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Design & Dynamic analysis of (SPC) Single Point Cutting Tool by varying tool content for various depth of cut rates

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ABSTRACT:

Tool wear is a worldwide problem in the industrial and automotive industries. The cutting tool and the job are subjected to varying stresses as a result of the machine's speed and the pressures applied, reducing tool life. This results in severe downtime when a tool is pulled out to be reconfigured or changed. This takes longer because every member of the production line is idle. Furthermore, the worn tool will have a significant impact on the machined part's quality and surface integrity. Because the goal of the automotive manufacturing industry is to create high volumes of high-quality goods in a short period of time, the machine's cutting tool remains a critical component that affects overall work performance. This project examines the most recent studies on increasing tool life.Metal cutting is the foundation of the engineering business, and it is used to make practically every product in modern society, either directly or indirectly. The study of metal cutting is critical, and a basic understanding of the principles of material machining and metal cutting theory will aid in the development of a scientific approach to solving machining difficulties. We looked at tool geometry, materials, qualities, working circumstances, and the effects of variables like cutting speed, feed, and depth of cut during the machining process in this project design and analysis of single point cutting tool.

Keywords **-** *Cutting Tool, stresses, Tool Life, FEA, Explicit Dynamic*.

I. INTRODUCTION

- A shaper machine is a one-point cutting tool because the single cutting edge, also known as the leading edge of the tool, remains in contact with the tool throughout the operation.
- A multipoint tool is one in which the actual cutting operation is performed with more than one cutting edge, and thus has a different cutter geometry depending on the type of operation performed in the working material.
- The shaper and the planer have similar structures, but the former can only handle small jobs, whereas the latter can handle work weighing up to several tones

Literature review

[1]. This paper reviews the important recent research contributions for control of machining processes {e.g., turning, milling, drilling, and grinding). The major research accomplishments are reviewed from the perspective of a hierarchical control system structure which considers servo, process, and supervisory control levels. The use

and benefits of advanced control methods (e.g., optimal control, adaptive control) are highlighted and illustrated with examples from research work conducted by the authors. Also included are observations on how significant the research to date has been in terms of industrial impact, and speculations on how this research area will develop in the coming decade.

[2]. The finite element method is used to study the effect of different rake angles on the force exerted on the tool during cutting. Researchers use this method to better understand the mechanisms of chip formation, the generation of heat in cutting zones, as well as the characteristics of tool-chip interfacial friction on machined surfaces. This study investigates the variation in values of Von-misses stress for three different rake angles for specified applied forces. The value of Von-misses stress decreases as rake angle is increased. In present study, mesh is created in ANSYS and the boundary conditions are applied and the analysis is carried out for the applied constraints. The results calculated on software can be verified.

[3]. This paper highlights the effect of the temperature and cutting forces generated on the tip of the Single Point Cutting Tool (SPCT) while working. In a 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. Modeling 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 analyzed 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.

[4]. Tool wear is a global issue in manufacturing as well automotive industry. The speed of the machines and the forces applied exposes the cutting tool and the work to different stresses which deteriorates the tool life. This causes a significant down time to pull out a tool either to reconfigure or change the tool. This consumes more time as every member in the production line remains idle. In addition, the worn tool will have a serious effect on the quality and surface integrity of the machined part. As the aim of automotive manufacturing industries is to produce high volumes and qualitative products in a brief period, the machine's cutting tool remains the key component which affects the overall preperformances of work. This paper reviews the latest researches on improvement of tool life.

[5]. The single point cutting tool is used in machines like lathe, shaper and planer machine to remove the excess material from work surface. In order to get a good work, finish it requires a good cutting tool which can essentially do the required task quickly, with ease and if having a longer tool life too will be an additional advantage. In order to gets an idea that which material will be the best we performed the finite elemental analysis

using ANSYS explicit dynamic solver. For modeling of the work piece and tool assembly we used CATIA V5R12 software and the two different tool contents are used to analyze their effect on various depth of cut to analyze the deformation values. Here the tool materials used are HSS (High Speed Steel) and HCHC (High chromium high carbon steel) whereas the work material is taken as nickel.

1.1 Tool Geometry: Face or rake surface, flank, cutting edges, and corner are the features that make up the geometry of a cutting tool. Geometry is mostly determined by the qualities of the tool material and the work material for cutting tools. Depending on the feed direction, a single point cutting tool can be either right or left-handed. The following diagram depicts conventional nomenclature. When creating single point instruments, angles like rake, relief, and end are crucial.

1.2 Study of Design: Tool engineering includes the development of single point cutting tools. This lesson looks at tool shank design, single point cutting tool design, and various forces that occur during workpiece machining. When developing a single point cutting tool, the tool's strength and stiffness are also taken into consideration.

1.3 Problem Statement

Cutting equipment usually fail because of:

1. Mechanical failure caused by high stresses and shocks. Such tool failures are unpredictable and severe, making them exceedingly dangerous.
2. Fast dulling owing to plastic deformation caused by high loads and temperatures.
3. A 20 percent increase in cutting speed reduces tool life by 50%. Tool life is reduced by 80% when cutting speed is increased by 50%. Chattering is common while cutting at low speeds (20–40m/min). As a result, tool life is reduced.
4. For cutting, low cutting time, long tool life, and high cutting precision are ideal.
5. In order to achieve these circumstances, efficient cutting conditions and tools must be chosen according on the work material, hardness, shape, and machine capabilities.

(1) Fracture failure,

(2) Thermal failure, and

(3) Progressive wear are the three tool failure modes.

1.4 Objective

1. To seek for more advanced tool materials in order to increase productivity and tool life.
2. In this project, I'll attempt to work on a single point cutting tool to see the effect of employing HCHC instead of HSS as a tool material for a range of depths of cut on a lathe machine.
3 .An explicit dynamic analysis is performed for the offered work to see the tool behavior at various moments as the cutting progresses in order to focus on the stress and deformation patterns for both tool content and tool content.
4. CATIA is used for modelling, while ANSYS Explicit Solver Workbench is used for analysis.

1.5 Methodology

Software's & worksheets required-

- CATIA v5 R21 for Designing of 3D model.
- ANSYS 20 R1 for simulating the above factors using explicit dynamics.
- Comparison study by varying depth of cut & material between HSS & HCHC.
- Four iterations will be carried out on different materials & different depth of cut of a lathe machine cutting tool.
- Literature review
- Material selection
- 3D development of product using CAD software.
- Simulation of solution Using ANSYS soft.
- Varying materials to know the strength of each at different depth of cut.
- Selection of efficient of one.
- Thesis writing.
- Conclusion.

1.6 The notations used in design of shank is given below

F = Permissible tangential force during machining, N

- f = Chatter frequency, cycle per second (c.p.s)
- H = Depth of shank, mm
- B = Width of shank, mm
- L0 = Length of overhung, mm
- d = Deflection of shank, mm
- E = Young's modulus of material, N/mm2
- I = Moment of inertia, mm4
- hc = Height of centres, mm
- σut = Ultimate tensile strength, N/mm2
- σper = Permissible stress of shank material, N/mm2
- Lc = Length of centres, mm

For the given value of chatter frequency f, the shank deflection can be calculated from the given as follows.

$$f = \frac{(15.76)}{\sqrt{d}} \text{ c.p.s.}$$

where, d is deflection in mm.

The permissible deflection of shanks ranges from 0.025 mm for finish cuts to 0.9 mm for rough cuts. Considering shank as a cantilever,

$$d = \frac{FL_0^3}{3EI}$$

$$d = \frac{FL_0^3}{3E}\left(\frac{12}{BH^3}\right) = \frac{4FL_0^3}{EBH^3}$$

The force F for given size of lathe is given by

$$F = f \times t \times C$$

1.7 Figures And Tables:

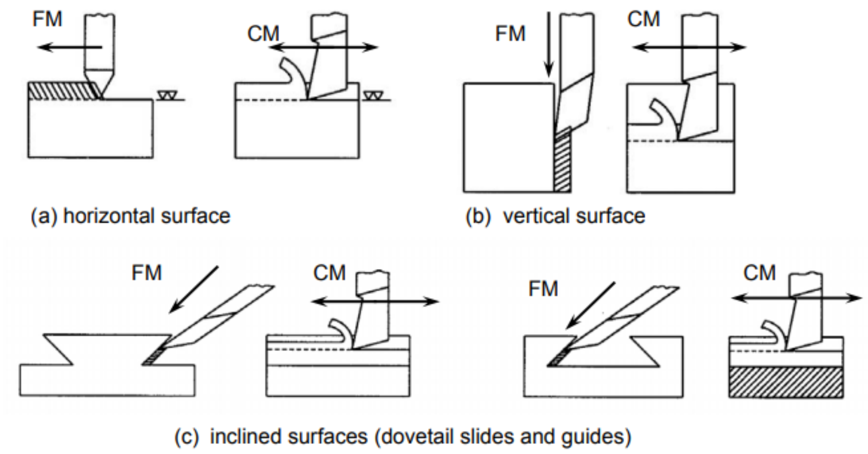

Fig.1 types of surfaces

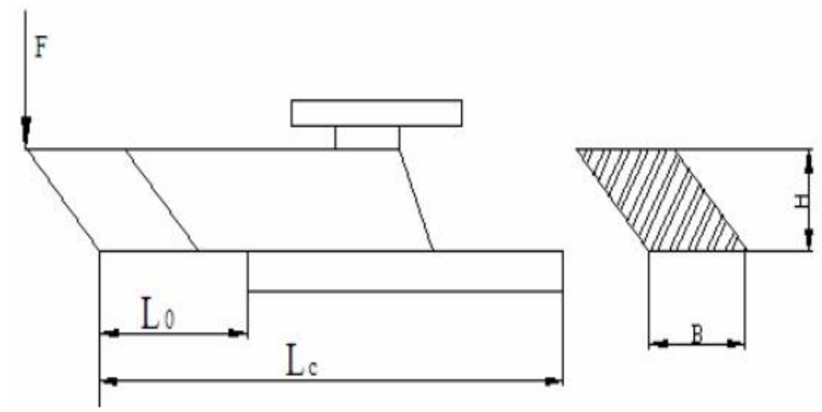

Fig.2 Force acting on tool shank

II. INTRODUCTION TO EXPLICIT DYNAMICS

The dynamic response of a structure due to the propagation of a stress wave, the impact, or the rapid change of time-dependent loads is determined using an explicit dynamic analysis. The exchange of momentum between moving bodies and inertial effects are usually key features of the sort of study done. This method can also be used to represent extremely nonlinear mechanical processes. Materials (e.g., hyperplastic, plastic flows, flaws), contacts (e.g., high-speed collisions and impacts), and geometric deformations can all cause non-linearity (e.g., buckling and collapsing). This sort of study effectively simulates events with time scales shorter than 1 second (usually on the order of 1 millisecond). Consider utilizing a transient analyzer for occurrences that last longer.

MODELING AND SIMULATION

It is discussed how to model and simulate a single point cutting tool using CATIA and ANSYS simulation software. The model was created with CATIA V5R12 software, and the analysis was performed with ANSYS Explicit. The analysis is performed using two different tool materials: high-speed steel (HSS) and high-carbon high-chromium steel (HCHC), with a cutting velocity of 14 m/s2.

III. CONCLUSION

We had been researching the design technique for constructing an SPC tool, as well as the testing strategies for validating the failure criteria under loading conditions using Ansys Workbench, till today. Catia v5 software will be used for design. The next step will be to prepare analytical calculations.

IV. ACKNOWLEDGEMENTS

An acknowledgement section may be presented after the conclusion, if desired

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