness in cold wire NGSAW is demonstrated through different tests such as impact energy test, fracture toughness tests, plane strain fracture toughness test KIc, and crack tip opening displacement test. K.Hakansson [10], A newly developed test method for centreline cracking or solidification cracking has been evaluated by adding nickel as cold wire to the weld metal. Welding was performed by using synergic cold wire submerged arc welding with various arc wire diameters to achieve different nickel contents in the weld metal. Welding was done as partial penetration single bevel groove joints in the PB position. This investigation showed that the test method picks up the sensitivity to centreline or solidification cracking. The amount of cracking increased as the nickel content in the weld metal increased. M.Vasudevan, M.V.Kuppuswamy, A.K. Bhaduri [11], Examined on Automated Gas Tungsten Arc Welding (GTAW) with filler wire addition using a wire feeder is a candidate process for welding of 316LN austenitic stainless steel, which is the major structural material for the Indian 500 MWe Fast Breeder Reactors. In GTAW, the quality of the weld is characterized by the weld-bead geometry as it influences the mechanical properties and its performance during service. This paper discusses the development of computational model using genetic algorithm for determining the optimum/near-optimum GTAW process parameters for obtaining the target weld-bead profile during automatic welding of 316LN stainless steel. Using the experimental data generated on the influence of process variables on weld-bead geometry, regression models correlating the weld-bead shape parameters with the process parameters were developed for determining the objective function in genetic algorithm. Close agreement was achieved between the target weld-bead profile and the model-computed weld-bead profile. This study has shown that use of genetic algorithm is an appropriate methodology for optimising process parameters to obtain target weld-bead profile in GTAW with wire feeder of 316LN stainless.

Aditya Kuamr, Sachin Maheshwari, Sathish Kumar Sharma,[12], Along with machining parameters, in SAW, flux composition plays a deciding role for good quality weld. In the present study both factors were taken into consideration. SiO2-Al2O3-CaO flux system was used. In a SiO2 based flux NiO, MnO and MgO were added in different proportions. Experiments were designed according to Taguchi L9 orthogonal array, while varying voltage at two levels in addition to alloying elements. Voltage was considered as a noise factor. Using ANOVA, effect of each flux alloying elements was revealed for Vickers hardness and impact strength of the weld. Optimal levels of NiO, MnO and MgO were selected using S/N analysis. Voltage as a noise factor affected the impact strength most. Then the results of optimal conditions were verified by confirmatory experiments.

3 Issues and Challenges Involved in the Present work

The various issues faced while welding IS 2062 using submerged arc welding are 1) multi passes are required for welding high thickness plates, 2) large area of Heat affected zone formation due to multi pass welding and 3) chance of over melting of base material by electrode. Heat Affected Zone will be more on welded areas due to overheating of base metal by electrode wire.

4 Scope and Objectives of the Present Work

To increase the metal deposition rate without affecting Heat Affected Zone in Welding to reduce the heat input in welding process and to get a good weld bead appearance and to obtain higher penetration. To get a better fusion between weld bead and parent metal.

To get a good weld bead appearance, geometry and to increase a weld deposition rate an electrically insulated cold wire is introduced into the weld puddle where the electrode and cold wire melts and form higher deposition rates in the weld area. In this process there will be good bead appearance and the variation of heat influence will be less by the introduction of cold wire.

5 Methodology of present work

The experimentation study has been carried using submerged arc welding machine with different kinds of current conditions with different % of cold wire usage and at various weld speed conditions.

5.1 Base Metal

Welding experiments are carried out with IS2062 Carbon steel. This type of steel is used in fabrication of boiler components. The chemical and mechanical properties are given below in the table 1 & table 2 :

Table 1. Chemical composition of IS 2062

GRADE	C %	Mn %	S %	P %	Si	C.E. %
A	0.23	1.5	0.05	0.05	-	0.42
B	0.22	1.5	0.045	0.045	0.04	0.41
C	.2	1.5	0.04	0.04	0.4	0.39

Table 2. Mechanical properties of IS 2062

Grade	**UTS(MPa) Min.**	**Y.S (MPa) Min.**			**EI.% Min. 5.65 Sqrt(So)**	**Bend Test**
A	410	250	240	230	23	3T
B	410	250	240	230	23	2T & 3T*
C	410	250	240	230	23	2T
***2T-< = 25mm*3T-> 25mm**						

The selected material is used for welding by Submerged Arc Welding process. The Raw Material IS 2062 is polished on top surface where welding is to be carried out.

Fig 1. IS 2062 Carbon Steel.

5.1 Consumables Used

A fused flux of manganese silicate type having a basicity index of 1.2 was used for carrying out wide groove welding by tandem submerged arc welding technique. For welding, an aluminate basic-type agglomerated flux having a basicity index of 1.6 was used. EL – 08(Copper Coated Continuous solid wire for Submerged Arc Welding) is used for welding.

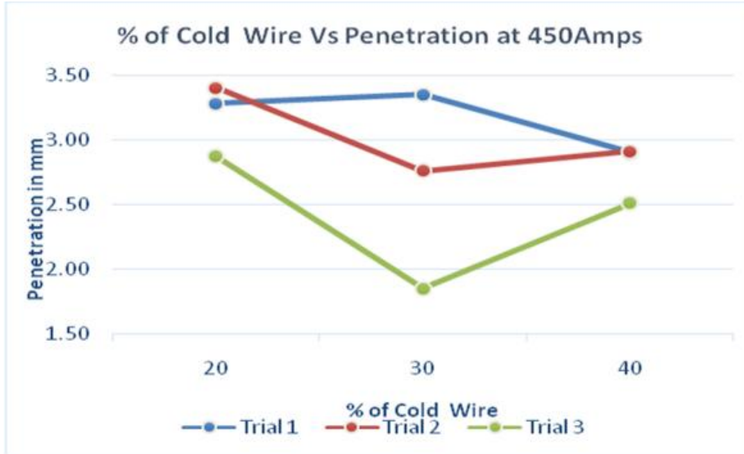
6 Present Work

The welding was carried out with EL-08 Copper coated electrode with ESAW submerged arc welding machine with different current and % of cold wire conditions with different heat input.

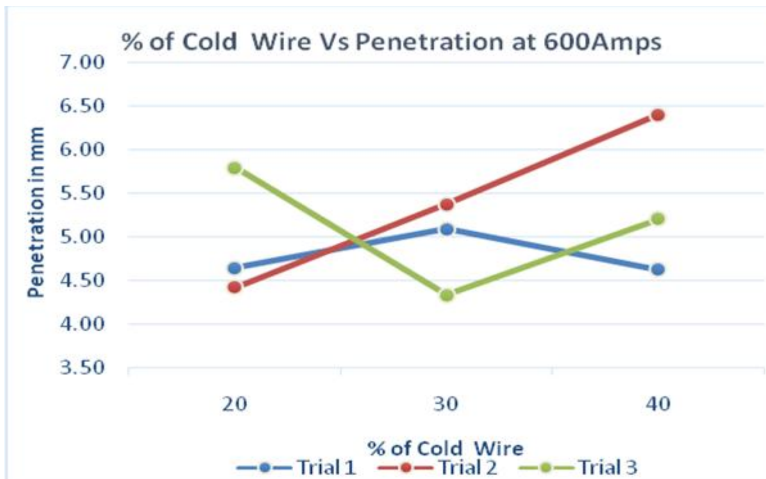
7-Data Analysis

7.1 % of Cold Wire Vs Penetration

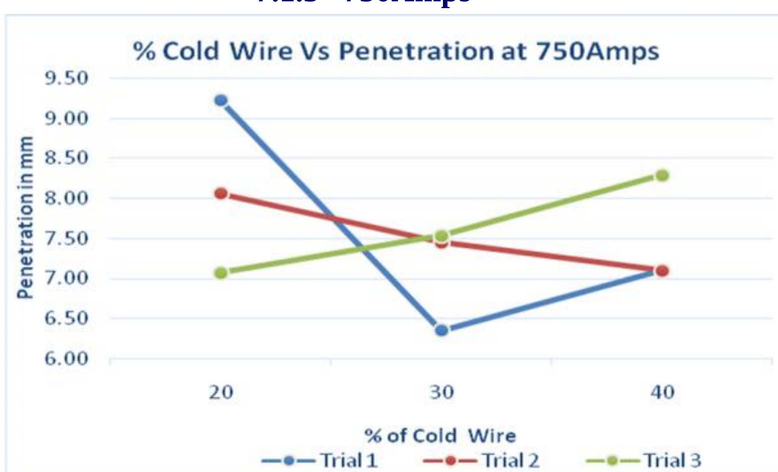
7.1.1 450Amps



7.1.2 600Amps



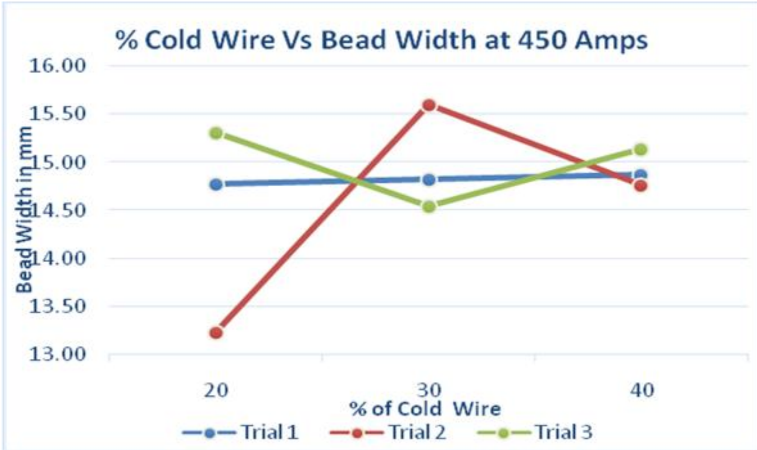
7.1.3 750Amps



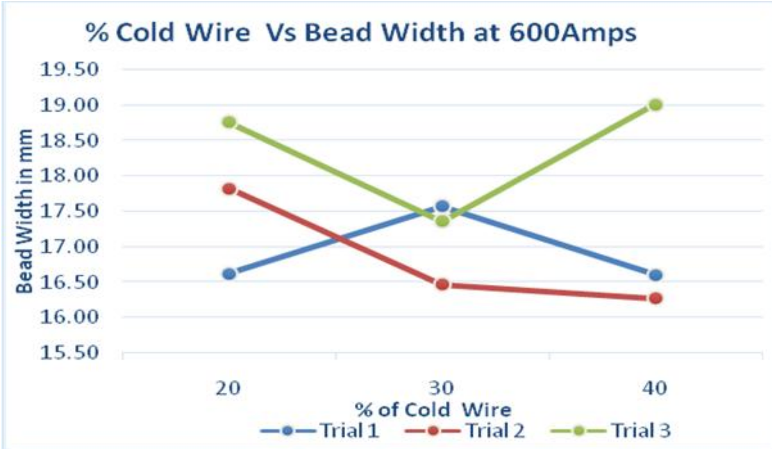
From the above three graphs Penetration increases to 03.40mm at 450Amps the maximum penetration at this current range with 20% cold wire addition, Variation in penetration occurs at 600Amps range and reaches maximum to 06.40mm at 40% cold wire addition, for 750Amps current range penetration reaches to maximum of 09.22mm at 20% cold wire addition. From the graphs it is inferred that bead width increases to maximum at 20% cold wire addition and at 750Amps

7.2% of Cold Wire Vs Bead Width

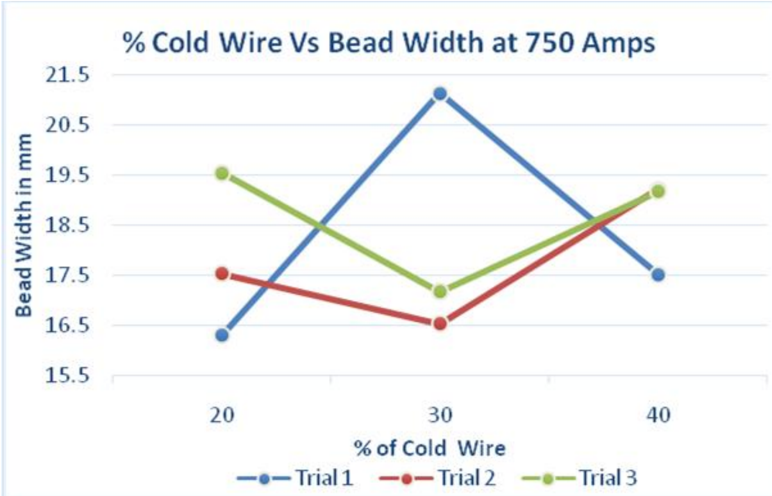
7.2.1 450Amps



7.2.2 600Amps



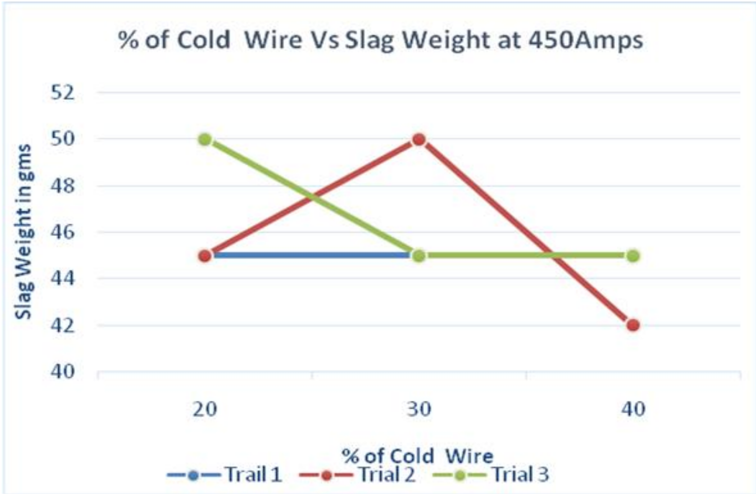
7.2.3 750Amps



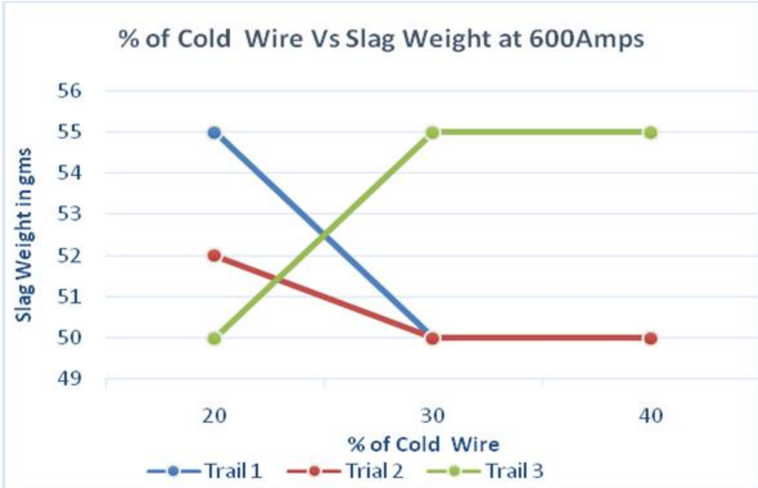
From the above three graphs weld bead increases to 15.60mm at 450Amps the maximum weld bead conditions at this current range with 30% cold wire addition, the graph increases and decreases at 600Amps range and reaches maximum to 19.01mm at 40% cold wire addition, for 750Amps current range the bead width reaches to maximum of 21.14mm at 30% cold wire addition. From the graphs it is inferred that bead width increases to maximum at 30% cold wire addition

7.3% of Cold Wire Vs Slag Weight

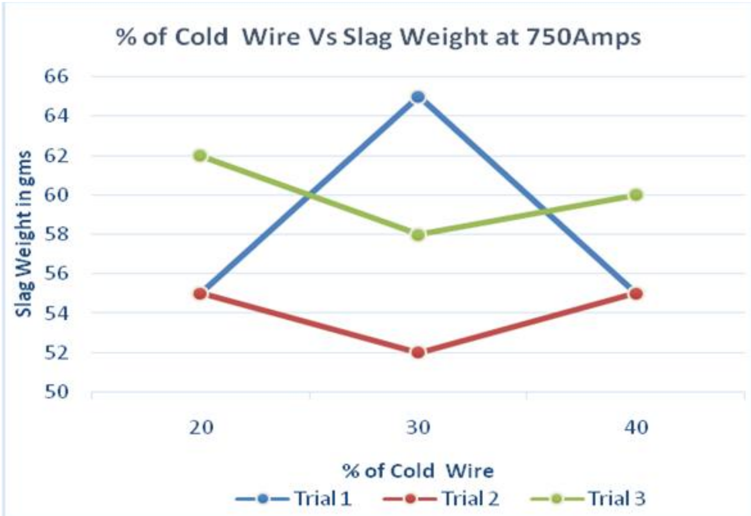
7.3.1 450Amps



7.3.2 600Amps



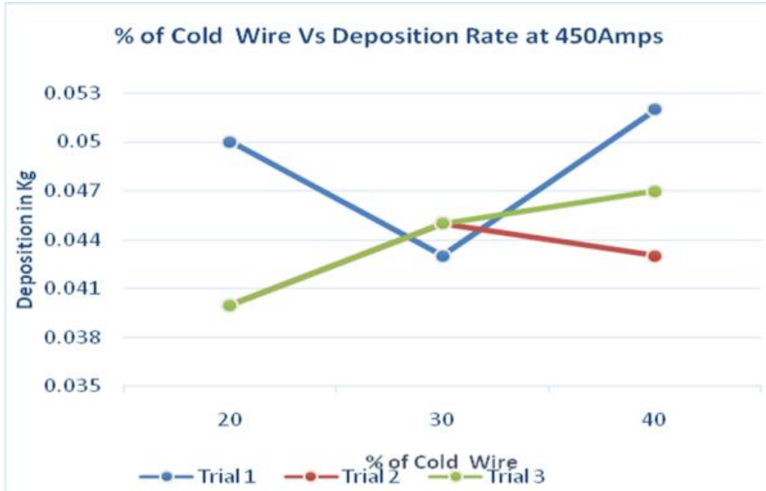
7.3.3 750Amps



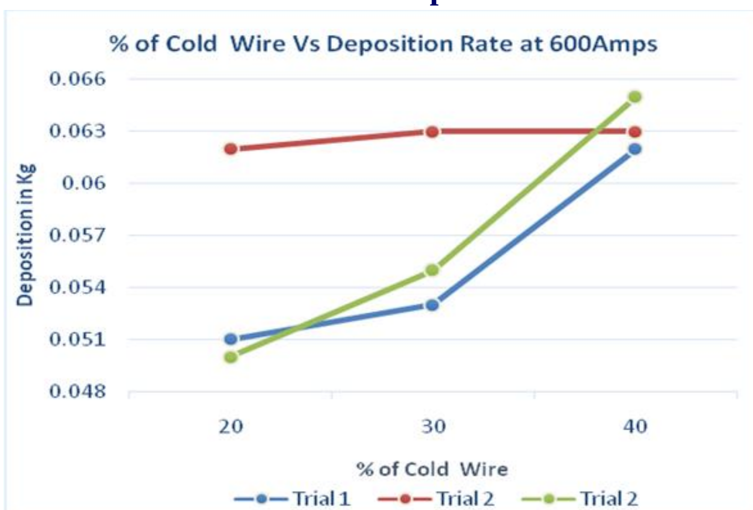
From the above graphs Slag weight are varying to maximum of 50gms at 450Amps, of 55gms occurs at 600Amps range and for 750Amps current range slag weight reaches a maximum of 65gms. Slag weight varies and steady at different current range based on graph slag weight decreases at 450 amps only.

7.4% of Cold Wire Vs Deposition Rate

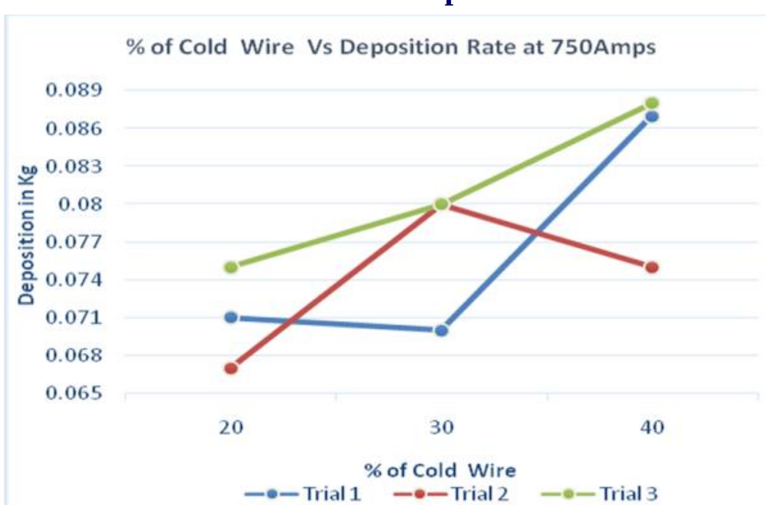
7.4.1 450Amps



7.4.2 600Amps



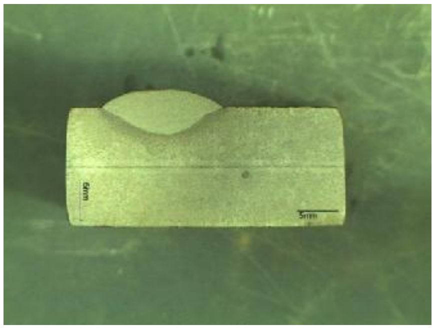
7.4.3 750Amps



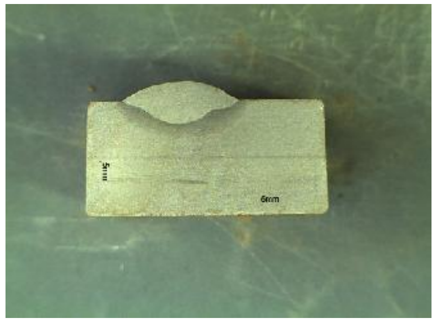
From the above graphs Deposition rates are varying from 0.04 to 0.052Kg for 450Amps, from 0.05 to 0.065Kg for 600Amps and from 0.067 to 0.088kg for 750Amps. It is inferred that for increase in current range there is increase in deposition rate. Cold wire addition also influences in deposition rate with varying current range.

8. Microstructural Images

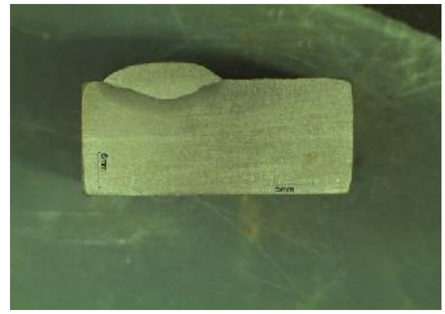
8.1 At 450Amps



20% Cold Wire Addition

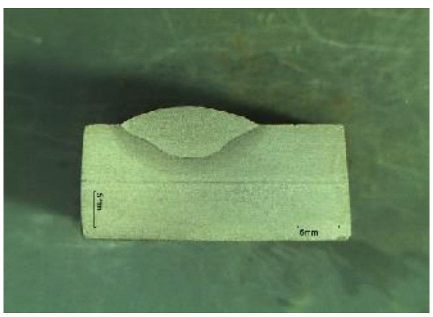


30% Cold Wire Addition



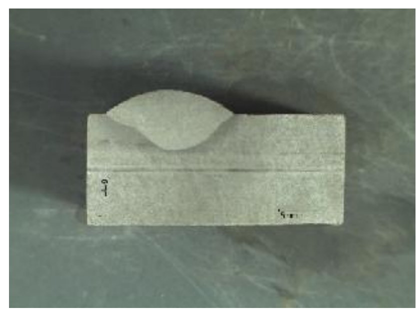
40% Cold Wire Addition

8.2 At 600Amps



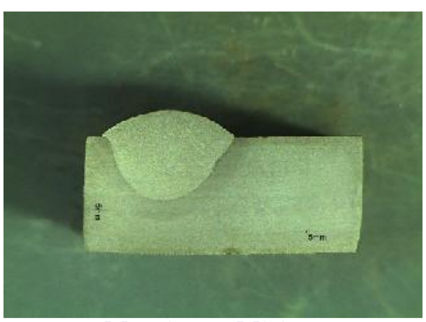
20% Cold Wire Addition

30% Cold Wire Addition

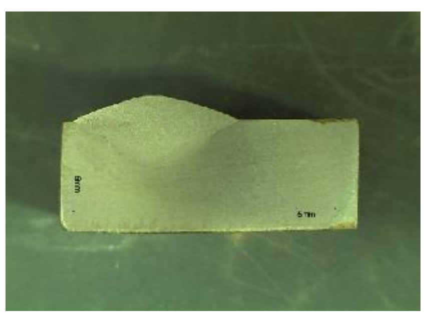


40% Cold Wire Addition

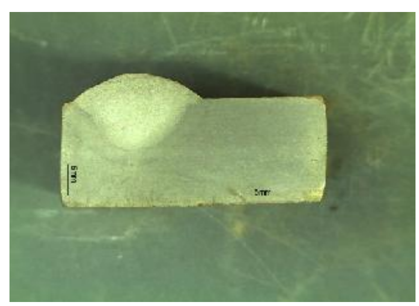
8.3 At 750Amps



20% Cold Wire Addition



30% Cold Wire Addition



40% Cold Wire Addition

9 Results and Discussion

In this varying welding conditions, the following points are arrived

1. Bead Width increases with varying current range and bead width reaches maximum at 750Amps and optimum at 650Amps.

2. Penetration increases with increase in current range and grain growth also good.

3. Heat Affected Zone reduced and grain growth are normal.

4. From the microstructural examination, the bead geometry is found to be more consistent.

5. The heat flow inside the weld bead is uniform and there is no distortion in the weld bead geometry.

6. The Arc efficiency also increased which leads to decrease in consumption of flux and formation of slag.

10 Conclusion

From the above graphs and microstructural images the heat affected zone reduces nearer to weld bead. Weld bead geometry is more consistent and penetration is high with respect to varying current conditions and % of cold wire addition. Grain growth is uniform in all direction with decreasing HAZ around weld bead.. Deposition rates and bead width also get increased with higher current and bead width also increases with high current input. In this way the deposition rate and productivity are increased, the consumption of shielding flux is reduced, and the arc efficiency is improved. For industrial application of the process, it will be necessary to design a suitable welding head and to study the most suitable welding parameters.

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How to cite this article:
R.D.Kesavan, B.Kumaragurubaran, T.Senthil Kumar, K.Ganesh Kumar. (2016). Influence of heat input variation using cold wire on performance of inverted type submerged arc welding process – Is 2062 carbon steel. Int. J. Adv. Multidiscip. Res. 3(6): 39-50.