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EFFECTS OF INPUT PARAMETERS ON WELD BEAD GEOMETRY OF SAW PROCESS

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ABSTRACT
Because of its high quality and reliability, Submerged Arc Welding (SAW) is one of the chief metals joining process employed in industry. In this paper, an attempt has been taken to develop a model to predict the yield characteristics (weld bead parameters) of Submerged Arc Welding (SAW) process with the help of neural network technique and analysis of various process control variables and important weld bead parameters in SAW. The SAW process has been chosen for this application because of the complex set of variables and high set up cost involved in the process as well as its significant application in the manufacturing of critical equipments which have a lot of economic and social implications. Also an attempt has been taken for prediction of out put variable of SAW process in this paper. For this purpose Neural Network model has been applied. Under this study the neural network model has been trained according to the actual inputs and outputs. After completing training, the desired inputs have been given to the model and it gives the estimated output value. And according to this we can also estimate the error between the actual and predicted results. Neural network is implemented here because of having remarkable ability to derive meaning from complicated or imprecise data and can be used to extract patterns and detect trends that are too complex to be noticed by either humans or other computer techniques. Hence a trained neural network can be thought of as an "expert" in the category of information it has been given to analyses.

Keywords: SAW, Neural Network, Reinforcement Height, Width, Metal Deposition Rate.

1. INTRODUCTION
Submerged arc welding (SAW), high quality, very high deposition rate welding process commonly used for joining plate. Here an arc is formed between a continuously-fed wire electrode and the work piece, and the weld is formed by the arc melting the work piece and the wire. To shield the arc from atmospheric contamination, the arc is completely submerged under a blanket of granular, fusible flux.

During welding the intense heat of the arc simultaneously melts the tip of the bare wire electrode and a part of the flux. The electrode tip and the welding zone are always surrounded and protected by molten flux, while all of them are covered by the top layer of unfused flux. As the arc progresses along the joint, the molten metal settles down while the lighter molten flux rises from the puddle in the form of slag. The weld metal, having a higher melting point solidifies first while the slag above it takes some more time to freeze.

The solidified slag continues to protect the weld metal while it is still hot, and is capable of reacting with the atmospheric oxygen and nitrogen. After the weld has solidified; the unfused flux is removed manually or by a vacuum pick up system, to be screened and reused.

The process can be fully automatic or semi-automatic. The submerged-arc welding (SAW) process is popular because of its ability to match the chemistry and physical properties of the base material. This ability allows a multitude of possible weld-wire and flux combinations. These combinations can be easily sorted and matched to specific applications.

SAW process is one of the major fabrication processes in industry because of its inherent advantages, including deep penetration and a smooth bead. In this parameters yield characteristics of SAW process have been predicted through Neural Network, which help to reduce the cost and time as well as to obtain the required information about the main and interaction effects on the yield characteristics.

This model is useful for selecting correct process parameters to predict desired weld bead parameters so this model facilitate optimization of the process and sensitivity analysis, also help to improve the understanding of the effect of process parameters on bead quality and to evaluate the interaction effect of bead parameters and to optimization the bead quality to obtain a high quality welded joint at a relatively low cost with productivity.

2. NEURAL NETWORK

A neural network is a powerful data modeling tool that is able to capture and represent complex input/output relationships. The motivation for the development of neural network technology stemmed from the desire to develop an artificial system that could perform "intelligent" tasks similar to those performed by the human brain. The true power and advantage of neural networks lies in their ability to represent both linear and non-linear relationships and in their ability to learn these relationships directly from the data being modeled. Traditional linear models are simply inadequate when it comes to modeling data that contains non-linear characteristics.

The most common neural network model is the multilayer perception (MLP). This type of neural network is known as a supervised network because it requires a desired output in order to learn. The goal of this type of network is to create a model that correctly maps the input to the output using historical data so that the model can then be used to produce the output when the desired output is unknown.

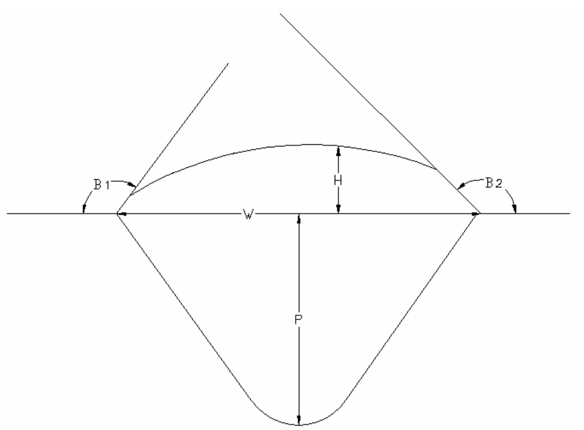

Fig 2: Weld bead geometry

where H Reinforcement height (mm), W-Width (mm), Penetration (mm).

3. EXPERIMENTAL PROCEDURE

Chosen input variables are – current, voltage &travel speed. The output variable was decided based on the guidelines in the reference material. The bead parameters were considered for measuring the response output. Three output parameters considered are (shown in figure 1).

3.1 Sample Preparation for the Experiment

Now the first thing for conducting the experiment was to prepare the sample for experiment. For this purpose a long mild steel piece was selected and was brought to the welding shop for cutting it to the required dimensions and shape. The mild steel piece was having thickness more than 10mm. Now here with the help of oxy-acetylene flame it was cut in the desired length. After cutting it into pieces it was left for cooling. After few hours of cooling the pieces were welded in pairs so that they remain together during the experiment. This was done with the help of welding. These samples were having a V-groove over which submerged arc welding was to be done.

Now the initial weight of each sample was taken and noted. Also the Submerged Welding Machine was started. Flux was filled in the machine so that there may be no problem in between the experiment. The machine was fully automatic. Now the welding was done on each sample. The welding parameters travel speed, current, voltage were varied each time. Total time taken during the welding was noted and weight after each welding was also taken.

3.2 Conducting the Experiment

This experimental study was conducted at ISM workshop (Dhanbad, India). For this study MEMCO semiautomatic welding equipment with constant voltage rectifier was used.

The welding parameters were noted during actual welding to determine the fluctuations if any. The slag was removed and the job as allowed to cool down. The values of the reinforcement height, and width were taken using venire caliper of least count 0.02mm. And metal deposition rate was also calculated with the help of stop watch and weighing machine.

Finally the readings obtained are tabulatedinTable- 1. Comparisons among the estimated value of weld bead parameters and experimental values are shown in table 2&3.

3.3 RESULT AND DISCUSSION

From Table -4, **SL.NO.1-**Increase of voltage has negative effect on weld bead parameters in the range shown in table7, sl.no.1

SL.NO.-2- If travel speed is increased (+1 unit) in the range 16-17cm/min, voltage remains unchanged and current is increased (+20unit) in the range 280-300 A, then reinforcement height will be increased (+1.3), bead width will be decreased (-2.5unit) and metal deposition rate also will be decreased. From this result we can understand that if influence of change of current on weld bead parameters dominates w.r.t change of travel speed & voltage in given range as we know that if travel speed increases then reinforcement height will be decreased, if current increases then reinforcement height will be increased, here reinforcement height is increased. This result proves that current is a dominating character in the given range.

Sl.No.3-In this given range change of metal deposition rate very little and current has negative effect on bead width.

Sl.No.4-From this result we can easily understand that input parameters have negative effect on weld bead width.

Sl.No.5-It has found that if travel speed is increased (+4 unit) in the range 20-24 cm/min, Voltage increased (+8 unit) in the range in the range 20-28 volt and current decreased (-120unit) in the range 400-280 A then reinforcement height will be decreased (-2.4 unit), bead width will be increased (+1.3unit) and metal deposition rate also will be decreased. From this result we can understand that if current decreases with faster rate then rate of decrease of MDR will be increased .So current interacts with V & TS for out put result.

Sl.No 6 -It has been found that if TS, C are increased by 1 unit and 20 unit respectively and V decreased by 3 unit (ranges are given in table) then RH and MDR will be and increased and but BW will be unchanged. That means in this range little change of TS & C effect on MDR & RH but BW will not so affected by little change of C,V,TS.

From Sl.No. 7-If TS increases slightly decrease and C is constant then RH, BW will be increased but MDR will be decreased. From this we can say that if TS will increase then RH, BW will be decreased. That means, in this given range, with out changing current if we increase TS 2 units and decreasing 1 unit voltage we get increment of RH & BW but MDR decreases .That means with the increase of TS, MDR will be decreased. From Sl.No.2 we can get increase with TS, MDR increase but in this case MDR decrease from this results it is clear that C & V interacts with TS for out put results.

Sl.No.8 – From the above result we understand that in maximum cases, with the increase of TS, MDR will be decreased but beyond the value of TS 27cm/min MDR will be increased .In the range (SL.No6,7) if we increase the current or keep constant we get increasing value of RH,BW.But in this case we get opposite result.

When value of TS 27cm/min or more than 27 cm/min then we get opposite result w.r.t when TS value less than 27 cm/min. Hence we conclude that beyond the value of TS 27cm/min has opposite effect on weld bead geometry.

Prediction of weld bead parameters-Model was developed using neural network. This model was first trained with the help of actual experimental data. And when the training is completed then it is used to predict the values of the output on the same input data to estimate the percentage of error between the experimental result and the result predicted with the help of neural network model.

4. CONCLUSION

From table 1 we can say that travel speed has a negative effect on all the three bead parameters. An increase in travel speed substantially reduces the heat input resulting in lower burn off rate. This reduced burn off rate decreases the metal deposition at the weld joint thereby lowering all the bead parameters. It has been seen that the penetration increases with increase in the current, the reinforcement height also increases marginally with an increase in the current but the width decreases i.e. it has a negative effect. It is generally observed that as the arc voltage increases, the weld bead becomes wider and flatter and the penetration decreases .Also understood that there are interactions present among the input parameters for output parameters.

Finally, a soft computing model was developed in C with the help of neural network. In which we first feed our actual experimental values which includes both inputs and outputs. And on the bases of these values the model is train. And when the training is completed then the desired value of inputs parameters is given to the model and it gives the predicted value of the outputs according the trend. On the bases of these actual and predicted values we can estimate the optimum value of the welding parameters. Also we can estimate the % of error (shown in table-3).

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6. NOMENCLATURE

Symbol	Meaning	Unit
MDR	METAL DEPOSITION RATE	(gm/sec)
RH	REINFORCEMENT HEIGHT	(mm)
C	CURRENT	(A)
V	VOLTAGE	(volt)
TS	TRAVEL SPEED	(mm/sec)

Table 1: Experimental value of weld bead parameters

Sl. No.	Travel speed (cm/min)	Voltage (in volts)	Current (in ampere)	Reinforcement Height (mm)	Bead Width (mm)	Metal Deposition Rate (gm/sec)
1	25	25	300	3.2	13.0	0.810
2	28	26	320	2.0	12.5	0.909
3	24	28	280	2.6	13.0	0.759
4	27	24	300	3.5	13.6	0.550
5	20	20	400	5.0	11.7	1.500
6	16	20	280	1.7	10.0	1.250
7	17	19	380	2.0	12.0	0.909
8	21	38	450	2.6	21.9	0.792
9	21	30	320	2.0	15.5	0.681
10	17	24	300	2.3	13.8	0.869
11	16	24	280	1.0	16.3	1.000
12	12	23	300	0.6	23.0	0.877
13	17	22	320	2.3	18.7	0.869
14	20	25	340	2.4	13.8	1.224

Table 2: Predicted data by the nn model

Travel Speed (cm/min)	Voltage (volts)	Current (amp)	metal deposition rate (gm/sec)	Bead Width (mm)	Reinforcement height (mm)
25	25	300	0.917307	11.93201	3.086965
28	26	320	1.096024	11.40573	3.301979
24	28	280	0.847951	12.27045	2.926106
27	24	300	0.798028	12.38977	2.960678
20	20	400	1.433275	10.78969	3.732686
16	20	280	1.268276	12.44933	1.607609
17	19	380	0.923675	13.8952	2.863566
21	38	450	0.659527	19.34244	2.285657
21	30	320	0.641438	16.61227	2.334672
17	24	300	0.763443	15.45693	1.868067
16	24	280	0.962939	16.21997	1.103829
12	23	300	0.841575	22.1554	0.627393
17	22	320	0.878619	13.70641	2.473048
20	25	340	1.07047	12.31951	3.090822

Table 3: Estimated error in percentage

	Experimental Input			Experimental Output			Estimated Output from NN Model			ESTIMATION ERROR IN %		
Sl. No.	Travel Speed cm/s	Voltage Volt	Current ampere	Reiforcement Height mm	Bead Width mm	Metal Deposition Rate gm/s	Reiforcement Height mm	Bead Width mm	Metal Deposition Rate gm/s	Reiforcement Height mm	Bead Width mm	Metal Deposition Rate gm/s
1	25	25	300	3.2	13	0.81	3.086965	11.93201	0.917307	3.5323	8.2153	-13.2478
2	28	26	320	2	12.5	0.909	3.301979	11.40573	1.096024	-65.0989	8.7542	-20.5747
3	24	28	280	2.6	13	0.759	2.926106	12.27045	0.847951	-12.5425	5.6119	-11.7195
4	27	24	300	3.5	13.6	0.55	2.960678	12.38977	0.798028	15.4092	8.8987	-45.0960
5	20	20	400	5	11.7	1.5	3.732686	10.78969	1.433275	25.3463	7.7188	4.4483
6	16	20	280	1.7	10	1.25	1.607609	12.44933	1.268276	5.4348	-24.4933	-1.4621
7	17	19	380	2	12	0.909	2.863566	13.8952	0.923675	-43.1783	-15.7933	-1.6144
8	21	38	450	2.6	21.9	0.792	2.285657	19.34244	0.659527	12.0901	11.6784	16.7264
9	21	30	320	2	15.5	0.681	2.334672	16.61227	0.641438	-16.7336	-7.1759	9.7827
10	17	24	300	2.3	13.8	0.869	1.868067	15.45693	0.763443	18.7796	-12.0067	12.1469
11	16	24	280	1	16.3	1	1.103829	16.21997	0.962939	-10.3829	0.49098	3.7061
12	12	23	300	0.6	23	0.877	0.627393	22.1554	0.841575	-4.5655	3.6722	4.03934
13	17	22	320	2.3	18.7	0.869	2.473048	13.70641	0.878619	-7.5238	26.7037	-1.069
14	20	25	340	2.4	13.8	1.224	3.090822	12.31951	1.07047	-28.78425	10.7543	12.5433

Table 4: Effect on weld bead geometry for changes of input parameters

SL. NO.	CHANGE OF TRAVEL SPEED(TS) (RANGE) CM/MIN	CHANGE OF VOLTAGE(V) (RANGE) VOLT	CHANGE OF CURRENT(C) (RANGE) AMPHERE	CHANGE REINFORCEMENT HEIGHT(RH) (RANGE) MM	CHANGE OF BEAD WIDTH(BW) (RANGE) MM	CHANGE OF METAL DEPOSITION RATE(MDR) (RANGE)GM/SEC
1.	0 (16-16)	+4 (20 – 24)	0 (280- 280)	- 0.7 (1.7 – 1.0)	-6.3 (16.3 - 10)	-0.25 (1.25-1)
2.	+1 (16 - 17)	0 (24 - 24)	20 (280 -300)	+1.3 (1-2.3)	-2.5 (16.3 – 13.8)	-0.131 (1 – 0.869)
3.	0 (17-17)	-5 (24-19)	+80 (300 -380)	-0.3 (2.3-2)	-1.8 (13.8 - 12)	+0.04 (0.869-0.909)
4.	+3 (17-20)	+1 (19-20)	+20 (380 - 400)	+3 (2-5)	-0.3 (12-11.7)	0.591 (0.909-1.5)
5.	+4 (20-24)	+8 (20-28)	-120 (400 -280)	-2.4 (5.0-2.6)	+1.3 (11.7-13.0)	-0.741 (1.5-0.759)
6.	+1 (24-25)	-3 (28-25)	+20 (280-300)	+0.6 (2.6-3.2)	0 (13-13)	+0.051 (0.759-0.810)
7.	+2 (25-27)	-1 (25-24)	0 (300-300)	+0.3 (3.2-3.5)	+0.6 (13.0-13.6)	-0.26 (0.810-0.759)
8.	+1 (27-28)	+2 (24-26)	+20 (300-320)	-1.5 (3.5-2.0)	-1.1 (13.6-12.5)	+0.359 (0.550-0.909)

[+ = increase, - = decrease,]