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Research Article

INVESTIGATING THE EFFECTS OF ELEMENTS ON WELDING REPAIRS USING NEURAL NETWORKS (CASE STUDY: CAR FACTORY OF ARAK)

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ABSTRACT
This paper tries to specify the effects of effective elements on the welding repairs using the neural networks in Car Factory of Arak. 12 important and effective parameters have been considered to increase the welding repairs in the mentioned plant. In order to model the neural network, 58 models of defects were gathered and studied for 5 years and then, the most suitable neural network model has been processed. Based on the results, it has been found that the increased defect repairs lead to the increase of total welding ones. Regarding the approximation of determination methods in order to calculate the rate of total welding repairs, neural networks with the maximum error given as 6.44% are of the acceptable accuracy which can predict the total welding repair by the means of above mentioned model. This paper aims to minimize and improve the total welding repair.

Keywords: *Welding Repair, Artificial Neural Network, MATLAB Software, Car Factory of Arak*

INTRODUCTION
Reduction of repairs has been introduced as one of tools in order to develop the companies and enhance the productivity in the projects and recently, has attracted the attention of managers and authorities of public and private companies since lack of controlling this process may result in the increased costs, the decreased customer satisfaction, the raised final product price, the increase of consumed welding materials, the re-modification of products and low quality of products. A solution to this problem may be to predict the effects of welding defects involving gas cavities, slag inclusion, lack of fusion, lack of penetration, cracks, under cuts, excess penetration, Tungsten inclusion, off sets, root concavity, surface irregularity and defects on base metal on the total welding repairs using the neural networks.
The most effective elements in creating the welding repairs can be identified and removed in order to control the welding process.
Also, the effects of them are able to be predicted. Therefore, welding defects are considered as the inputs of neural network for a 5 year period by the help of monthly statistics and the most effective elements in increasing the welding repairs are specified. By identifying and removing the mentioned elements, welding repairs may be appropriately limited. Artificial neural network is a computational model which has been derived from the structure and activities of human brain cells and is capable of processing and transmitting the experimental information, the hidden knowledge of data and laws to the network structure.
The simplest and most common artificial neural network is the feed-forward multilayer neural network accompanied with a supervisor which is used in many engineering sciences and applies the error propagation method. In the network, first layer into which the inputs enter is called the input layer. Last layer which provides the outputs is called the output layer. Between input and output layers, there exist one or several layers called the hidden or middle ones which are not directly connected to the inputs and outputs. Number of neurons in the input layer equals the number of elements in the input vector; on the other hand, number of neurons in the output layer equals number of elements in the output vector. Accurate and actual analysis to find the number of neurons in the middle layers is very complicated but it

can be stated that number of neurons in the hidden layer may be a function of number of elements in the input vector and the maximum number of areas in the input space which are linearly separated.
Thus, number of neurons in the hidden layer is experimentally achieved. Expertise systems and intelligent modeling are applied to recognize the relationships of parameters due to the fact that no clear and specific relationships are observed between them. Prediction can be mentioned as an example concerning the detection scope of welding repairs in Machine-building plant of Arak. In this respect, a variety of studies has been conducted.

For example, Bellhid *et al.,* (2010) suggested a new model in order to select the welding process automatically by the means of neural network's multilayers. Aktept and Ersöz (2012) Aktept and Öncel (2011) determined the required input-output ratio in Mkek factory using the neural network in order to reconstruct the welding process and minimize the rate of defective products.

This model predicts the values of output parameters which are based upon the quality characteristics. Furthermore, on the basis of quality characteristics, the optimum values of some input parameters are computed for the welding operation.

Singh (2012) presented a system regarding the defective models which has been implemented using the neural network.

Abholimen and Achebo (2014) predicted the optimization of welding or the application of tungsten gas and steel pipes by the help of neural network.

General structure of artificial neural network has been derived from human biological networks and is able to perform the operations like natural neural systems.

These systems transfer the hidden laws of data to the structure through processing the experimental data and therefore, they are called intelligent systems because according to the input calculations of numerical data or examples, they take the general rules into consideration. Human nervous system consists of thousands of neurons.

Each neuron is connected to thousand neurons, receives their signals and sends its own ones. Figure 1 shows a mathematical model of neuron.

Artificial neuron has been designed to imitate the first-order features of biological neurons. Inherently, a set of inputs is used. Every input is an indicator of another neuron's output.

Each input is multiplied by its corresponding weight indicating the connection power of 2 and then, sum of all the weighted inputs is obtained in order to determine the stimulation level of neuron. In the following, a model is demonstrated with respect to the mentioned theory (Reeisizadeh, 2010).

Neuron is usually shown by a set of weighted linear nets and a function of f (net) which can be linear or nonlinear. Function of f (net) determines the amount of outputs based upon the inputs and is called the transmission function. If the i_{th} input signal from the j_{th} neuron and its weight are demonstrated by the help of X_i and Wij, the sum of weighted signals will be calculated as follows: $net_j = \sum_{i=1}^{n} w_{ij} x_i + w_0$

Afterwards, through doing a nonlinear action by f (net) on the weighted inputs, the neuron output will be achieved as below. $f(net_j) = f(\sum_{i-1}^{n} w_{ij} x_i + w_0)$

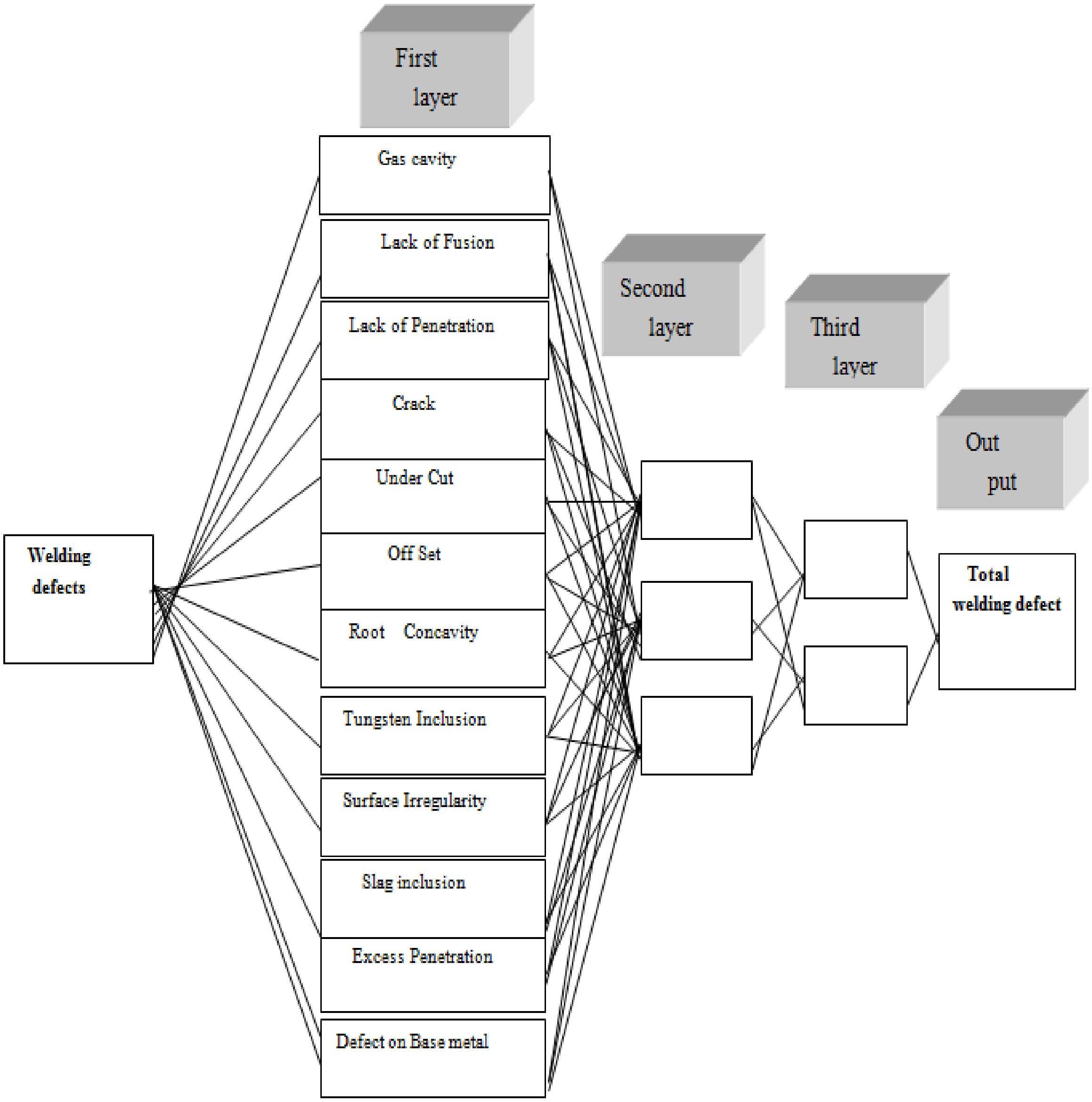

Figure 2: Matematical model a Artificial neuron

Data and Analysis

In this study, 58 data related to the information obtained during 2009-2013 were gathered in Car Factory of Arak and the most appropriate neural network has been specified. Welding defects which were considered as the consequences of a 5 year performance in the mentioned plant have been presented in the following. They included gas cavity or porosity, slag inclusion, lack of fusion, lack of penetration, cracks, under cuts, excess penetration, tungsten inclusion, off sets, root concavity, surface irregularities and defects on base metal. Neural network was programmed in MATLAB and the existing 58 data were applied for training the desired network. 52 data and 6 ones have been used for training and examining the network in order to assess the accuracy of its performance. Neural network involves a two-layer feed-forward network. With respect to the inputs and outputs, the network has been suitably trained and the error percent for 6 examined models was given as 6.44%. There are different types of functions which are able to put in the desired neural network. Furthermore, number of hidden layers and number of internal neurons in each layer are introduced as the parameters which considerably affect the accuracy and

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precision of the given network. To find the suitable function, there exist no general principles in a variety of issues and the appropriate parameters are more likely to be achieved by the error and trial method. In the used program, there are 12 inputs such as welding defects and 1 output that is the whole network repair. As it has been stated, 6 models were selected to test the network. In other words, after training the network, 12 impact factors have been demonstrated as the results. Therefore, the network accuracy and precision can be found through comparing these results. To do the desired comparisons, a command is written in the program to compute the error percent of each output concerning the actual outputs of the studied factory and then, maximum value is printed. As the network parameters (type of used function, number of hidden layers and number of neurons in every layer) and the program implementation are changed, the network will be trained, compute the outputs and calculate the maximum error value. Repeating this action and using a variety of functions provided the best situation with the maximum error of 6.44% that is acceptable with regard to the given value and the maximum error value of 6%. Table 1 presents and compares the values of neural network and the desired plant for welding defects.

Table 1: Comparison of network outputs and available data

Model	Determined repair rate by neural network	Repair rate in Machine- building plant of Arak	م
1	237.33	235	
2	201.47	200	
3	84.61	88	
4	81.84	84	
5	64.21	66	
6	237.33	235	

At the end of program, neural network was applied to draw a graph of network and factory results in order to facilitate the comparisons. Thus, horizontal axis shows the points 1 to 6 for 6 tested models and vertical axis indicates the total network repair by both methods. Connecting the points produces two graphs (Figure 2).

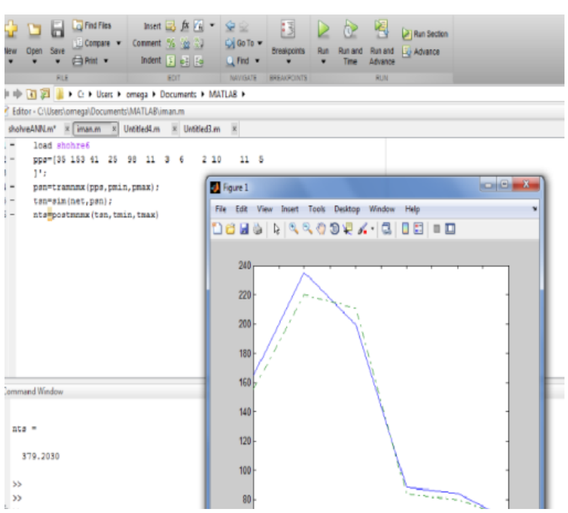


Figure 2: Comparisons of network and actual results prediction graph

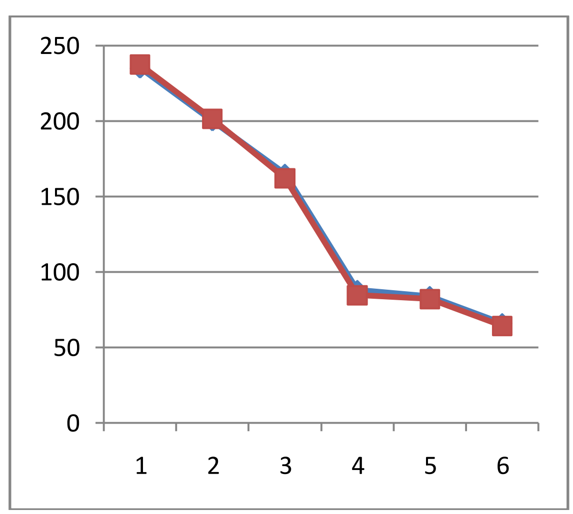


Figure 3: Differences of actual model and the of neural network

While conducting the suitability analysis and training to investigate the model quality with regard to the examination data, the network output (X) with the correlation coefficient of 0.98% gets closer to the actual value (Y) (Figure 3).

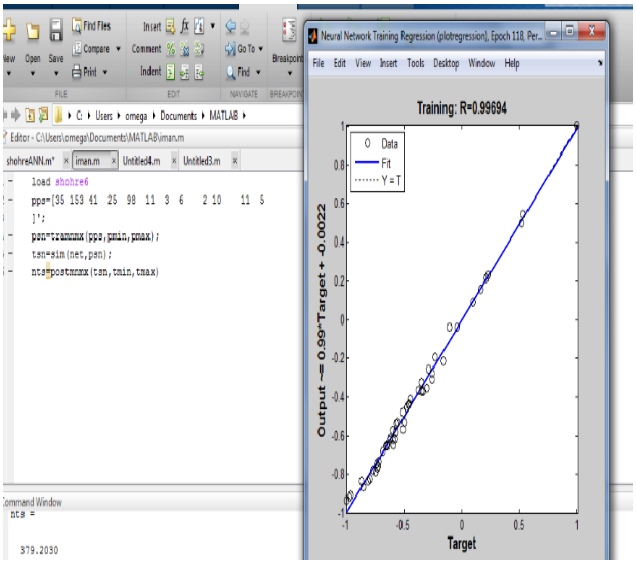


Figure 4: Suitability analysis after training

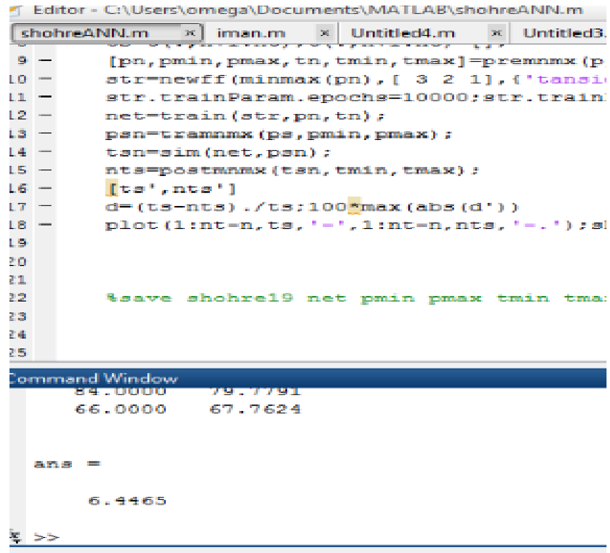


Figure5: prediction error percent(6.44%)in neural network

In this paper, neural network studies the effects of welding defects on the whole welding repair and new models with the error of 6.44% can be created by the neural network regarding the actual data reported by the studied plant and due to the fact that the given error value was achieved after training the neural network. Increasing these models by the network can prepare the graphs showing the effects of such parameters as gas cavity and welding defects on the whole welding repair.

Following figures indicate the situation of welding defects during a 5 year period in a manner that the related graphs are based on the sum of each defect per year (2009-2013) and total sum of repairs in that year.

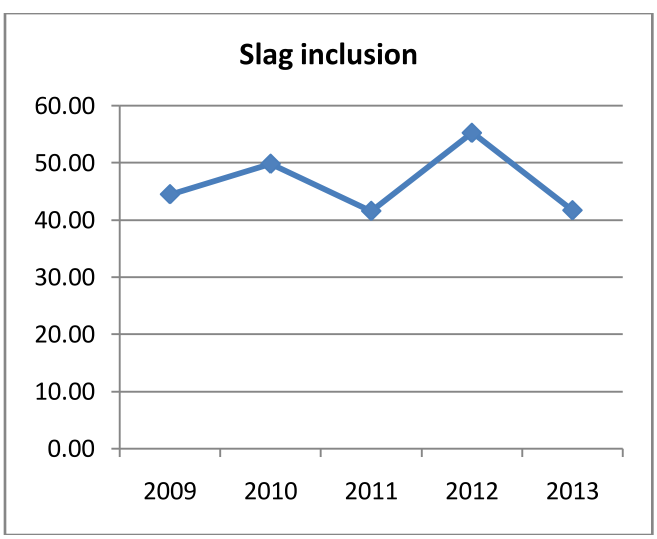


Figure 6: Defects per year to the whole repair ratio

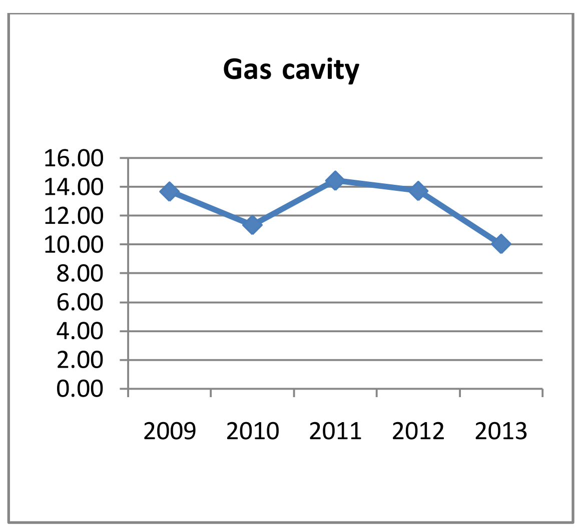


Figure 7: Defects per year to the whole repair ratio

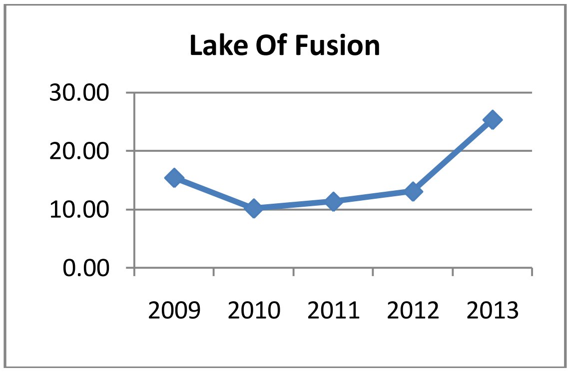


Figure 8: Defects per year to the whole repair ratio

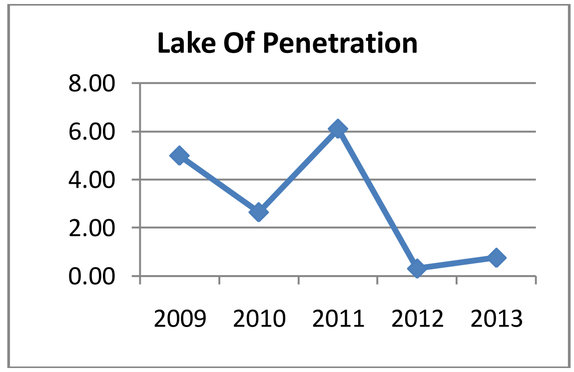


Figure 9: Defects per year to the whole repair ratio

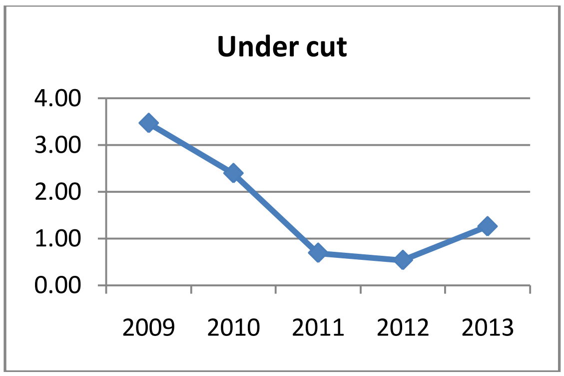


Figure10: Defects per year to the whole repair ratio

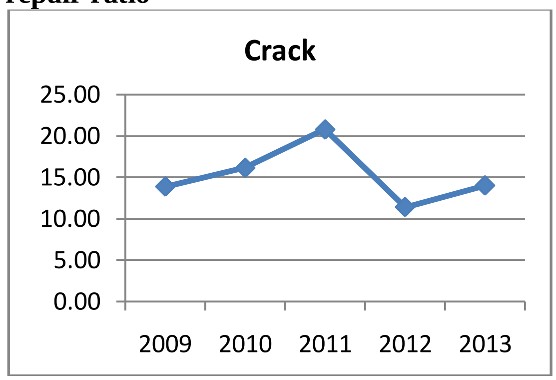


Figure 11: Defects per year to the whole repair ratio

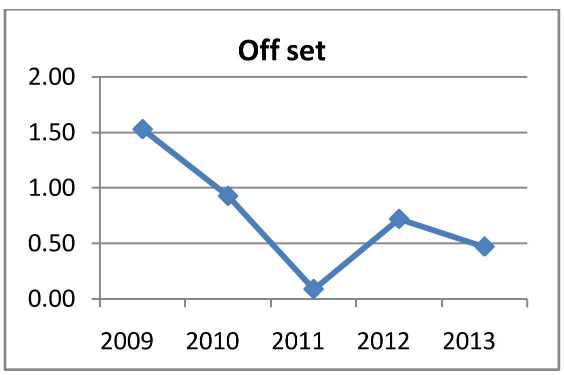


Figure 12: Defects per year to the whole repair ratio

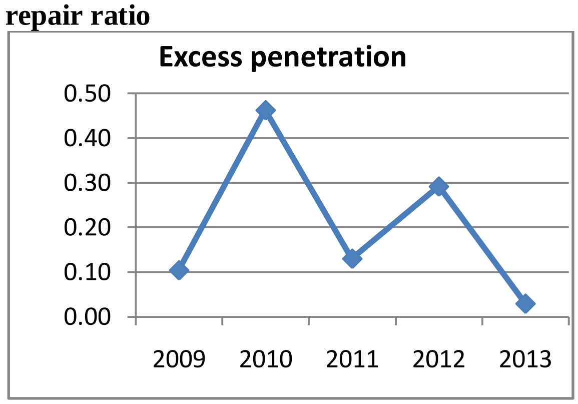


Figure 13: Defects per year to the whole repair ratio

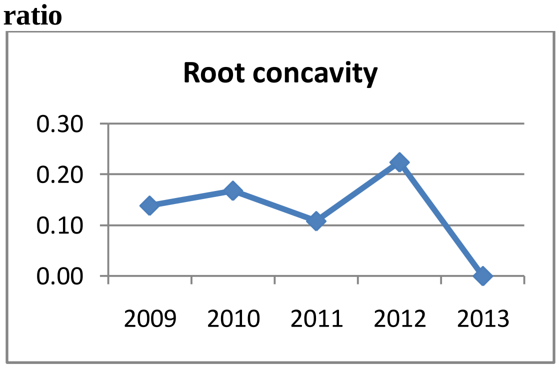


Figure 14: Defects per year to the whole repair ratio

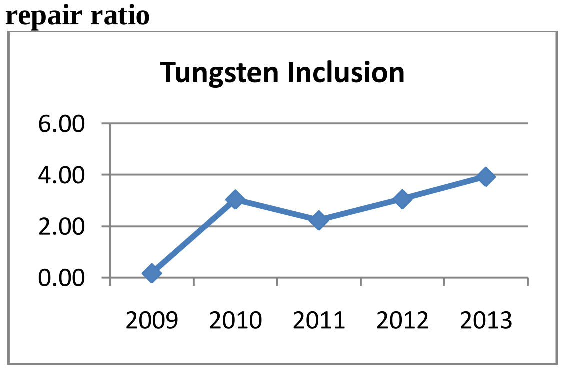


Figure 15: Defects per year to the whole repair ratio

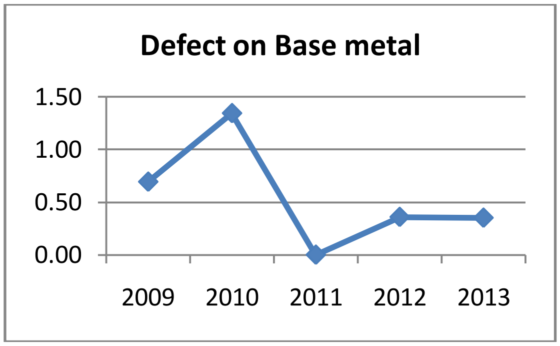


Figure 16: Defects per year to the whole repair ratio

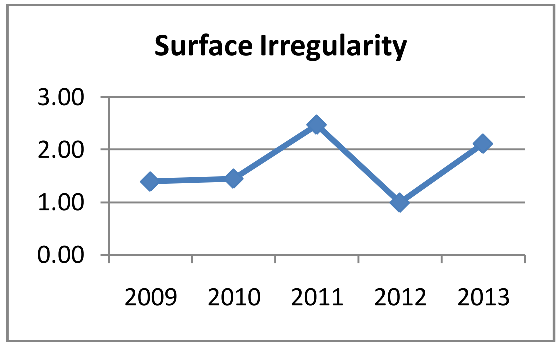


Figure 17: Defects per year to the whole repair ratio

The highest and lowest rates of reported defects are related to slag inclusion and excess penetration, root concavity and defects on base metal, respectively. Following graph shows the defect rate per year which created total repair rate of 11244.33.

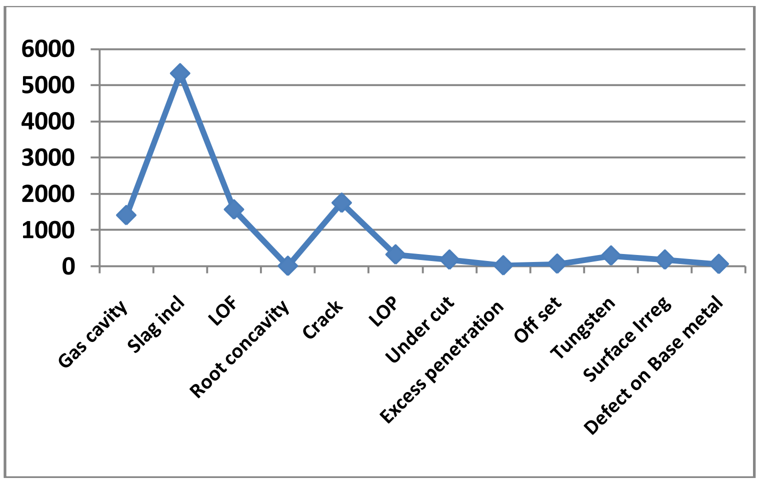


Figure 18: Defects per year to the total welding repair rate

Investigating the Effects of Defects on Total Welding Repair Rate using Neural Network

In the following figures, investigating the welding defect status by the use of neural network has demonstrated that total welding repair rate is increased as the defect rate increases.

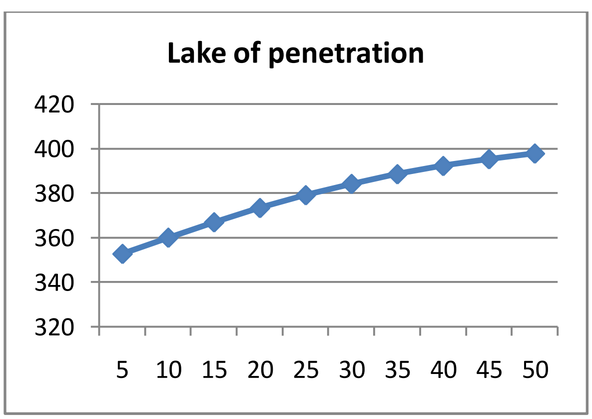


Figure 19: Welding defect rate with the constant parameters

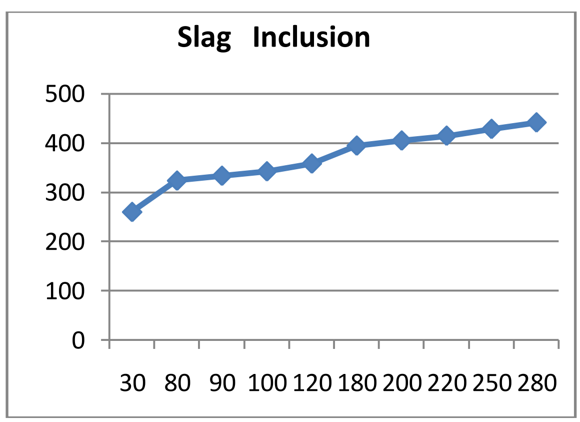


Figure 20: Welding defect rate with the constant parameters

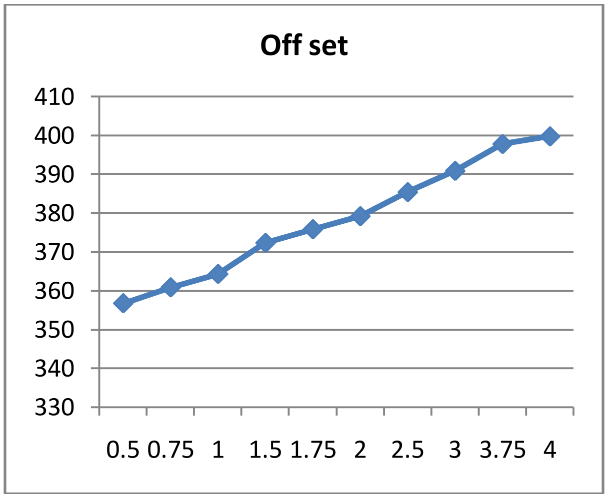


Figure 21: Defect rate with the constant parameters

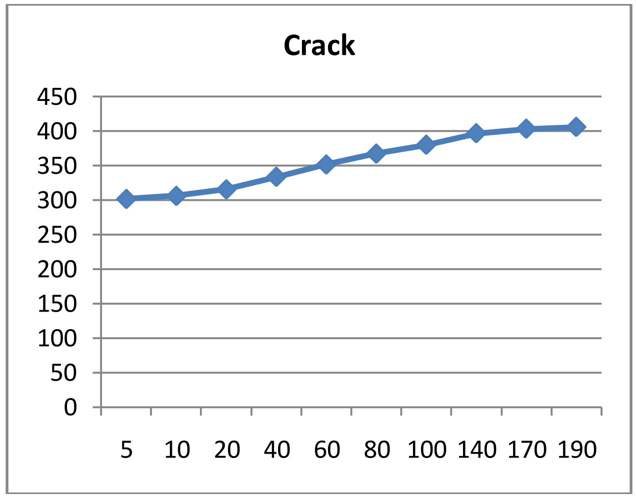


Figure 22: Defect rate with the constant parameters

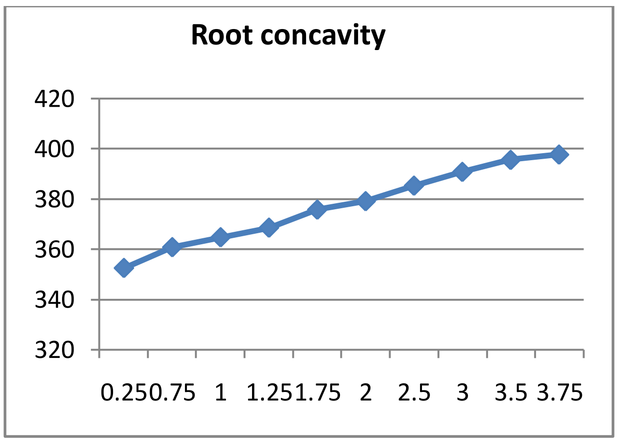


Figure 23: Defect rate with the constant parameters

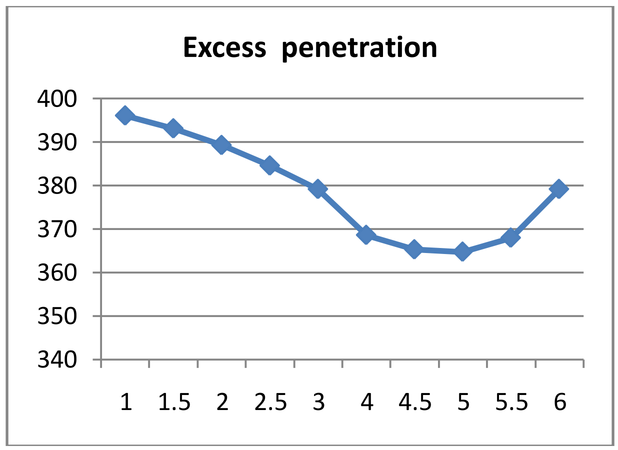


Figure 24: Defect rate with the constant parameters

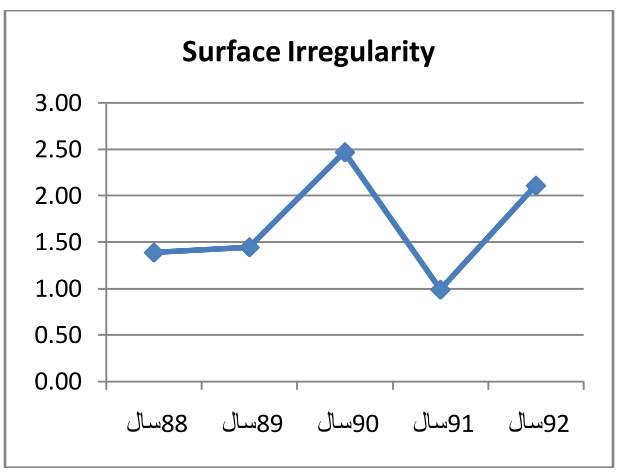


Figure 25: Defect rate with the constant parameters

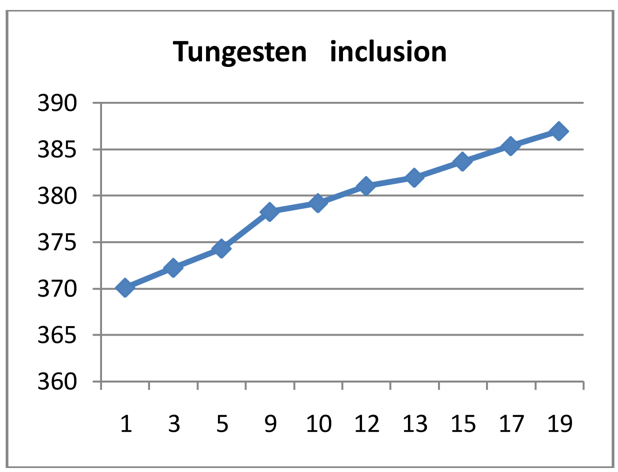


Figure 26: Defect rate with the constant parameters

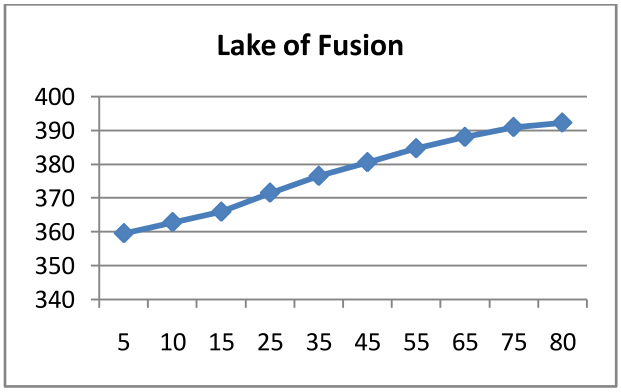


Figure 27: Defect rate with the constant parameters

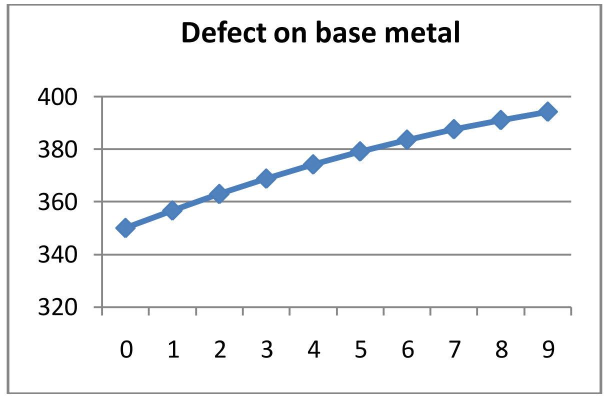


Figure 28: Defect rate with the constant parameters

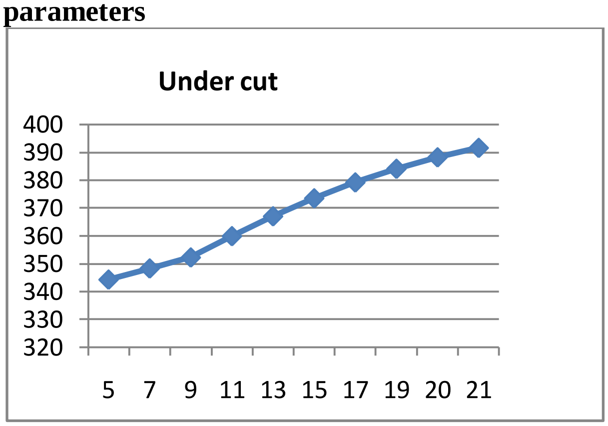


Figure 29: Defect rate with the constant parameters

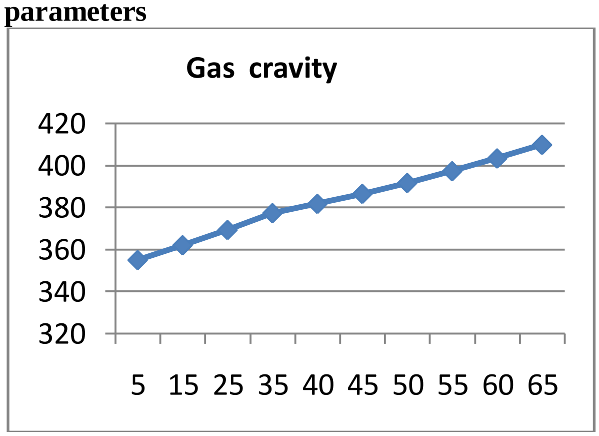
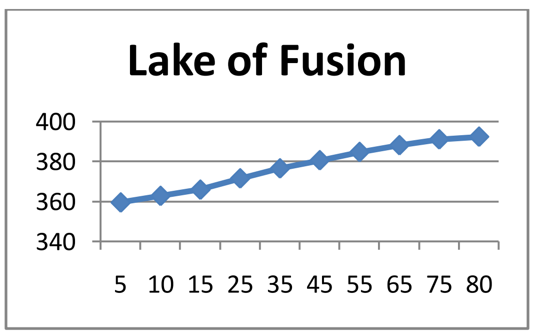


Figure 30: Defect rate with the constant parameters



RESULTS AND DISCUSSION

In this study, welding defects involve gas cavity or porosity, slag inclusion, lack of fusion, lack of penetration, cracks, under cuts, excess penetration, Tungsten inclusion, off sets, root concavity, surface irregularities and defects on base metal. They have been investigated and neural network was designed to determine the optimum value of defects while training and examining 58 models acquired from the desired plant. Determining total repair rate, the error value was computed as 6.44% for 10 test models which can be regarded as an acceptable value. Above-mentioned parameters have been easily measured by Quality Assurance Unit in order to estimate total repair rate accurately. Every parameter's effects on total rate were studied. According to the results, the increased defects of these parameters led to the considerable increase of total repair rate. Defects rate is accounted as one of the important elements in welding repairs. Neural network is capable of determining the welding defects' values for the desired plant and computing total welding repair rate while having a low error value. Investigating the impacts of each parameter on total welding repair rate indicated that the most and least impacts can be attributed to slag inclusion and surface irregularities, respectively. Considering the computations of neural network based on the presented graphs, the highest and lowest effects may be related to gas cavity and excess penetration and slag inclusion, respectively.

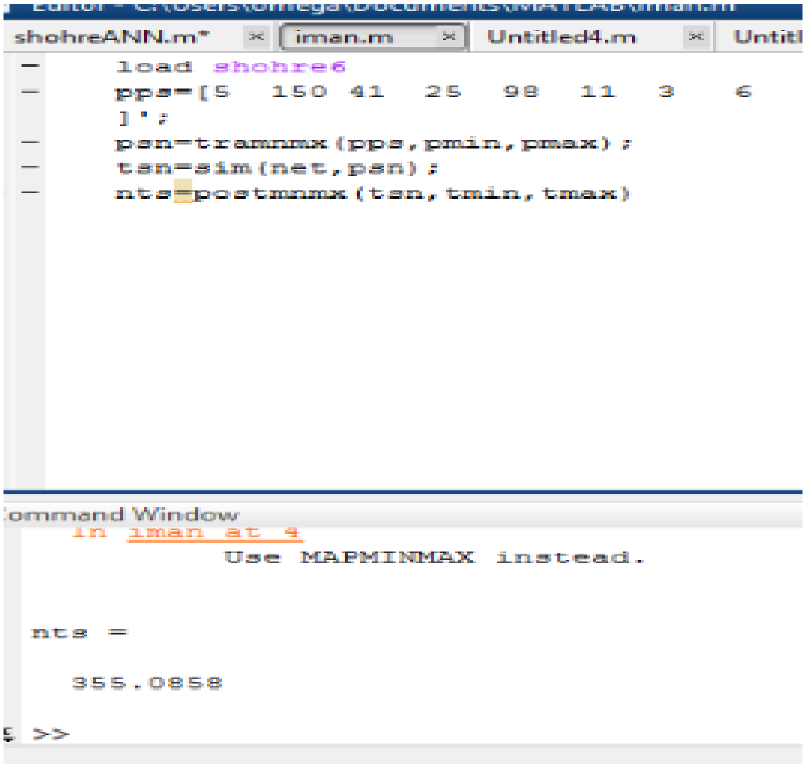


Figure 31: Calculation of total output as 355 in neural network

Conclusion

Finally, it can be concluded that the increased welding defects resulted in the increase of total repair rate during a 5 year period. Particularly, gas cavity and excess penetration given as 388 and 380.5 had the highest effects on total repair rate.

Table 3: Effects of parameters on the output (mean total welding repair)

Variable parameter	Total repair (mean output) (m)
Gas cavity	382
Excess penetration	380.5
Surface Irregularity	378.5
Tungsten Inclusion	378
Off set	377.5
Lake Of Fusion	375.5
Root concavity	374.5
Lake Of Penetration	375.5
Defect on Base metal	372
Under cut	367.5
Crack	353.5
Slag inclusion	350

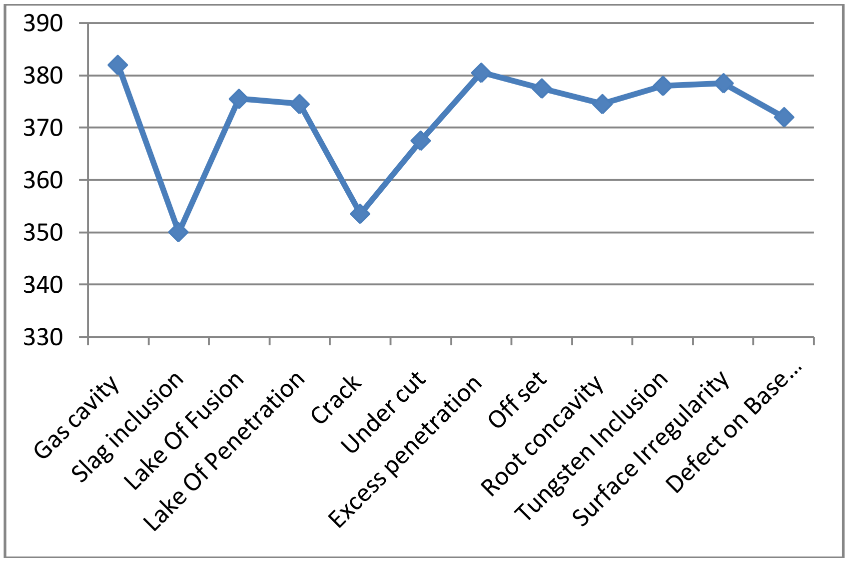


Figure 32: Impact of each defect on total welding repair by neural network

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