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EXPERIMENTAL INVESTIGATION ON DIFFERENT MATERIALS WITH CNC MACHINING PROCESS BY USING TAGUCHI METHOD

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ABSTRACT

Turning process is one of the most fundamental machining processes used in the manufacturing industry. The process of turning is influenced by many factors such as cutting velocity, feed rate, depth of cut, geometry of cutting tool, and cutting conditions etc., to name a few. In machining operations, achieving the desired surface quality of the machined product is really a challenging job. This is due to the fact that quality is highly influenced by process parameters directly or indirectly. However, the extent of significant influence of the process parameters is different for different responses.

In this thesis the effect of insert nose radius and machining parameters including cutting speed, feed rate and depth of cut on surface roughness and material removal rate (MRR) in a turning operation are investigated by using the Taguchi optimization method.

In this project, at different materials and cutting parameters are at spindle speed of 2400,1600 and 800 rpm, feed rate of 140, 120, 100 mm/min, depth of cut of 0.5 ,0.6 and 0.7 mm while for material removal rate are at spindle speed of 2400,1600 and 800 rpm, feed rate of 140, 120, 100 mm/min, depth of cut of 0.5 ,0.6 and 0.7 mm. Taguchi optimization and taguchi method done by MINITAB software.

INTRODUCTION TO TURNING

Turning is the removal of metal from the outer diameter of a rotating cylindrical workpiece. Turning is used to reduce the diameter of the workpiece, usually to a specified dimension, and to produce a smooth finish on the metal. Often the workpiece will be turned so that adjacent sections have different diameters.

Turning

The general process of turning involves rotating a part while a single-point cutting tool is moved parallel to the axis of rotation. Turning can be done on the external surface of the part as well as the internal surface (the process known as boring). The starting material is generally a workpiece generated by other processes such as casting, forging, extrusion, or drawing.

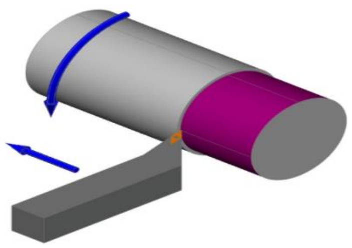

Fig: 1 Turning

CNC Turning

CNC Turning is a manufacturing process in which bars of material are held in a chuck and rotated while a tool is fed to the piece to remove material to create the desired shape. A turret (shown center), with tooling attached is programmed to move to the bar of raw material and remove material to create the programmed result. This is also called “subtraction machining” since it involves material removal. If the center has both tuning and milling capabilities, such as the one above, the rotation can be stopped to allow for milling out of other shapes.

The starting material, though usual round, can be other shapes such as squares or hexagons.

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Depending on the bar feeder, the bar length can vary. This affects how much handling is required for volume jobs.

CNC lathes or turning centers have tooling mounted on a turret which is computer-controlled. The more tools that that the turret can hold, the more options are available for complexities on the part.

CNC's with "live" tooling options, can stop the bar rotation and add additional features such as drilled holes, slots and milled surfaces.

LITERATURE SURVEY

KomsonJirapattarasilp and ChoobunyenKuptanawin presented paper on, [1] "Effect of Turning Parameters on Roundness and Hardness of Stainless Steel: SUS 303". Stainless steel JIS:SUS 303 is widely used for automotive part. This part is mostly manufactured by turning operation. However, turning parameters could be affected to roundness and hardness of work pieces. The purpose of this research was to study factors, which were affecting to roundness and hardness of stainless steel turning. Cutting tool was inserted carbide coated TiCN+Al2O3+TiN with polycrystalline vapor deposited (PVD) cutting tools. Experimental design was conducted as two factors and three levels. The parameters were consisted of cutting speed at 100, 150 and 200 m/min. Feed rate was setting at 0.08, 0.12 and 0.16 mm./rev. Furthermore, the experiment was done by turning with cooling and non-cooling. The results showed that only one factor affected to roundness was cooling condition. It means that cooling would cause on better roundness than non-cooling. On the other hand, cutting speed and feed rate was not affected to roundness. Moreover, the hardness of specimens was not increasing after turning. The studied parameters were not affected to hardness after turning significantly.

INTRODUCTION TO SURFACE ROUGHNESS

Surface measurement - also known as surface metrology - refers to measuring the topography (or surface roughness) of precision surfaces. Surface measurement can be essential for determining a surface's suitability for a particular application. Component failures can often be traced back to a precision surface that was not manufactured to specification, either due to an improperly set up machine or use of a process that is not capable of repeatably producing the quality of surface needed

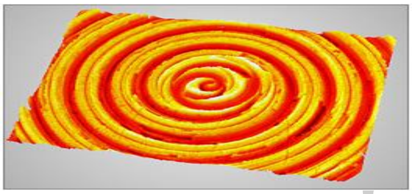


Fig:Surface Measurement of Machining Marks

Parameters

A roughness value can either be calculated on a profile (line) or on a surface (area). The profile roughness parameter (Ra, Rq,...) are more common. The area roughness parameters (Sa, Sq,..) give more significant values.

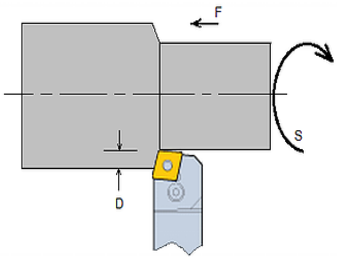
Profile roughness parameters

The profile roughness parameters are included in BS EN ISO 4287:2000 British standard, identical with the ISO 4287:1997 standard.[5] The standard is based on the ″M″ (mean line) system.

INTRODUCTION TO MATERIAL REMOVAL RATE

From month to month or quarter to quarter, as you buy more efficient (and expensive) machines, cutting tools and fixtures, you should be cutting more metal in the same time. How do you ensure that this is happening, and track your progress ? The MRR is a single number that enables you to do this. It is a direct indicator of how efficiently you are cutting, and how profitable you are.

MRR is the volume of material removed per minute. The higher your cutting parameters, the higher the MRR



MRR = D x F x S mm/min

Where,

D: Depth of cut, mm.

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F: Feed rate,mm/rev.

S: Cutting speed, m/min

Since these parameters reduce all of the information in a profile to a single number, great care must be taken in applying and interpreting them. Small changes in how the raw profile data is filtered, how the mean line is calculated, and the physics of the measurement can greatly affect the calculated parameter. With modern digital equipment, the scan can be evaluated to make sure there are no obvious glitches that skew the values.

OBJECTIVE

1) Studying the various effects of various CNC turning parameters on the surface roughness.

2) Performing Taguchi's method on multiple responses to determine the optimum parameters and most influencing parameters.

3) Development of a mathematical model and predicting the responses.

METHODOLOGY

Methodology to carry out the Present Work the methodology adopted for the proposed work is as follows

1) Initial study to determine various controllable and uncontrollable parameters.

2) Selection of work material based on literature.

3) Selection of parameters, responses and their levels.

4) Selection of experimental layout using Taguchi' method.

5) Conduction of experiment.

6) Measurements of responses using standard equipments.

7) Analysis of data using statistical tool.

EXPERIMENTAL INVESTIGATION

The experiments are done on the CNC turning machine with the following parameters:

CUTTING TOOL MATERIAL –Cemented Carbide Tool

WORK PIECE MATERIAL – STEEL ALLOY, ALUMINUM ALLOY 6061

FEED – 100mm/min, 120mm/min, 140mm/min

CUTTING SPEED – 800rpm, 1600rpm, 2400rpm,

DEPTH OF CUT – 0.5mm, 0.6mm, 0.7mm

Fig: CNC lathe (turning)

Fig :finished work pieces

Table : Input parameters for turning

PROCESS PARAMETERS	**LE VEL1**	**LEVEL2**	**LEVEL3**
CUTTING SPEED (rpm)	2400	1600	800
FEED RATE (mm/rev)	140	120	100
DEPTH OF CUT (mm)	0.7	0.6	0.5

Design of experiments (DOE)

JOB NO.	**SPINDLE SPEED (rpm)**	**FEED RATE (mm/min)**	**DEPTH OF CUT (mm)**
1	2400	140	0.7
2	2400	120	0.6
3	2400	100	0.5
4	1600	140	0.6
5	1600	120	0.7

6	1600	100	0.5
7	800	140	0.7
8	800	120	0.5
9	800	100	0.6

Table: L9 orthogonal array

Tests conducted

Surface roughness measuring instrument

The Talysurf is a simple to operate high accuracy instrument capable of roughness and waviness measurement. The systems low noise axes and high resolution gauge ensures measurement integrity.

Decades of experience, ultra precision machining expertise and FEA optimized design combine to provide low noise and near flawless mechanical execution of the measuring axes. Further enhancement via the use of traceable standards and exclusive algorithms effectively eliminates instrument influence from the measurement results.

Fig: surface roughness testing

SURFACE ROUGHNESS VALUES FOR STEEL ALLOY MATERIAL

JOB NO.	SPINDLE SPEED (rpm)	FEED RATE (mm/min)	DEPTH OF CUT (mm)	Surface Roughness (R_a) µm
1	2400	140	0.7	3.15
2	2400	120	0.6	3.91
3	2400	100	0.5	4.01
4	1600	140	0.6	3.45
5	1600	120	0.7	4.12
6	1600	100	0.5	4.21
7	800	140	0.7	4.15
8	800	120	0.5	4.72
9	800	100	0.6	4.95

SURFACE ROUGHNESS VALUES FOR ALUMINUM ALLOY 6061 MATERIAL

JOB NO.	SPINDLE SPEED (rpm)	FEED RATE (mm/min)	DEPTH OF CUT (mm)	Surface Roughness (R_a) µm
1	2400	140	0.7	3.01
2	2400	120	0.6	3.52
3	2400	100	0.5	3.93
4	1600	140	0.6	3.72
5	1600	120	0.7	4.02
6	1600	100	0.5	4.15
7	800	140	0.7	4.07
8	800	120	0.5	4.56
9	800	100	0.6	4.81

MATERIAL REMOVAL RATE

Formula :

MRR = mm^3/min or in ^{3}/min

$= \pi D_{avg}\, d\, f\, N$

Where,

N = rotational speed of the work piece (Rpm)

F = feed (mm/min)

D =average diameter of work piece(mm)

d =depth of cut (mm)

MRR TABLE FOR STEEL ALLOYL

JOB NO.	SPINDLE SPEED (rpm)	FEED RATE (mm/min)	DEPTH OF CUT (mm)	MRR(mm^3/min)
1	2400	140	0.7	43.23
2	2400	120	0.6	39.12
3	2400	100	0.5	38.98
4	1600	140	0.6	31.24
5	1600	120	0.7	33.15
6	1600	100	0.5	30.17
7	800	140	0.7	29.87
8	800	120	0.5	22.19
9	800	100	0.6	24.52

MRR TABLE FOR ALUMINUM ALLOY 6061

JOB NO.	SPINDLE SPEED (rpm)	FEED RATE (mm/min)	DEPTH OF CUT (mm)	MRR(mm^3/min)
1	2400	140	0.7	48.56
2	2400	120	0.6	41.25
3	2400	100	0.5	39.15
4	1600	140	0.6	36.85
5	1600	120	0.7	35.58
6	1600	100	0.5	31.97
7	800	140	0.7	30.48
8	800	120	0.5	25.36
9	800	100	0.6	28.62

INTRODUCTION TO MINITAB SOFTWARE

MINITAB is a software product that helps you to analyze the data. This is designed essentially for the Six Sigma professionals. It provides a simple, effective way to input the statistical data, manipulate that data, identify trends and patterns, and then extrapolate answers to the current issues. This is most widely used software for the business of all sizes - small, medium and large. Minitab provides a quick, effective solution for the level of analysis required in most of the Six Sigma projects.

INTRODUCTION TO TAGUCHI TECHNIQUE: Genichi Taguchi could be a Japanese Engineer United Nations agency has been active within the improvement of Japans industrial product and processes since the late 1940's. He has developed each philosophy and methodology for the method or product quality improvement that depends principally on applied mathematics ideas and tools, particularly statistically designed experiments .several Japanese companies achieved nice success by applying his strategies.

TAGUCHI PARAMETER DESIGN FOR TURNING PROCESS

In order to identify the process parameters affecting the selected machine quality characteristics of turning, the following process parameters are selected for the present work: cutting speed (A), feed rate (B) and depth of cut (C). the selection of parameters of interest and their ranges is based on literature review and some preliminary experiments conducted.

Selection of Orthogonal Array

The process parameters and their values are given in table. It was also decided to study the two – factor interaction effects of process parameters on the selected characteristics while turning. These interactions were considered between cutting speed and feed rate (AXB), feed rate and depth of cut (BXC), cutting speed and depth of cut (AXC).

FACTORS	PROCESS PARAMETERS	LEVEL1	LEVEL2	LEVEL3
A	CUTTING SPEED(rpm)	2400	1600	800
B	FEED RATE (mm/rev)	140	120	100
C	DEPTH OF CUT(mm)	0.7	0.6	0.5

TAGUCHI ORTHOGONAL ARRAY

JOB NO.	SPINDLE SPEED (rpm)	FEED RATE (mm/min)	DEPTH OF CUT (mm)
1	2400	140	0.7
2	2400	120	0.6
3	2400	100	0.5
4	1600	140	0.6
5	1600	120	0.7
6	1600	100	0.5
7	800	140	0.7
8	800	120	0.5
9	800	100	0.6

OBSERVATION

The following are the observations made by running the experiments. The cutting forces are measured using dynamometer.

SURFACE FINISH FOR STEEL ALLOYL

STEEL ALLOYL Surface Roughness (R_a) µm	ALUMINUM ALLOY 6061 Surface Roughness (R_a) µm
3.15	3.01

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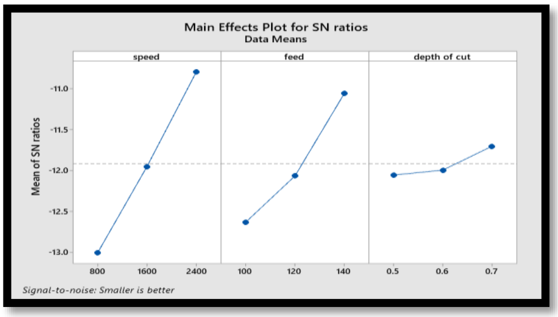
3.91	3.52
4.01	3.93
3.45	3.72
4.12	4.02
4.21	4.15
4.15	4.07
4.72	4.56
4.95	4.81

FOR STEEL ALLOYL MATERIAL

speed	feed	depth of cut	surface roughness
2400	140	0.7	3.15
2400	120	0.6	3.91
2400	100	0.5	4.01
1600	140	0.6	3.45
1600	120	0.5	4.12
1600	100	0.7	4.21
800	140	0.5	4.15
800	120	0.7	4.72
800	100	0.6	4.95



FOR ALUMINUM ALLOY 6061 MATERIAL

speed	feed	depth of cut	surface roughness
2400	140	0.7	3.01
2400	120	0.6	3.52
2400	100	0.5	3.93
1600	140	0.6	3.72
1600	120	0.5	4.02
1600	100	0.7	4.15
800	140	0.5	4.07
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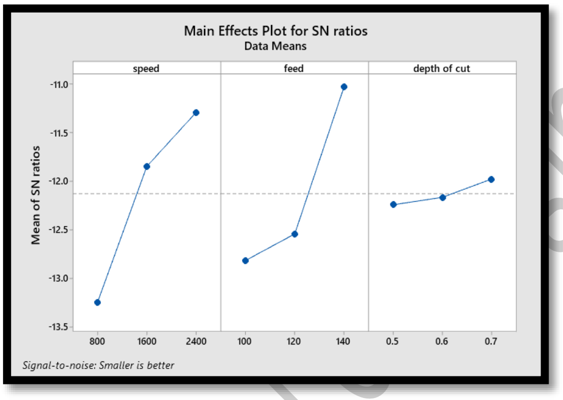
800	100	0.6	4.81



CONCLUSION

In this thesis an attempt to make use of Taguchi optimization technique to optimize cutting parameters during high speed turning of EN 31 tool steel using cemented carbide cutting tool.
The cutting parameters are cutting speed, feed rate and depth of cut for turning of work piece EN 31 tool steel. In this work, the optimal parameters of cutting speed are 2400rpm, 1600rpm and 800rpm, feed rate are 100mm/min, 120mm/min and 140mm/min and depth of cut are 0.5mm, 0.6mm and 0.7mm. Experimental work is conducted by considering the above parameters.

The Surface roughness is principally plagued by feed rate, depth of cut and spindle speed. With the rise in feed rate the surface roughness conjointly will increase, because the depth of cut will increase the surface roughness initial increase and reduce and because the spindle speed increase surface roughness decreases.
From multivariate analysis analzsis, parameters making very important result on surface roughness area unit feed rate and depth of cut. The parameters taken within the experiments area unit optimized to get the minimum surface roughness potential.
The optimum setting of cutting parameters for prime quality turned elements is as:-
1. Spindle speed = 2400 rpm
2. Feed rate = 100 mm/ min
3. Depth of cut = 0.5 mm
The parameters thought of within the experiments area unit optimized to realize most material removal rate .The simplest setting of input method parameters for defect-free turning (maximum material removal rate) at intervals the chosen variable is as follows:-

1. Spindle speed = 2400 rpm

2. Feed rate = 140 mm/ min

3. Depth of cut = 0.7 mm

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