[1.]Nikhil V. NAIK

COIL BREAKS PREDICTION IN SKIN PASS MILL USING CLASSIFICATION ALGORITHM IN MACHINE LEARNING

[1.] Dept. of Mechanical Engineering. Viva Institute of Technology. Mumbai University, Maharashtra, INDIA

Abstract: Coil breaks are persistent menace for almost every Cold Rolling steel plant. The uncertain demand flow pattern combined with extreme competitive environment has made the steel industry Quality driven. The steel industry consists of processes like Iron Making, Steel Making, Casting, Hot Rolling, Cold rolling, etc. Cold rolling being end process considers defects as wastage of all previous processes, costs, and time invested to achieve the product. Quality defects are considered grave problems for any cold rolling production line. The study aims to predict the formation of coil breaks by use of an artificial neural network at Skin pass mill. The study is conducted at the Tata Steel Cold Rolling Complex (CRC-West) at Tarapur Midc, Boisar. At CRC-W the production lines present are Pickling, 4 hi Rolling mill, Cleaning, Annealing, Skin pass mill, Slitting, Multi blanking line, Cut to length. We are concerning ourselves with the formation of coil breaks at the Skin pass mill. The coil breaks occurs as a result of non-uniform yielding behavior post forming. Typically observed in Deep drawn and extra deep drawn material, however it can also occur in under stabilized IF steel. Prediction of the formation of coil breaks can be done by an artificial neural network program. An ANN is computing system that learns to perform tasks by considering examples and data sets, generally without being programmed with task-specific rules. The appropriate ANN model is to be developed. The input and output parameters of each of these cases have been decided based on criteria as discussed later. With the Input and Output parameters decided, now the dataset can be taken from the tracking software at the Skin pass mill. The Artificial neural network must be trained so as to increase reliability. The trained ANN must now be validated and tested using a program called Python. The ANN will start predicting if coil breaks will occur or not after skin passing using parameters. The accuracy of ANN will increase as size of dataset increases so for further applications; the ANN could be upgraded to include real time monitoring and prediction.

Keywords: coil breaks, skin pass mill, artificial neural network, cold rolled coils, non-uniform yielding, data sets, load, tension, prediction, analysis

INTRODUCTION

The Coil breaks mainly occur due to the material internal defects. The occurrences of coil breaks and their causes have not been studied properly. This dataset is originally from Tata Steel depository. The objective is to predict whether a coil break occurs or not. We use Python to make the artificial neural network. Python is an important language for machine learning as it removes complex operations. Its extensive library and machine learning concepts are very helpful. We use supervised learning, in which datasets and learning is predefined to make the model. The work for project is undergone at Tata Steel, Tarapur which is a cold rolling plant.

Artificial neural network is a structure patterned on the human brain. It contains the compound layers of straightforward processing elements called neuron. Certain of its neighbors with coefficients of connectivity that represent the strengths of these connections are linked to each of the neurons. The overall network learns by adjusting these strengths to output appropriate results. Diagnostic systems, biochemical analysis, image analysis and Internet Algorithm are the various areas where artificial neural network is used successfully. An ANN is a flexible mathematical structure that is capable of identifying complex nonlinear relationships between input and output data sets [1].

In Steel plants systems, normally artificial neural network are used to detect Surface defects. In chemical analysis artificial neural network have been used to analyze Iron and copper samples, track rust levels in pipes and detect conditions such as blowholes. Spots detection on coils, classification of materials according to grades and determination of skeletal age from x-ray images are some of the applications where artificial neural network is being used for image analysis.

Human brain contains (10)^14 tiny cells called Neurons. A neuron is composed of a cell body, a tabular axon and a multitude of hair like dendrites. The dendrites form a very tiny filamentary brush surrounding at the body neuron. The axon is a long, thin tube that splits into branches terminating in little end bulbs that touch the dendrites of other neuron cells. The Synapse is called a small gap between an end bulb and a dendrite. The axon of a single neuron forms synthetic connections with many other neurons. The neuron that produces a signal refers to pre synaptic side of the synapse. The post synaptic side refers in the neuron that receives the signal.

The aim of this this study is to better predict and understand the defect of coil breaks which are formed on the steel coils using the artificial neural network.

LITERATURE REVIEW

The study conducted by authors N. Q. Hung, M. S. Babel, S. Weesakul, and N. K. Tripathi entailed the use of artificial neural network to better forecast rainfall in Bangkok, Thailand. A real world case study was set up in Bangkok ; The ANN models were developed using 4 years of hourly data after 75 rain gauge stations in the area. The developed ANN model is being applied for real time rainfall forecasting and flood management in Bangkok, Thailand. Distinct network types were tested with different kinds of input in-formation targeted at providing forecasts in a near real time schedule,. Preliminary tests showed that a generalized feed-forward ANN model using hyperbolic tangent transfer function achieved the best generalization of rainfall. Especially, the use of a mixture of meteorological parameters (relative humidity, air pressure, wet bulb temperature and cloudiness), the rainfall at the idea of forecasting and rainfall at the neighboring stations, as an input data, advanced ANN model to concern with continuous data containing rainy and non-rainy period, permissible model to subject forecast at any moment [2].

Another study focuses more on simulation and advanced calculations. In this study the focus of author Masoud Bakhtyari Kia is to develop a flood model using various flood causative considerations using ANN techniques and geographic information system (GIS) to modelling and replicate flood-prone areas in the southern part of Peninsular Malaysia. The ANN model for this study was established in MATLAB applying seven flood causative factors. Relevant thematic levels (including rainfall, slope, elevation, flow accumulation, soil, land use, and geology) are generated utilizing GIS, remote sensing data, and field surveys. In the context of objective weight assignments, the ANN is used to directly produce water levels and then the flood map is constructed in GIS [3].

In this particular interesting study author D.A. Fadare used the predictive and simulative abilities of artificial neural network to make a model which shows the solar energy potential in Nigeria. The outcomes show that the correlation coefficients between the ANN forecasts and actual mean monthly global solar radiation intensities for training and testing datasets were higher than 90%, thus suggesting a high dependability of the model for appraisal of solar radioactivity in locations where solar radiation data are not obtainable. The forecasted solar emission values from the prototype were given in form of quarterly maps. The monthly mean solar emission capacity in northern and southern regions ranged from 7.01–5.62 to 5.43–3.54 kWh/m2 day, respectively. A graphical user interface (GUI) was created for the function of the model. The model can be used easily for estimation of solar emission for primary layout of solar applications [4].

PROBLEM DEFINITION

The Problem to be highlighted in the project is the prediction of coil breaks. We are specifically targeting coil breaks formed at Skin pass mill as it is within our scope. There are two types of coil breaks, first is formed at a hot rolling mill and second is formed at Skin pass mill which comes under cold rolling process. As the plant does cold rolling process we can study coil breaks at Skin pass mill. The 80/20 rule is applied and the defects are segregated. We see that the 84.5 % of all the defect tonnages occurs in 3 defects namely coil breaks, rubbing and work roll marks. Nearly 50 % of the tonnages occur in Coil breaks generated at SPM. The defect Coil breaks generated at SPM must be considered and studied as this successful study can help to reduce defect tonnages. The major fact to be considered is that the defect occurs in final stages of overall factory production lines which render all the material cost used before waste.

The problem is severe at plant level as it forms at the skin pass mill which is final process of the cold rolling process and any defect can undermine all the previous work and cost applied to the material. The prediction of the coil breaks is very difficult due to its running condition. So we are training a python run artificial neural network to predict the formation of coil breaks.

DATASET

The dataset contains the 9 attributes in total. The inputs as a whole are of cold rolling coils. The dataset is in two forms namely Data depository and Defect data. The Data depository is very useful to solve the major problems faced at the company due to its availability and storage of data. The Defect data is made available by the Quality department which collects the relevant data regarding all the defects in the company. The month of September is taken as a random month. We first took the coil breaks occurring in the particular month of September. The overall input data contains Average speed of the mill, Rolling force actual average, Elongation Average, Elongation SP average, POR tension average, Recoil tension average, Negative bending, Positive bending, Output in form if coil break occurs or not. Now we will trace which coils have shown coil breaks in the Quality checks. The coils which have coil break will be tagged as "1" for output and the coils which do not have coil breaks will be tagged as "0".

The skin pass mill has many defects, but the coil breaks are shown to be most persistent one and have nearly 50 % of defect tonnage of all defects at the machine. The skin pass mill is nearly end process for cold rolling process [5]. So any defects at this step would result in the loss of all factors applied for the material. Instability in the plastic flow is generally characterized by the appearance/formation of deformation bands on the material surface at the macroscopic scale. These deformation bands induce surface roughness thereby affecting the surface quality of sheet metal products during metal forming operations such as deep drawing, stamping and also during loading conditions while the component is in service.

METHODOLOGY

The methodology involves the collection of data which can be done by data depository. We have already specified the procedure. The analyzing of the input parameters involves data preprocessing by scaling values in form close to 0 or 1. The scaling of data is important as it helps in the further calculations. The normalizing of the parameters involves making data correlations; it helps for establishing relationships between the data values.

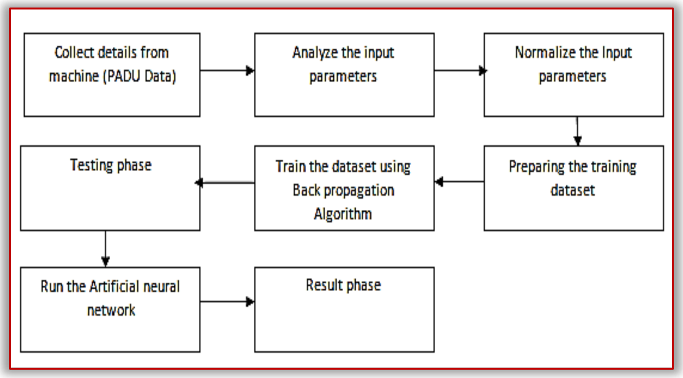


Figure 1. Block diagram for methodology

Around 89 data sets were collected from Tata Steel repository where the data is collected from storage, problem troubleshooting, etc. The primary data involved the total number of coil breaks in month of September. Then the coil number for each was matched with main datasets for the machine. The Data is then portioned in ratio of 80:20. The further process involves the training phase in neural network which would take 80 % of the data set and train it.

The Logistic regression is a predictive analysis module which is used when the output or value takes a form of binary type of data [6]. Here the output is 0 or 1 which is binary. The K neighbor classifier is a statistical recognition module. It is used to determine the nearest value to the given answer. So the issue of the which is nearest 0.6 or 0.4 to 1 can be easily solved. The Gaussian naive Bayes is used as a conditional probability, It assumes all the factors have impact on results and calculates probability accordingly. The Support vector classifier is approximate line which divides two data like coil breaks occur or not on a graph. The Testing step is also an important one as the 20 % of the data testing will enable further increase in accuracy in the model.

The artificial neural network program is now run, we create a fake coil which would be required to input data for which it is to be tested. The input for the coil which is to be checked will involve all the inputs only the coil break input in form of 0 or 1 is not to be input. The artificial neural network will predict this data in array form with 0 or 1 as output.

EXPERIMENTS

The histogram shows the input relationship for individual inputs. The density is high at the Average speed, Elongation average and rolling force average. But the clarity is not seen for the inputs. We have now seen the possible relations in these three inputs on output. Further perfection can be achieved by the program output.

Starting with pair plot we will start exploratory analysis. One thing that we were able to deduce from the pair plot was that all the parameters overlap for the Outcome value, i.e., no matter if coil break occurs or not, you can have the same parameters.

Next in our list was the heat map plot which did give us some insight about the parameters and the relation it has with the other parameters and the Outcome as well.

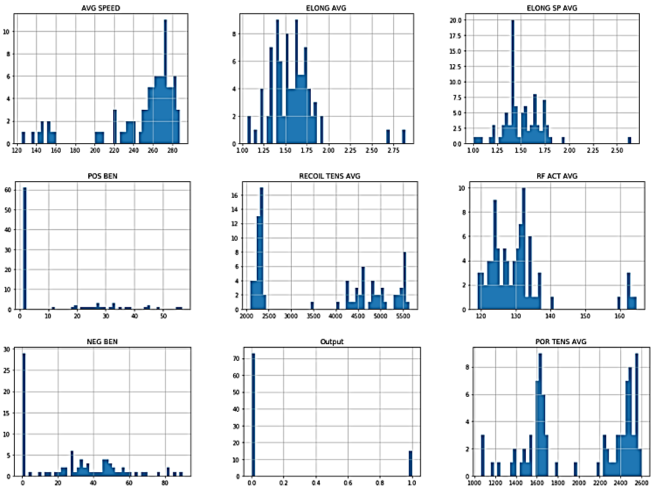


Figure 2. Histogram for all the inputs using Python

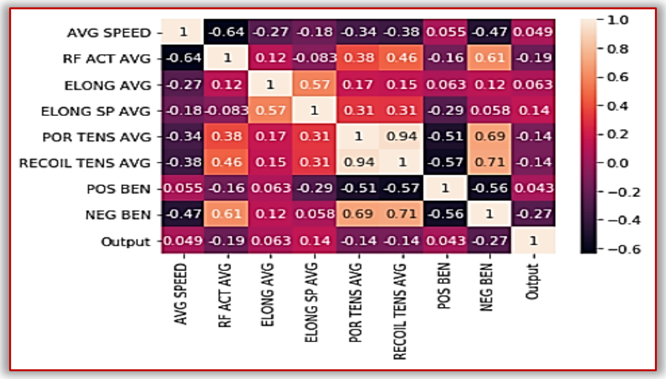


Figure 3. Heat Map for inputs using Python for the model

We find that some pairs have relationship like

- Negative bending and rolling force,
- Elongation average and Elongation SP average,
- POR Tension and recoil tension,
- Negative bending and recoil tension.

This heat map has shown that along with elongation average, POR tension average some factors like Recoil tension average and Negative bending are also significant. Heat map along with histogram has confirmed the effect of Negative bending, elongation average, POR tension, recoil tension on the coil break formation.

So now we make a feature significance plot using the python, it will show all the significant factors after computing the data.

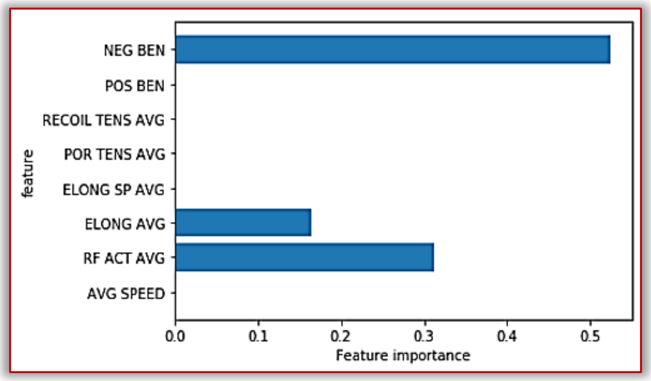


Figure 4. Feature Significance for all inputs on the output using Python

So now we have plot the feature significance for all the inputs. We can see the three inputs Negative bending, Elongation average, rolling force average to be factors which are affecting the output the most. Hence we will further look the feature significance between them.

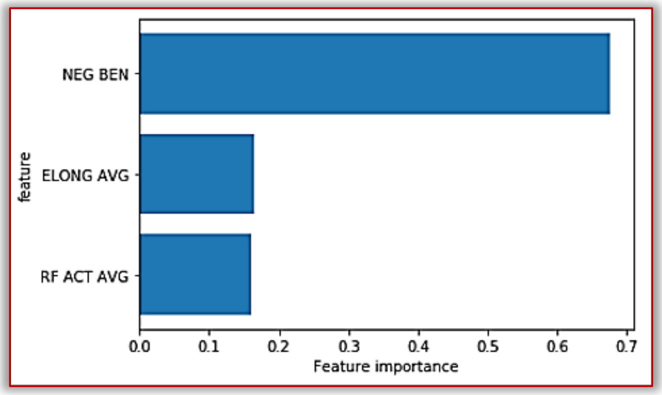


Figure 5. Feature significance for important factors for the model

Parameters used for model are

- Number of unique class labels is 10 for the given neural network, 9 inputs and 1 output.
- Lambda value for L1-regularization is not done so its value will remain 0. This type regularization assigns insignificant value of lambda so as to make the input significance on the outputs similar [7].
- Lambda value for L2-regularization done so the value is 0.1. Regularization is the technique to make program simpler. This also solves over fitting problem as the loss function is penalized [8]. The L2 regularization forces the inputs to act similarly, it does not make the value zero but close to insignificant.
- Number of epochs means number of passes over the training set is 1000.
- The learning rate for the particular neural network is 0.1. Learning rate is an important parameter that helps to decide how much to change model so as to accommodate the error occurred [9].
- The momentum constant is 0.1.

Momentum constant is the factor multiplied with the gradient of the previous epoch t-1 to improve learning speed [10].

$$w(t) := w(t) - (grad(t) + alpha*grad(t-1))$$

- The value of decrease constant is 0.00001

Decrease constant shrinks the learning rate after each epoch using the formula [11].

$$eta / (1 + epoch*decrease\_const)$$

- Shuffles training data every epoch if True to prevent circles. For this neural network the shuffle is kept to true. Shuffling data enables that the model is not biased towards a particular series [12].
- Mini batches means that for efficiency training data is divided into k minibatches. If k=1 it is normal gradient descent learning.
- For this neural network we have set minibatches to 50.

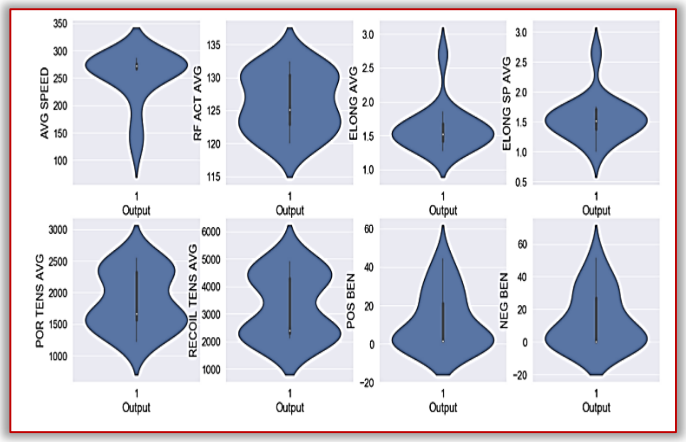


Figure 6. Violin Plot for the outputs in the model

We then wanted to see the distribution of the data points of all the parameters for the entire dataset therefore we plot the violin plots for positive and negative outcome separately.

The violin plots shows quartile ranges properly along with their median and distribution.

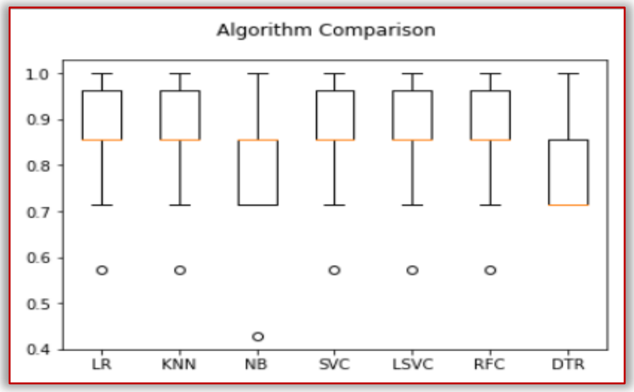


Figure 7. Box Plot using python

We also plot box plot as it along with violin plot will help clarify minute problems. Box plot also works on same ideas violin plot but violin plot is much more detailed as it shows the distribution in form of the shaded area surrounding it [13]. The shaded are around box plot informs the distribution of values. The circles on the graph are called as outliers. The quartiles are of two types for the box plots. The upper quartile is the range which splits 25% of the highest data. The lower quartile is the range that splits 25 % of the lowest data [14].

RESULTS AND DISCUSSIONS

The support vector helped to understand the plot very well. Support vector divides the plot in to two parts and are used for binary data and classification type data [15]. Here the plot is divided into two parts namely 'Blue' means the area where coil break will not occur and 'Red' means area where coil break will occur. We had given 8 inputs to the artificial neural network which will analyze the data and give an output if coil break is formed or not.

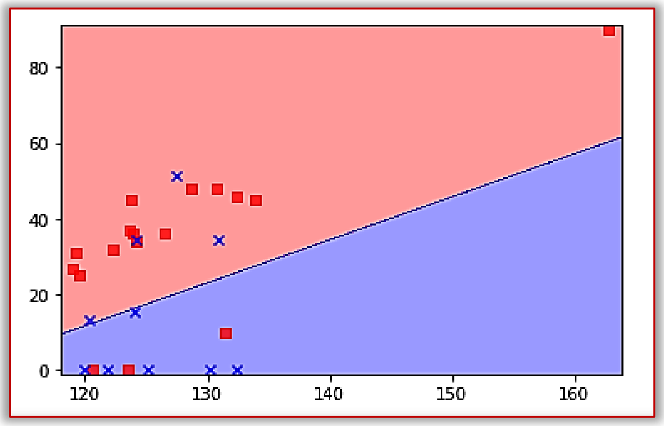
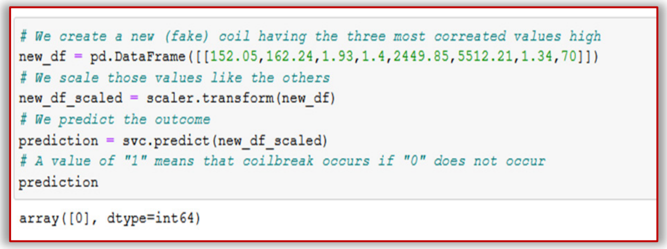


Figure 8. Support Vector for all the outputs



```
# We create a new (fake) coil having the three most correated values high
new_df = pd.DataFrame([[152.05,162.24,1.93,1.4,2449.85,5512.21,1.34,70]])
# We scale those values like the others
new_df_scaled = scaler.transform(new_df)
# We predict the outcome
prediction = svc.predict(new_df_scaled)
# A value of "1" means that coilbreak occurs if "0" does not occur
prediction

array([0], dtype=int64)
```

Figure 9. Output in the python for the model

The above figure shows the working of the predictor in the artificial neural network. The above figure shows the output given by an artificial neural network. The new coil is created where the inputs are given by the user and we could find out if coil break is formed or not. This has effectively created a predictor. In the above example 8 inputs were fed to the predictor, it can be seen that the output is given as array [0]. The value inside array will vary as per the prediction. If the coil break is formed then the array [1] would be seen else the value of array would be array [0]. Here the prediction made is array [0] so we can safely say that the coil break is not formed.

The Defect data will be made available to the Quality department which collects the relevant data regarding all the defects in the company. This will enable the defects are documented and future projects can be undertaken for improvement and quality control.

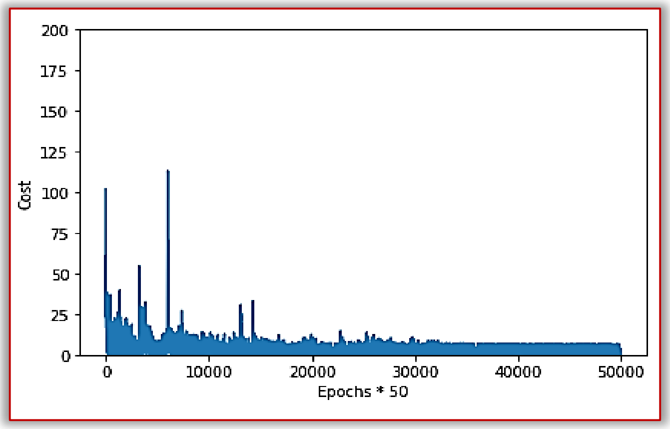


Figure 10. Cost vs epoch graph for the model

The accuracy for training graph is 89.43% which is acceptable and as for testing accuracy it increased to 94.89% accuracy. The model is hence successfully done.

CONCLUSION AND FUTURE SCOPE

Thus we can conclude that after execution of this project the coil breaks which were quite difficult to predict before are now effectively predicted. This will effectively reduce wastage up to a great extent and thus increase the efficiency & availability of the system as well as reducing unnecessary labor fatigue also improving the safety and moral of workers.

The design makes the existing model more accurate and reliable. There are multiple ideas presented in this project and one of them is taken into consideration and elaborated thoroughly to the vision of making its idea clearer. The use of simple yet effective artificial neural network reduces pitfalls and makes the system reliable and quick. Its mechanism along with its operation has been properly elucidated along with its advancement from its early design which is attempted to optimize.

In the future many advance techniques for achieving the above purposes such as provision of cameras for inspection purpose, auto control of loading, bending and other parameters and auto entry of coil in the system with the help of real-time data. This will enable accurate data and further enhance the predictability.

Acknowledgments

- Whenever a work is done successfully, there are many people behind that success. I would wish to take this opportunity to sincerely thank people whom I owe a lot. I feel much delighted in expressing deep sense of gratitude to my respected guide Prof. Niyati Raut for her wholehearted cooperation, encouragement, motivation, valuable suggestions and guidance at every stage of this work leading me to my objectives. I would like to be grateful Mr. Uday Mhatre (Head of Cluster) and Mr. Surendra Chougule (Head of Improvement) for their valuable guidance to my project work. Also my grateful thanks to Mr. Aniket Chatterjee (Manager,SPM Line) for their valuable knowledge about manufacturing given to me during this training period.
- I would also like to thank the whole SPM dept. staff that helped me in solving my difficulties and motivating in my efforts. I am grateful to Principal Dr. Arun Kumar for giving me the opportunity to complete this work.

- The authors declare that the Skin pass mill data supporting the findings of this study are available within the article and its supplementary information files.
- All data generated or analyzed during this study are included in this published article and its supplementary information files attached in the editorial manager system.
- The authors whose names are listed in this paper certify that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

References

[1] Sajjad Ahmad, An artificial neural network model for generating hydrograph from hydro-meteorological parameters ,Journal of Hydrology,volume 315, 2005, pp 236-251
[2] N. Q. Hung, N. K. Tripathi An artificial neural network model for rainfall forecasting in Bangkok, Thailand, Copernicus Publications, volume 13, 2009,pp 1413–1425,
[3] Masoud Bakhtyari Kia, Saied Pirasteh, An artificial neural network model for flood simulation using GIS: Johor River Basin, Malaysia, Environmental Earth Sciences, volume 67, 2012, pp 251–264.
[4] D.A.Fadare, Modelling of solar energy potential in Nigeria using an artificial neural network model, Elsevier Journal, volume 86, 2009, pp 1410-1422.
[5] Paisan Kittisupakorn, Neural network based model predictive control for a steel pickling process,Elsevier Journal,vol no 19,2009 , pp. 579
[6] Recep Kazan, Prediction of springback in wipe-bending process of sheet metal using neural network,Journal of Materials & design,vol no 30,2009, pp.418.
[7] S.Sohrabkhani,Annual electricity consumption forecasting by neural network in high energy consuming industrial sectors, Elsevier Journal,vol no 49, 2008, pp. 2272
[8] M.Yılmaz,An artificial neural network model for toughness properties in micro alloyed steel in consideration of industrial production conditions,vol no 28, 2007, pp.485
[9] Sh.Mesroghli,Prediction of microbial desulfurization of coal using artificial neural networks,Minerals Engineering Journal,vol no 20, 2007, pp.1285
[10] Liujie Xu,Artificial neural network prediction of retained austenite content and impact toughness of high-vanadium high-speed steel (HVHSS),Materials Science and Engineering Journal,vol no 433,2006,pp.251
[11] M.Wong, Automatic digital modulation recognition using artificial neural network and genetic algorithm, Signal Processing, Vol 84, 2004, pp 351-365
[12] Z Zhang,Artificial neural networks applied to polymer composites, Composites Science and Technology, Vol 63, 2003, Pages 2029-2044
[13] Yichun Sun, Application of artificial neural networks in the design of controlled release drug delivery systems, Advanced Drug Delivery Reviews, Vol 55, 2003, pp 1201-1215
[14] Chienhung Wei, Dynamic Bus Arrival Time Prediction with Artificial Neural Networks ,Journal of Transportation Engineering, Vol 128,2002, pp 224-245
[15] J Kusiak, Modelling of microstructure and mechanical properties of steel using the artificial neural network, Journal of materials processing technology, vol no 127, 2002, pp.115

ISSN: 2067-3809