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EXPERIMENTAL INVESTIGATION TO PREDICT TOOL LIFE IN FACE MILLING OF ALUMINUM ALLOY USING DESIGN OF EXPERIMENTS

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Abstract:

Milling process is the second most common method (after turning) for metal cutting and especially for the finishing of machined parts. In modern industry the goal is to manufacture low cost, high quality products in short time. Predictive models of machining processes and tool life can be applied to help businesses gain a competitive edge.

In this time of expanding global markets, it has become essential for manufacturers to improve process efficiencies, maintain stricter part tolerances, and enhance part quality.

Furthermore, the motivation for using analytical tools for process optimization, rather than costly trial and error, has perhaps never been greater.

In this thesis, the tool life is optimized using technique Design of Experiments by machining Aluminum alloy 7075 varying parameters spindle speed, feed rate and depth of cut. Experiments are conducted by considering machining parameters and evaluating tool life. Design of Experiments is done using Taguchi in Minitab software.

I. INTRODUCTION

Milling is the process of cutting away material by feeding a work piece past a rotating multiple tooth cutter. The cutting action of the many teeth around the milling cutter provides a fast method of machining. The machined surface may be flat, angular, or curved. The surface may also be milled to any combination of shapes. The machine for holding the work piece, rotating the cutter, and feeding it is known as the Milling machine.

Face Milling

Face milling is the most common milling operationand can be performed using a wide range of different tools. Cutters with a 45º entering angle are most frequently used, but round insert cutters, square shoulder cutters and side and face mills are also used for certain conditions.

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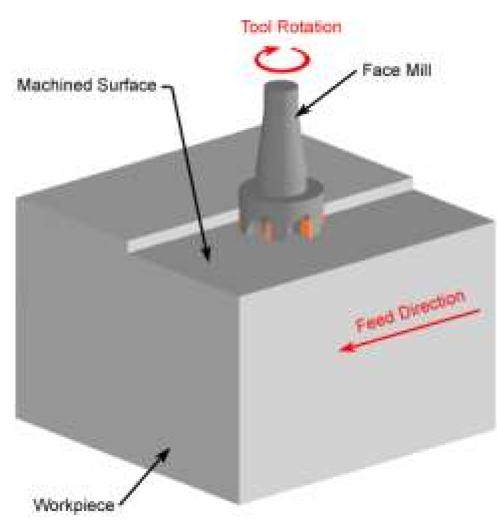

Fig: 1 face milling

TAGUCHI TECHNIQUE

Taguchi defines Quality Level of a product as the Total Loss incurred by society due to failure of a product to perform as desired when it deviates from the delivered target performance levels.This includes

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costs associated with poor performance, operating costs (which changes as a **Taguchi Methods**

Help companies to perform the Quality Fix!, Quality problems are due to Noises in the product or process system, Noise is any undesirable effect that increases variability, Conduct extensive Problem Analyses, Employ Inter-disciplinary Teams, Perform Designed Experimental Analyses, Evaluate Experiments using ANOVA and Signal-to noise techniquesproduct ages) and any added expenses due to harmful side effects of the product in use.

SURFACE FINISH

Surface finish, also known a surface texture or surface topography, is the nature of a surface as defined by the 3 characteristics oflay, surface roughness, and waviness. It comprises the small local deviations of a surface from the perfectly flat ideal (a true plane).Surface texture is one of the important factors that control friction and transfer layer formation during sliding. Each manufacturing process (such as the many kinds of machining) produces a surface texture. The process is usually optimized to ensure that the resulting texture is usable. If necessary, an additional process will be added to modify the initial texture. The latter process may be grinding (abrasive cutting), polishing, lapping, abrasive blasting, honing, electrical discharge machining (EDM), milling,lithography, industrial etching/chemical milling, laser texturing, or other processes.

II. METHODOLOGY

In this work, experimental results were usedfor Optimization of input machining parametersspeed, feed, and depth of cut using Taguchi Technique for the response Surface finish ,material removal rate and tool life.

. III. LITERATURE SURVEY

Modeling of the Influence of Cutting Parameters on the Surface Roughness, Tool Wear and Cutting Force in Face Milling in Off-Line Process Control by Dražen Bajić* – Luka Celent – Sonja Jozić, University of Split, Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture, Croatia

Off-line process control improves process efficiency. This paper examines the influence of three cutting parameters on surface roughness, tool wear and cutting force components in face milling as part of the off-line process control. The experiments were carried out in order to define a model for process planning. Cutting speed, feed per tooth and depth of cut were taken as influential factors. Two modeling methodologies, namely regression analysis and neural networks have been applied to experimentally determined data. Results obtained by the models have been compared. Both models have a relative prediction error below 10%. The research has shown that when the training dataset is small neural network modeling methodologies are comparable with regression analysis methodology and can even offer better results, in which case an average relative error of 3.35%. Advantages of off-line process control which utilizes process models by using these two modeling methodologies are explained in theory.

PREDICTION OF SURFACE ROUGHNESS IN END MILLING WITH GENE EXPRESSION PROGRAMMING by Yang Yang, Xinyu Li, Ping Jiang, Liping Zhang

Surface roughness has a great influence on the functional properties of the product. Finding the rules that how process factors and environment factors affect the values of surface roughness will help to set the process parameters of the future and then improve production quality and efficiency. Since surface roughness is impacted by different machining parameters and the inherent uncertainties in the machining process, how to predict the surface roughness becomes a challengeable problem for the researchers and engineers. In this paper, a method based on gene expression programming (GEP) has been proposed to construct the prediction model of surface roughness. GEP combines the advantages of the genetic algorithm (GA) and genetic programming (GP). By considering GEP as a very successful technique for function mining and formula found, it should be suitable to solve the above problem. On the basis of defining a GEP environment for the problem and improving the method of creating constant, the explicit prediction model of surface roughness can been constructed. To verify the feasibility and performance of the proposed approach, experimental studies conducted to compare this approach with some previous works are presented. The experimental

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results show that the proposed approach has achieved satisfactory improvement and obtained good results for several widespread studied problems

INPUT PARAMETERS

EXPERMENTAL SETUP

Experiments have been performed in order to investigate the effects of one or more factors of the process parameters (spindle speed, feed rate and depth of cut) on the surface finish, tool life and material removal rate of the machined surface.

The main aim of the project is to determine the influence of radius carbide tips in metal working. The investigation is based on surface roughness during face milling of Aluminum alloy 7075 with carbide tool. The cutting parameters considered are feed rate, spindle speed and depth of cut.

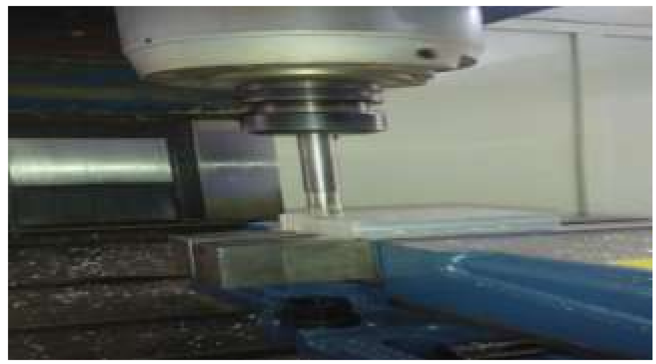
TABLE 2: ORTHOGONAL ARRAY WITH PROCESS PARAMETERS

JOB NO.	SPINDLE SPEED (rpm)	FEED RATE (mm/min)	DEPTH OF CUT (mm)
1	2000	200	0.3
2	2000	300	0.4
3	2000	400	0.5
4	2500	200	0.4
5	2500	300	0.5
6	2500	400	0.3
7	3000	200	0.5
8	3000	300	0.3
9	3000	400	0.4

Milling machining process

TABLE 1:PROCESS PARAMETERS AND THEIR LEVELS

PROCESS PARAMETERS	LEVEL1	LEVEL2	LEVEL3
CUTTING SPEED(rpm)	2000	2500	3000
FEED RATE (mm/rev)	200	300	400
DEPTH OF CUT(mm)	0.3	0.4	0.5



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MATERIAL REMOVAL RATE

JOB NO.	SPINDLE SPEED (rpm)	FEED RATE (mm/min)	DEPTH OF CUT (mm)	MRR(mm^3/sec)
1	2000	200	0.2	0.298
2	2000	300	0.3	0.334
3	2000	400	0.4	0.487
4	2500	200	0.3	0.887
5	2500	300	0.4	1.95
6	2500	400	0.2	0.747
7	3000	200	0.4	2.08
8	3000	300	0.2	0.41
9	3000	400	0.3	0.314

Tool life

JOB NO.	SPINDLE SPEED (rpm)	FEED RATE (mm/min)	DEPTH OF CUT (mm)	TOOL LIFE (min)
1	2000	200	0.3	500
2	2000	300	0.4	418
3	2000	400	0.5	321
4	2500	200	0.4	932
5	2500	300	0.5	856
6	2500	400	0.3	714
7	3000	200	0.5	1139
8	3000	300	0.3	907
9	3000	400	0.4	785

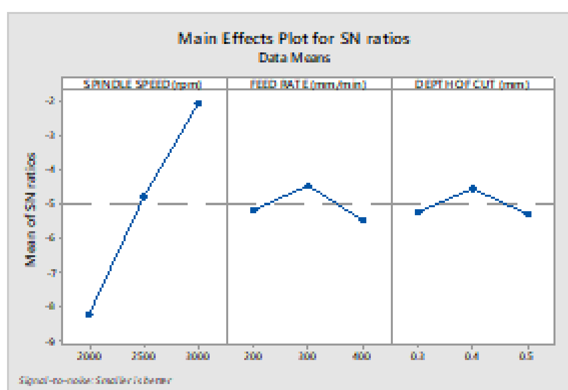
RESULTS AND DISCUSSION

In the Taguchi method the results of the experiments are analyzed to achieve one or more of the following three objectives. To establish the best or the optimum condition for a product or a process. To Studying the main effects of each of the factors identifies the

JOB NO.	SPINDLE SPEED (rpm)	FEED RATE (mm/min)	DEPTH OF CUT (mm)	Surface finish (R_a) μm
1	2000	200	0.3	2.89
2	2000	300	0.4	2.25
3	2000	400	0.5	2.64
4	2500	200	0.4	1.59
5	2500	300	0.5	1.64
6	2500	400	0.3	1.84
7	3000	200	0.5	1.3
8	3000	300	0.3	1.16
9	3000	400	0.4	1.35

optimum condition (Figures 2 and 3). The process involves minor arithmetic manipulation of the numerical result and usually can be done with the help of a simple calculator. The main effects indicate the general trend of the influence of the factors. Knowing the characteristic, i.e., whether a higher or lower value produces the preferred result, the levels of the factors, which are expected to produce the best results, can be predicted. Estimate the contribution of individual factors. To estimate the response under the optimum conditions. The knowledge of the contribution of individual factors is the key to deciding the nature of the control to be established on a production process.

EFFECT OF milling PARAMETERS ON Surface finish FOR S/N RATIO



EFFECT OF milling PARAMETERS ON Surface finish FOR MEANS

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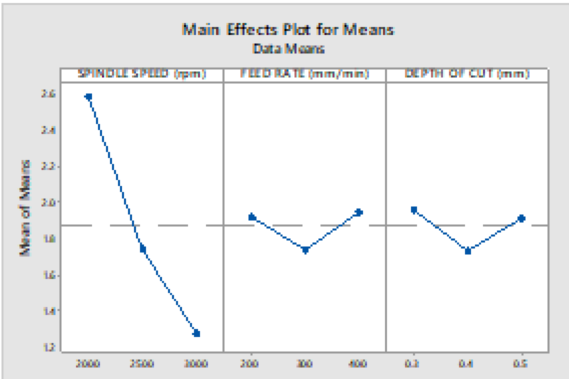
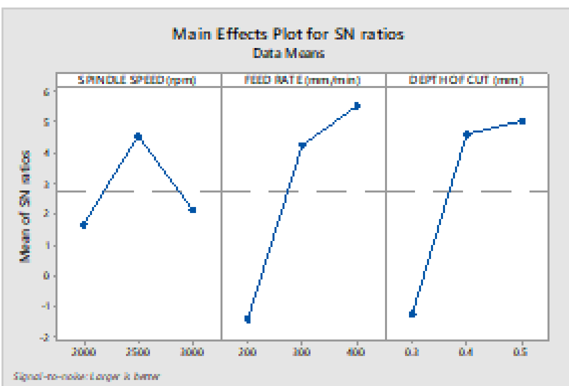
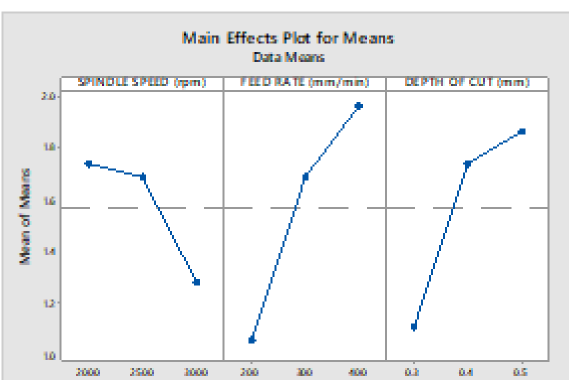


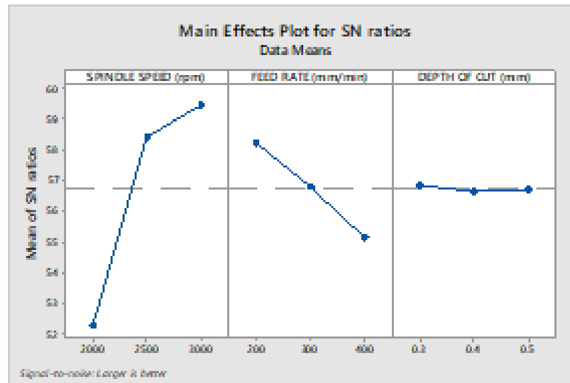
Effect of milling parameters on MRR for S/N ratio



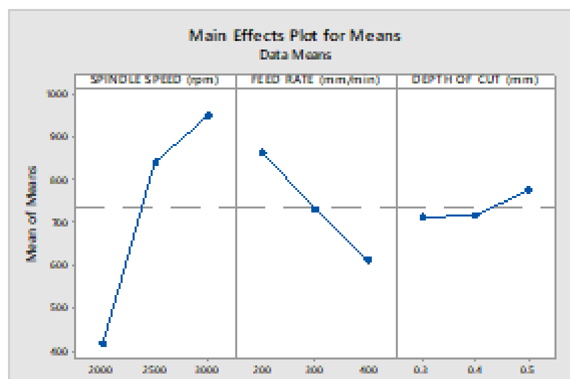
Effect of milling parameters on MRR for Means



Effect of milling parameters on tool life for S/N ratio



Effect of milling parameters on tool life for Means



Taguchi method stresses the importance of studying the response variation using the signal–to–noise (S/N) ratio, resulting in minimization of quality characteristic variation due to uncontrollable parameter. The cutting force is considered as the quality characteristic with the concept of "the smaller-the-better". The S/N ratio for the smaller-the-better is:

$$S/N = -10 *\log(\Sigma(Y^2)/n))$$

Where n is the number of measurements in a trial/row, in this case, n=1 and y is the measured

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value in a run/row. The S/N ratio values are calculated by taking into consideration above Eqn. with the help of software Minitab 17.

The force values measured from the experiments and their corresponding S/N ratio values are listed in Table

CONCLUSION

The cutting parameters are cutting speed, feed rate In this thesis experiments are done to optimize cutting parameters while machining Aluminum alloy 7075 using carbide cutting tool on a CNC vertical milling machine.

The cutting parameters are cutting speed, feed rate and depth of cut. In this work, the parameters considered for cutting speed are 2000rpm, 2500rpm and 3000rpm, feed rate are 200mm/min, 300mm/min and 400mm/min and depth of cut are 0.3mm, 0.4mm and 0.5mm. Experimental work is conducted by considering the above parameters. Surface finish and material removal rates are validated experimentally.By observing the experimental results the following conclusions can be made:

To get better surface finish, the optimal parameters are spindle speed – 3000rpm, feed rate – 300mm/min and depth of cut – 0.4mm.

To get high material removal rates, the optimal parameters are spindle speed – 2500rpm, feed rate – 400mm/min and depth of cut – 0.5mm.

To attain more tool life, the optimal parameters are spindle speed – 3000rpm, feed rate – 200mm/min and depth of cut – 0.3mm.

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