International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 09 | Sep 2019 www.irjet.net p-ISSN: 2395-0072

"Tensile and Shear Strength Approximate Prediction of Friction Surfaced Tool Steel through ANN"

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ABSTRACT - Friction surface treatment is well-established solid technology and is used for deposition, abrasion and corrosion protection coatings on rigid materials. This novel process has wide range of industrial applications, particularly in the field of reclamation and repair of damaged and worn engineering components. In this paper, we present the prediction of tensile and shear strength of friction surface treated tool steel using ANN for simulated results of friction surface treatment. This experiment was carried out to obtain tool steel coatings of low carbon steel parts by changing input process parameters such as friction pressure, rotational speed and welding speed. The simulation is performed by a 3^3-factor design that takes into account the maximum and minimum limits of the experimental work performed by the 2^3-factor design. Neural network structures, such as the Feed Forward Neural Network (FFNN), were used to predict tensile and shear strength of tool steel sediments caused by friction.

Keywords: Friction surfacing, Artificial Neural Networks (ANN), Process Parameters.

1. INTRODUCTION

Friction surfacing is an advanced technology that can effectively deposit a metal on another metal. In this process, the consumable rod is rotated and forced against the substrate in the axial direction. A large quantity of hotness is produced due to the friction among the consumable rod and the friction contact surface between the substrates, and the contact end of the metal consumption rod is plasticized after a certain period of time. The substrate is then horizontally moved to a vertically consumable rod, so that a layer of mechanical material is deposited on the substrate. Friction surface treatment has been used for a variety of hard surface metal coatings, such as mild steel or stainless steel coating on the tool steel coating. In this process, the strong adhesion between the coating and the substrate can only be achieved by applying a high contact pressure, but this requires expensive machinery [1,2].

Friction surface treatment has significant advantages over conventional fusion welding processes. This novel process correlates many process parameters, which directly affect the quality of the deposit. In this process, the obtained coating is fairly flat and regular, and there is no conventional cross-sectional profile of the invasive meniscus [3]. This process can be considered in another key area that is damaged and damaged by the reclamation and repair of engineering components [4]. A number of industrial applications have been observed in friction surface treatment and are mainly used to deposit hard materials on the cutting edges of various tools required for the food processing, chemical and medical industries. The process can be widely used in tool steel, aluminum, stainless steel and mild steel, copper-nickel alloy and other materials [5-7]. This innovation process can be carried out in open air [8], water [9] and inert gas [10].

In the process, the right choice of process factors is critical to attaining the quality of the coating. The axial force acting on the consumable rod, the rotational speed of the rod and the transverse velocity of the substrate are the main process parameters affecting the coating properties such as coating thickness, coating width and adhesive strength. In order to achieve the desired mechanical properties, it is necessary to understand the correlation between mechanical properties and process parameters. Okuyucu Kurt and Areaklioglu [11] obtained correlation between mechanical properties and FSW parameters using artificial neural networks (ANNs), whose attempts focused on linking process parameters rather than optimizing them. Now in the field of metal processing, the use of artificial neural net works is also increasingly important.

The focus of this study is on computer-aided ANN models to predict the tensile and shear strength of tool steel M2 deposits formed by friction surfaces. Due to the limitations of the experimental work, the simulation was carried out by taking into account the maximum and minimum 33 factor designs of the experimental work carried out by 23 factor designs. The feed forward neural network (FFNN) was used to predict the tensile and shear strength of the friction surfacetoolsteelM2sediments.

Artificial neural networks (ANNs) can be used in various fields of engineering applications, by using the input data to obtain the required information, to overcome the shortcomings of traditional methods [12]. The prediction of the friction surface response is carried out by the mathematical modeling of ANN, which represents the tensile and shear strength of the input parameters.

The structure of the feedforward neural network (FFNN) consisting of three layers consists of a concealment and output layer and an arbitrary activation function is a general approximator [12]. The architecture of the FFNN network model is shown in Figure 1.

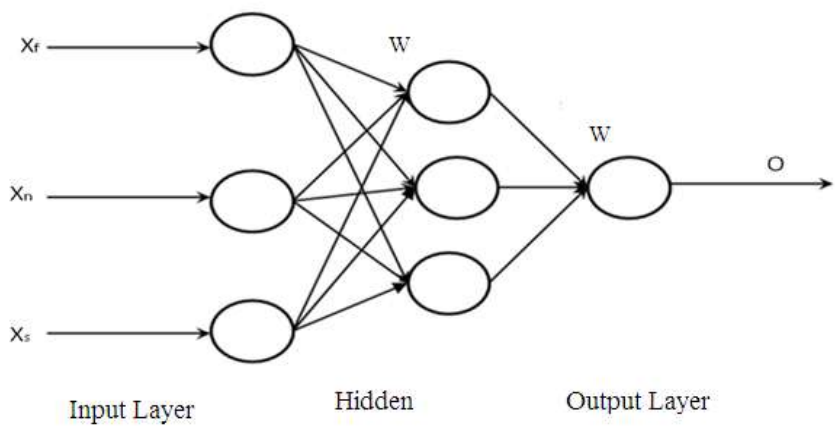

Fig .1. Architecture of FFNN network model

Figure 1 depicts the network model of input neurons, hiding neurons and output neuronal structures. Input layers include network input process parameters such as friction pressure, velocity, and welding speed. Hidden layers include neurons known to map points in the input area to coordinates in the output area. The output area is called the transfer function of the activation function processing input layer. In this case, the hyperbolic tangent function is selected as the activation function because it tests the minimum mean square error between the other functions, such as Gaussian and logarithmic functions [12].

2. EXPERIMENTAL WORK

The main process constraints such as friction, rotational speed and welding pressure are selected as the process constraints for the investigational procedure of numerous manageable process parameters which affect the tensile and shear strength of the friction surface tool steel M2.

For the experimental work, the range of the friction pressure (X1) was set to 105 kN, the mechanical speed (X2) was (100-300 rpm), and the substrate traverse speed (X3) was (40-60 mm / min). The main parameters with 23 factor designs were selected and the tool steel M2 was deposited on the mild steel. The sediments obtained from these eight treatments are shown in Table 1. After each test, a preliminary test was conducted in the workshop to determine the bond strength of the low carbon steel tool steel deposits.

Table.1.The process parameters used and tool steel deposits over low carbon steel obtained in the experimental work.

TC	Process Parameters			Tensile strength	Shear strength	Tool steel deposit over low carbon steel
	X_1	X_2	X_3			
	MPa	rpm	mm/min	N/ mm^2	N/ mm^2	
1	5	100	40	61	26	
2	10	100	40	132	56	
3	5	300	40	69	26	
4	10	300	40	124	50	
5	5	100	60	69	29	
6	10	100	60	64	25	
7	5	300	60	164	76	
8	10	300	60	144	62	

The tensile strength was determined experimentally by applying a tangential force in the contact area by tensile test method and shear strength. The values obtained are listed in Table 1. Tensile strength is of paramount importance for designing various engineering components such as containers, pressure vessels, turbine blades, helicopter blades and pumps. Samples for tensile strength tests have square-sized deposits and have round holes from the other side of the sample. The friction surface of the tool steel deposits is separated from the low carbon steel substrate by the influence of the tension applied by the indenter. The tensile strength of the sample is then calculated by the ratio of the applied tensile load to the bearing area of the sample. The shear strength test is of the utmost importance for the design point of view, which is determined by applying tangential loads to the deposit. The shear strength of the specimen is calculated by dividing the applied load by the shear area. Tensile strength test before and after the test sample in Table 2.

Table. 2. Specimens before and after testing

Specimens	Before Test	After Test
Tensile Strength		
Shear Strength		

3. EFFECT OF PROCESS PARAMETERS ON BOND STRENGTH OF THE DEPOSIT

3.1. Determination of Regression Equations

Construct the variance analysis (ANOVA) table to check the importance of all the process parameters for the tensile strength to determine the regression equation. The regression equation for the response to tensile strength, after eliminating less important terms, can be rewritten as
y = 103.4 + 15.125X1 + 21.875X2 + 6.875X3-18.87 X1X3 + 21.875X2X3
Similarly, the regression equation for the shear strength after eliminating the least significant term can be rewritten as y = 43.75 + 4.5X1 + 9.75x2 + 4.25X3-9X1X3 + 11.25X 2X3

3.2 Prediction of Tensile and Shear Strength by using Artificial Neural Network (ANN)

The MATLAB R2012a version of the neural network toolbox is used to develop artificial neural networks (ANN) models for predicting the tensile and shear strength of frictional surface sediments. The input layer consists of three process parameters, namely, friction pressure, speed and welding speed, the output layer represents the tensile strength and shear strength. Initially enter the input data into the neural network, and then simulate to achieve the output. When creating a neural network, the velocity constants and the maximum number of neurons are changed to achieve different results. This is done by using trial and error methods. The experimental parameters of the artificial neural network (ANN) model are shown in Table 3.1.

Table 3.1 Experimental plan for selecting process parameters

TC	Friction pressure MPa	Rotational speed rpm	Welding speed mm/min
1	5	100	40
2	7.5	100	40
3	10	100	40
4	5	100	50
5	7.5	100	50
6	10	100	50
7	5	100	60
8	7.5	100	60
9	10	100	60
10	5	200	40
11	7.5	200	40
12	10	200	40
13	5	200	50
14	7.5	200	50
15	10	200	50
16	5	200	60
17	7.5	200	60
18	10	200	60
19	5	300	40
20	7.5	300	40
21	10	300	40
22	5	300	50
23	7.5	300	50
24	10	300	50
25	5	300	60
26	7.5	300	60
27	10	300	60

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 09 | Sep 2019 www.irjet.net p-ISSN: 2395-0072

The effect of process parameters such as friction pressure, rotational speed and welding speed on mean of tensile potency and mean of shear potency are indicated in the figures 3.3, 3.4, 3.5, 3.6, 3.7 and 3.8

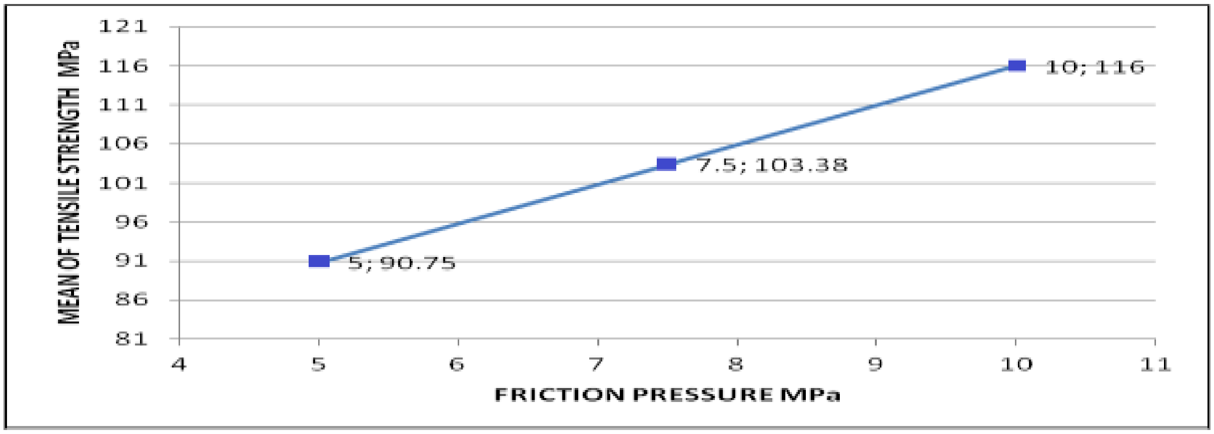

Fig 3.3: Variation of mean of tensile strength at different friction pressures

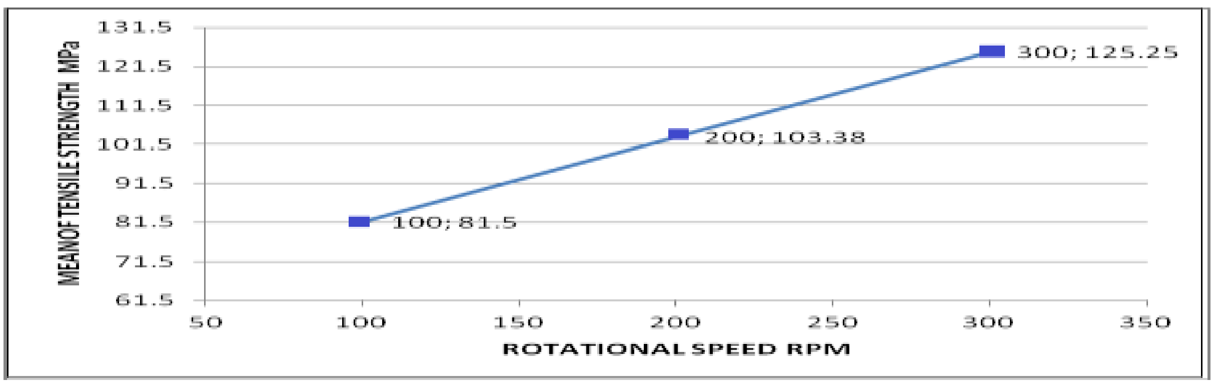

Fig 3.4: Variation of mean of tensile strength at different rotational speeds

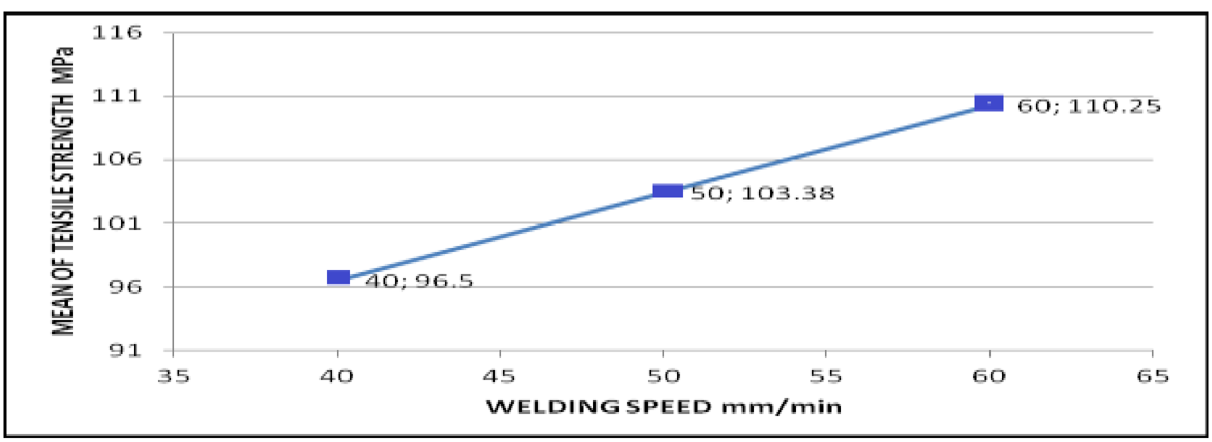

Fig 3.5: Variation of mean of tensile strength at different welding speeds

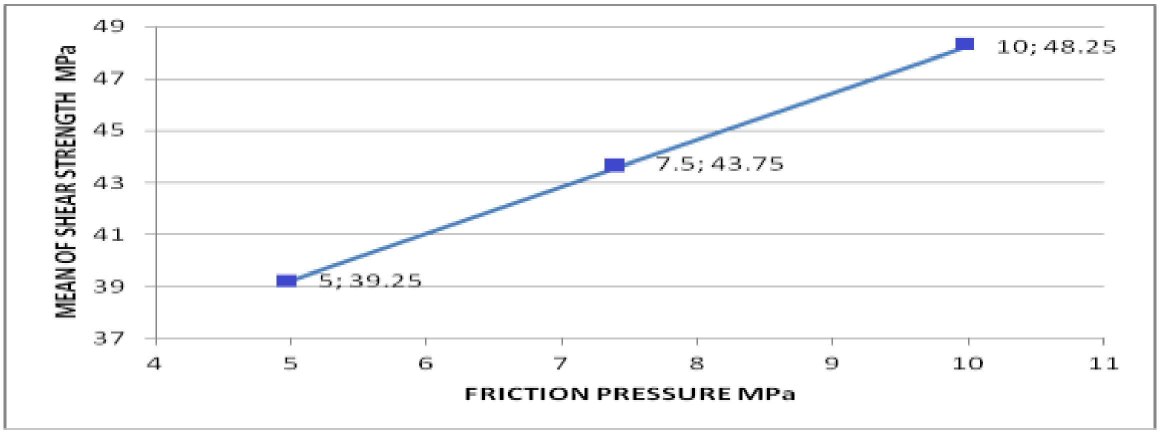

Fig 3.6: Variation of mean of shear strength at different friction pressures

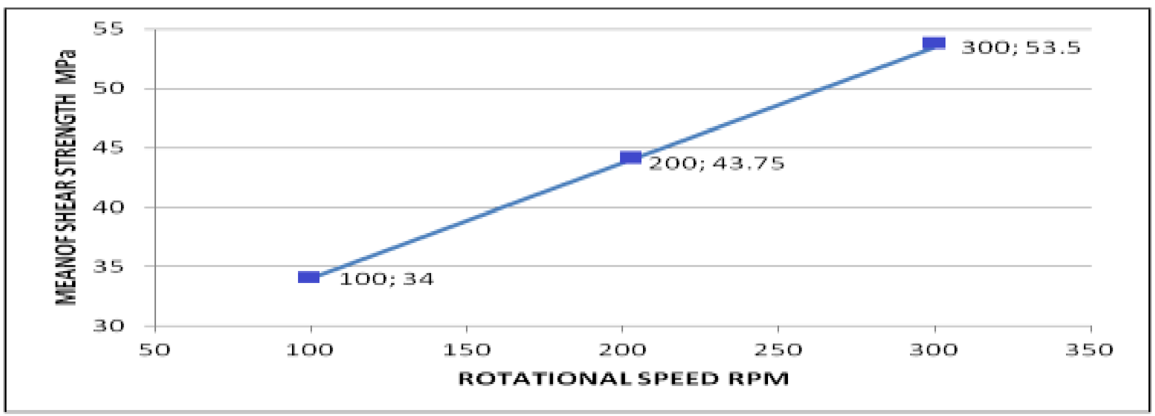

Fig 3.7: Variation of mean of shear strength at different rotational speeds

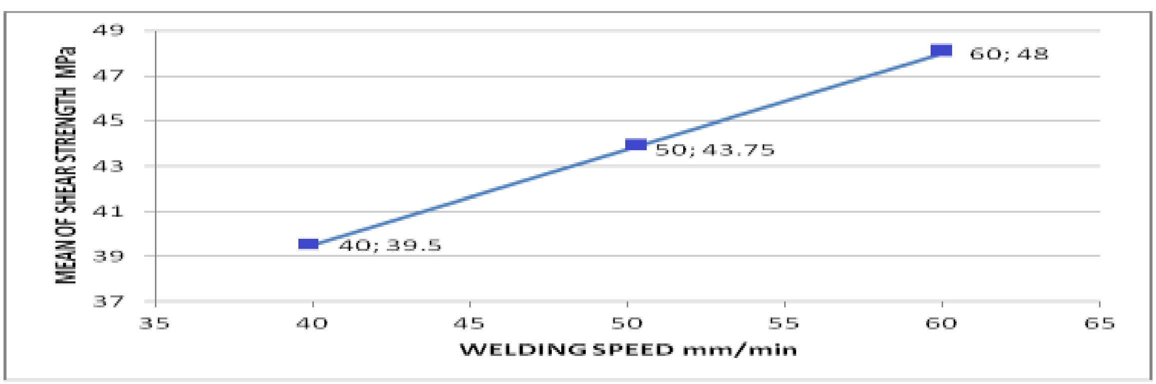

Fig 3.8: Variation of mean of shear strength with welding speeds

4. RESULTS AND DISCUSSIONS

From the regression equation, the results show that the tensile strength is proportional to the combined effect of friction pressure, rotational speed, speed and welding speed. From the prediction of artificial neural network (ANN) model, the average value of tensile strength and shear strength increases with the increase of friction pressure, rotational speed and welding speed. Therefore, ANN can be used to determine the effect of process parameters on bond strength. Figure 4.1 depicts

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Volume: 06 Issue: 09 | Sep 2019 www.irjet.net p-ISSN: 2395-0072

the predicted values of the tensile strength of the sediments using FFNN and the experimental values. Figure 4.2 shows the predicted Vs experimental values for shear strength.

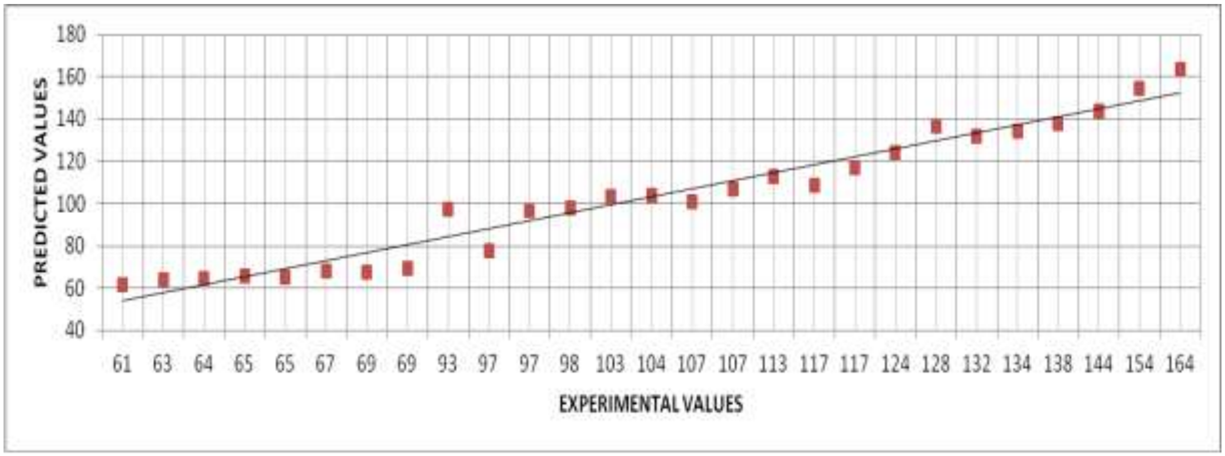

Fig. 4.1. Depicts the variation of predicted and experimental values of tensile strength of the deposit by using FFNN

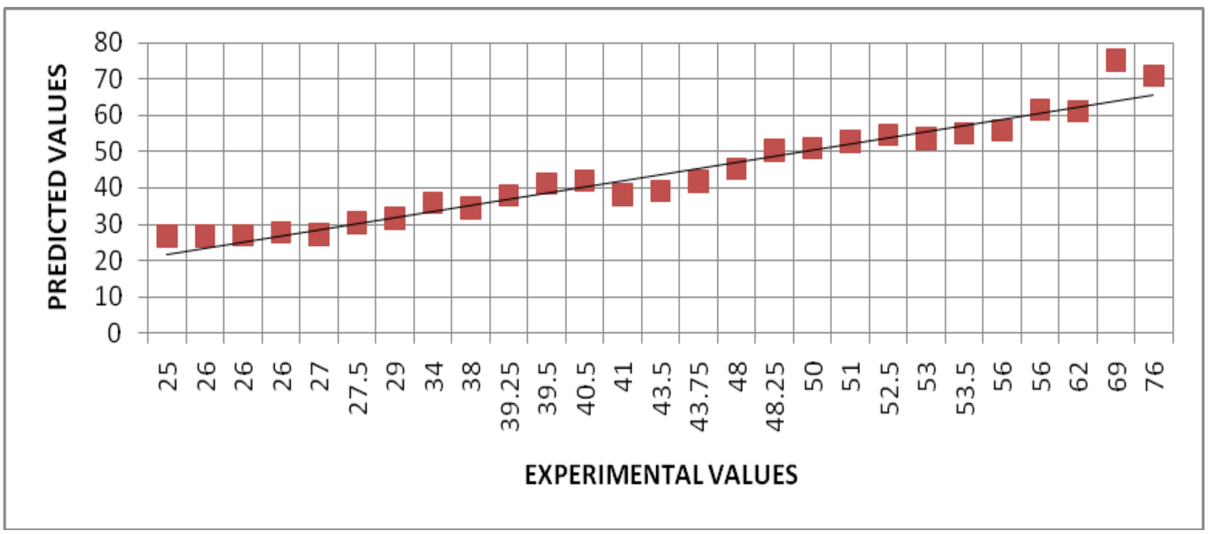

Fig 4.2: Predicted Vs Experimental Values for Shear Strength

CONCLUSION

By changing the input process parameters, 23 factor designs were used to perform experiments on a friction surfacing machine. Due to the limitations of the experimental work, taking into account the maximum and minimum experimental work, carried out a 3 3 times the design of the simulation. The tensile and shear strength of the samples were measured using a universal testing machine. It can be seen from the regression equation that the tensile strength and shear strength are proportional to the friction pressure, the rotational speed and the welding speed. The tensile and shear strength of the tool steel M2 deposit produced by the friction surface treatment is predicted by a feedforward neural network (FFNN) using artificial neural networks (ANN). The results show that the predicted values are closely related to the experimental values. Thus, ANN technology is the most effective method for predicting the tensile and shear strength in friction surface treatment and can also be tested in many other surface modification processes. Therefore, ANN is an alternative to validating experimental values.

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