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Analysis of Turning Process By Using Artificial Neural Network Technique

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Abstract

Turning is one of the most widely used metal cutting processes. The increasing importance of turning operations is gaining new dimensions in the present industrial age. This project shows the clear idea about the detailed methodology of mathematical model formulation for the surface roughness, tool temperature, machine vibration and operator pulse rate during the turning process. It helps to develop an accurate and reliable model for predicting and optimizing the critical process parameters which affects the quality, productivity and the safety of the operator during a step turning process. This represents the detailed about the formulation of field data based model to analyze the impact of various machining field parameters on the machining of Aluminum 6063,S.S 304,BRASS, EN1A, EN8.In Indian scenario where majority of total machining operation are still executed manually which needs to be focused and develop a mathematical relation which simulate the real input and output data directly from the machining field where the work is actually being executed. The findings indicate that the topic understudy is of great importance as no such approach of field data based mathematical simulation is adopted for the formulation of mathematical model.

Keywords: **Artificial Neural Network, Turning Process, Field Data Base Model, Model Formulation.**

1. Introduction

Artificial neural networks (ANNs), as an emerging discipline, studies or emulates the information processing capabilities of neurons of the human brain. It uses a distributed representation of the information stored in the network, and thus resulting in robustness against damage and corresponding fault tolerance (Shadbolt and Taylor, 2002). Usually, a neural network model takes an input vector X and produces output vector Y. The relationship between X and Y is determined by the network architecture. There are many forms of network architecture inspired by the neural architecture of the human brain. The neural network generally consists of one input layer. In the neural network model, it is widely accepted that a three-layer back propagation neural network (BPNN) with an identity transfer function in the output unit and logistic functions in the middle-layer units can approximate any continuous function arbitrarily well given a sufficient amount of middle-layer units (White, 1990). Furthermore, in the practical applications, about 70 percent of all problems are usually trained on a three-layer back-propagation network. The back propagation learning algorithm, designed to train a feed-forward network, is an effective learning technique used to exploit the regularities and exceptions in the training sample. A major advantage of neural networks is their ability to provide flexible mapping between inputs and outputs. The arrangement of the simple units into a multilayer framework produces a map between inputs and outputs that is consistent with any underlying functional relationship regardless of its "true" functional form. Having a general map between the input and output vectors eliminates the need for unjustified priori restrictions that are needed in conventional statistical and econometric modeling. Therefore, a neural network is often viewed as a "universal approximator", i.e. a flexi- (Hornik et al., 1989; White, 1990). Both theoretical proof and empirical applications have confirmed that a three-layer BP neural network (BPNN) model with an identity transfer function in the output unit and logistic functions in the middle-layer units is adequate for foreign exchange rates forecasting, which is our research focus in this book. Therefore, a three layer BP neural network model with identity activation function in the output unit and logistic function in the middle-layer units is used throughout this book except specially specified.

2. Reduction of Variables

The various independent and dependent variables of the system with their symbols and dimensional formulae are given in nomenclature. There are several quite simple ways in which a given test can be made compact in operating plan without loss in generality or control. The best known and the most powerful of these is dimensional analysis. In the past dimensional analysis was primarily used as an experimental tool whereby several experimental Variables could be combined to form one.

The field of fluid mechanics fluid mechanics and heat transfer were greatly benefited from the application of this tool. Almost every major experiment in this area was planned with its help. Using this principle modern experiments can substantially improve their working techniques and be made shorter requiring less time without loss of control.

Deducing the dimensional equation for a phenomenon reduces the number of independent variables in the experiments. The exact mathematical form of this dimensional equation is the targeted model. This is achieved by applying Buckingham's π theorem (Hibert, 1961).When we apply this theorem to a system involving n independent variables, (n minus number of primary dimensions viz. L, M, T) i.e. (n-3 numbers of π terms are formed.; From equation (2) total number of variables n = 23; All these variables can be expressed in terms of three primary dimensions i.e. mass (M), Length (L) and Time (T), m = 3 According to Bucking ham's theorem Number of Pi terms = n – m = 23 – 03 = 20 dimensionless terms.

$$f(\pi_1, \pi_2, \pi_3, \pi_4, \ldots \ldots \pi_{20}) = 0 \quad (1)$$

Number of repeating variables are, m=3; Choosing D, VC and FC are the repeating variables.

3. Experimentation

For multifactor experiments two types of plans viz. classical plan or full factorial and factorial plan are available, in this experimentation conventional plan of experimentation is recommended. In all data was collected from total 585 experiments of five material S.S.304, en1a, en8, al 6063 and Brass. The experimental set up is as shown in figure 1

Fig. 1 Experimental Plan.

4. Simulation by Using Artificial Neural Network (ANN)

Artificial neural networks (ANN) can replicate numerous functions of human behaviour, which are formed by a predetermined number of layers with altered computing elements called neurons. In order to build a network, the neurons are interrelated. The crowd of connections determines the form and objectives of the ANN. The processing capacity of the network is stored in the inter unit connection strengths, or weights, which are tuned in the learning process.

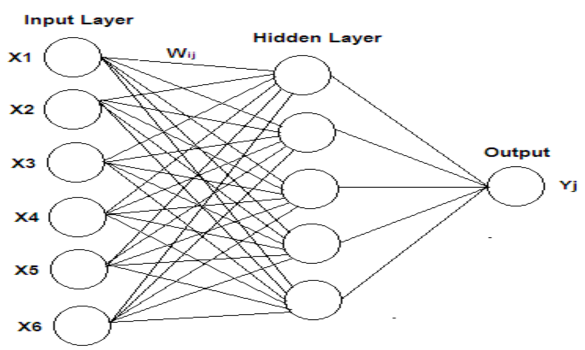

Fig.2 Basic structure of ANN 6/5/1 network

Table 1: List of Process Variables

S.N	Variables	Symbols
1	Operator Anthropometric ratio	An
2	Cutting Tool angles ratio.	AR
3	Tool nose radius	R
4	Tool overhang length	Lo
5	Weight Raw material	W
6	Initial Diameter of the Work piece	Di
7	Length to be turned	L
8	Shank Height	H
9	Tool Length	Lt
10	Experience	Exp
11	Density of the work piece material	DEN
12	Pulse required	Pa
13	Cutting Speed	VC
14	Feed	F
15	Depth of Cut	D
16	Cutting force	FC
17	Maximum W/P interface Temperature	T
18	Machine Specification ratio	SP
19	Power of Machine motor	P
20	Atmospheric Humidity	HUM
21	Surface Roughness	Ra
22	Light Intensity	LUX
23	Air flow	Af

The training algorithm is defined as a procedure that consists of adjusting the weights and biases of a network that minimize selected function of the error between the actual and desired output. Following are the basic steps of Neural network

1. Input layer: [X1,X2,…..Xn] t , where t means vector transpose
2. Hidden layer: I j net j Y j
3. Output layer: Yj

Three ways of generating output: normalized, competitive output, competitive learning

4. Weights: Wij means the value connecting between layers
5. Processing Elements (PE)
6. Learning:

Based on the ANN model used, learning is using a set of training pattern to adjust weights in the network.

7. Scaling and De-Scaling:

Based on the ANN model used, rescaling is applying the real data pattern into the trained network to generate the output.

8. Thresholds

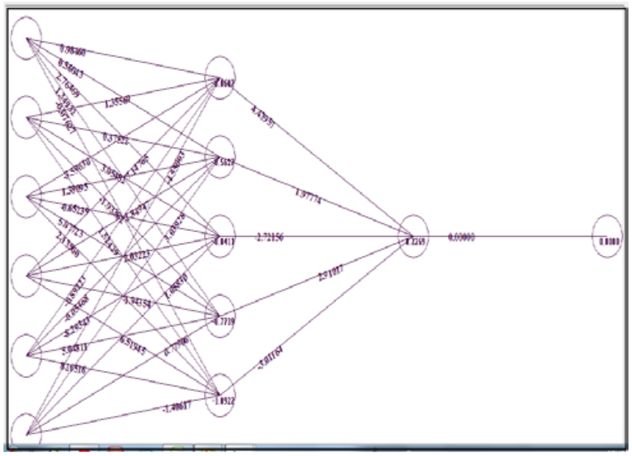

Fig. 3: ANN 6/5/1 Network for Ra value

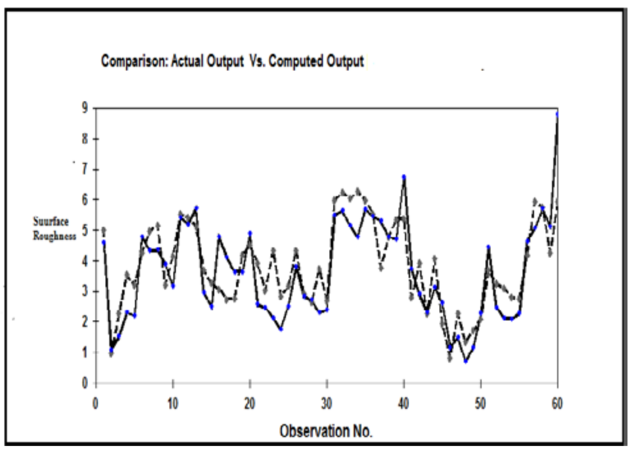

Fig.4: Comparison between Actual Vs ANN for Ra value

Mode1: Surface Roughness

1.From fig 4 we have seen that experimet no. 2 ,3 ,9 ,16 ,17 ,18 ,22 ,24 ,27 ,30 ,41 ,45 ,48 ,49 ,54 ,55 got the minimum roughness value which is desirable.

2.We also seen that the experimet no. 1 ,8 ,11 ,12 ,13 ,31 ,32 ,33 ,34 ,35 ,36 ,39 ,40 ,57 ,60 have the maximum roughness value.

3.The experiment no.48 have the lowest roughness value which is ideal for experimentation.

4.The experiment no. 34 got themaximum roughness value which is not desirable for experimentation

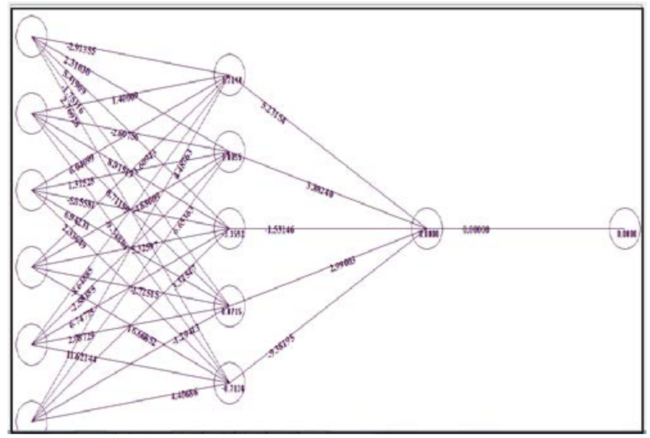

Fig. 5: ANN 6/5/1 Network for machine vibration value

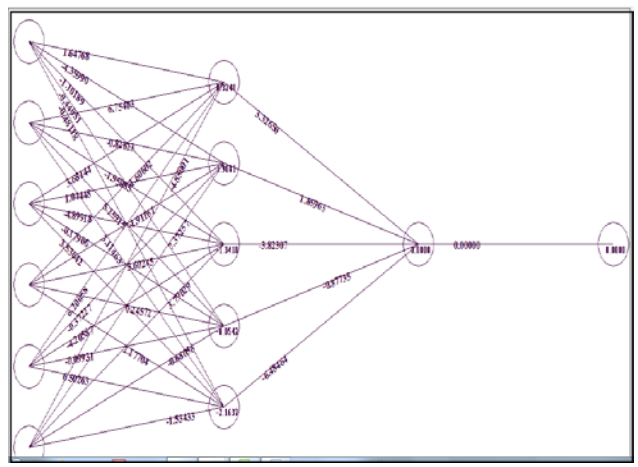

Fig.7: ANN 6/5/1 Network for Tool temperature value

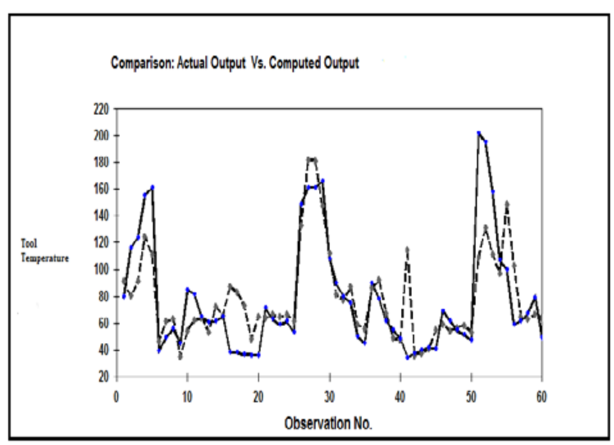

Fig.8: Comparision for tool temprature value

Table. 2: Input- Output Variables

Simulation Case	Input Variables						Output
	Operator	Tool	Work piece	Feed	Machine	Atmospheric	
Surface Roughness							Surface Roughness
Machine Vibration							Machine Vibration
Tool Temperature							Tool Temperature
SPO2							SPO2

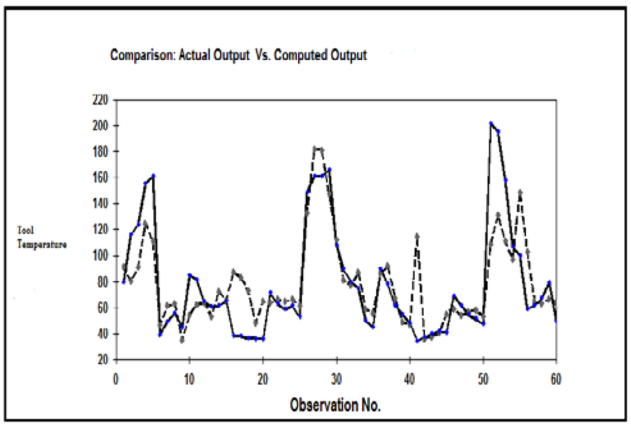

Fig.8: Comparision for tool temprature value

Model 2 : Machine Vibration

1 . From fig we observed that machine vibration is increase for experiment no. 2, 7, 9, 11, 12, 18, 24, 25, 41, 42, 43, 44, 45, 48.

2. We also observed that machine vibration is decrease for experiment no. 38, 39, 40, 46, 49, 51, 52, 55, 56.

3 .The experiment no.49 given minimum viration value.

4. experiment no. 2 have given maximum viration value which will have large effect on Ra vale and SpO2 value.

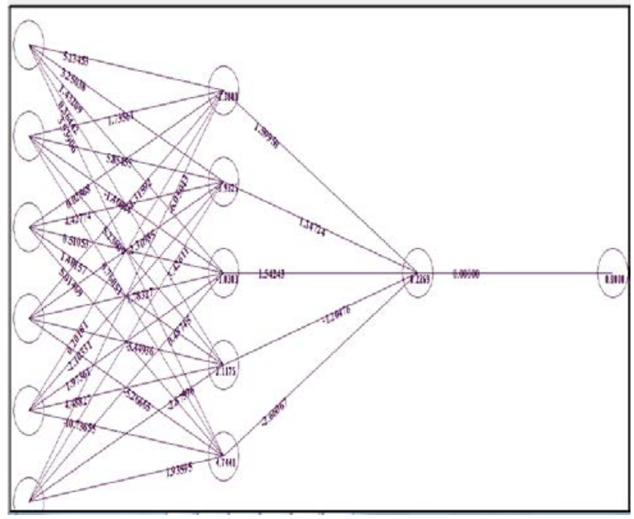
Fig.9: ANN 6/5/1 Network for SPO2 value

Model 3 : Tool Temperature

1. 6, 9, 15, 19, 34, 35, 38, 39, 40, 42, 43, 44, 45, 46, 47, 48, 49, 58 are those experiments which gives minimum tool temp value .

2. 5, 27, 28, 29, 30, 41, 51, 52, 53, 55, 56 are the experiments which have the maximum tool temprature value.

3. experiment no. 9 givs lowest value of tool temprature which will eliminate the need of coolent.

4. experiment no. 27 givs maximum value of tool temprature which is not desirable.

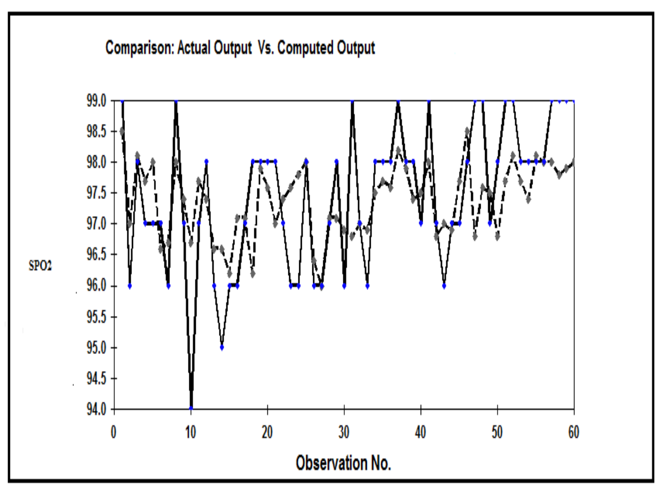

Fig.10: Comparision for SPO2 value

Model4 : SPO2

1. Experiment no.1, 3, 5, 8, 11, 19, 34, 35, 37, 38, 53, 68 have maximum value of SPO2 which is good for human health.
2. Experiment no. 6, 7, 10, 13, 14, 15, 18, 26, 34, 44, 50 have minimum value of SPO2 which is not good for human health.
3. Experiment no.1 have the highest value of SPO2.
4. Experiment no.15, 18 have the lowest value of SPO2.

4. Conclusions

1. **Model for ra value :**

ANN network shows feed and machine has large impact on RA value. The weight of feed and machine shows this impact on RA value. Also experiment no. 48 is ideal for minimum surface roughness so we are looking to follow the parameters of experiment no. 48 to do turning process on lathe. This will help to increase quality of workpiece surface.

Table. 3: Observation for the various Input- Output Variables

Sr.	Operator	Tool	Work	Feed	Machine	Atmosphere	Ra	Machine	Maximum	SPO2
1	0.688660	1016.094	8147567.2	0.098522	0.208944	101.40695				
2	0.083474	1016.094	2250978.5	0.027007	0.265050	25.173139	1.1	25.9	116.1	96
3	0.024924	1016.094	1073961.6	0.012295	0.447691	7.3491854	1.5	26.6	123.9	98
4	0.010462	1873.858	600244.62	0.007115	0.551696	1.156193	2.3	24.8	155.3	97
5	0.015239	1873.858	1039858.7	0.012019	0.48804	4.2220951	2.2	27.2	160.5	97
6	0.006538	4761.774	587390.58	0.006989	0.653517	5.169383	4.7	30.2	39.2	97
7	0.015540	4761.774	1080320.5	0.012185	0.486299	9.3839601	4.3	25.8	49.3	96
8	0.050371	5957.803	2284609.2	0.026462	0.457306	15.909731	4.3	27.5	55.9	99
9	0.491155	5957.803	9072891.4	0.102291	0.293393	106.77037	3.8	28.8	44.8	97
10	0.004146	5957.803	396160.68	0.004568	0.680756	5.0654808	3.1	32.5	84.6	94
11	0.063057	5219.264	2214347.3	0.026355	0.442423	13.3453	5.4	29.2	81.3	97
12	0.517613	5219.264	9219451.1	0.099886	0.313653	53.268541	5.2	32.9	64.8	98
13	0.004156	5219.264	338673.66	0.004538	0.647561	3.7879868	5.7	28.1	60.3	96
14	0.055121	8363.148	321393.67	0.030627	0.154364	6.220445	2.9	32.2	61.6	95
15	0.023293	8363.148	184285.03	0.017673	0.154586	5.210236	2.5	25.8	65.2	96
16	0.00786	8363.148	119021.58	0.011564	0.176427	2.3207708	4.7	27.3	38.2	96
17	0.004685	8363.148	84231.849	0.008138	0.182406	4.3817716	4.1	28.7	38.1	97
18	0.003702	8363.148	61412.147	0.006044	0.161516	2.5454784	3.6	26.1	36.3	98
19	0.157719	8363.148	707981.77	0.065231	0.195041	41.316614	3.6	29.4	36.1	98
20	0.012485	182.2571	172622.68	0.016425	0.182689	0.8093101	4.8	26.9	35.7	98
21	0.021488	182.2571	290822.61	0.031307	0.122930	1.9553478	2.5	25.8	71.3	98
22	0.005646	182.2571	112619.65	0.009547	0.199057	2.6783372	2.4	22.2	62.8	97
23	0.029860	182.2571	301775.51	0.022345	0.183070	4.5681276	2.1	29.2	58.9	96
24	0.097162	182.2571	443645.43	0.027258	0.220461	16.209935	1.7	32.6	61.2	96
25	0.305999	182.2571	979652.63	0.058970	0.200621	25.700271	2.5	29.7	52.8	98
26	0.531242	895.9690	10076647	0.212432	0.201038	142.03181	3.8	24.3	149.3	96
27	0.175151	895.9690	5100657.7	0.077541	0.314320	117.85892	2.8	17.7	161.2	96
28	0.075445	895.9690	2252630.2	0.027007	0.462558	86.538991	2.7	19.2	160.5	97
29	0.053695	895.9690	1202774.4	0.011970	0.612999	48.419249	2.3	18.4	165.8	98
30	0.014787	895.9690	533672.92	0.005408	0.639131	30.161505	2.3	18.8	107.6	96
31	0.000618	3817.448	97720.312	0.003132	0.467625	1.8087665	5.4	21.5	89.3	99
32	0.000320	3817.448	61758.832	0.002015	0.435277	0.7166797	5.6	19.2	79.9	97
33	0.000105	3817.448	35388.024	0.001207	0.463650	0.2687345	5.1	15.9	74.7	96
34	0.000432	3817.448	76090.784	0.002478	0.355480	0.5979604	4.7	16.6	49.7	98
35	0.000600	3817.448	97671.215	0.003120	0.338191	1.2148679	5.6	16.8	44.8	98
36	0.721167	1016.407	8315333.1	0.098330	0.463354	141.69508	5.4	15.7	89.3	98
37	0.091624	1016.407	2163211.9	0.026462	0.545595	30.433654	5.3	18.3	78.5	99
38	0.027331	1016.407	10589339	0.012135	0.598598	10.658699	4.7	18.9	61.8	98
39	0.011696	1016.407	598567.42	0.006996	0.718167	7.1682234	4.7	12.4	54.9	98
40	0.011742	1016.407	557631.16	0.006971	0.721348	6.5434541	6.7	16.4	48.6	97
41	0.014697	1050.507	1067088	0.012135	0.562799	8.4821368	3.7	27.2	34.3	99
42	0.006288	2465.918	588953.05	0.006996	0.732974	5.2705982	2.9	25.4	37.6	97
43	0.003278	2465.918	391253.52	0.004555	0.819235	3.6472577	2.3	32.5	39.7	96
44	0.015119	2465.918	1124774.4	0.012127	0.652311	7.0740434	3.1	26.1	41.2	97
45	0.050615	5957.803	2194227.2	0.026195	0.889220	11.445063	2.6	29.1	40.9	97
46	0.524072	5957.803	8139602.8	0.098330	0.529005	102.19528	1.1	18.7	69.3	98
47	0.004251	5957.803	369081.05	0.004538	0.739746	2.3150163	1.4	22.9	61.8	99

Table. 4: Comparison between actual Vs ANN responses

Obs. No	Roughness		Machine Vibration		Tool Temperature		SPO2	
	Actual	ANN	Actual	ANN	Actual	ANN	Actual	ANN
1	4.6	5.01	25.6	24.7	79.5	91.4	99	98.5
2	1.1	0.969	25.9	32.1	116	80.5	96	97
3	1.52	2.27	26.6	23.6	124	91.1	98	98.1
4	2.31	3.55	24.8	24.9	155	125	97	97.7
5	2.21	3.22	27.2	25.2	161	111	97	98
6	4.78	4.27	30.2	29	39.2	46.8	97	96.6
7	4.32	4.98	25.8	27.6	49.3	61.2	96	96.7
8	4.36	5.16	27.5	31	55.9	62.9	99	98
9	3.89	3.22	28.8	30.7	44.8	35.1	97	97.4
10	3.16	4.15	32.5	20.8	84.6	54.4	94	96.7
11	5.4	5.54	29.2	30.6	81.3	62.1	97	97.7
12	5.2	5.42	32.9	32	64.8	64.2	98	97.4
13	5.72	5.13	28.1	26.2	60.3	53.1	96	96.6
14	2.96	3.69	32.2	26.9	61.6	72.7	95	96.6
15	2.5	3.27	25.8	28.2	65.2	65.8	96	96.2
16	4.77	3.08	27.3	23.6	38.2	87.6	96	97.1
17	4.11	2.74	28.7	23.2	38.1	82.8	97	97.1
18	3.64	2.76	26.1	26.1	36.3	72.8	98	96.2
19	3.63	4.18	29.4	31.2	36.1	48.3	98	97.9
20	4.88	4.52	26.9	20.6	35.7	64.5	98	97.6
21	2.56	3.92	25.8	22.2	71.3	63.6	98	97
22	2.46	3.02	22.2	22	62.8	66.2	97	97.4
23	2.14	4.35	29.2	21.7	58.9	64.8	96	97.6
24	1.76	2.85	32.6	28	61.2	66.2	96	97.8
25	2.51	3.16	29.7	31.6	52.8	61.9	98	98
26	3.82	4.35	24.3	20.5	149	133	96	96.4
27	2.84	2.93	17.7	19.5	161	182	96	96
28	2.73	2.64	19.2	14.9	161	181	97	97.1
29	2.3	3.74	18.4	13.2	166	148	98	97.1
30	2.38	2.69	18.8	21	108	112	96	96.9
31	5.48	5.98	21.5	21	89.3	81.4	99	96.8
32	5.63	6.24	19.2	20.2	79.9	77.2	97	97
33	5.14	6.05	15.9	20.9	74.7	86.9	96	96.9
34	4.78	6.27	16.6	18.8	49.7	58.7	98	97.5
35	5.67	5.99	16.8	18.6	44.8	55.8	98	97.7
36	5.46	5.53	15.7	16.2	89.3	86.1	98	97.6
37	5.31	3.77	18.3	13.8	78.5	91.8	99	98.2
38	4.78	4.78	18.9	14.3	61.8	67.7	98	97.9
39	4.71	5.34	12.4	16.7	54.9	48.7	98	97.4
40	6.72	5.39	16.4	16.1	48.6	47.6	97	97.5
41	3.72	2.8	27.2	26.5	34.3	115	99	98
42	2.91	3.92	25.4	29.9	37.6	36.2	97	96.8
43	2.32	2.27	32.5	28.6	39.7	37.5	96	97
44	3.12	4.06	26.1	30.4	41.2	40.6	97	96.9
45	2.6	1.93	29.1	26.7	40.9	55.1	97	97.7
46	1.17	0.829	18.7	17.9	69.3	59.2	98	98.5
47	1.49	2.26	22.9	21.4	61.8	53.9	99	96.8
Correlation	**0.833605**		**0.754685**		**0.780164**		**0.587272**	

2. **Model for machine vibration value :**

workpiece, feed, atmosphere hve the largest impact on machine vibration which can be seen from ANN model. From comparision chart it is also seen that machine vibration at some starting experiment is very high because friction losses are very high at the starting. To imrove the quality of workpiece and to reduce noise level we could follw experiment no. 49, this will give satisfactory result for turning process on lathe.

3. **Model for tool temperature value :**

material of tool and feed have greatest impact on tool temperature, it can be concluded from ANN network. As we feed increases the tool temprature will increase. Also if hardness of tool is very high then tool temperature will be also high. High temperature will affect the surface finish of workpeice. For reducing this nrisk we can follw the experiment no. 9 which will give perfect parameters for turning process.

4.**Model for SPO2 value:**

ANN network shows the SPO2 has great impact on the workers pulse rate.From network diagram of SPO2 value the column no.1,2 & 3 has more avg.value of input layer output than experiment no.3,4 & 5.Hence the experiment no.1,2 & 3 is more suitable for this experiment.Hence it is suggested to use the suggested levels of the input parameters for getting the various response according to the customers requirements.

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