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Application of Artificial Neural Network for Prediction of Hardness of Shielded Metal Arc Welded Joints under the Influence of External Magnetic Field

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Abstract:- The present study presents the influence of welding current, welding voltage, welding speed and external magnetic field on hardness of shielded metal arc welded mild steel joints. Mild steel plates of 6 mm thickness were used as the base material for preparing single pass butt welded joints. Speed of welding was provided by cross slide of a lathe machine, external magnetic field was obtained by bar magnets. Hardness properties of the joints fabricated by E-6013 electrodes as filler metals were evaluated and the results were reported. From this investigation, it was found that the hardness of weld decreased if either voltage or current increased, and it increased if either of speed of welding or external magnet field increased. An artificial neural network technique was used to predict the hardness property of the weld for the given welding parameters after training the network. The study reveals that the artificial neural network technique is an efficient tool to predict the hardness correctly if welding parameters are known.

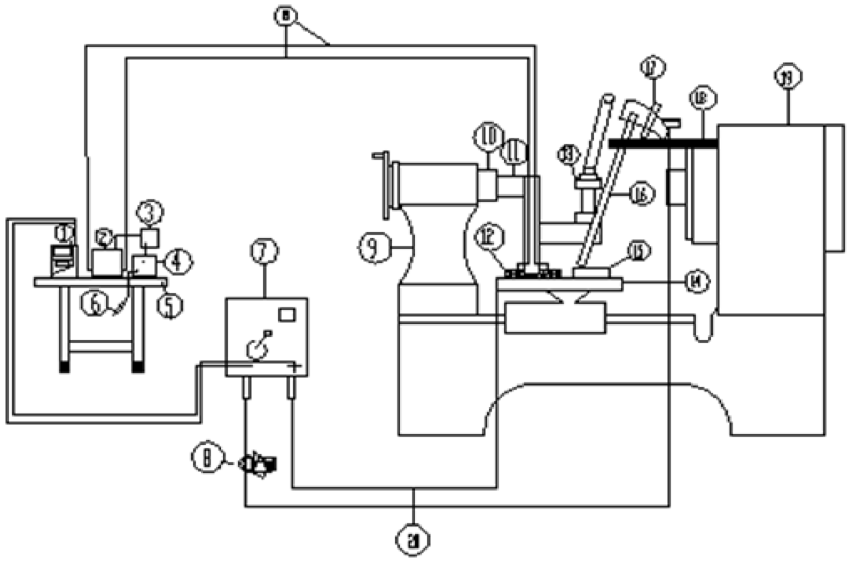
Key Words:- Shielded metal arc welding, Back propagation, Hardness, Artificial neural network.

I. INTRODUCTION

The need for increased productivity of the manufacturing industry provides an ongoing incentive to find sources to improve the manufacturing processes used. the ability to increase the efficiency of the welding process while maintaining weld integrity has been a source of research for many years. Welding is a process of joining two or more pieces of the similar or dissimilar materials to achieve complete coalescence. This is the only method of developing monolithic structures and is often accomplished by the use of heat and pressure. it is fast replacing other joining processes like riveting and bolting because it provides continuous strong joints, alleviates crevice and galvanic corrosion problems often associated with fasteners, and also offers enhanced aesthetics to the application. at times it may be used an alternative to casting. Shielded metal arc welding (smaw) is a welding process in which the joint is produced by heating the work piece with an electric arc set up between a flux coated electrode and the work piece. the advantages of this method are that it is the simplest of the all arc welding processes. The equipment is often small in size and can be easily shifted from one place to the other. Cost of the equipment is also low [1]. This process finds numerous applications because of the availability of a wide variety of electrodes which makes it possible to weld a number of metals and their alloys. the welding of the joints may be carried out in any position with highest weld quality by smaw process. Both alternating and direct current power sources could be used effectively. power sources for this type of welding could be plugged into domestic single phase electric supply, which makes it popular with fabrications of smaller sizes. However, non equilibrium heating and cooling of the weld pool can produce micro structural changes which may greatly affect mechanical properties of weld metal. mild steel is perhaps the most popular steel used in the fabrication industry for constructing several daily used items due to its good strength, hardness and moderate to low temperature notch toughness characteristics. good weld design and selection of appropriate and optimum combinations of welding parameters are imperative for producing high quality weld joints with the desired strength, hardness and toughness. Improper welding practice which resulted in inadequate toughness, hardness and strength of the welded joints has been linked to several catastrophic service failures [2]. Understanding the correlation between the process parameters and mechanical properties is a precondition for obtaining high productivity and reliability of the welded joints. Although mild steel is widely used in the industry for many applications requiring good strength, hardness and toughness, there is not much information in the open literature about variations in its hardness properties with changing heat input or other performance-altering welding parameters [3]. the purpose of this work was to determine the effect of travel speed, welding voltage, current and external magnetic field on the hardness of mild steel welded joints prepared using the smaw process. hardness measurement can provide information about the metallurgical changes caused by welding. hardness measurements can provide information about the metallurgical changes caused by welding. in construction of steels, rapid cooling from high haz temperature may cause the formation of martensite of much higher hardness than the base metal. hardness values in a welded joint are usually sensitive to such conditions of welding, as the process used, heat input, preheat or inter-pass temp, electrode compositions, and plate thickness [4]. this study will improve the current understanding of the effect of heat input, speed of welding and external magnetic field on the hardness of this versatile structural steel. back propagation artificial neural network having one input layer, one output layer and two hidden layers, was used to predict the impact strength of weld. at first this network was trained with the help of 18 sets of data having four input welding parameters (current, voltage, speed of weld and external magnetic field) and one output mechanical property (rockwell hardness) of the weld, which were obtained with the help of corresponding welding and different tests. after this the trained artificial neural network could be used to predict the hardness of weld for given sets of input welding parameters [5]. In this way the desired hardness of the weld could be obtained by applying needed input welding parameters.

II. EXPERIMENTATION

The mild steel plates of 6 mm thickness were cut into the required dimension (150 mm×50 mm) by oxy-fuel cutting and grinding. The initial joint configuration was obtained by securing the plates in position using tack welding. Single 'V' butt joint configuration was used to fabricate the joints using shielded metal arc welding process. The speed of welding was obtained with the help of the cross slide of a lathe machine [6]. All the necessary cares were taken to avoid the joint distortion and the joints were made with applying clamping fixtures. The specimens for testing were sectioned to the required size from the joint comprising weld metal, heat affected zone (HAZ) and base metal regions. The welded joints were sliced using power hacksaw and then machined to the required dimensions (10mm x 6mm) for hardness test. Hardness testing of welds is performed on ground, polished, or polished and etched cross-section of the joint area. Indentations are made in the specific areas of interests, including the weld center line, face or root regions of the deposit, the HAZ, and the base metal. The hardness test was conducted on Rockwell (B scale) hardness testing machine. The welding set-up is shown in figure 1 [7].



1. Multi-meter 2. Battery Eliminator 3. Electric Board 4. Gauss Meter 5. Table
6. Measuring Prob 7. Transformer Welding Set 8. Clamp meter 9. Tail Stock 10. Sleeve
11. Link (Wood) 12. Solenoid 13. Tool post 14. Iron sheet 15. Workpiece
16. Electrode 17. Electrode Holder 18. Metal Strip Connected with head stock
19. Head stock 20. Connecting Wires

Fig.1: Welding Set-up (Line Diagram)

Table 1: Data for Training and Prediction

	Serial Number	Current (A)	Voltage (V)	Welding Speed (mm/min)	Magnetic Field (Gauss)	Rockwell Hardness (B)
Data for Training	1	90	24	40	0	90
	2	90	24	40	20	90
	3	90	24	40	40	90
	4	90	24	40	60	92
	5	90	24	40	80	94
	6	95	20	60	60	91
	7	95	21	60	60	88
	8	95	22	60	60	86
	9	95	23	60	60	84
	10	95	24	60	60	82
	11	100	22	40	40	88
	12	100	22	60	40	90
	13	100	22	80	40	93
	14	90	20	80	20	89
	15	95	20	80	20	86
	16	100	20	80	20	84
	17	105	20	80	20	83
	18	110	20	80	20	80
Data for Prediction	1	90	23	40	0	91
	2	95	22	60	40	86
	3	95	21	80	60	89
	4	100	24	40	40	89
	5	105	21	60	40	81
	6	105	22	60	20	78
	7	110	21	60	20	79

Table II: Measured and Predicted Values with percentage Error

S.N.	Current (A)	Voltage (V)	Welding Speed (mm/min)	Magnetic Field (Gauss)	Rockwell Hardness (HRB) Measured	Rockwell Hardness (HRB) Predicted	Error in Rockwell Hardness % age
1	90	23	40	0	91	85.6	-5.53
2	95	22	60	40	86	85.1	-1.05
3	95	21	80	60	89	85.4	-4.04
4	100	24	40	40	89	85.2	-4.27
5	105	21	60	40	81	84.8	4.44
6	105	22	60	20	78	84.6	8.46
7	110	21	60	20	79	83.9	6.20

III. RESULTS

The hardness across the weld cross-section was measured using a Rockwell hardness testing machine, and the readings were displayed in table 1[8]. The hardness of weld metal (WM) region was found greater than the HAZ region, but lower than the base metal (BM) region, irrespective of filler metals used. There was no effect of magnetic field on hardness if the strength of the field was less than 40 gauss and if it was increased from 40 gauss to 80 gauss the hardness increased from 90 RHB to 94 RHB. If the speed of welding was increased from 40 mm /min to 80 mm/ min the hardness increased from 88RHB to 93 RHB. If the voltage was increased from 20 V to 24 V the hardness decreased from 91 RHB to 82 RHB. If the current was increased from 90 V to 110 V, the hardness decreased from 89 RHB to 80 RHB. The variation of hardness properties with magnetic field, voltage, welding speed and current were shown in figures 2, 3, 4 and 5 respectively.

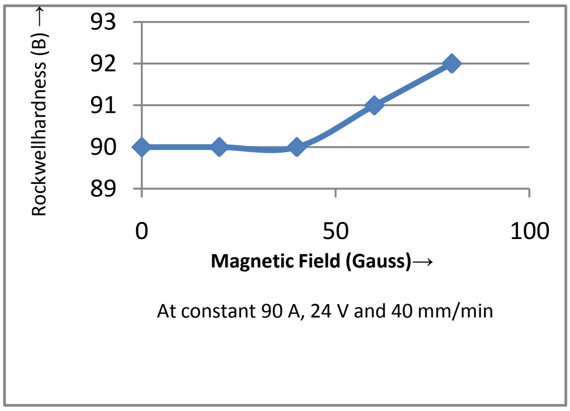


Fig. 2: Magnetic Field vs. Hardness

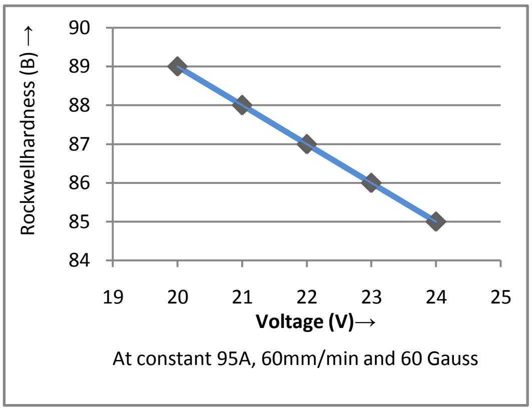


Fig. 3: Voltage vs Hardness

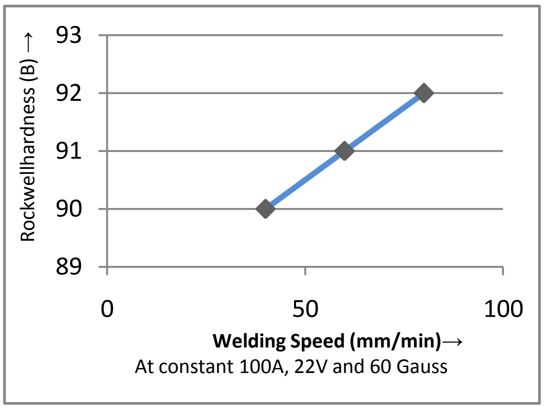


Fig. 4: Welding Speed vs Hardness

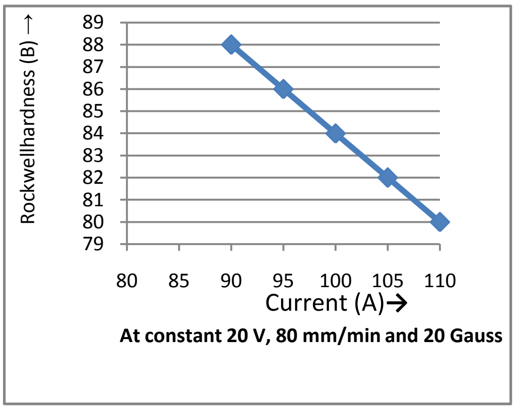


Fig. 5: Current vs Hardness

IV. PREDICTION MADE BY ARTIFICIAL NEURAL NETWORK

From the table 2, it is clear that the prediction made by artificial neural network is almost the real value. The maximum positive and negative percentage errors in prediction of Rockwell hardness are 8.46 and 5.53 respectively. The other predictions are in between the above ranges and hence are very close to the practical values, which indicate the super predicting capacity of the artificial neural network model.

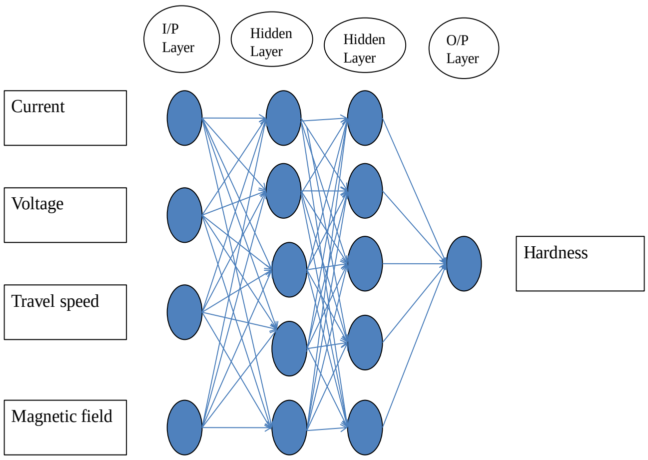


Fig. 6: 4-5-5-1 Artificial Neural Network

V. DISCUSSION

In this investigation, an attempt was made to find out the best set of values of current, voltage, speed of welding and external magnetic field to produce the best quality of weld in respect of hardness. Shielded metal arc welding is a universally used process for joining several metals. Generally in this process speed of welding and feed rate of electrode both are controlled manually but in the present work the speed of welding was controlled with the help of cross slide of a lathe machine hence only feed rate of electrode was controlled manually which ensures better weld quality. In the present work external magnetic field was utilized to distribute the electrode metal and heat produced to larger area of weld which improves several mechanical properties of the weld. The welding process is a very complicated process in which no mathematical accurate relationship among different parameters can be developed. In present work back propagation artificial neural network was used efficiently in which random weights were assigned to co-relate different parameters which were rectified during several iterations of training. Finally the improved weights were used for prediction which provided the results very near to the experimental values.

VI. CONCLUSIONS

Based on the experimental work and the neural network modeling the following conclusions are drawn:
(1) A strong joint of mild steel is found to be produced in this work by using the SMAW technique.
(2) If amperage is increased, hardness of weld generally decreases.
(3) If voltage of the arc is increased, hardness of weld generally decreases.
(4) If travel speed is increased, hardness of weld generally increases.
(5) If magnetic field is increased, hardness of weld generally increases.
(6) Artificial neural networks based approaches can be used successfully for predicting the hardness of weld as shown in table 2. However the error is rather high as in some cases in predicting hardness, it is more than 8 percent. Increasing the number of hidden layers and iterations can minimize this error.

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