International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 5, May - 2014

Optimization of Single Point Turning Tool

1 .Roopsandeep Bammidi
2. Prathyusha
1,2-PG Student

3.Dr. B. V. Ramana Murty
Professor, Dept. of. Mechanical Engg.
GVP College Of Engineering(A),
Madhurwada, Viakhapatnam-48

Abstract: - **Metal cutting process forms the basis of the engineering industry and is involved either directly or indirectly in the manufacture of nearly every product of our modern civilization. The Study of metal cutting is of vital importance and a basic knowledge of the fundamentals of machining of materials and of the theory of metal cutting will help to develop a scientific approach in solving problems encountered in machining.**

In our paper design and analysis of single point turning tool, we studied the metal cutting theory in which mainly focused on tool-geometry, materials, properties, working conditions, characteristics and effects of variable parameters like cutting speed, feed and depth of cut during the machining process.

This paper includes designing of single point turning tool with commercial angles and then the analysis of it. After knowing the results of analysis we modified the geometrical design and designed various tools, then analyzed them individually (design was modified using iterative method, in analytical manner not practically). By comparing the analysis results of above modified tools we finally selected the optimized geometry of tool, which works efficient than existed.

CUTTING TOOL MATERIALS AND TOOL GEOMETRY:

The performance of a cutting tool material in a given machining application is mainly determined by properties such as wear resistance, hot hardness and toughness. Wear resistance and toughness are two characteristics, which are, interdependent, the gain of one result in the loss of the other.

To cater to the needs of industry, e.g. higher rates of production, good surface finish, close tolerances, etc., various tool materials have been developed. In many instances the development of new tool materials has necessitated a change in the design trend of machine tools to make full use of the potentialities of tool materials for higher productivity. The tool materials developed include tool steels, high speed steels, carbides and ceramics and synthetic diamond.

Tool Steels:- Carbon steel or carbon tool steel is the kind of steels having carbon percentage ranging from 0.8-1.5%.Tools made from carbon steels can be easily hardened and used for cutting ferrous and non ferrous metals. Disadvantages of carbon steel are its less hot hardness and poor wear resistance. They loose their hardness at around 200-250 deg C, and therefore are used for the manufacture of cutting tools, which operate at low cutting speeds. Plain carbon steel when used as cutting tools lacks certain necessary characteristics such as red hardness, corrosion resistance wear resistance, etc. To improve these properties, alloying elements such as chromium, magnesium, and nickel are added to steel.

High Speed Steel:

Alloying steel with tungsten, chromium, molybdenum, etc. produces alloy steel known as high speed steel (HSS).It can retain the hardness up to 600 deg C. Owing to its superior hot hardness and wear resistance, it can be widely used. It can operate at cutting speeds 2-3 times greater than that of carbon steels. HSS can be classified into three types based on alloying elements and their percentage.

18-4-1HSS. This alloy steel contains 18% tungsten,4% chromium and 1% vanadium. This type of steel provides good hot hardness and form stability. This type of steel is also known as tungsten based HSS.

8-4-1HSS. This alloy steel contains 8% molybdenum,4% chromium and 1% vanadium, and functions as effectively as 18-4-1 HSS. It can be seen that only half as much molybdenum as tungsten is required on a weight basis to achieve the same effect. It has excellent toughness and cutting ability. This type of steel is also known as molybdenum based HSS.

Cobalt based HSS. This steel contains 2-15% cobalt to increase the hot hardness and wear resistance. Since, the hot hardness is very high it can operate at very high speeds. This steel is also known as super high speed steel.

Carbides:

The basic ingredient of most carbide is tungsten carbide. Carbide suitable for steel machining consists of 82% tungsten carbide, 105 titanium carbide and 8% cobalt. Carbides have very high hardness over a wide range of temperatures and have relatively high thermal conductivity. They have a strong tendency to form pressure welds at low cutting speeds and hence they should be operated at high speeds considerably in excess of those used for HSS tools.

Abrasives:

Abrasives are mainly used for machining harder material and/or where a superior finish is required. Abrasive particles are used in the manufacture of grinding wheels.

Diamond:

Diamond is the hardest known material and can be used at cutting speeds about 50 times those used for HSS. It is suitable for machining very hard materials such as ceramics. Under proper conditions, diamond can machine 10,000-50,000 pieces or sometimes even 1, 00, 000 pieces in a single set up whereas carbides can machine only 300-400 pieces before requiring a re-sharpening or replacement.

Diamonds perform well at the highest possible speeds, low feeds and low depth of cut. While using diamonds, the machine should be in excellent condition and vibration free; otherwise there is every possibility of the diamond getting fractured because of its inherent brittleness.

Cubic boron nitride (CBN):

Diamond being a form of carbon is not thermally very stable and at high temperature readily reacts with iron. Cubic boron nitride has been developed as an alternative to diamond, for machining ferrous materials. CBN consists of nitrogen and boron, with a special structural configuration similar to diamond. CBN is the second hardest material known and has red hardness up to 1000 deg C.

Ceramics:

Even though the carbides can make the process of cutting highly productive, they are very expensive. Ceramic is an inexpensive tool material and in many cases, they are efficient substitutes for cemented carbides. Their main constituent is aluminum oxide.

Ceramic tool can cut almost any metal and withstand high heat, but they are very brittle and will not take shock. Ceramic tools can give extremely fine finishes to the surface of a material. The red hardness of ceramic tool is of the order of 1200 deg C.

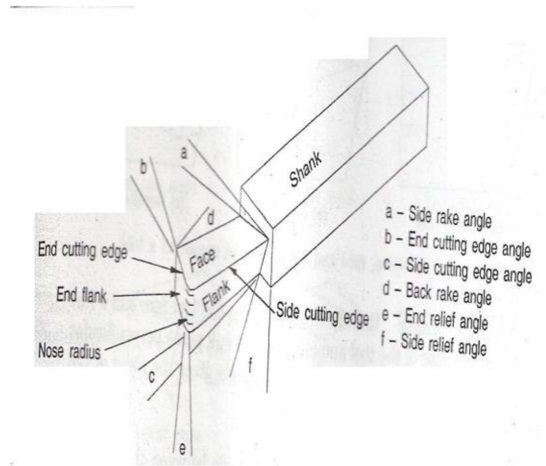
Cast alloys:

These cast-able non ferrous alloys contain primarily Cobalt (40-55%), Chromium (25 to 35%), tungsten (1.5-3%) and carbon (0 to 5%). Cobalt acts as a solvent matrix with chromium as the major alloying element. Tungsten provides hardness to the material. Low percentages of carbon up to 1% make the tool tough and capable of withstanding shock loads and higher carbon contents make the tool highly wear resistant but brittle. Other elements may also be added to increase the hardness of the cast alloy. These include vanadium, molybdenum, tantalum and boron. Nickel on the other hand decreases the hardness but increases the toughness of the alloy. The cast alloys retain their hardness up to temperature as high as 750 deg C and have low coefficient of friction. Because this tool material is cast-able, it is specially useful for making form tools.

Cutting tool geometry:

Geometry of single-point turning tool:

The geometry of single point tool has three orthographic views. A single-point tool consists of a neck, which is known as operating end, and the shank or body. Shank is used to hold the tool in the tool post or tool holder. The tool neck has the following elements: face, flank, cutting edges and nose. The face is the surface on which the chip impinges and along which it flows as it is separated from the work. The flanks are the two surfaces of the tool facing the work. They are called the side or main flank and the end or auxiliary flank.



The cutting edges are formed by the intersections of the face and the flanks. They are called the side or main cutting edge and end cutting edge. The side or main cutting edge is the main sharp edge for the cutting process. It is formed by the intersection of the face and the side flank. The end cutting edge is formed by the intersection of face and end flank. The nose is the element formed at the junction of the side and the end cutting edges. This junction or the nose has a curve of small radius, known as nose radius.

Cutting tool angles:

Five angles define the geometry of the cutting tool, these are described below:

Back rake angle: Back rake angle, commonly called rake angle, is the angle between the face of the cutting tool and normal to the machined surface at the cutting edge. Rake angles may be positive, zero or negative, respectively. The strength of the tool is a function of rake angle. A tool with positive rake angle has got less cross-sectional area for resisting the cutting forces. Hence, the strength of the tool with positive rake is less as compared to other tools. Tool with negative rake angle has more cross-sectional area for resisting the cutting forces. Hence, the strength of the tool is maximum when rake angle is negative.

Side rake angle: It is the angle between the tool face and a line parallel to the base of the tool and is measured in a plane perpendicular to the base and the side cutting edge. This angle gives the slope of the face of the tool from the cutting edge.

Relief angle: The relief angle is the angle between the flank of the cutting tool and the tangent to the machined surface at the cutting edge. The side and the end face of the flank form side and relief angles, respectively. The relief angles enable the flank of the cutting tool to clear the work piece surface and prevent rubbing. These relief angles are also referred to as clearance angles.

Side cutting edge angle: Angle formed by the side cutting edge with the normal to machined surface is known as side cutting edge angle. It is essential for enabling the cutting tool at the start of cut to the first contact the work back from the tool tip. A large side cutting edge angle increases the force component, which tends to force the cutting tool away from the work piece.

End cutting edge angle: The angle formed by the end cutting edge with the machined surface is called end cutting edge angle. It provides a clearance for that portion of that cutting edge, which is behind the nose radius. This reduces the length of the cutting edge in contact with the work. Also, it is undesirable to have a cutting edge, just contact the work surface without actually cutting. These results in rubbing action causing more tool wear and may spoil the surface finish.

CUTTING TOOL DESIGN:

In the design of a cutting tool, the requirement of the geometry of the cutting edge is important. For the structural requirement and physical shape of the tool different strength considerations and physical shape of the tool are inevitable. In addition to that empirical relations and other factors based on experiments are also used in a tool design.

Apart from analytical methods, graphical solutions are also useful in many aspects of tool design. The design of a cutting tool comprises of the following:

1. Determination of size and shape of all the elements of the tool comprising cutting element and mounting element by analytical or graphical method.

2. Finding the optimum tool geometry and shape of the tool.

3. Selecting a suitable tool material.

4. Finding the tolerances on the dimensions of the cutting and mounting elements of the tool, guided by the accuracy required.

5. Based on the cutting forces finding the strength and rigidity of the cutting and mounting element of the tool.

6. Preparation of the drawing of the cutting tool gives all the necessary

Specifications and tolerances.

A good understanding of the working of the process, the kinematics' motions involved in the cutting operation, the variables in the process, the nature of the operation, the nature of the stresses on the tool, the method of working of the tool and method of chip disposal are essential for designing a cutting tool.

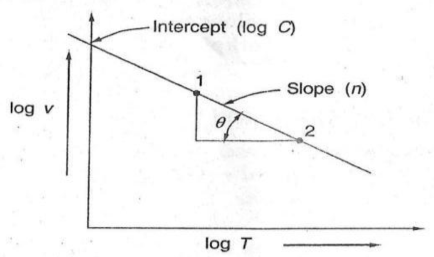
TOOL LIFE:
Tool life is defined as the time for which a tool can cut effectively or it is the time between two successive re-sharpening of a cutting tool. Cutting speed has more influence on tool life when compared to feed and depth of cut. The tool life as a function of speed is shown in figure.

The logarithm of tool life in minutes when plotted against the logarithm of cutting speed in m/min, the resulting curve is very nearly a straight line in most instances. For all practical purposes it can be considered as a straight line. This curve is expressed by the

Taylor's expression or tool life equation, which is given by

$$VT^n = C$$

Where,
V = cutting speed in m/mm
T = tool life in minutes
C= a constant which depends on the tool and work material. It is equal to the intercept of the curve and ordinate. Actually it is the cutting speed for a one minute tool life.



Tool life graph

n=slope of the curve which depends on tool and work material, and is given by

$$\frac{\log v_1 - \log v_2}{\log T_2 - \log T_1} = n \tan\theta$$

Where T1 and T2 are the tool life at cutting speeds v1 and v2

Pro/E:

Pro/ENGINEER, PTC's parametric, integrated 3D CAD/CAM/CAE solution, is used by discrete manufacturers for mechanical engineering, design and manufacturing. The parametric modeling approach uses parameters, dimensions, features, and relationships to capture intended product behavior and create a recipe which enables design automation and the optimization of design and product development processes. Pro/ENGINEER provides a complete set of design, analysis and manufacturing capabilities on one, integral, scalable platform. These capabilities include Solid Modeling, Surfacing, Rendering, Data Interoperability, Routed Systems Design, Simulation, Tolerance Analysis, and NC and Tooling Design. Pro/Engineer is a feature based modeling architecture incorporated into a single database philosophy with advanced rule based design capabilities. The capabilities of the product can be split into the three main heading of Engineering Design, Analysis and Manufacturing.

ANSYS:

The Mechanical Toolbar walks you through an analysis using tabs, icons, context-sensitive help, and other ease-of-use features. The goals of the Mechanical Toolbar are to allow engineers to work through their most common analyses quickly and easily, to allow occasional users to use ANSYS productively without requiring extensive knowledge of the product, and to help new users get started quickly without a steep learning curve.

While the Mechanical Toolbar has no modeling capabilities of its own, it does provide a variety of import options. These include importing model geometry from existing ANSYS models, as well as support for IGES models and the various ANSYS Connections filters.

You can use the Mechanical Toolbar to complete an entire linear static/modal or thermal analysis of a part or an assembly without having to access the full ANSYS menu system. This toolbar walks you through all required tasks, from setting up an analysis and importing a model through loading, solution, post processing, and new to the ANSYS product, generating a report. If you have to perform a more complex analysis, use the Mechanical Toolbar to complete as much of the analysis as possible, and move on to the full ANSYS menu system only when you have to use an advanced feature.

DESIGN OF SINGLE POINT TURNING TOOL:

The most common method of metal removal is to use an edged cutting tool. This process is based upon the separation of the base metal by pressure applied with a cutting tool made from a harder material. It has developed through the ages from a crude chisel like object powered and guided by the human hand to the present state of art, where a powerful machine tool forces and automatically guides a multi edged cutting tool through a large block of metal.

The basic elements of modern machining process consist of a machine tool, a control system, and the cutting tool. Each element may be compared to the leg of a tripod. If one leg is missing, the other two will fall. Thus, a machine tool and control system are useless without cutting tools and vice versa. The primary duty of tool designer may be to select or design tools for a metal cutting operation. Fortunately, the tool designer's job has been simplified in recent years because cutting tool manufacturers have made standard tools available in wide variety of shapes and sizes. Most machining operations can be performed by the application of standard tools. In this case, the major problem of tool designer is to select the standard cutting tool which will do the job in most efficient and economical way. To select proper tool efficiently, he must have a good knowledge of the metal cutting process, be familiar with tool geometry, and be aware of types of standard tools available. It should be emphasized that standard cutting tools should be used whenever possible for reasons of economy.

Factors to be considered in design of single point cutting tool:

- Type of work piece and tool material.
- Type of operation and surface finish required.
- Permissible speed, feed, depth of cut.
- Cutting force F z
- Overhung of the tool from the tool post.
- Accuracy of the work in terms of permissible deflection of the job with respect to the tool.

Design procedure:

The shank of a single-point tool may be

rectangular, square or round in cross section. The rectangular cross section is most often used because the reduction in strength of the shank is less than for a square shank when a seat is cut for a tip. Rectangular cross sections with various H-to-B ratios are used. In most cases, H/B=1.25 or 1.6 is used. It is advisable to use tools with H/B=1.6 for semi finishing operations and those with H/B=1.25 for roughing. In a single point cutting tool the shank may be rectangular, square or round. Normally rectangular sections are used with the H/B ratio of 1.25 or 1.6. For roughing operations the ratio of 1.25 is used. For semi-finishing and finishing operations the H/B ratio of 1.6 used. Square shanks are used for boring tools, turret tools and screw cutting tools. Round shanks are used for boring tools and light duty thread cutting tools.

Standard rectangular sections used in the manufacture of single point tools are 10 x 16, 12 x 16, 12 x 20, 16 x 20, 16 x 25, 20 x 25, 20 x 32, 25 x 32, 25 x 40, 32 x 40, 32 x 50 and 40 x 50 mm.

To determine the minimum permissible size of the shank cross section on a strength basis, it is necessary to equate the actual bending moment to the maximum bending moment permitted by the cross section of the shank, i.e.

$$M_b = M_b^1$$

$$M_b = F_z l$$

$$M_b' = \sigma_b Z$$

$$F_z L = \sigma_b Z$$

Where,

L= Overhang of the tool after clamping
Fz = Component of force
σ_b = permissible bending stress of the shank material.
Z = Section modulus of the tool shank, mm^3.

The section modulus of rectangular cross section is given by

$$Z = \frac{BH^2}{6}$$

Where B and H are the width and height of the shank at the critical cross section, mm. Hence we can write

$$F_z L = \frac{BH^2}{6}\sigma_b$$

$$BH^2 = \frac{6F_z L}{\sigma_b}$$

In rectangular shanks of a height H=1.6B. Therefore,

$$B = \sqrt[3]{\frac{6F_z L}{2.56\sigma_b}}$$

Since in square shanks the width is equal to the height, then

$$BB^2 = \frac{6F_z L}{\sigma_b}$$

$$B = \sqrt[3]{\frac{6F_z L}{\sigma_b}}$$

The section modulus for a round cross section is

$$Z = \frac{\pi d^3}{32}$$

$$F_z L = \frac{\pi d^3}{32}\sigma_b$$

$$d = \sqrt[3]{\frac{32F_z L}{\pi\sigma_b}}$$

The calculations given above for the plane bending of tool shanks are simple but not entirely exact. Only the force is taken into consideration and only the bending deformation it causes. But three forces—Fz, Fy, Fx –act on the tool in cutting, and their action leads to additional stresses so that shank is subjected to combined stress.

Checking for Rigidity:

It is necessary to check the rigidity of the tool shank. The maximum permissible load for rigidity F_r is given by

$$F_{zr} = \frac{3\delta EI}{L^3}$$

Where,

δ = Permissible deflection of the tool. Considering the tool to be Cantilever, the value can be assumed to be 0.1 mm for roughing operation and 0.05 mm for finishing operation.

E = Young's modules of the tool shank material.

I = Moment of inertia of the shank cross-section. Moment of Inertia for different shank cross section.

In designing a single point tool the height of the tool shank section should be checked against the distance from the tool supporting surface to the line of the axis of the machine. In the above design it is assumed that the critical section is at a distance L from the tool tip. Actually it must be designed for the weakest section. Single point tools used in shaping, planning and slotting machines are subjected to impact load in operation. Their cross-section are to be more by 25 to 50% of the lathe tools to resist impact loads. The length of the single point should be approximately ten times the height of its cross section.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 5, May - 2014

Basic tool geometry for HSS/Carbon steel:

Back rake angle = 8 deg

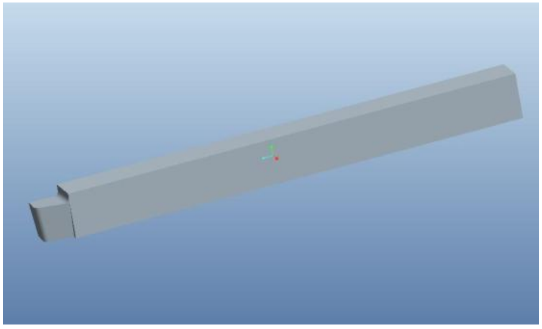
Side cutting edge angle = 12 deg

End clearance angle = 6 deg

End cutting edge angle = 5 deg

Side clearance angle = 6 deg

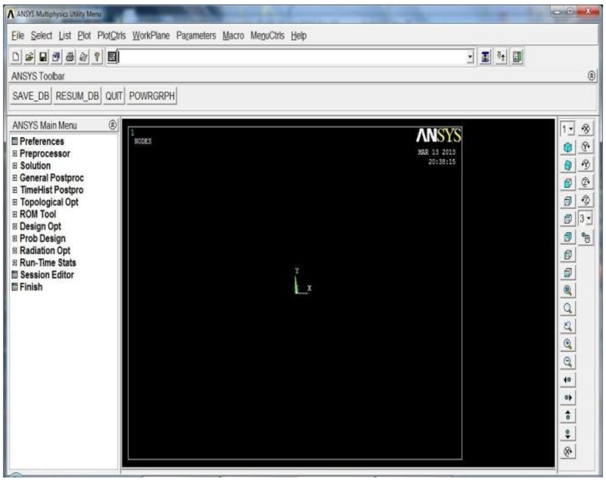
Side rake angle = 10 deg



Output Pro-E Package with Commercial Angles

Structural analysis on single point turning tool By Using ANSYS Analysis

Report Generated by ANSYS Mechanical Toolbar



Summary

The analysis was performed using the ANSYS 12.0.1 CAE software.

The part *single point cutting tool* was assigned properties of the material high speed steel and showed the following results:

Maximum total displacement is 6.36313E-02 mm
Maximum equivalent stress is 2416.3 MPa

Model Information:

The part *single point cutting tool* has a weight of 1.610 N (0.1643 kg). Figure 1 shows the model geometry and Figure 2 shows the finite element mesh. Table 1 lists the properties of the material (high speed steel) used in the model.

Finite Element Mesh

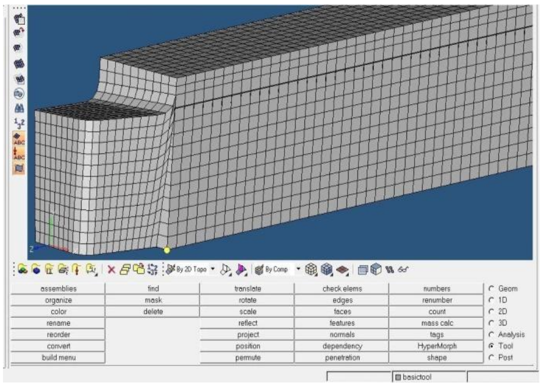


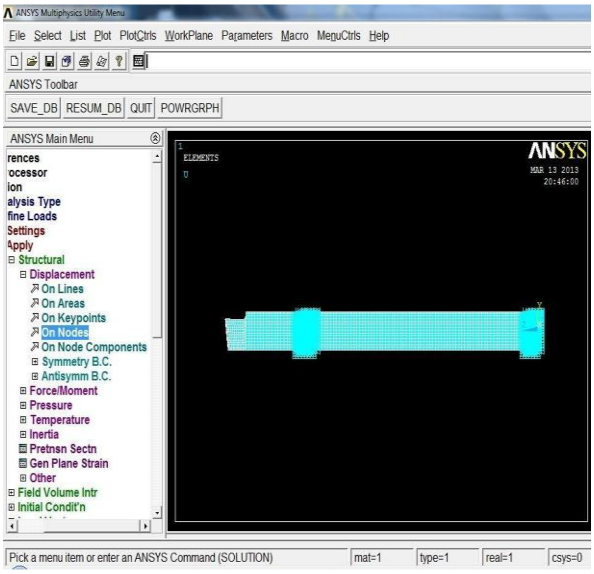
Table1. Material Properties

Material Properties for high speed steel	
Modulus of Elasticity [MPa]	2.2400E+05
Density [kg/mm^3]	8.6700E-06
Poisson's Ratio	0.3000
Thermal Expansion Coefficient [1/degC]	9.7000E-06

Model Information:

The part *single point cutting tool* was subjected to the load environment (see Figure 3 and Table 2) and evaluated with a linear static analysis.

Loads and Boundary Conditions:



Single point turning tool was constrained at 30mm distance from the tip and at the end of shank as shown in figure above.

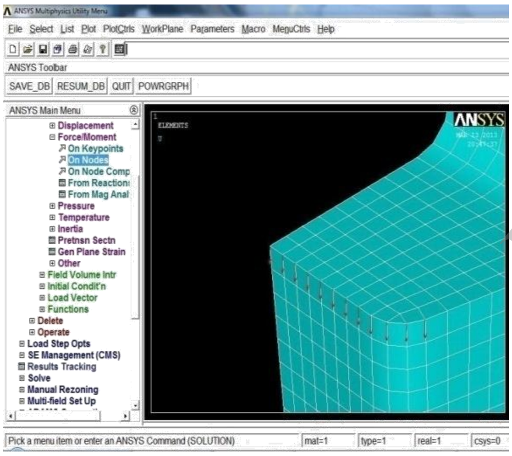
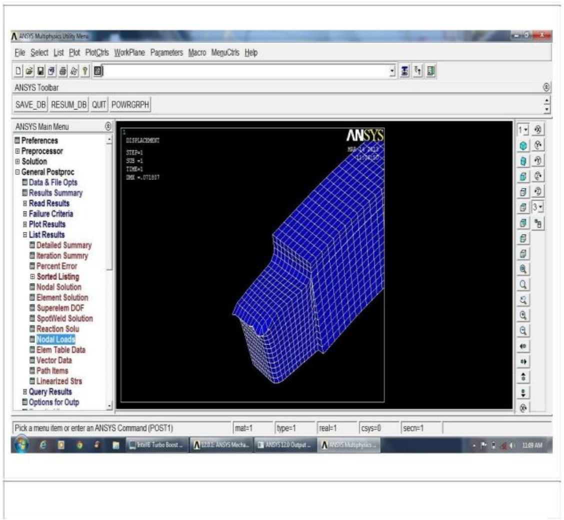


Table2. Load Conditions for Environment:

Loads					
		Values (Global Cartesian Directions)			
Type	Entity	X	Y	Z	Applied to Entities
Force [N]	Vertex	0.000	-2150.0	0.000	13
Gravity [mm/s^2]	Volume	0.000	0.000	0.000	All
Angular Velocity [RPM]	Volume	0.000	0.000	0.000	All
Uniform Temperature [deg C]	Volume	0.000	(Tref= 0.000)		All

Results:

The following figures and tables show the response of the part *single point cutting tool* to the load environment. The maximum total displacement is 6.36313E-02 mm and the maximum equivalent stress is 2416 MPa.



Direct Stresses

Direct Stresses [M Pa]			
	X	Y	Z
Minimum	-276.38	-1578	-265.92
Maximum	312.3	226.87	419.09

Stress Intensity and Equivalent Stress

	Stress Intensity	Equivalent Stress
Minimum	0.0000	0.0000
Maximum	2128	1932

The stress distribution at the tool tip (node 12)

S y	S z
1084	2890

Note: The stress distribution values are taken from the general post processor of the Ansys software(GUI Interface)
Similar analysis is done on the basic tool geometry, by varying the cutting tool angles.

Study and analysis of effects of operating conditions in machining:

Assumptions:

Cutting speed = 50m /min.

Feed = 0.2mm/rev.

Depth of cut = 1 mm.

Tensile strength of the work piece material is assumed as 70 kgf/mm2.
Chip thickness =s sin x = 0.195

Where x= plan approach angle

Specific cutting resistance offered by the work piece material= 240 kgf/mm^2

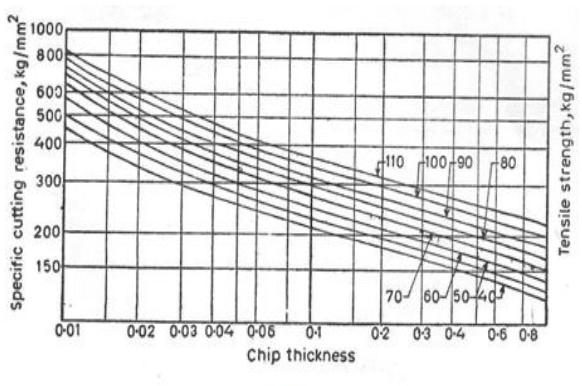


Fig:9-----
Source: Production technology-HMT

The cutting force F z can be calculated by

$$F_z = C_{Fz} s^{xz} t^{yz} v^{nz} k_{r1} k_{r2} k_w$$

Where F z =cutting force.

CFz=specific cutting resistance offered by the work material. v, s, t = cutting speed, feed, depth of cut.
x z, y z, n z = exponents of depth of cut, feed, cutting speed. The values are assumed as 1.0, 0.75, -0.15.
K r1 = Correction factor for back rake angle = 1.02 K r2 = Correction factor for side rake angle = 0.98 K w = Correction factor for wear = 1.0

EXAMPLE:

S=0.2 mm/rev

T=1 mm

V=50 mm/min

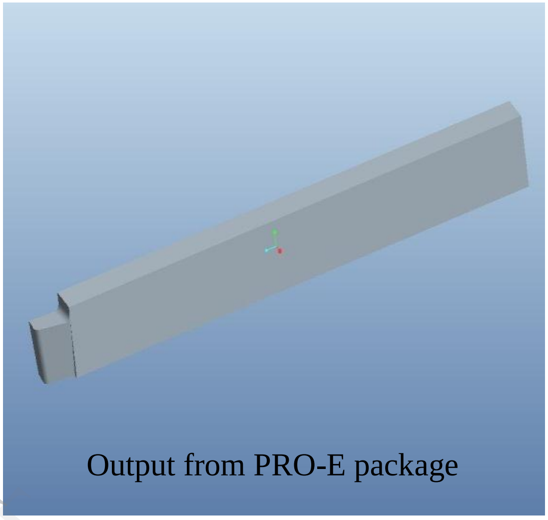
C F z = 240 kgf/mm^2.

Chip thickness = s sin x = 0.1956,
where x = plan approach angle = 78 deg Tensile strength of the work piece material = 70 kgf/mm^2

$$F_z = C_{Fz} s^{xz} t^{yz} v^{nz} k_{r1} k_{r2} k_w$$

= 39.89 kgf

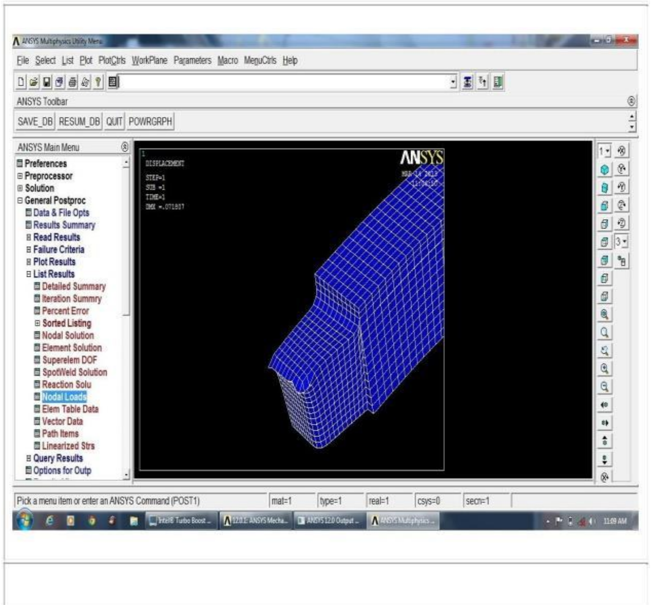
RESULTS AND DISCUSSIONS:



Output from PRO-E package

Results:

The following figures and tables show the response of the part *single point cutting tool* to the load environment. The maximum total displacement is 6.36313E-02 mm and the maximum equivalent stress is 2416 MPa.



The stress distribution values are taken from the general post processor of the Ansys software (GUI Interface)

Direct Stresses

Direct Stresses [M Pa]			
	X	Y	Z
Minimum	-276.38	-1578	-265.92
Maximum	312.3	226.87	419.09

Stress Intensity and Equivalent Stress

	Stress Intensity	Equivalent Stress
Minimum	0.0000	0.0000
Maximum	2128	1932

The stress distribution at the tool tip (node 12)

S y	S z
1084	2890

Effects of rake angle :

Rake angle	S_z (kg f/mm2)	S_y (kg f/mm2)
8	142.72	47.54
9	146.56	48.98
10	179.35	19.85
11	191.38	24.42
12	185.44	39.31
13	163.1	19.43
14	172.08	34.24

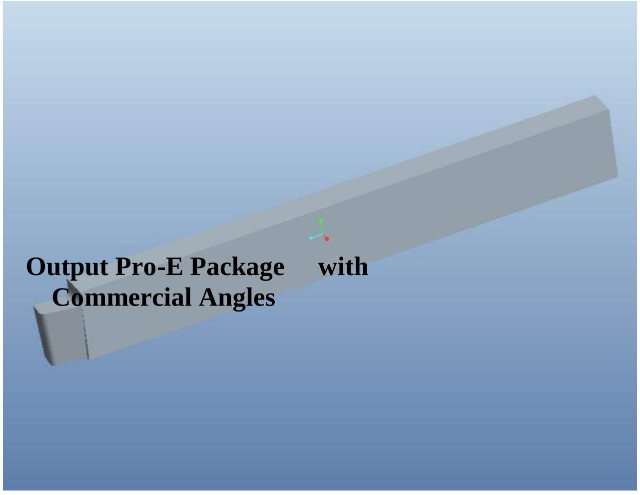
Side cutting edge angle	S_z (kg f/mm2)	S_y (kg f/mm2)
12	142.72	47.54
13	139.11	40.74
14	132.33	55.71
15	154.41	41.13
16	185.02	63.18
17	151.56	50.35
18	183.26	47.91

End clearance angle	S_z(kgf/mm2)	S_y(kgf/mm2)
6	142.72	47.54
7	195.1	42.42
8	202.14	33.9
9	151.59	21.6
10	168.2	24.95
11	139	59.74
12	137.3	23.99

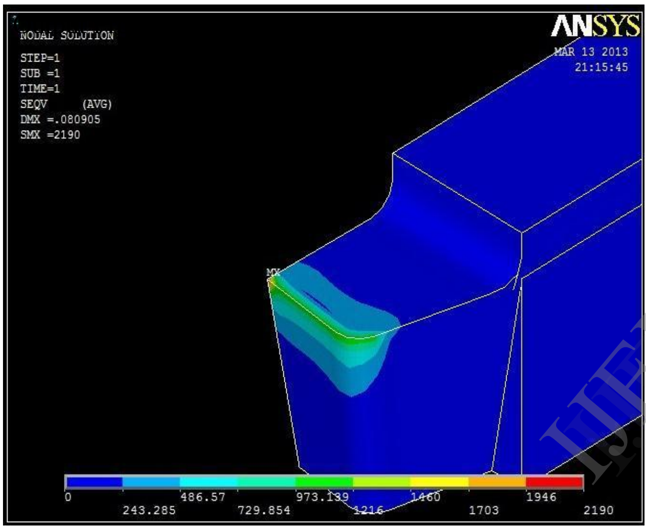
End cutting edge angle	S_z(kgf/mm2)	S_y(kgf/mm2)
5	142.72	47.54
6	146.3	36.33
7	146	38.62
8	148.38	40.72
9	150.86	38.2
10	258.61	42.4

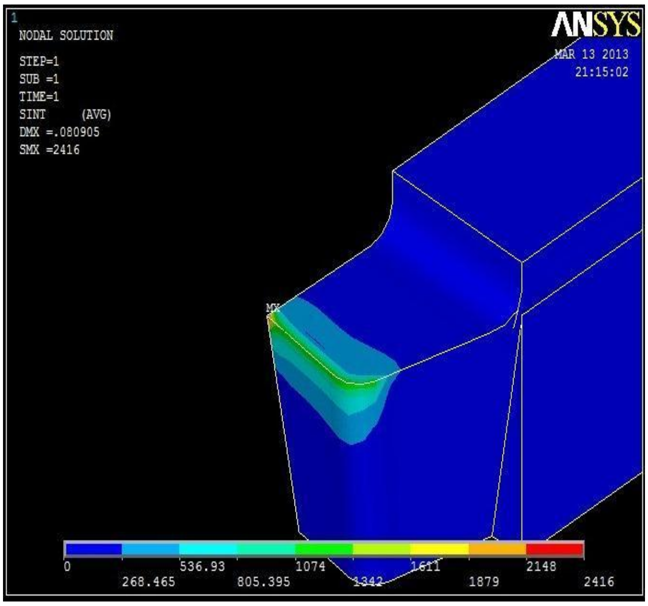
Side rake angle	S_z(kgf/mm2)	S_y(kgf/mm2)
10	142.72	47.54
11	175.46	36.52
12	166.71	15.27
13	149.29	3.43
14	165.75	-18.98
15	151.77	5.36

Side clearance angle	S_z(kgf/mm2)	S_y(kgf/mm2)
6	142.72	47.54
7	214.41	44.78
8	147.44	42.85
9	130.67	65.05
10	130.18	41.69
11	173.8	7.93
12	230.36	29.31



Output Pro-E Package with Commercial Angles





Effect of basic angles:

Back rake angle:

Decrease deformation of the layer of material removed by the tool, facilitate cutting, decrease deformation of the layer of material removed by the tool, facilitate chip flow, reduce the cutting force and power consumption, and improve the surface finish. Thinner chips result from higher rake angles consequently, the dynamic shear strain is less and, therefore, the cutting forces decrease with increased rake angle. However, further increase in the rake angle, beyond an optimum point weakens the cutting edge, and reduces heat transfer. It is recommended that cutting tools with large rake angles should be used in cutting soft and ductile materials to facilitate chip flow, and that tools with smaller rake angles should be used to machine hard and brittle materials to increase the strength of the cutting tool as well as to enhance tool life, in practice, the selection of proper rakes depends not only upon the work piece material to be machined but also upon the tool material.

Side cutting edge angle:

The side cutting edge angle determine the true feed or thickness of the uncut chip layer, a, perpendicular to the cutting edge, as well as the width, b of the un deformed chip.

At the same feed(s) and depth of cut (t), increase in side cutting edge angle will decrease the true feed (a) and increase the width (b) of the chip.

The tool/chip interface temperature, θ_i, is related to true feed, s1, according to:

$$\theta_i \, \alpha \sqrt{s_1}$$

Hence, the interface temperature will be less with a reduced feed, s, because of a increased side cutting edge angle, Further, the heat generated during the cutting process will be distributed over a longer length of the cutting edge. This improves heat removal from the cutting edge, increasing tool life and permitting the cutting speed to be substantially increased. On the other hand, increase in side cutting edge angle will increase the radial component of cutting force, F_y. When the work piece is insufficiently rigid, this force, F_y causes the work piece to bend, resulting in a loss of dimensional accuracy and causing server vibration or chatter of both the work piece and cutting tool. Chatter is the cause of poor quality on surface finishes and may often chip the cutting edge of a tool.

End Clearance Angle:

The end clearance angle decreases friction between the principal flank surface and the work piece. This reduces heating at the clearance surface and consequently reduces wear. The selection of end clearance angle depends upon (1) the properties of the material being machined, and (2) the cutting conditions

A large end clearance angle is generally used soft and ductile materials; hard and brittle materials require less clearance. However, the principal factor governing the selection of the clearance angle is the cutting condition of feed.

The end clearance angle can improve tool life by reducing friction, but as the clearance angle increases, the strength of the tool decreases, which decreases tool life. A decrease in feed increases the wear on the flank of the tool, requiring a larger clearance angle for optimum performance.

The optimum end clearance angle also depends upon the work piece material to be machined.

End cutting angle:

The end cutting edge angle is provided in tool design to prevent the auxiliary cutting edge from cutting, thereby reducing the friction of the auxiliary flank on the machined surface of the work piece. The inherent process roughness, particularly maximum roughness height, h_{max}, is related to end cutting edge angle

As end cutting edge angle is increased, h_{max} increase; thus surface quality is expected to deteriorate, as indicated. However a reduction in end cutting edge angle increases the radial component of the cutting force F_y, because the auxiliary cutting edge becomes more active and may cause chatter in insufficiently stiff work pieces. No improvement in tool life is expected beyond the optimal end cutting edge angle.

Side rake angle:

The side rake angle is positive if the tool face is sloping upwards towards the side cutting edge and is negative if it is sloping downwards towards the side cutting edge. Positive side rake angle gives better cutting action, thus resulting in lower cutting forces and lesser power requirements.

Side clearance angle:

Side clearance is the clearance on the side cutting edge. Higher side clearance values reduce the wear and result in a clean cut on metals of low strength. Lower values give a better support to the cutting edge, and they are suitable for cutting tougher metals.

Optimization of tool shape:

Optimal tool geometry

Back rake angle	= 11 deg
Side cutting edge angle	= 16 deg
End clearance angle	= 8 deg
End cutting edge angle	= 7 deg
Side rake angle	= 11 deg
Side clearance angle	= 7 deg

Justification:

As the cutting angles are increased the area along the body of the tool decreases, due to which the stress increases. The maximum stress is taken as the optimal angle, because maximum stress occurs at lower cross sectional area of tool tip, and the deformation produced by the tool in the work material is less at lower cross sectional area of tool tip due to which less cutting forces are generated and heat generated by the tool will be less.

Conclusion:

The optimal tool geometry is expected to have more tool life than the basic tool. Depth of cut has greatest influence upon the cutting force, followed by feed; with cutting speed has least influence. The cutting speed has maximum influence on temperature generated at cutting zone during machining. To achieve the greatest machining efficiency, use the heaviest feed that will allow the required surface finish, use the maximum depth of cut consistent with the available power and rigidity of work-piece and machine and then establish the cutting speed to give the desired tool life.

REFERENCES:

1. N.N. Zorev, Metal Cutting Mechanics, Pergamon Press, Oxford, 1966
2. G.C.I. Lin, Prediction of cutting forces and chip geometry in oblique machining from flow stress properties and cutting conditions, International Journal of Machine Tool Design and Research 18 (1978) 117–130.
3. R.S. Hu, P. Mathew, P.L.B. Oxley, Allowing for end cutting edge effects in predicting forces in bar turning with oblique machining conditions, Proceedings of the Institution of Mechanical Engineers 200 (C2) (1986) 89–99.
4. L.V. Colwell, Predicting the angle of chip flow for single-point cutting tools, Transactions of the ASME 76 (1954) 199–204
5. T.D.Marusich, M.Ortiz, *"Modeling and Simulation of High Speed Machining"*, 1995.
6. Thomas H.C. Childs, "*Modelling Requirements for Computer Simulation of Metal Machining*" Journal of Manufacturing Science and Engineering, 1998.
7. Kalhori, V., "*Modelling and Simulation of Mechanical Cutting*", Doctoral thesis, Institution for Maskinteknik, Avdelningen for Datorstodd maskinkonstruktion, Lulea Tekniska Universitet, 2001.
8. Black, J. T. and Huang, J. M., "*An evaluation of chip separation criteria for the fem simulation of machining"*, ASME Journal of Manufacturing Science and Engineering, 1995.
9. Marusich, T.D. and Ortiz, M., "*Modeling and simulation of high-speed machining*,"International Journal for Numerical Methods in Engineering1995