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.

Keywords: Leafspring, CREO, taguchi optimization

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 operation and 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. Milling Machine

INTRODUCTION TO CUTTING TOOLS

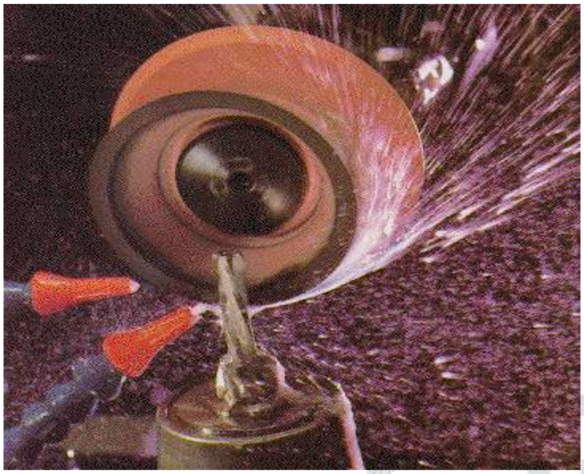
Cutting is the separation of a physical object, or a Portion of a physical object, into two portions, through the Application of an acutely directed force. An implement Commonly used for cutting is the knife or in medical cases The scalpel. However, any sufficiently sharp object is capable Of cutting if it has a hardness sufficiently larger than the Object being cut, and if it is applied with sufficient force. Cutting also describes the action of a saw which removes Material in the process of cutting. Cutting is a compressive And shearing phenomenon, and occurs only when the total Stress generated by the cutting implement exceeds the Ultimate strength of the material of the object being cut. The Simplest applicable equation is stress = force/area: The stress generated by a cutting implement is directly proportional to the force with which it is applied, and inversely proportional to the area of contact. Hence, the smaller the area (i.e., the sharper the cutting implement), the less force is needed to cut something.

INTRODUCTION TO CUTTING FLUIDS

Cutting fluids are used in metal machining for a variety of reasons such as improving tool life, reducing workpiece thermal deformation, improving surface finish and flushing away chips from the cutting zone. Practically all cutting fluids presently in use fall into one of four categories:

- Straight oils
- Soluble oils
- Semisynthetic fluids
- Synthetic fluids

Straight oils are non-emulsifiable and are used in machining operations in an undiluted form. They are composed of a base mineral or petroleum oil and often contains polar lubricants such as fats, vegetable oils and esters as well as extreme pressure additives such as Chlorine, Sulphur and Phosphorus. Straight oils provide the best lubrication and the poorest cooling characteristics among cutting fluids.



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 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.

III. LITERATURE SURVEY

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.

EXPERIMENTAL SETUP AND PROCEDURE

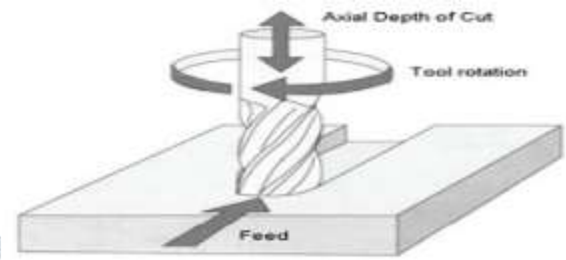
Experiments have been performed in order to investigate the effects of one or more factors of the process parameters (spindle speed, feed rate and depth of cut) on the surface finish, tool life and material removal rate of the machined surface.

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.

EXPERIMENTAL PROCEDURE

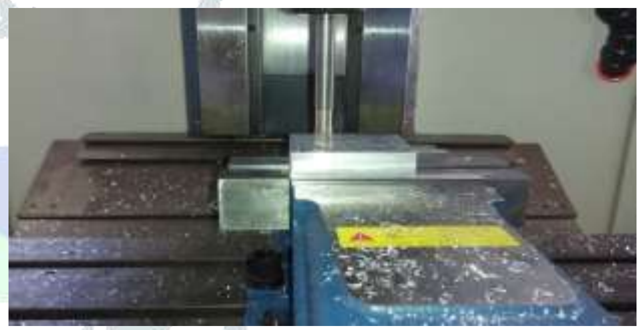
This experiment employed a CNC vertical milling machine. Carbide cutting tool is used. The experiment has been done under conditions of feed rate 200mm/min, 300mm/min, 400 mm/min, spindle speeds are 2000rpm, 2500rpm, 3000rpm, and depth of cut 0.3mm, 0.4 and 0.5mm.

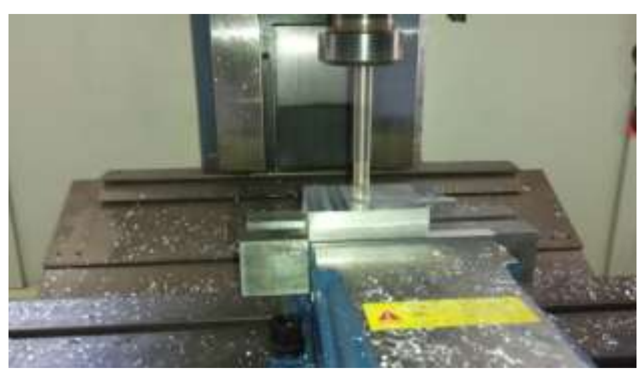
Square piece of aluminum alloy 7075 material is taken for machining.

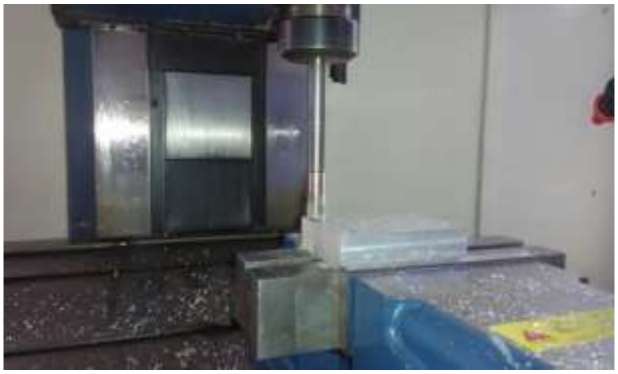


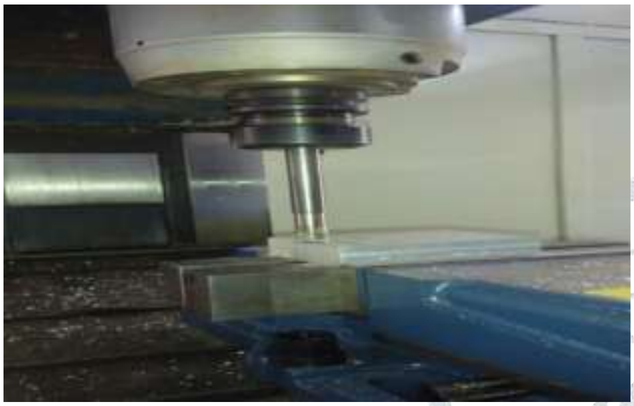
MACHINE SPECIFICATIONS

Machine Model – Feeler
Control – Siemens 840d
Travel Size X – 1000mm, Y – 500mm, Z – 500mm









SELECTION OF PROCESS PARAMETERS AS PER TAGUCHI TECHNIQUE

PROCESS PARAMETERS	LE VEL1	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

OBSERVATION

The following are the observations made by running the experiments.

SURFACE FINISH

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

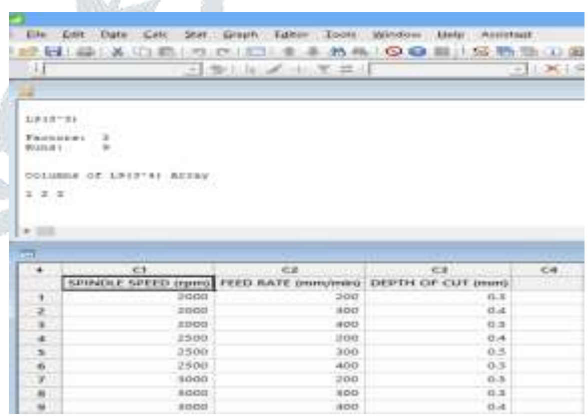
MATERIAL REMOVAL RATE

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

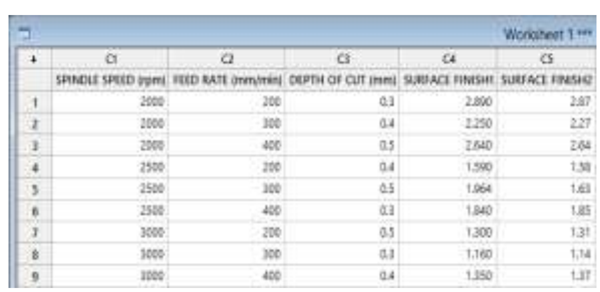
TOOL LIFE

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

OPTIMIZATION OF MACHINING PARAMETERS USING MINITAB SOFTWARE



SURFACE FINISH

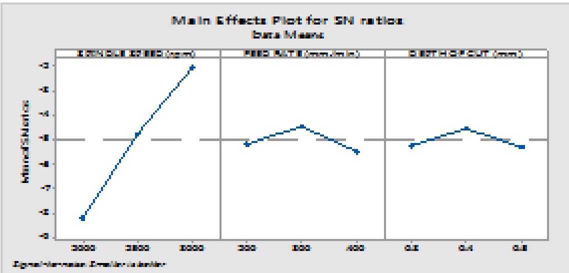


Worksheet 1 ***

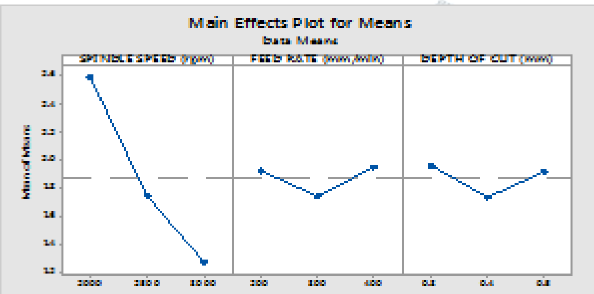
↓	C1	C2	C3	C4	C5
	SPINDLE SPEED (rpm)	FEED RATE (mm/min)	DEPTH OF CUT (mm)	SURFACE FINISH1	SURFACE FINISH2
1	2000	200	0.3	2.890	2.87
2	2000	300	0.4	2.250	2.27
3	2000	400	0.5	2.640	2.64
4	2500	200	0.4	1.590	1.58
5	2500	300	0.5	1.964	1.63
6	2500	400	0.3	1.840	1.85
7	3000	200	0.5	1.300	1.31
8	3000	300	0.3	1.160	1.14
9	3000	400	0.4	1.350	1.37

Worksheet 1 ***

↓	C1 SPINDLE SPEED (rpm)	C2 FEED RATE (mm/min)	C3 DEPTH OF CUT (mm)	C4 SURFACE FINISH1	C5 SURFACE FINISH2	C6 SNRA1	C7 MEAN1
1	2000	200	0.3	2.890	2.87	-9.18798	2.880
2	2000	300	0.4	2.250	2.27	-7.08225	2.260
3	2000	400	0.5	2.640	2.64	-8.43209	2.640
4	2500	200	0.4	1.590	1.38	-4.00860	1.589
5	2500	300	0.5	1.964	1.63	-5.12831	1.797
6	2500	400	0.3	1.840	1.85	-5.31998	1.845
7	3000	200	0.5	1.680	1.31	-3.31227	1.303
8	3000	300	0.3	1.160	1.14	-1.21428	1.150
9	3000	400	0.4	1.390	1.37	-2.87181	1.380



Effect of milling parameters on surface finish for S/N ratio



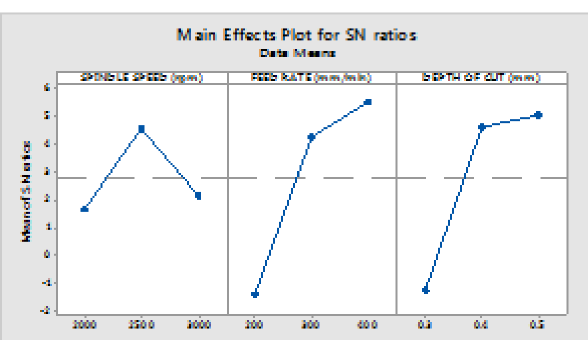
Effect of milling parameters on surface finish for Means

MATERIAL REMOVAL RATE

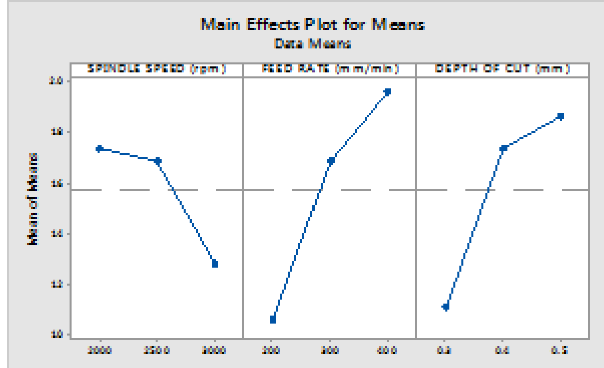
↓	C1 SPINDLE SPEED (rpm)	C2 FEED RATE (mm/min)	C3 DEPTH OF CUT (mm)	C4 MRR1	C5 MRR2
1	2000	200	0.3	0.298	0.295
2	2000	300	0.4	2.250	2.270
3	2000	400	0.5	2.640	2.670
4	2500	200	0.4	1.590	1.570
5	2500	300	0.5	1.640	1.630
6	2500	400	0.3	1.840	1.870
7	3000	200	0.5	1.300	1.310
8	3000	300	0.3	1.160	1.190
9	3000	400	0.4	1.350	1.390

Worksheet 1 ***

↓	C1 SPINDLE SPEED (rpm)	C2 FEED RATE (mm/min)	C3 DEPTH OF CUT (mm)	C4 MRR1	C5 MRR2	C6 SNRA2	C7 MEAN2
1	2000	200	0.3	0.298	0.295	-10.5598	0.2965
2	2000	300	0.4	2.250	2.270	7.0819	2.2600
3	2000	400	0.5	2.640	2.670	8.4006	2.6550
4	2500	200	0.4	1.590	1.570	3.9728	1.5800
5	2500	300	0.5	1.640	1.630	4.2702	1.6350
6	2500	400	0.3	1.840	1.870	5.3668	1.8550
7	3000	200	0.5	1.300	1.310	2.3120	1.3050
8	3000	300	0.3	1.160	1.190	1.5988	1.1750
9	3000	400	0.4	1.350	1.390	2.7216	1.3700



Effect of milling parameters on MRR for S/N ratio



Effect of milling parameters on MRR for Means

Worksheet 1 ***

↓	C1 SPINDLE SPEED (rpm)	C2 FEED RATE (mm/min)	C3 DEPTH OF CUT (mm)	C4 MRR1	C5 MRR2	C6 SNRA2	C7 MEAN2
1	2000	200	0.3	0.298	0.295	-10.5598	0.2965
2	2000	300	0.4	2.250	2.270	7.0819	2.2600
3	2000	400	0.5	2.640	2.670	8.4006	2.6550
4	2500	200	0.4	1.590	1.570	3.9728	1.5800
5	2500	300	0.5	1.640	1.630	4.2702	1.6350
6	2500	400	0.3	1.840	1.870	5.3668	1.8550
7	3000	200	0.5	1.300	1.310	2.3120	1.3050
8	3000	300	0.3	1.160	1.190	1.5988	1.1750
9	3000	400	0.4	1.350	1.390	2.7216	1.3700

TOOL LIFE

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L9(3^4)

Factors: 3
Runs: 9

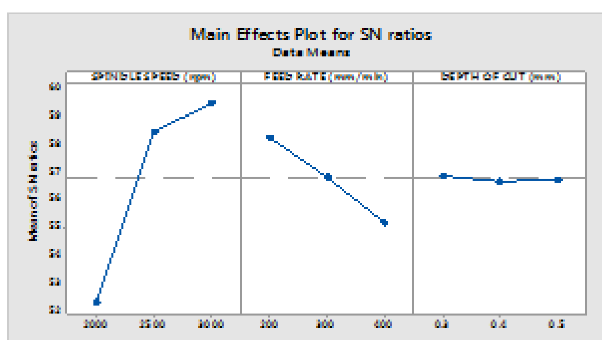
Columns of L9(3^4) Array

1 2 3

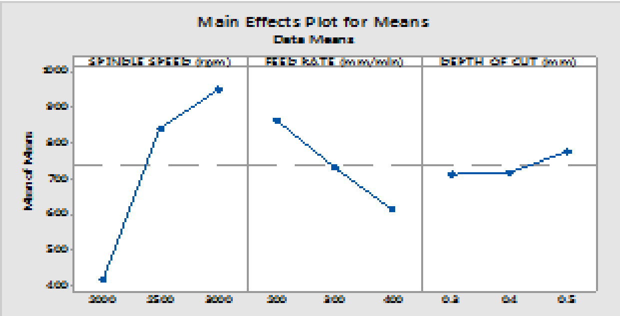
↓	C1 SPINDLE SPEED (rpm)	C2 FEED RATE (mm/min)	C3 DEPTH OF CUT (mm)	C4
1	2000	200	0.3	
2	2000	300	0.4	
3	2000	400	0.5	
4	2500	200	0.4	
5	2500	300	0.5	
6	2500	400	0.3	
7	3000	200	0.5	
8	3000	300	0.3	
9	3000	400	0.4	

Worksheet 1 ***

↓	C1 SPINDLE SPEED (rpm)	C2 FEED RATE (mm/min)	C3 DEPTH OF CUT (mm)	C4 TOOL LIFE1	C5 TOOL LIFE2
1	2000	200	0.3	500	512
2	2000	300	0.4	418	425
3	2000	400	0.5	321	334
4	2500	200	0.4	932	943
5	2500	300	0.5	856	859
6	2500	400	0.3	714	729
7	3000	200	0.5	1139	1147
8	3000	300	0.3	907	918
9	3000	400	0.4	785	799



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



Effect of milling parameters on tool life for Means

CONCLUSION

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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