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DYNAMIC ANALYSIS OF SINGLE POINT CUTTING TOOL USING FEM"

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Abstract: Finite element analysis method is used to study the effect of different rack angles & nose radius on the force exerted on the tool during cutting. In present study, the two different rake angles & nose radius are studied to find out the variation in values of Von-misses stress for the specified applied forces. As we increase the rake angle then the value of Von-misses stress goes on decreasing. Finding the comparative study of software and analytical results for rack angles 3^0 & 5^0 and nose radius 0.3 mm & 0.5 mm on von-misses stresses and total deflection of cutting edge.

Keywords: Single point cutting tool, Ansys, FEM

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INTRODUCTION

Among various machining parameters, tool nose radius has a significant contribution to the cutting dynamics and the stability of a machining process. Nose radius is a major factor that affects surface finish of the machined surface. A larger nose radius produces a smoother surface at lower feed rates and a higher cutting speed. Large nose radius tools have, along the whole cutting period, slightly better surface finish than small nose radius tools.

For single point cutting tool most important angle is back rake angle. The back rake angle affects the ability of the tool to shear the work material and form the chip. It can be positive or negative.

Finite Element Method (FEM) based modeling and simulation of machining processes is continuously attracting researchers for better understanding the chip formation mechanisms, heat generation in cutting zones, tool-chip interfacial frictional characteristics and integrity on the machined surfaces. Predicting the physical process parameters such as temperature and stress distributions accurately plays a pivotal role for predictive process engineering of machining processes. The cutting forces vary with the tool angles, feed and cutting speed. Knowledge about the forces acting on the cutting tool may help the manufacturer of machining tool to estimate the power requirement. Tool edge geometry is very important, because its influence on obtaining most desirable tool life and surface integrity is extremely high.

Tool Geometry

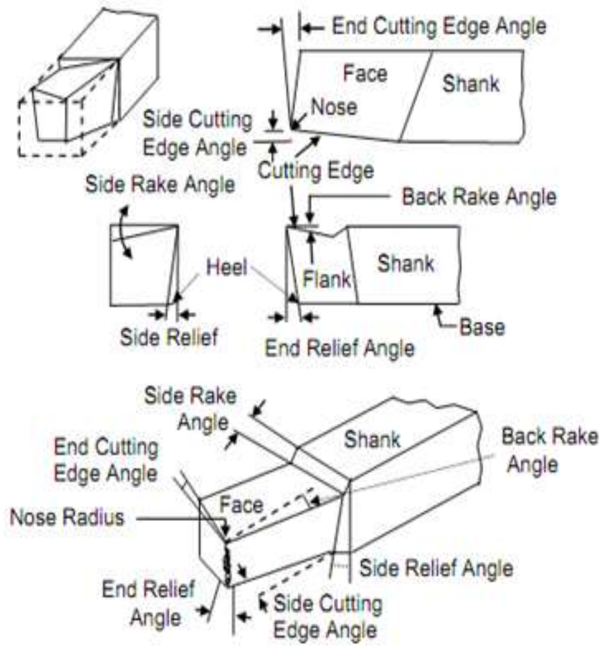

Fig.1- Tool Geometry

1. Shank: – It is main body of tool. The shank used to grip in tool holder.

2. Flank: – The surface or surface below the adjacent of the cutting edge is called flank of the tool.

3. Nose: – It is the point where side cutting edge & base cutting edge intersect.

4. Cutting edge: – It is the edge on face of the tool which removes the material from work piece. The cutting edges are side cutting edge (major cutting edge) & end cutting edge (minor cutting edge).

5. Tool angles: - Tool angles have great importance. The tool with proper angle, reduce breaking of tool, cut metal more efficiently, generate less heat**.**

6. Back Rake Angle: - The angle between face of the tool and a line parallel with the base of the tool, measured in a perpendicular plane through the side cutting edge is called back rake angle.

7. **Side Rake Angle: -** The angle between the face of the tool and a line parallel with the base of the tool, measured in a plane perpendicular to the base and side cutting edge is called side rake angle.

Sample Analytical Calculation

For conducting the test on specimen material following data was considered for first set of readings with 3 degree rake angle & 0.3 mm nose radius

The following data from the orthogonal cutting test is available,

Rake Angle = 3^0

Chip Thickness Ratio = 0.5

Nose radius =0.3 mm

Uncut Chip Thickness = 0.3 mm

Width of Cut = 3 mm

Yield Shear Stress of Work Material = 380 N/mm2

Mean Friction Coefficient on Tool Face = 0.65

Determine the

1. Cutting force

2. Radial force

3. Normal force on the tool

4. Shear force on the tool.

Solution:-

Shear angle β = tan−1 (rcosα/1−rsinα)

Shear angle β = (0.5cos3/1−0.5sin3)

β = 270

µ = tanϒ

Friction angle, ϒ = tan-1µ = tan-1[0.65] = 33

To find shear stress,

τ = sinβ*Fs/A

Fs = τxA1/sinβ = 380 * 3 * 0.3sin27

Fs = 750 N

Fs = FCosθ = Fcos (β+ϒ−α)

F = Fscos (β+ϒ−α) = 750cos (27+33−3)

F=1376N

Cutting force, Fz = Fcos (ϒ−α) = 1376cos (33−3) = 1191.6N

F = √Fz2+Fx2

Radial force, Fx= √F2+Fz2 = √ (1376)2− (1191.6)2

Fx=688N

Normal force on the tool,

N = Fzcosα−Fxsinα = 1191.6cos3−688sin3

N=1154N.

Results

Shear force (Fs) = 750 N

Cutting force (Fz) = 1191.6 N

Radial force (Fx) = 688 N

Normal force on tool (N) = 1154 N

Theoretical normal force at width of cut 3mm bar when advancing = 115

Observation Table

No. of Samples	Rake angle (degree)	Nose radius (mm)	Normal Force (N)	Cutting Force (N)	Compressive stress (N/mm^2)
1.	3	0.3	1154	1191.6	3.61
2.	3	0.5	1923.5	1986.6	6.01
3.	5	0.3	1096.3	1154.3	3.42
4.	5	0.5	1827.8	1924.3	5.71

Table No.1:- Analytical forces and stresses at different sets of rake angles

Software Modeling and Analysis

Fig.2: - Single point cutting tool in CATIA.

ANSYS Boundary Condition and Results for STATIC Loading

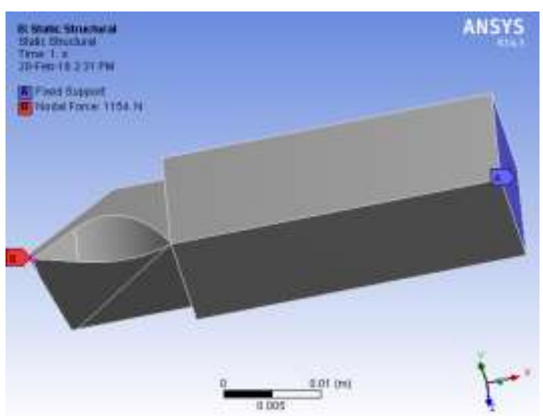

Fig.3- Boundary Conditions

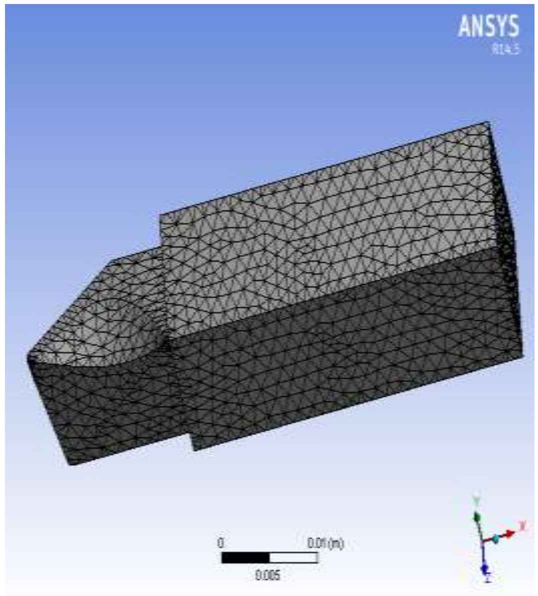

Fig.4- Meshed Product

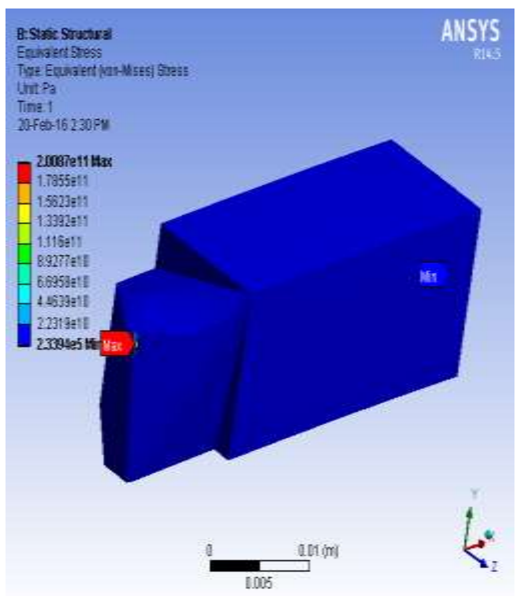

Fig.5- Equivalent Stress at 1154N force.

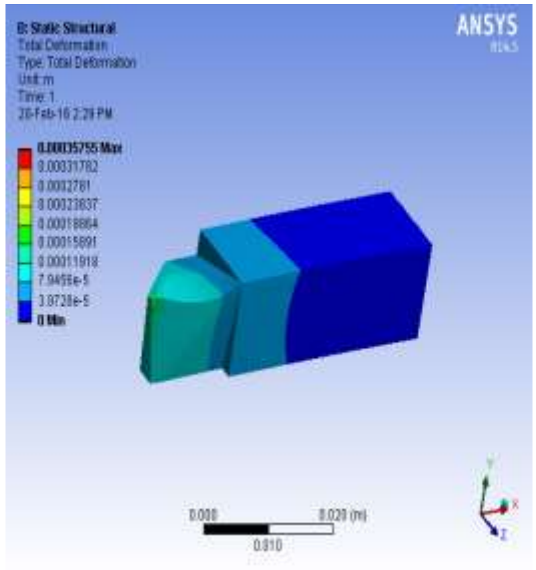

Fig.6- Total deformation at 1154N force

ANSYS Observation Table for STATIC loading

Table 2- ANSYS Result

Rake angle (degree)	Nose radius (mm)	Normal Force (N)	Cutting Force (N)	Compressive stress (N/mm^2)	Deform-ation in Normal Directi-on (mm)
3	0.3	1154	1191.6	2.00	0.03
3	0.5	1923.5	1986.6	3.80	0.125
5	0.3	1096.3	1154.3	2.20	0.075
5	0.5	1827.8	1924.3	3.65	0.119

ANSYS Results for MODAL Analysis

MODE	FREQUENCY (Hz)
1	5050.4
2	5052.7
3	17605
4	22928
5	23361
6	29390

Table 3- Frequency of Single Point Cutting Tool

CONCLUSION

1. As the single point cutting tool is one of the major part of machining process, to increase tool efficiency and performance along with its life. It is very necessary to analysis it.

2. It is observed that as depth of cut increases, the von-misses stresses developed in the tool increases which are the main reason of tool failure.

3. With the help of calculated tool life, it is possible to determine the range of optimal cutting parameters with maximum tool life.

4. Variation in nose radius and rake angle has a predominant influence on tool life.

5. Tool shows better performance with 5 degree rake and 0.3 mm nose radius with minimal tool wear and there by better tool life.

6. It is observed that with increasing nose radius tool life decreases, it is less for 0.5 mm nose radius as compare to 0.3 mm.

7. The wear of tool with 0.5 mm nose radius is less than 0.3 mm nose radius and the stress in tool is lower with 0.3mm node radius for 3 degree rake angle tool.

8. The wear of tool with 0.5 mm nose radius is less than 0.3 mm nose radius and the stress in tool is lower with 0.5mm node radius for 5 degree rake angle tool.

9. Rake angle of 5 degree provides better cutting force, lesser stress and lowest wear.

10. The Harmonic analysis of above mentioned single point cutting tool is done to determine the variation of vibration when this tool is subjected to different forces which acts on it while machining operation is done.

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