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Development of New Genetic Algorithm Software for Blow Mould Process

K.Kadirgama[1], M.M.Noor[2], R.Daud[2], M.R.M.Rejab[2], M.S.M.Sani[2], Z.Ghazalli[2], Z.Hamedon[3]
[1]Automotive Excellent Center, Universiti Malaysia Pahang,
[2]Faculty of Mechanical Engineering, Universiti Malaysia Pahang,
[3]Faculty of Manufacturing Engineering and Technology Management,
Lebuhraya Tun Abd Razak, 26300, Kuantan, Pahang, MALAYSIA.
Phone: +609-5492223, Fax: +6095492244,
(kumaran@ump.edu.my / muhamad@ump.edu.my)

Abstract This paper is concerned on the optimization of the surface roughness when milling mould aluminium alloys (AA6061-T6) with carbide coated inserts with newly develop Genetic Algorithm (GA) software. Optimization of the milling is very useful to reduce cost and time for machining mould. The approach is based on newly development of Genetic Algorithm software. In this work, the objectives were to optimized parameters with newly develop software and compare with statistical software. The optimized value has been used to develop a blow mould. Results from the newly develop GA software is closer with the statistical software. This software directly reduces in term of machining cost.

Keywords: Genetic Algorithm, software, blow mould, optimized

I. INTRODUCTION

Roughness plays an important role in determining how a real object will interact with its environment. Rough surfaces usually wear more quickly and have higher friction coefficients than smooth surfaces. Roughness is often a good predictor of the performance of a mechanical component, since irregularities in the surface may form nucleation sites for cracks or corrosion. Although roughness is usually undesirable, it is difficult and expensive to control in manufacturing. Decreasing the roughness of a surface will usually increase exponentially its manufacturing costs. This often results in a trade-off between the manufacturing cost of a component and its performance in application.

Recent investigation performed by Alauddin *et al.* [1] has revealed that when the cutting speed is increased, productivity can be maximised and, meanwhile, surface quality can be improved. According to Hasegawa *et al*. [2], surface finish can be characterised by various parameters such as average roughness (Ra), smoothening depth (Rp), root mean square (Rq) and maximum peak-to-valley height (Rt). The present study uses average roughness (Ra) for the characterisation of surface finish, since it is widely used in industry. By using factors such as cutting speed, feed rate and depth of cut, Hashmi and his coworkers [3, 4] have developed surface roughness models and determined the cutting conditions for 190 BHN steel and Inconel 718. EI-Baradie [5] and Bandyopadhyay [6] have shown that by increasing the cutting speed, the productivity can be maximised and, at the same time, the surface quality can be improved. According to Gorlenko [7] and Thomas [8], surface finish can be characterised by various parameters. Numerous roughness height parameters such as average roughness (Ra), smoothening depth (Rp), root mean square (Rq), and maximum peak-to-valley height (Rt) can be closely correlated. The present study uses average roughness (Ra) for the characterisation of surface roughness, due to the fact that it is widely adopted in the industry for specifying the surface roughness. Mital and Mehta [9] have conducted a survey of the previously developed surface roughness prediction models and factors influencing the surface roughness. They have found that most of the surface roughness prediction models have been developed for steels.

II. RESPONSE SURFACE METHOD

Box-Behnken Design is normally used when performing non-sequential experiments. That is, performing the experiment only once. These designs allow efficient estimation of the first and second –order coefficients. Because Box-Behnken design has fewer design points, they are less expensive to run than central composite designs with the same number of factors. Box-Behnken Design do not have axial points, thus we can be sure that all design points fall within the safe operating. Box-

Behnken Design also ensures that all factors are never set at their high levels simultaneously [10 - 12].

Genetic Algorithm (GA) was used to find the optimum weight, momentum and step size to be used in Radian Basis Function Network (RBFN). Later the optimum weight will be fed to the RBFN. Then, train the network until the R.M.S.E reaches a satisfactory value. The training data acquired from Response Surface Method to RBFN mode, and the epoch number is 10,000 [13]. After 1,000 iterations, the RBFN is better enough to produce acceptable results. Transfer function used as sigmoid, while for the momentum used is 0.7.

III. EXPERIMENTAL SET-UP

The 27 experiments were carried out on HAANS machining centre with 6-axis as shown in Figure 1. The water soluble coolant was used in these experiments. Each experiment was stopped after 90 mm cutting length. For the surface roughness measurement surface roughness tester was used. Each experiment was repeated three times using a new cutting edge every time to obtain accurate readings of the surface roughness. The physical and mechanical properties of the workpiece are shown in Table 1 and Table 2. After the preliminary investigation, the suitable levels of the factors are used in the statistical software to deduce the design parameters for Aluminium Alloys (AA6061-T6) as shown in Table 3. The lower and higher speed values selected are 100 m/s and 180 m/s, respectively. For the feed, the lower value is 0.1 mm/rev and the higher value is 0.2 mm/rev. For the axial depth, the higher value is 0.2 mm and the lower value is 0.1 mm and for the radial depth the higher value is 5 mm and lower value is 2 mm.

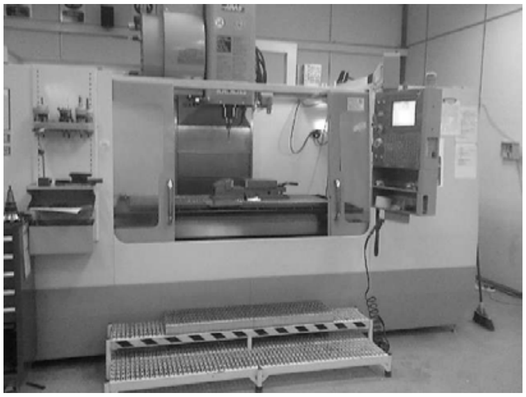


Figure 1: HAANS CNC milling with 6-axis

Table 1: Physical properties for workpiece

Component	Al	Cr	Cu	Fe	Mg	Mn	Si	Ti	Zn
Wt %	95.8-98.6	0.04-0.35	0.15-0.4	Max 0.7	0.8-1.2	Max 0.15	0.4-0.8	Max 0.15	Max 0.25

Table 2: Mechanical properties for workpiece

Hardness, Brinell	95
Hardness, Knoop	120
Hardness, Rockwell A	40
Hardness, Rockwell B	60
Hardness, Vickers	107
Ultimate Tensile Strength	310 MPa
Tensile Yield Strength	276 MPa
Elongation at Break	12 %
Elongation at Break	17 %
Modulus of Elasticity	68.9 GPa
Density	2.7 g/cc

Table 3: Design Parameters

Cutting speed (m/min)	**Feedrate (mm/rev)**	**Axial depth (mm)**	**Radial depth (mm)**
140	0.15	0.1	5
140	0.15	0.15	3.5
100	0.15	0.15	5
140	0.15	0.15	3.5
180	0.15	0.2	3.5
180	0.15	0.15	2
100	0.2	0.15	3.5
140	0.15	0.15	3.5
180	0.15	0.15	5
100	0.15	0.2	3.5
140	0.2	0.1	3.5
180	0.1	0.15	3.5
140	0.15	0.2	2
180	0.15	0.1	3.5
140	0.1	0.15	2
140	0.15	0.2	5
100	0.15	0.1	3.5
140	0.2	0.15	2
100	0.15	0.15	2
140	0.2	0.15	5
140	0.1	0.1	3.5
140	0.2	0.2	3.5
140	0.15	0.1	2
100	0.1	0.15	3.5
180	0.2	0.15	3.5
140	0.1	0.2	3.5
140	0.1	0.15	5

IV. RESULTS AND DISCUSSION

The first order linear equation for predicting the surface roughness is expressed as:

$$y = 0.5764 + 0.0049x_1 - 3.5850x_2 + 1.5383x_3 - 0.016x_4 \qquad (1)$$

Generally, reduction in cutting speed, axial depth of cut will cause the surface roughness to become larger. On the other hand, the increase in feedrate and axial depth will slightly cause a reduction in surface roughness. The feedrate has the most dominant effect on the surface roughness, followed by the axial depth, cutting speed and radial depth. Hence, a better surface roughness is obtained with the combination of low cutting speed and axial depth, high feederate and radial depth. The adequacy of the first order model was verified using the analysis of variance (ANOVA). At a level of confidence of 95%, the model was checked for its adequacy.

As it is shown in Table 4, indicates that the model is adequate since the P values of the lack-of-fit are not significant and F- statistics is 2.27. This implies that the model could fit and it is adequate. The optimum value for surface roughness is 0.4261 µm, which corresponds to design variables: Cutting speed (m/min) =100, Feed rate (mm/rev) = 0.2, Axial depth (mm) = 0.1 and Radial depth (mm) = 5.0. Figure 2 shows the surface roughness values obtained by experimentation and the values predicted by the first order model and RBFN. It is clear that the predicted values by RBFN are very close to the experimental readings. The sensitivity test done to obtained the most effecting variables towards surface roughness as shown in Figure 3a. The test shows that federate is the main domain followed by axial depth, radial depth and cutting speed. The final product of the blow mould has a surface roughness 0.45µm as shown in Figure 3b. Eventually the time of machining has been reduced with the optimized method.

Table 4: ANOVA analysis

Source	Degree of freedom	Seq. sum of square	Adj. sum of square	Adj. mean of square	F-ratio	P-ratio
Regression	4	0.9309	0.9309	0.2327	0.78	0.552
Linear	4	0.9309	0.9309	0.2327	0.78	0.552
Residual Error	22	6.5937	6.5937	0.2997		
Lack-of-Fit	20	6.3151	6.3151	0.3158	2.27	0.351
Pure Error	2	0.2786	0.2786	0.1393		
Total	26	7.5246				

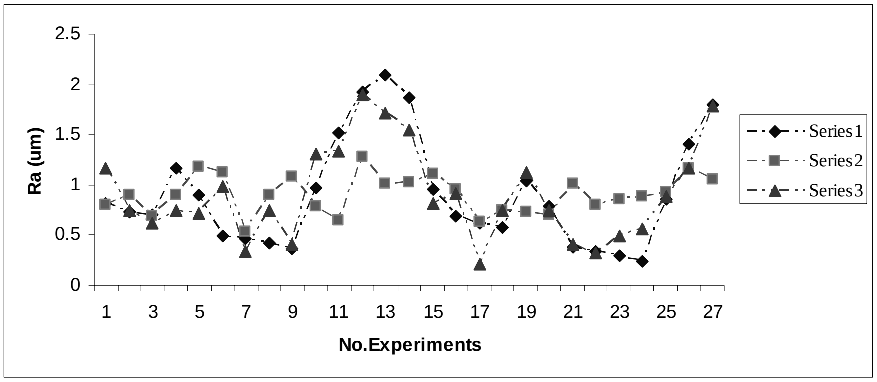
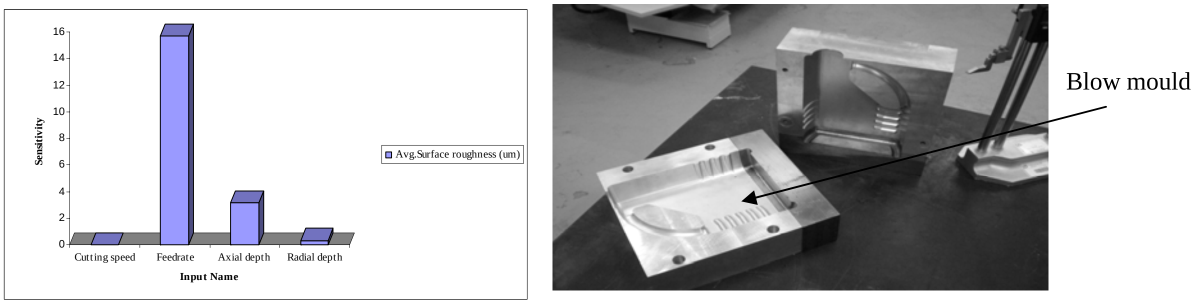


Figure 2: Comparison between experimental results and predicted results (First order & RBFN)



(a)

(b)

Figure 3: (a) Sensitivity test; (b) Blow mould

V. CONCLUSION

The developed software has been found to accurately representing surface roughness values with respect to experimental results. The models reveal that feedrate is the most significant design variable in determining surface roughness response as compared to others. With the model equations obtained, a designer can subsequently select the best combination of design variables for achieving optimum surface roughness. This eventually will reduce the machining time and save the cutting tools.

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