

Analysis of Single Point Cutting Tool in Plain Turning

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Abstract – This paper highlights the effect of the change in depth of cut (DOC) cutting forces generated on the tip of the Single Point Cutting Tool (SPCT) while working. The tool is first reduced to standard dimension using the method of grinding and the tool geometry is kept within standard dimensions and all angles and edges are measured. Cutting forces acting on cutting tool are recorded at different depth of cut. Where cutting forces are measured using lathe tool dynamometer. Years of research has conclusively shown that it a process involving plastic deformation in which large strains and strain rates are developed by localized shear deformation of work material immediately ahead of tool. Heat generated during the chip formation process as a result of plastic deformation and friction. The heat influences chip shape, tool wear, surface finish and cutting forces.

Keywords – Single Point Cutting Tool (SPCT), depth of cut (DOC), cutting forces, tool geometry, angles, edges, stresses, ANSYS.

I. INTRODUCTION

Metal cutting, or simply machining, is one of the oldest processes for shaping the components in the manufacturing industry. It is estimated that 15% of the value of all mechanical components manufactured worldwide is derived from machining operations. When machining metals and alloys most of the energy required to form the chips is converted into heat. Therefore, the temperature generated in the cutting zone is an important factor to take into consideration. This factor is of a major importance to the performance of the cutting tool and quality of the work piece.

Temperatures in cutting zone depend on contact length between tool and chip, cutting forces and friction between tool and work piece material. A considerable amount of heat generated during machining is transferred into the cutting tool and work piece. The remaining heat is removed with the chips. Therefore, contact length between the tool and the chip affects cutting conditions and performance of the tool and tool life. The two basic methods of metal cuttings using a single point cutting tool are the orthogonal or two-dimensional, and the oblique or three dimensional. Orthogonal cutting takes place when the cutting face of the tool is 90° to the line of action or path of the tool.

If, however, the cutting face is inclined at an angle less than 90° to the path of the tool, the cutting action is known as oblique. Cutting Forces Cutting is a process of extensive stresses and plastic deformations. The high

compressive and frictional contact stresses on the tool face result in a substantial cutting force F as shown in fig 1

Knowledge of the cutting forces is essential for the following reasons:

1. Proper design of the cutting tools
2. Proper design of the fixtures used to hold the work piece and cutting tool
3. Calculation of the machine tool power
4. Selection of the cutting conditions to avoid an excessive distortion of the work piece

Cutting force components usually in orthogonal cutting, the total cutting force F is conveniently resolved into two components in the horizontal and vertical direction, which can be directly measured using a force measuring device called a dynamometer.

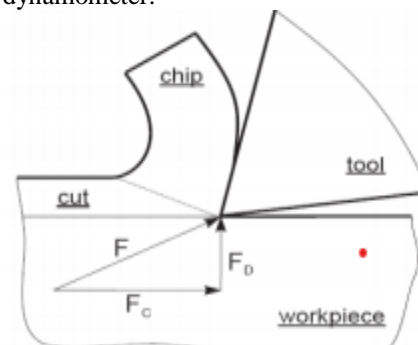


Fig.1.cutting Forces.

The dynamometers being commonly used now-a-days for measuring machining forces desirably accurately and precisely (both static and dynamic characteristics) are either

- Strain gauge type

- Piezoelectric type

Strain gauge type dynamometers are inexpensive but less accurate and consistent, whereas, the piezoelectric type is highly accurate, reliable and consistent but very expensive for high material cost and stringent construction. Turning dynamometers may be strain gauge or piezoelectric type and may be of one, two or three dimensions capable to monitor all forces acting on tool and workpiece.

Heat is produced during shearing action. The heat generated raises the temperature of tool, work and chips. The temperature rises in cutting tool tends to soften it and causes loss of intensity in the cutting edge leading to its failure. This temperature during metal cutting is maximum at the tip of the tool. Due to this temperature the tool gets soften at the tip and various stresses and deformation is take place in the tool. It is essential to find out the effect of forces acting on the tip of the tool.

II. RATURE REVIEW

The effect of the temperature and cutting forces generated on the tip of the Single Point Cutting Tool (SPCT) while working. In an experimental work, temperature measurement is done by using thermocouple at various depth of cut and it found that the temperature increases with increase in depth of cut. Cutting forces acting on cutting tool are determined analytically at different depth of cut. Modelling of single point cutting tool is done by PRO-Engineer Wildfire-4 software.

The model is then imported in ANSYS software and meshing is done. Then the temperature readings and the forces calculated at different depths of cut are given as an input to the software. The software analysed the model by finite element analysis at various forces and calculated the stresses developed at the tip of the tool and also the deformation of the tip of the tool. In Finite element analysis of single point cutting tool the maximum stresses are developed at the tip of tool which is the main cause of failure. Also, the maximum deformation takes place at the tip of tool which blunts the tool, is the cause of failure.[1] (Safal A. Shambharkar., Amar. W. Kawale., Chetan J. Choudhari., “Analysis of Single Point Cutting Tool Using ANSYS”, International Journal on Recent and Innovation Trends in Computing and Communication Volume: 4 Issue: 5 May 2016)

The geometry of cutting tool surfaces is one of the crucial parameters affecting the quality of manufacturing process and has been traditionally defined using the principles of projective geometry. The parameters of geometry defining the various cutting tool angles are described by means of taking appropriate projections of the cutting tool surfaces. Development in the field of computer Aided Geometric Design (CAGD) now provide more elegant approach for specifying the cutting tool surfaces as a set of biparametric surface patches. This study of machining

processes involves analysing the chip formation process. Years of research has conclusively shown that it a process involving plastic deformation in which large strains and strain rates are developed by localized shear deformation of work material immediately ahead of tool. Heat generated during the chip formation process as a result of plastic deformation and friction. The heat influences chip shape, tool wear, surface finish and cutting forces.[2] (NBV Lakshmi Kumari., S. Irfan Sadaq., G. Prasana Kumar., “Analysis of Single Point Cutting Tool of a Lathe Machine Using FEA” International Journal of Engineering Trends and Technology (IJETT) – Volume 20 Number 5 – Feb 2015)

A single point cutting tooltip interface is determined. In which we are going to explain a study which we have done on the Geometry of single point cutting tool. In this the no. of angles, edges. Single point cutting tool have only a one cutting point through which they perform various type of functions such as Turning, Boring, and Shaping operations. These tools are used in lathe, Boring, and shaper machines. S.P.C.T has a sharp cutting edges to remove the material a large cutting force get develop on S.P.C.T due to which various noise or vibration created cutting forces get increase while the Depth of Cut. As our paper is on single point cutting tool the Tool Signature will be there for the arrangement of 6 angles and nose radius.[3] (Pranay Batwe., Akshay Pawar., Pushmod Metange., Raunak Suryawanshi., Dr. Vinod Bhaiswar., “Review on Single Point Cutting Tool” International Journal of Engineering Trends and Technology (IJETT) Volume: 04 Issue: 11 | Nov -2017)

High speed machining is one of those main methods of increasing production efficiency and shorten machining times. High speed machining (HSM) has become a common trend supplied in manufacturing industry since the successful development of high-speed spindle and modern material techniques. But wear happens during the cutting operation of the cutting tool. Since tool wear may cause poor dimensional accuracy, as well as deterioration of surface integrity of the workpiece, and even cause damage of workpiece if neglected. Therefore, the variation of tool wear of the tools during high speed machining process must be known. If the quantity of tool wear is learned, it is possible to make tool compensation for maintaining workpiece accuracy. And the replacement time of the tool can be determined, in order to prevent the occurrence of workpiece damage.[4] (Lin W.S., “The reliability analysis of cutting tools in the HSM processes”, Archives of Materials Science and Engineering, Volume 30, Issue 2, April 2008, Pages 97-100.)

III. METHODOLOGY

Take tool (HSS) specimen of standard dimension (12.70 X 152.40 mm). Grind the tool specimen using universal grinding machine to rake angle of 80 and nose radius of

40. Then using profile projector project, the tool view and measure its angles and note down the angles. Then weigh the tool weight using digital weighing machine and not it down. Fix the tool in tool post of lathe; machine the work piece for a set of speed (180,450), feed (0.18), and depth of cut (0.5,1,1.5,2). Note down the time of machining. Measure the length and diameter of the specimen. Then again weigh the tool for its weight. Repeat the above for various parameters and note down the respective readings. Then note down the good result.

Table –I: Cutting Tool Dimensions.

Sl.No	Parameters	Tool dimensions (in deg)
1.	Back rake (α_s)	8°
2.	End relief (γ_s)	6°
3.	End cutting edge (C_s)	16°
4.	Side cutting edge (C_s)	15°

Nose radius of the tool, $r = 4\text{mm}$

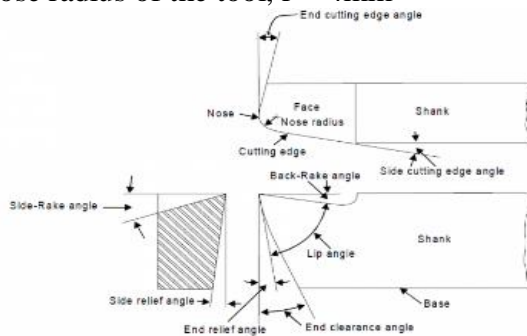


Fig.2. Single point cutting tool nomenclature.

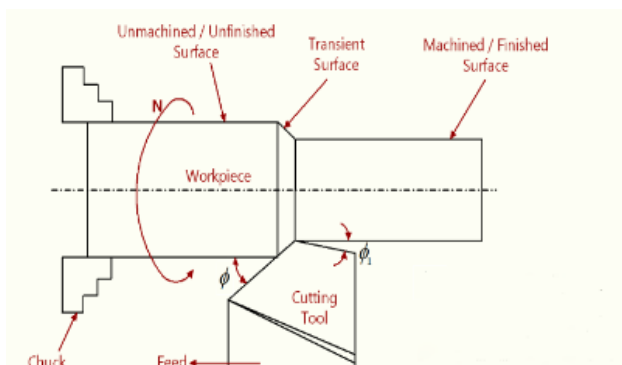


Fig.3. Machining Process.

Table-II: Cutting Forces at different DOC.

Sl.No	Speed 'N' (rpm)	Feed 'f' (mm/min)	DOC 't' (mm)	Feed Force 'P _x ' (Kgf)	Cutting Force 'P _z ' (Kgf)	Thrust Force 'P _y ' (Kgf)
1.	180	0.18	0.5	8	40	4
2.	180	0.18	1	14	70	6
3.	180	0.18	1.5	28	120	6
4.	280	0.18	1	14	44	4
5.	280	0.315	1.5	35	105	7
6.	280	0.5	0.5	4	35	5

DOC= Depth of Cut.

IV. RESULTS AND DISCUSSION

On comparing the values obtained and computing these values using graph at different speeds where the feed rate is kept constant throughout the process we came to know that the change in depth of cut influences more in tool wear as the forces increases the stresses developed at the tool tip increases and also temperature also increases. From graph 1, as the depth of cut increases the required cutting forces also increases. At DOC=0.5 the $P_x=8\text{Kgf}$, $P_y=4\text{Kgf}$, $P_z=40\text{Kgf}$ whereas at DOC=1.5 the $P_x=28\text{Kgf}$, $P_y=6\text{Kgf}$ and $P_z=120\text{Kgf}$ we can compare these two values where the speed and feed rate are kept same throughout the completion of the trial and as the depth of cut increases there is change in cutting force and there is more stresses developed at the tip of the tool which results in tool ware and change in tool geometry which causes tool failure and rough surface finish.

From graph 2, as the depth of cut increases the required cutting forces also increases. At DOC=0.5 the $P_x=4\text{Kgf}$, $P_y=5\text{Kgf}$, $P_z=35\text{Kgf}$ whereas at DOC=1.5 the $P_x=35\text{Kgf}$, $P_y=7\text{Kgf}$ and $P_z=105\text{Kgf}$ we can compare these two values where the speed and feed rate are kept same throughout the completion of the trial and as the depth of cut increases there is change in cutting force and there is more stresses developed at the tip of the tool which results in tool ware and change in tool geometry which causes tool failure and rough surface finish.

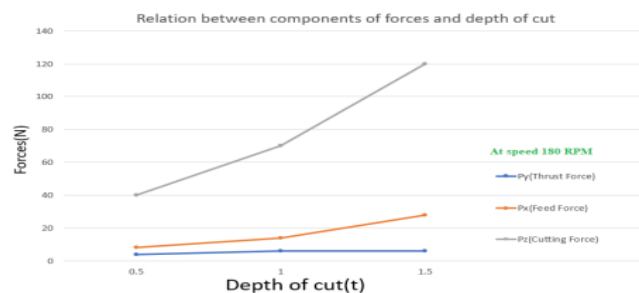


Fig. 4 Graph 1 Relation between components of forces and depth of cut

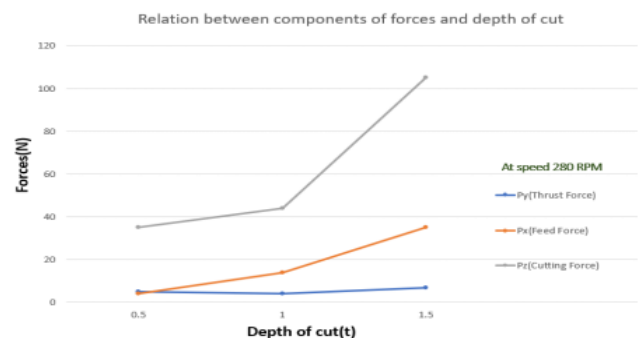


Fig. 5 Graph 2 Relation between components of force and depth of cut

V. CONCLUSIONS

1. The work presented in this paper regarding the project highlights that as the depth of cut increases, the stresses developed in the tool increases. It is the main reason for tool failure.
2. Also, as the speed of the spindle increases the required cutting forces also increases these leads to more stress develops at the tip of tool due to more frictional forces exerted at the chips and tool surface and as a result this frictional force results in increase in temperature as the temperature increases the physical properties of the tool changes which results in tool failure.
3. The deformation also on higher side with every interval of rise in depth of cut. It is also one of the reasons for tool failure. As the depth of cut is increased further from 0.5 mm to 1.5 mm vibrations are set up in the tool, due to which the geometry of the tool gets affected and the tool becomes unusable.

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