



## Experimental Based Prediction of Shear Strength of Friction Surfaced Tool Steel Deposit by Using Artificial Neural Networks

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**Abstract**—An artificial neuron network (ANN) is a computational model is widely used for computation work in the engineering filed. ANN is used by the so many researcher for various worked here in this paper I am used the ANN as Computation model for prediction of Shear strength friction surfaced. ANNs are considered nonlinear statistical data modeling tools where the complex relationships between inputs and outputs are modeled or patterns are found. 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 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 shear strength of tool steel sediments caused by friction.

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

### 1. INTRODUCTION

Recently, with the developments in artificial intelligence; researchers have a great deal of attention to the solution of non-linear problems in physical and mechanical properties of metal alloys [1]. Researchers are putting much emphasis on the manufacturing, shaping, bonding problems to widespread the use of composites in common industry markets. The produce of composites, Ni-Ti alloys to have been used with powder metallurgy method and which produce of composites, determine of using field important to present [2]. Joining of the powder metallurgy products (P/M) by diffusion bonding process is important both to protect the microstructural properties of parent materials and bonding behavior of joining materials [3]. 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 networks is also increasingly important. The focus of this study is on computer-aided ANN models to predict 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 and shear strength of the friction surfacetoolsteel M2 sediments.

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 shear strength of the input parameters.

Computers are an integral part of day to day activities in engineering design and engineers have utilized various applications to assist them improve their design [11-12]. ANN mimic some basic aspects of the brain functions. ANNs are based on the neural structure of the human brain, which processes information by means of interaction between many neurons and in the past few years there has been a constant increase in interest of neural network modeling in different fields of materials science. The basic unit in the ANNs is the neuron. The neurons are connected to each other with weight factor [13-14]. Artificial neural networks (ANNs) are networks of highly interconnected neural computing elements that have the ability to respond to input stimuli and to learn to adapt to the environment. ANN includes two working phases, the phase of learning and that of recall. During the learning phase, known data sets are commonly used as a training signal in input and output layers. The recall

phase is performed by one pass using the weight obtained in the learning phase. ANN is now a well established tool and details about it can be found elsewhere. Various nomenclatures are used to describe neural network paradigms [15-16-17]. Whereas, a single-layer network has single input/output units, a multi-layer network has one or more hidden units between input and output layers Figure 1.

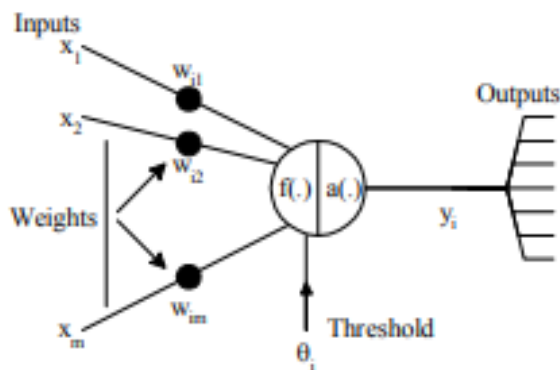


Figure 1. AI Block Diagram

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 2.

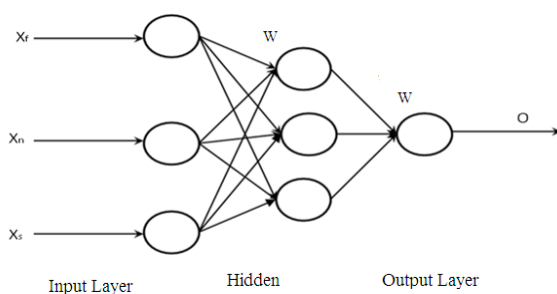


Figure 2. Architecture of FFNN network model

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 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 Prameters |           |              | Shear Strength |
|----|-------------------|-----------|--------------|----------------|
|    | X1<br>Mpa         | X2<br>Rpm | X3<br>Mm/min |                |
| 1  | 5                 | 100       | 40           | 40             |
| 2  | 15                | 500       | 60           | 72             |
| 3  | 10                | 300       | 45           | 49             |
| 4  | 5                 | 100       | 40           | 59             |
| 5  | 10                | 300       | 60           | 47             |
| 6  | 10                | 300       | 70           | 62             |
| 7  | 5                 | 100       | 60           | 64             |
| 8  | 10                | 300       | 50           | 39             |
| 9  | 15                | 500       | 40           | 93             |
| 10 | 10                | 300       | 60           | 42             |
| 11 | 5                 | 100       | 60           | 29             |
| 12 | 15                | 500       | 60           | 83             |
| 13 | 5                 | 100       | 40           | 45             |
| 14 | 5                 | 100       | 40           | 65             |
| 15 | 10                | 300       | 50           | 54             |
| 16 | 15                | 500       | 60           | 62             |
| 17 | 10                | 300       | 50           | 87             |
| 18 | 15                | 500       | 60           | 54             |
| 19 | 5                 | 100       | 40           | 53             |
| 20 | 5                 | 100       | 40           | 32             |

The strength was determined experimentally by applying a tangential force in the contact area by test method and shear strength. The values obtained are listed in Table 1. strength is of paramount importance for designing various engineering components such as containers, pressure vessels, turbine blades, helicopter blades and pumps. Samples for 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 strength of the sample is then calculated by the ratio of the applied 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. strength test before and after the test sample in Table 2.

**Table. 2. Specimens before and after testing**

| Specimens      | Before Test   | After Test  |
|----------------|---|---|
| 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 strength to determine the regression equation. The regression equation for the response to strength, after eliminating less important terms, can be rewritten as  $y = 103.4 + 15.125X_1 + 21.875X_2 + 6.875X_3$

$-18.87 X_1X_3 + 21.875X_2X_3$  Similarly, the regression equation for the shear strength after eliminating the least significant term can be rewritten as  $y = 43.75 + 4.5X_1 + 9.75x_2 + 4.25X_3 - 9X_1X_3 + 11.25X_2X_3$

$$\{Y_{1, sim}\}_n^{after} = \left( \{Y_{1, sim}\}_{d, r}^{after} - INP(:, 1) \right) ./ INP(:, 2)$$

$$INP = \begin{bmatrix} 1.86738675958188 & 1.75441900815846 \\ 0.256292682926829 & 0.139298384453331 \\ 37.6049268292683 & 15.4296708553494 \\ 0.0117466550522648 & 0.00502496069944280 \\ 0.00317436153310105 & 0.00313405738707657 \\ 0.747257839721253 & 0.672593729449374 \\ 0.409189895470383 & 0.355659673580697 \\ 2.49434083623694 & 1.56947133251911 \\ 3.09112818815331 & 1.68344744643481 \\ 2.37830191637631 & 1.27920413483700 \end{bmatrix}$$

#### Prediction of 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 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 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 | Rotational speed | Welding speed |
|----|-------------------|------------------|---------------|
|    | MPa               | rpm              | 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            |

The effect of process parameters such as friction pressure, rotational speed and welding speed on mean of potency and mean of shear potency are indicated in the figures 2.

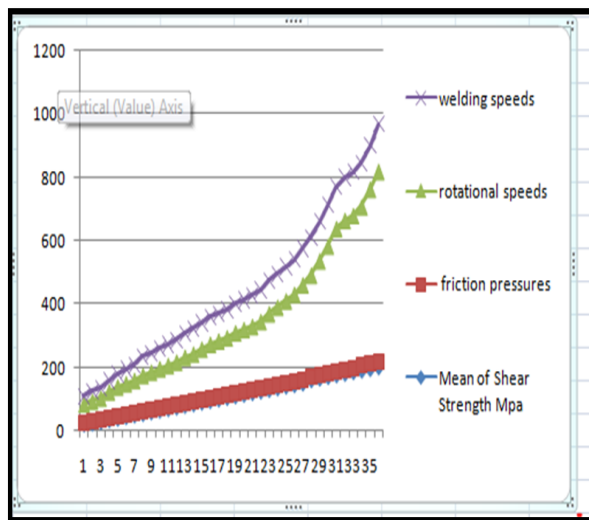


Figure 2: Variation of mean of shear strength at different friction pressures / at different rotational speeds/ welding speeds

**Table : different Variation with Mean Value**

| Mean of Shear Strength Mpa | friction pressures | rotational speeds | welding speeds |
|----------------------------|--------------------|-------------------|----------------|
| 22                         | 3                  | 60                | 25             |
| 25                         | 3.2                | 65                | 30             |
| 30                         | 3.5                | 70                | 33             |
| 35                         | 3.8                | 85                | 35             |
| 40                         | 4.5                | 95                | 40             |
| 45                         | 4.7                | 100               | 45             |
| 50                         | 4.8                | 105               | 50             |
| 55                         | 5.4                | 115               | 58             |
| 60                         | 5.8                | 120               | 60             |
| 65                         | 6.4                | 125               | 65             |
| 70                         | 6.9                | 130               | 67             |
| 75                         | 7.5                | 135               | 70             |
| 80                         | 7.9                | 145               | 75             |
| 85                         | 8                  | 150               | 80             |
| 90                         | 8.5                | 160               | 82             |
| 95                         | 8.9                | 170               | 85             |
| 100                        | 9.2                | 175               | 87             |
| 105                        | 9.4                | 180               | 89             |
| 110                        | 9.7                | 190               | 92             |
| 115                        | 9.9                | 195               | 95             |
| 120                        | 10                 | 200               | 99             |
| 125                        | 10.3               | 210               | 101            |
| 130                        | 10.5               | 230               | 104            |
| 135                        | 10.7               | 245               | 106            |
| 140                        | 10.9               | 260               | 108            |
| 145                        | 11.1               | 275               | 110            |
| 150                        | 11.4               | 300               | 115            |
| 160                        | 11.8               | 320               | 119            |
| 165                        | 11.9               | 360               | 125            |
| 170                        | 13.4               | 400               | 130            |
| 175                        | 13.7               | 450               | 132            |
| 180                        | 14.5               | 470               | 135            |
| 185                        | 14.9               | 480               | 138            |
| 190                        | 17.2               | 500               | 139            |
| 195                        | 17.8               | 550               | 140            |
| 200                        | 18.9               | 600               | 150            |

#### 4. RESULTS AND DISCUSSIONS

From the regression equation, the results show that the 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 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.

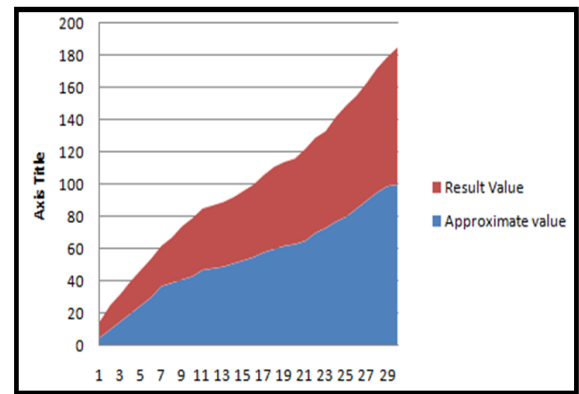


Figure 3: Approximate Value and Result Value

#### 5. CONCLUSIONS

By changing the input process parameters, with different 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 shear strength of the samples were measured using a universal testing machine. It can be seen from the regression equation that the shear strength are proportional to the friction pressure, the rotational speed and the welding speed. The shear strength of the tool steel M2 deposit produced by the friction surface treatment is predicted by a feed forward 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 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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| Approximate value | Result Value |
|-------------------|--------------|
| 5                 | 10           |
| 10                | 15           |
| 15                | 17           |
| 20                | 20           |
| 25                | 22           |
| 30                | 24           |
| 37                | 25           |
| 39                | 28           |
| 41                | 33           |
| 43                | 36           |
| 47                | 38           |
| 48                | 39           |
| 49                | 40           |
| 51                | 41           |
| 53                | 43           |
| 55                | 45           |
| 58                | 48           |
| 60                | 51           |
| 62                | 52           |
| 63                | 53           |
| 65                | 57           |
| 70                | 59           |
| 73                | 60           |
| 77                | 65           |
| 80                | 69           |
| 85                | 70           |
| 90                | 73           |
| 95                | 77           |
| 99                | 80           |
| 100               | 85           |

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