OPTIMIZATION OF PROCESS PARAMETERS TO MINIMISE SURFACE ROUGHNESS IN TURNED PARTS BY EXPERIMENTATION AND ANALYTICAL

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Abstract: The objective of the paper is to obtain an optimal setting of turning process parameters, cutting speed, feed rate resulting in optimal values of the surface finish while machining Aluminum alloy 6082. The effects of the selected process parameters on the chosen characteristics and the subsequent optimal settings of the parameters have been accomplished using Taguchi's parameter design approach. The cutting parameters are cutting speed, feed rate and depth of cut for turning of work piece material Aluminum alloy 6082. In this work, the optimal parameters of cutting speed are 2000rpm and2500rpm, feed rate are 200mm/min, 300mm/min and 500mm/min and depth of cut are 0.8mm, 0.9mm and 1mm.

Experimental work is conducted by considering the above parameters. Surface finish is validated experimentally. The cutting parameters are optimized for better surface finish quality.The effect of parameters cutting speed, feed rate and depth of cut on forces are formulated mathematically. A parametric model of cutting tool and work piece is designed using 3D modeling software Pro/Engineer. Analytical investigations are to be made on the model by applying the forces by taking different values of cutting speed, feed rate and depth of cut. Analysis is done in Ansys.

***Index Terms* - Aluminum alloy 6082, Pro E, ANSYS.**

I.INTRODUCTION

Turning is a machining process in which a cutting tool, typically a non-rotary tool bit, describes a helical tool path by moving more or less linearly while the work piece rotates. The tool's axes of movement may be literally a straight line, or they may be along some set of curves or angles, but they are essentially linear (in the nonmathematical sense). Usually the term "turning" is reserved for the generation of external surfaces by this cutting action, whereas this same essential cutting action when applied to internal surfaces (that is, holes, of one kind or another) is called "boring". Thus the phrase "turning and boring" categorizes the larger family of (essentially similar) processes. The cutting of faces on the work piece (that is, surfaces perpendicular to its rotating axis), whether with a turning or boring tool, is called "facing", and may be lumped into either category as a subset.

6082 aluminum alloy is an alloy in the wrought aluminum-magnesium-silicon family (6000 or 6xxx series). It is one of the more popular alloys in its series (alongside alloys 6005, 6061, and 6063), although it is not strongly featured in ASTM (North American) standards. It is typically formed by extrusion and rolling, but as a wrought alloy it is not used in casting. It can also be forged and clad, but that is not common practice with this alloy. It cannot be work hardened, but is commonly heat treated to produce tempers with a higher strength but lower ductility.

Surface roughness, often shortened to roughness, is a measure of the texture of a surface. It is quantified by the vertical deviations of a real surface from its ideal form. If these deviations are large, the surface is rough; if they are small the surface is smooth. Roughness is typically considered to be the high frequency, short wavelength component of a measured surface (see surface metrology). However, in practice it is often necessary to know both the amplitude and frequency to ensure that a surface is fit for purpose.

II.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. The machining is done on 3 round pieces, on each 3 experiments are conducted by varying the process parameters. The combination of process parameters is designed according to Taguchi Method.

The process parameters and their values are given in table. It was also decided to study the three – factor interaction effects of process parameters on the selected characteristics while turning Aluminum alloy 6082. 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).

Table 2.1: Orthogonal array based on Taguchi method

JOB NO	SPINDLE SPEED (rpm)	FEED RATE (mm/min)	DEPTH OF CUT (mm)
1	2000	200	0.8
2	2000	300	0.9
3	2000	500	1
4	2500	200	0.9
5	2500	300	1
6	2500	500	0.8

Inference :Table shown above indicate the spindle speed ranges from 2000 to 3000 rpm, feed rate ranges from 200 to 500 (mm/min) and depth of cut ranges from 0.8 to 1 mm.

Table 2.1: Measured Surface Roughness Values

JOB NO.	SPINDLE SPEED (rpm)	FEED RATE (mm/min)	DEPTH OF CUT (mm)	Surface Roughness (R_a) μm
1	2000	200	0.8	0.05
2	2000	300	0.9	0.09
3	2000	500	1	0.38
4	2500	200	0.9	0.13
5	2500	300	1	0.057
6	2500	500	0.8	0.23

Inference :Table shown above indicate that for given spindle speed feed rate and depth of cut the surface roughness values are obtained by using surface roughness tester.

III.MODELING AND ANALYSIS OF WORK PIECE AND CUTTER ASSEMBLY

Cutting Force Calculations

Power Requirement $P = \frac{Fc*Vc}{60000*\eta}$

Where

P = Motor Power in KW

Fc = Cutting Force in N

Vc = Feed in mm/min

Ƞ = Efficiency = 0.8

Motor Power of the Lathe Machine = 440W = 0.44KW

1. Feed – 200mm/min

Work piece dia = 37mm

$$Fc = \frac{P*60000*\eta}{Vc}$$

$$Fc = \frac{0.44*60000*0.8}{200} = 105.6N$$

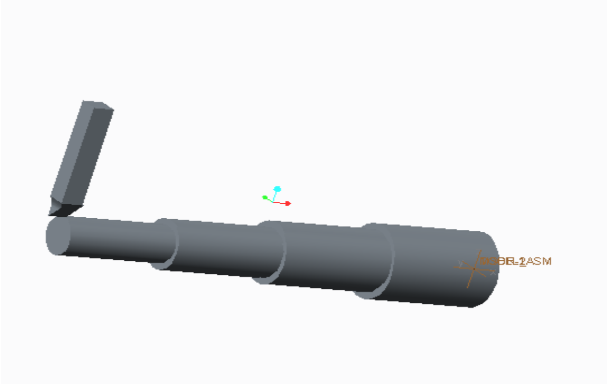
2. Feed – 300mm/min

Work piece dia = 31mm

$$Fc = \frac{0.44*60000*0.8}{300} = 70.4N$$

3. Feed – 500mm/min

Work piece dia = 25mm



$$Fc = \frac{0.44 * 60000 * 0.8}{500} = 42.24N$$

Fig 3.1: Assembly of work piece and Cutting Tool

IV. STATIC ANALYSIS

4.1Speed- 2000 RPM

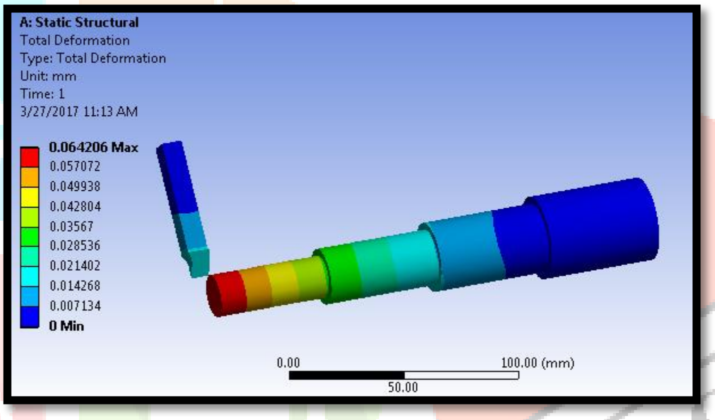


Fig 4.1 - Total Deformation for force 105.6 N

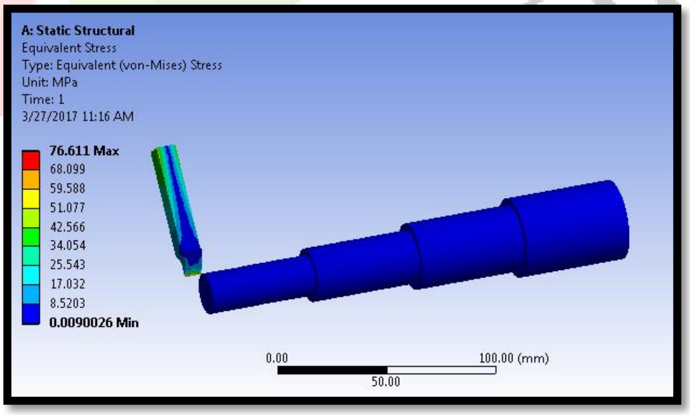


Fig 4.2 - Von-mises Stress for force 105.6 N

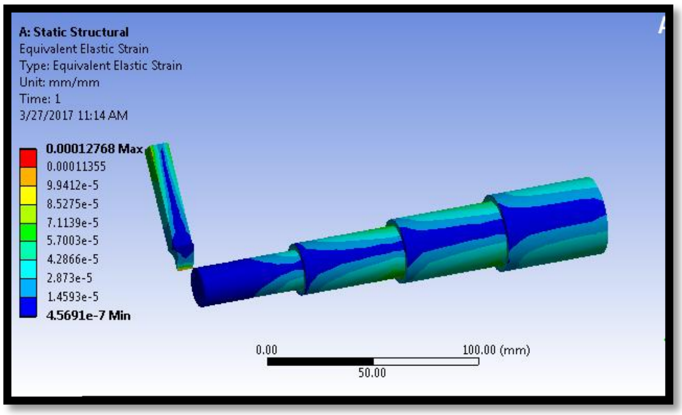


Fig 4.3 - Von-mises Strain for force 105.6 N

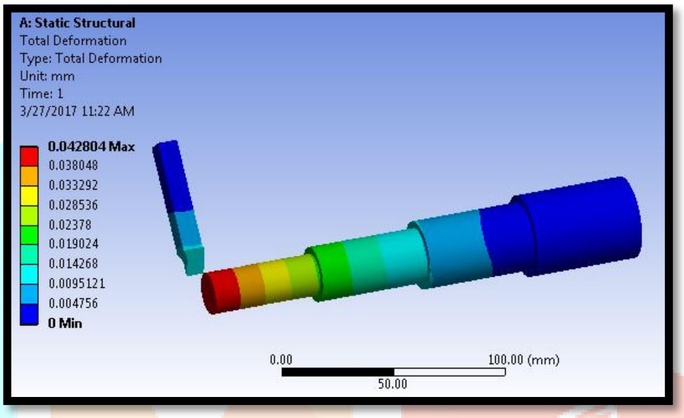


Fig 4.4 - Total Deformation for force 70.4 N

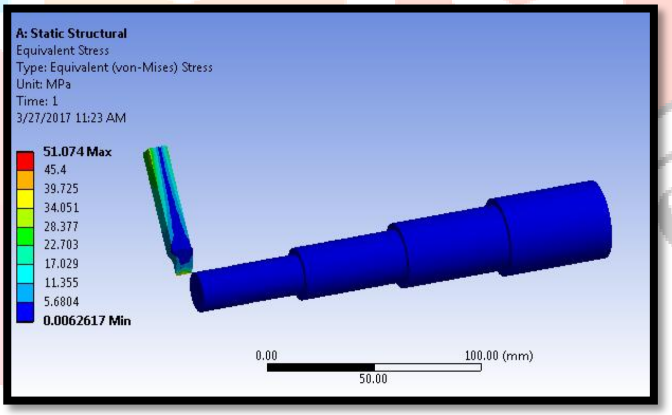


Fig 4.5 - Von-mises Stress for force 70.4 N

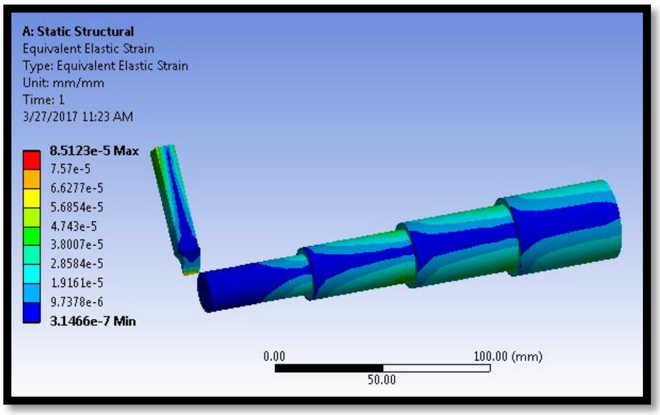


Fig 4.6 - Von-mises Strain for force 70.4 N

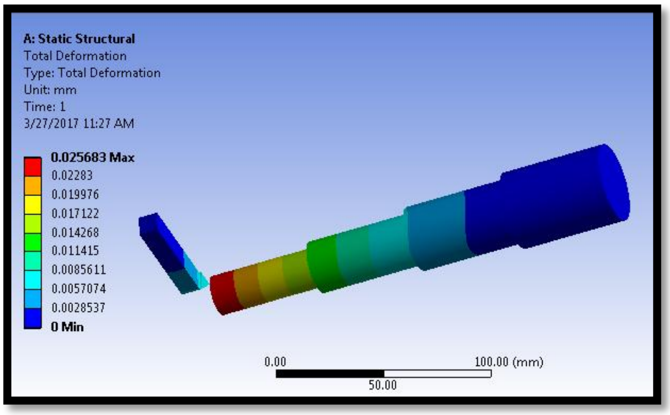


Fig 4.7 - Total Deformation for force 42.24 N

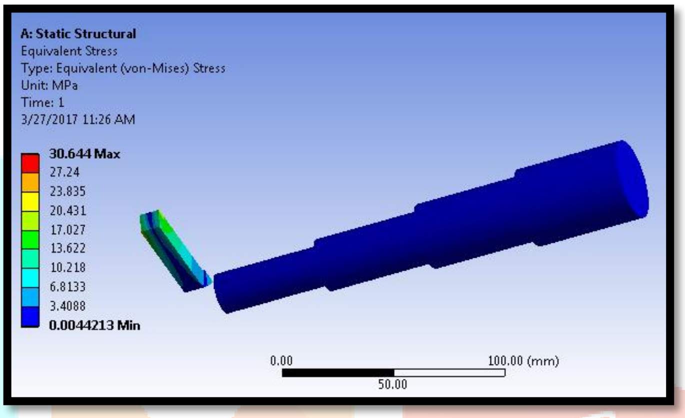


Fig 4.8 - Von-mises Stress for force 42.24 N

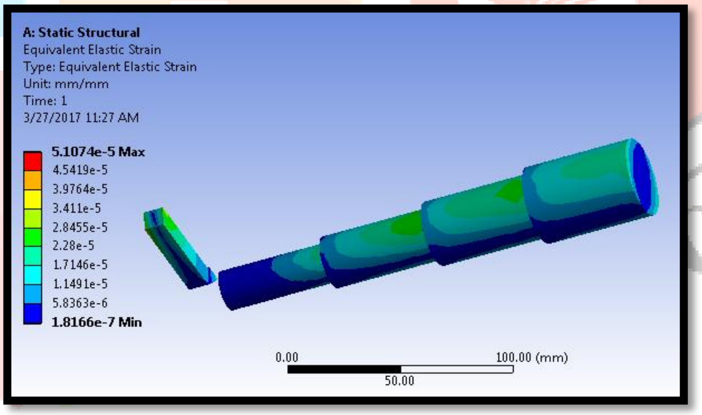


Fig 4.9 - Von-mises Strain for force 42.24 N

4.2.Speed- 2500 RPM

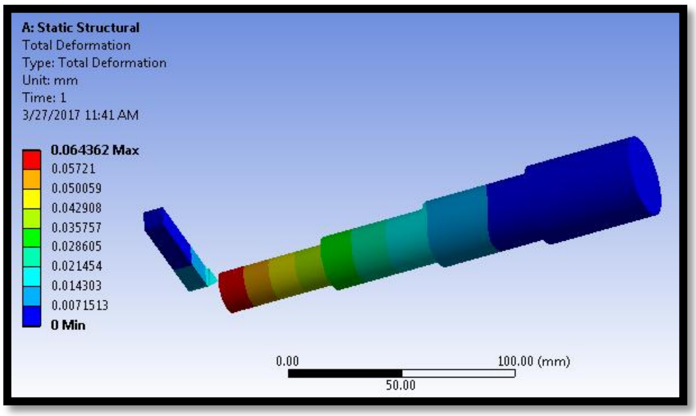


Fig 4.10 - Total Deformation for force 105.6 N

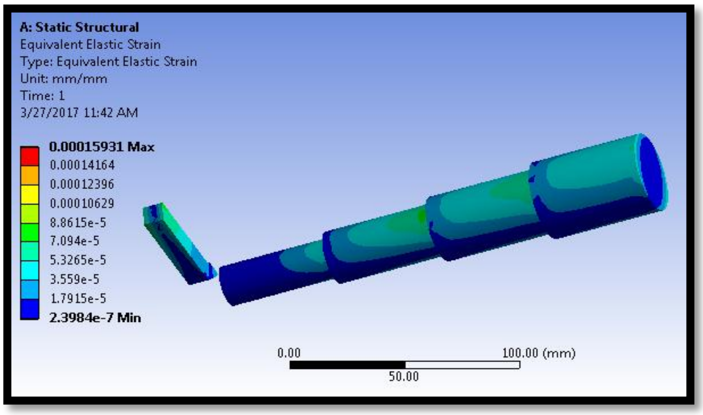


Fig 4.11 - Von-mises Stress for force 105.6 N

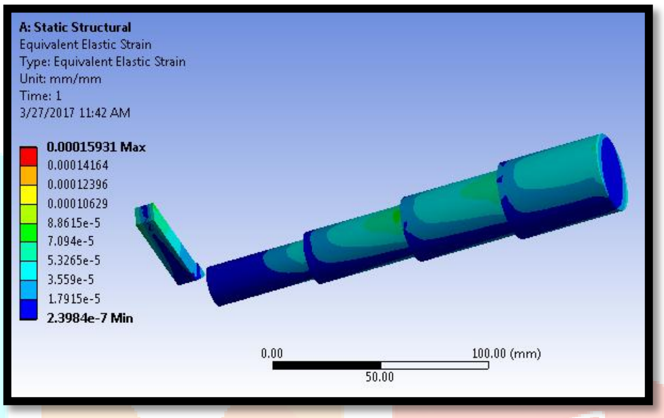


Fig 4.12- Von-mises Strain for force 105.6 N

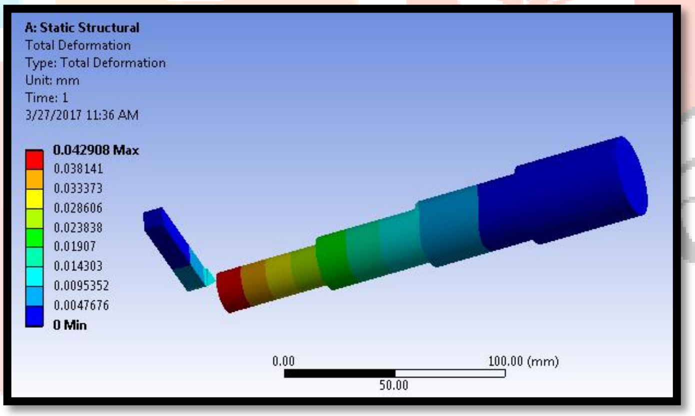


Fig 4.13 - Total Deformation for force 70.4 N

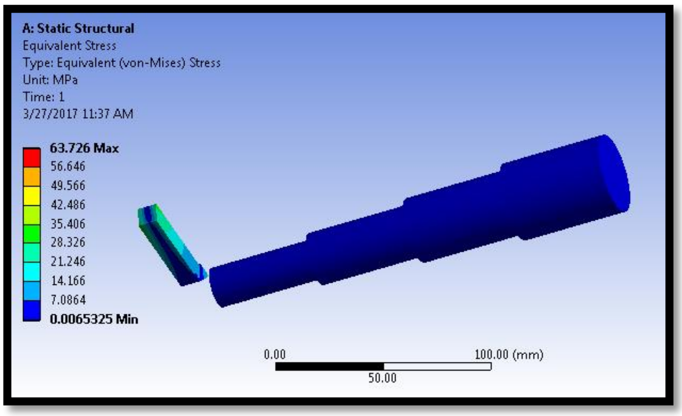


Fig 4.14 - Von-mises Stress for force 70.4 N

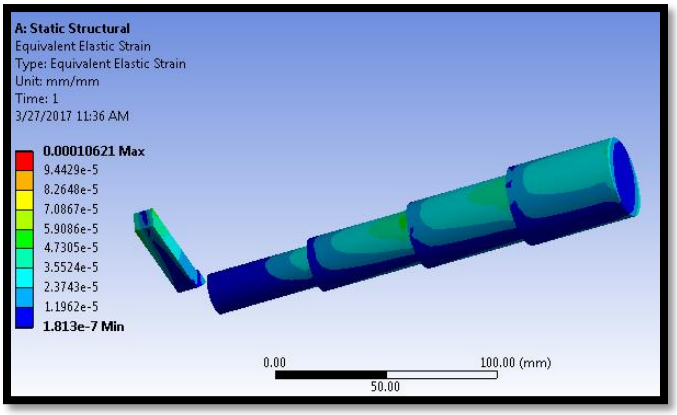


Fig 4.15 - Von-mises Strain for force 70.4 N

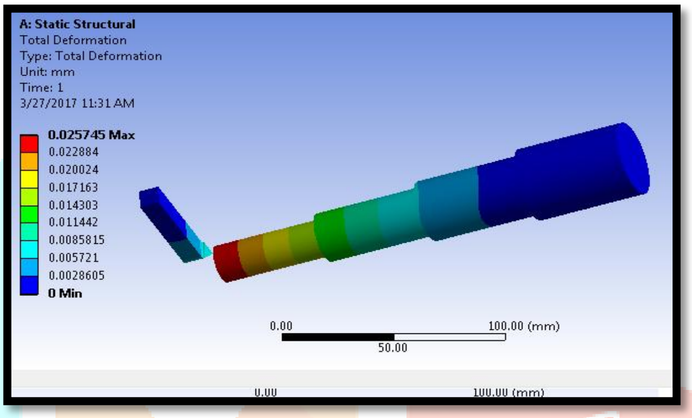


Fig 4.16- Total Deformation for force 42.24 N

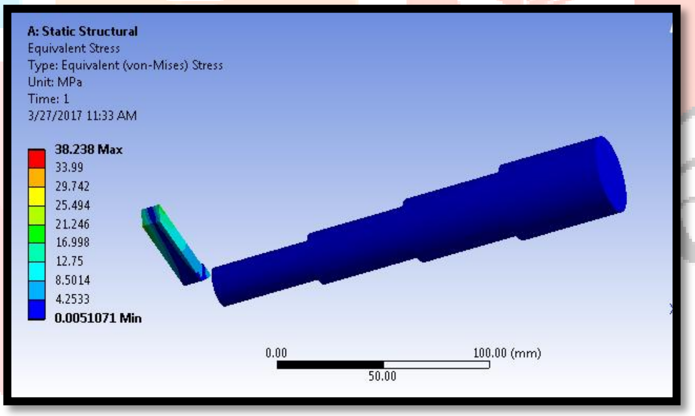


Fig 4.17 - Von-mises Stress for force 42.24 N

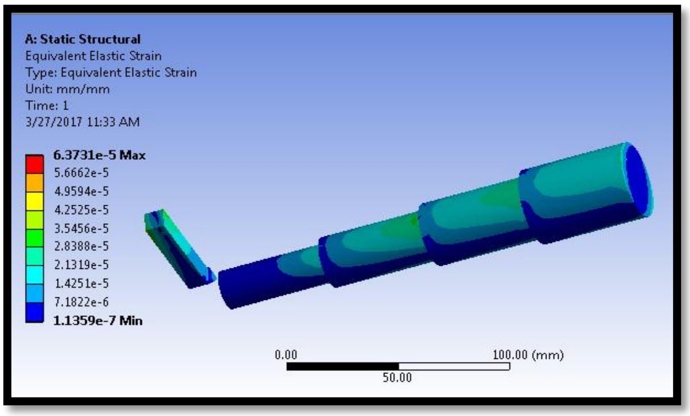


Fig4.18 - Von-mises Strain for force 42.24 N

V. RESULTS

Table 5.1: Results

SPEED (rpm)	FORCE (N)	DEFORMATION (mm)	STRAIN	STREES (N/mm^2)
2000	105.6	0.064206	0.00012768	76.611
	70.4	0.042804	0.000085412	51.074
	42.4	0.025683	0.00005107	30.644
2500	105.6	0.064362	0.00015931	95.589
	70.4	0.042908	0.00010621	63.726
	42.4	0.025745	0.00006371	35.238

Inference:Table shown above indicate that by applying the forces at different speeds, the values of deformation strain and stress values are obtained by using ansys.

VI.CONCLUSION

In this paper experiments are done to optimize cutting parameters during turning of Aluminum alloy 6082 using tungsten carbide cutting tool. The parameters varied are, cutting speed - 2000rpm and 2500rpm,feedrate – 200mm/min, 300mm/min, 500mm/min and depth of cut – 0.8mm, 0.9mm and 1mm.Experimental work is conducted by considering the above parameters. Surface finish values 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 – 2500rpm, feed rate – 300mm/min and depth of cut – 1mm.Cutting forces are calculated theoretically and structural analysis is performed on the tool and work piece assembly to determine stresses and displacements.By observing the analysis results, it is observed that the deformations and stresses are reducing by increasing the feed rates due to reduced cutting forces, the stresses are increasing by increasing the speeds. The stress values are less than that of the yield strength of work piece material Aluminum alloy 6082 and the strain values are reducing by increasing the feeds due to reduced cutting forces.The combustion process on the Gasoline Direct fuel Injection system has been analyzed ANSYS 17.0 and the outcomes have been gotten.

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