Chapter 8

Optimization of the Machining Parameter of Lm6 Aluminum Alloy in CNC Turning Using Neural Network

S Arunkumar[1*], V Muthuraman[2], T Vinod Kumar[3], R Muraliraja[3]

[1]Assistant Professor, Department of Mechanical Engineering, Vels Institute of Science, Technology and Advanced Studies, Chennai-600 117, Tamil Nadu, India*

[2]Professor, Department of Mechanical Engineering, Vels Institute of Science, Technology and Advanced Studies, Chennai-600 117, Tamil Nadu, India

[3]Associate Professor, Department of Mechanical Engineering, Vels Institute of Science, Technology and Advanced Studies, Chennai-600 117, Tamil Nadu, India

**Corresponding mail id: gct.arunkumar@gmail.com*

Abstract

With the emergence of the global manufacturing era, the manufacturing environment has become increasingly competitive, as markets become more dynamic and customer driven. This intense competition has focused the attention of manufacturers towards automation. To realize full automation in machining, computer numerically controlled (CNC) machine tools have been implemented during the past decades. In this project a solution is trained for the problem of choosing machine setup parameters for a turning operation using the theories of artificial neural networks.

Artificial neural networks have the ability to learn mapping between a set of input and output values. Once a network is trained, it can be used to forecast output values for a given set of input values. Trained program can be used to generate process inputs such as cutting speed, feed, depth of cut and coolant flow rate and their corresponding process output such as surface finish. This method uses back propagation neural networks to accomplish forward mapping of process inputs and process outputs. These networks can then be used interactively to choose the best machine setup parameter. A program has been developed in MATLAB for solving the model. The result from the experiment is validated with a neural network.

Keywords: *Aluminim alloy, CNC Turning, Optimization, Machining parameter, Neural Network.*

1. Introduction

The machining parameters are chosen to satisfy various economic objectives. These objectives can maximize production, minimize cost, and maximize surface Finish. Parameter selection for a machining process is choosing the right combination of machine speed, feed, and depth of cut and coolant flow rate. Traditionally choosing the parameters has been based on experience using a lot of trial and error. Machine shops maintained historical data on metal cutting characteristics of work piece tool combination. Often these data are used to set up a machine. Lots of times, these data become outdated with the introduction of newer materials, newer cutting tools, and machine tools. Generating metal cutting characteristics for newer material, cutting tools, and machine tools requires significant investment in terms of time, machine and human resource. In this project a solution is prepared for the problem of choosing appropriate machine setup parameters for a CNC turning operation using the theories of artificial neural networks.

ISBN 978-819704204-1

2. Experimental Procedure

2.1 Problem definition:

The percentage contributions of parameters namely, cutting speed, feed rate, depth of cut and coolant flow rate has to be estimated in order to better control the surface roughness.

2.2. Importance of surface roughness:

To a manufacturing engineer, production costs, production rates, and surface quality are of very much importance. Although a high production rate will probably lead to low production costs, these two factors are considered separately and that the manufacturing conditions giving maximum production rate will not be identical to those conditions giving minimum cost of production. Although the analysis of production cost and rate can be very complicated, experience gained over the years has led to certain empirical rules or guiding principles for choosing the optimum cutting conditions for a given machining operation.

2.3 Neural Networks:

An Artificial Neural Network is an information processing paradigm that is inspired by the way biological nervous systems, such as the brain, process information. The key element of this paradigm is the novel structure of the information processing system.

2.3.1 How the Neural Network Works:

Neural networks take a different approach to problem solving than that of conventional computers. Neural networks process the information in a similar way the human brain does. The network is composed of a large number of highly interconnected processing elements working in parallel to solve a specific problem. Neural networks learn by example.

3. Experimental Process

3.1 Experimental setup:

The experiments were conducted on a CNC turning machine the cutting tool used was Corbite cutting tools. A Taly surf profile meter was used to measure the surface of the turned parts. The work piece material was LM6 Aluminium Alloy.

3.2 Experimental setting of the work piece and turning process:

Fig 1: JOBER XL CNC turning machine

Fig.1 Illustrates the experimental settings in this project for work piece and turning operations.

3.3 Work piece:

The materials used for the experiment were 50mm dia x 30mm length LM6 aluminIum alloy.

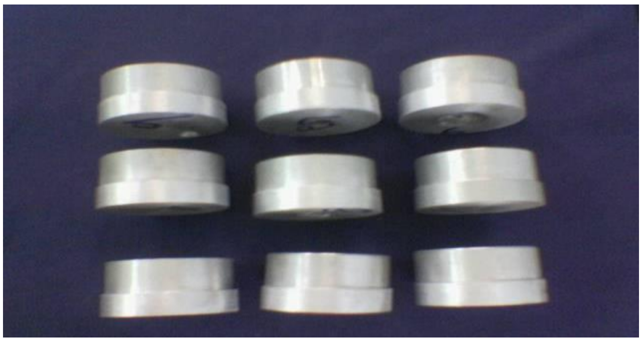

Fig 2: Specimen

ISBN 978-819704204-1

3.4 Details of experiments conducted:

Taguchi experiments to identify the optimum surface roughness and to find the percentage contribution of parameters namely speed, feed rate, depth of cut and coolant flow rate. Taguchi $L_9(3^4)$ orthogonal array was used to design the experiments. Following are the parameters and their levels.

Table. 1 Variables factor levels

Controllable factors	Level 1	Level 2	Level 3
Depth of cut (mm)	0.4	0.6	0.8
Spindle speed (rpm)	1400	2000	2600
Feed (mm/rev)	0.05	0.15	0.25
Coolant flow rate (lit/sec)	0.02	0.05	0.1

Table. 2 Orthogonal array $L_9(3^4)$

Experiment no	Control factor assignment and column number				Average Response Value (Ra_i) µm
	Dept of cut (mm)	Speed (rpm)	Feed (mm/rev)	Coolant flow rate (lit/sec)	
1	0.4	1400	0.05	0.02	0.69
2	0.4	2000	0.15	0.05	2.27
3	0.4	2600	0.25	0.1	2.72
4	0.6	1400	0.15	0.1	2.03
5	0.6	2000	0.25	0.02	1.94
6	0.6	2600	0.05	0.05	0.71
7	0.8	1400	0.25	0.05	1.75
8	0.8	2000	0.05	0.1	0.70
9	0.8	2600	0.15	0.02	0.82

The predicted optimal surface roughness = 0.01≤Ra ≤0.59 (μm)

The calculation C.I for confirmation runs =±0.29

The predicted optimal range (99% C.I) of the surface roughness for confirmation runs: Ra<0.59(μm)

The average value of surface roughness for confirmation runs at the optimal setting of turning process parameters was found to be 0.54μ m.

3.5 Objective functions:

MINITAB software is used for calculating the coefficient of regression equation. This Linear surface roughness model has been used to find predicted value

3.6 Objective function equations:

Linear Surface Roughness Model

F(X) = 1.31238 - 2.00833*(C1) -0.00006*(C2) + 7.1833*(C3) + 7.97279*(C4)

C1=depth of cut (mm), C2=spindle speed (rpm), C3=feed rate (mm/rev)

C4=coolant flow rate (lit/sec)

3.7. Balanced L9 (3^4) orthogonal array:

Balanced L9 (3^4) Orthogonal Array have make for 81 different sequence, I have take for randomly 27 sequences.

ISBN 978-819704204-1

Table. 3 Predicted Values

Ex.No	Depth of Cut (mm)	Speed (rpm)	Feed (mm/rev)	Coolant Flow Rate (lit/sec)	Predicted value (µm)
1	0.4	1400	0.05	0.02	0.94
2	0.4	2000	0.15	0.05	1.86
3	0.4	2600	0.25	0.1	2.94
4	0.6	1400	0.15	0.1	2.29
5	0.6	2000	0.25	0.07	1.94
6	0.6	2600	0.05	0.05	0.70
7	0.8	1400	0.25	0.05	1.81
8	0.8	2000	0.05	0.1	0.74
9	0.8	2600	0.15	0.02	0.78
10	0.6	1400	0.05	0.02	0.54
11	0.8	1400	0.05	0.02	0.58
12	0.4	2000	0.05	0.05	1.14
13	0.8	2600	0.05	0.05	0.30
14	0.4	2600	0.05	0.1	1.50
15	0.6	2000	0.05	0.1	1.14
16	0.4	1400	0.15	0.02	1.66
17	0.6	2000	0.15	0.02	1.22
18	0.6	2600	0.15	0.05	1.42
19	0.8	2000	0.15	0.05	1.06
20	0.4	1400	0.15	0.1	2.29
21	0.8	1400	0.15	0.1	1.49
22	0.4	2000	0.25	0.02	2.34
23	0.8	2600	0.25	0.02	1.50
24	0.4	1400	0.25	0.05	2.61
25	0.6	1400	0.25	0.05	2.21
26	0.6	2000	0.25	0.1	2.58
27	0.8	1400	0.25	0.1	2.21

4. Results and Discussions

4.1 Discussions of results obtained through neural network:

The predicted values of the network seem to fall in acceptable range. In certain cases, the percentage error went around 10%. Though such errors can be treated as exceptional cases and ignored, they can also be justified as the actual values are very small and even a small deviation in the predicted value can result in a higher percentage of error. Although the network has successfully derived the relationship between the input and output parameters.

4.2 Testing phase:

The 10 sets of data were used for the testing purpose. The test data also should be normalized from. After the successful training, the test data will be given as input to the system. The network gives the predicted output parameters. The test data is given in the table.

Table.4 Testing phase

Ex.No	Depth of Cut (mm)	Speed (rpm)	Feed (mm/rev)	Coolant Flow Rate (lit/sec)	Predicted value (µm)	Neural network value (µm)	% Error
18	0.6	2600	0.15	0.05	1.42	1.36	4.20
19	0.8	2000	0.15	0.05	1.06	1.07	-0.97
20	0.4	1400	0.15	0.1	2.29	2.21	3.40
21	0.8	1400	0.15	0.1	1.49	1.42	4.60
22	0.4	2000	0.25	0.02	2.34	2.41	-2.99
23	0.8	2600	0.25	0.02	1.50	1.56	-4.00
24	0.4	1400	0.25	0.05	2.61	2.68	-2.61
25	0.6	1400	0.25	0.05	2.21	2.14	3.16
26	0.6	2000	0.25	0.1	2.58	2.62	-4.00
27	0.8	1400	0.25	0.1	2.21	2.28	-3.16

ISBN 978-819704204-1

4.3 Simulation phase:

The two sets of data were used for the simulation purpose. The data also should be in normalized form. The simulation data will be given as input to the system. The Network gives the predicted output surface roughness. The simulation data was conducted for the experiment and measured the Ra value. If the Ra value from the neural network is nearer to the Ra from the experiment, it can be concluded that the trained network is correct.

Table. 5 Simulation phase

Ex.No	Depth of Cut (mm)	Speed (rpm)	Feed (mm/rev)	Coolant Flow Rate (lit/sec)	Neural network value (µm)	Experimental Value
1	0.75	1500	0.16	0.02	1.50	1.54
2	0.45	1300	0.06	0.03	0.93	0.97

4.4. Optimum predicted values for neural networks:

Thus the optimal turning process parameters obtained from the neural network.

Depth of cut = 0.8 mm

Speed = 2600 rpm

Feed rate = 0.05 mm/rev

Coolant flow rate = 0.05 lit/sec

Surface roughness value = 0.38 µm

5. Conclusion

Artificial Neural Networks have successfully predicted the outputs. Many efforts were required for finding out optimum architecture. It was noticed that for a particular pattern of data, there exists a particular network architecture, which can minimize the errors and this is to be found out by trial and error method and sometimes by experience. The