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Computer Aided Modeling and Simulation of Single Point Cutting Tool with Varying Tool Material

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Abstract: Metal cutting is one of the processes to convert the raw material into finished goods. There are number of parameters which are mainly depend upon the tools and its geometry like the quality of cut, surface finish of cutting surface, power consumption of the machine etc. So the right design of the tool is very much important.

In present work the single point cutting tools is modeled and analyzed for the best material out of the three materials namely High speed steel, high carbon steel and CBN (cubic boron nitride). For modeling we have used CATIA V5R12 software where as the analysis is carried out using ANSYS 14.0 workbench. It has been found that for the same loading conditions the High speed steel tool proves to be the best out of the three materials taken into account.

***Index Terms* – Single point cutting tool, CATIA V5R12, ANSYS 14.0, high speed steel, high carbon steel, cubic boron nitride.**

I. Introduction

Machining is an essential process of finishing by which work pieces are produced to the desired dimensions and surface finish by gradually removing the excess material from the preformed blank in the form of chips with the help of cutting tool(s) moved past the work surface(s).

Cutting tools may be classified according to the number of major cutting edges (points) involved as follows:

1. Single point: e.g., turning tools, shaping, planning and slotting tools and boring tools.
2. Double (two) point: e.g., drills.
3. Multipoint (more than two): e.g., milling cutters, broaching tools, hobs, gear shaping cutters etc.

Tool Signature of the single point cutting tool:

According to the ASME the tool angles are mention in following order:

(a) Back rake angle
(b) Side rake angle
(c) End relief angle
(d) Side relief angle
(e) End cutting edge angle
(f) Side cutting edge angle
(g) Nose radius

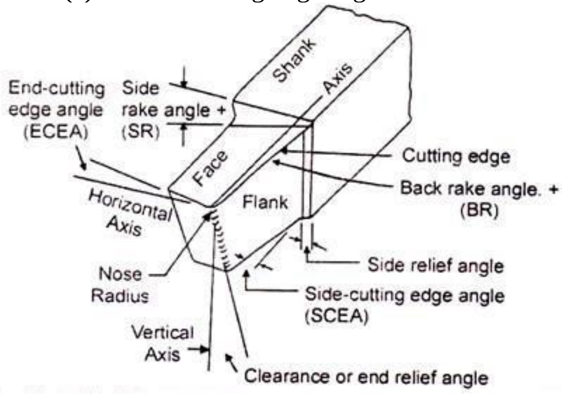

Figure 1.1 Single Point Cutting Tool

II. Literature Review

Nagarajan, A. et. al. [1] Presents the wear characteristics of the tool on indexable cutting inserts coated with titanium nitride (Tin) and Al2O3. SAE-AISI 1037 Carbon Steel Cutting Tool. Test results show that coated tools are suitable for producing parts with excellent surface quality when selecting cutting parameters. This article examines the performance of coated equipment when dry machining hardened steels. The results show that the tinned tool outperforms the uncoated cutting tool. **Sowjanya, S.et. al. [2]** This work evaluates the useful life of an HSS tool with various cutting parameters during turning. Tool life has been found to decrease with increasing feed and cutting speeds. **Wang, M. H. et. al. [3]** MD simulations were used to investigate the effect of dynamic adjustment of shear angles on the nano-shear behavior of mono-crystalline silicon. **Lee, Y. J. et. al. [4]** shows the improvement in heat treatment to handle the hard and brittle materials in a number of ways.

Gurbuz, H. et. al. [5] experimentally investigated the effect of cutting tool size and cutting parameters on surface integrity during machining AISI 316L steel. **Gupta, M. K. et. al. [6]** the researchers proposed an improved strategy to improve the cooling strategy, based on minimum amount of lubrication (MQL). It has an advantage over water cooling, as it allows better control of its parameters (eg compressed air, cutting fluid). **Gangadhar, N. et. al.** [7] This article discusses engraving tool failure diagnosis using a vibration signal-based machine learning approach. The technique involved collecting 40 acceleration vibration samples for five different classes of industrial wear conditions. **Li, Y., Daniel et. al. [8]** In this article, FE models with fine solid elements were created for the conical forming process to investigate the deformation mechanism. First, the FE model is verified experimentally by comparing the formation forces. FE modeling confirms that the elongation in the ISF process is a combination of stress, bending and shear.

III. Methodology

3.1 Flow Chart:

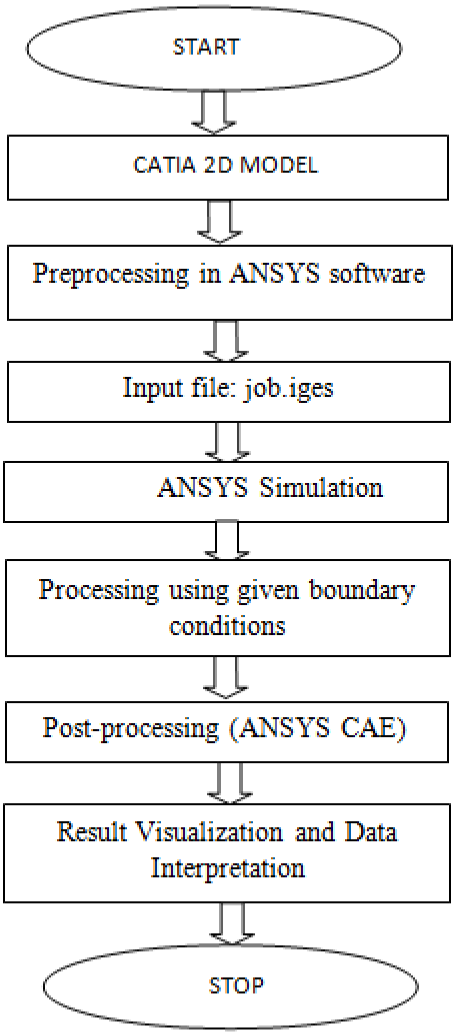

Figure 3.1: Flowchart of Single point cutting tool analysis.

Figure 3.1 represents the flow chart of the single point cutting tool analysis here first we model the two dimensional cuboidal model of the tool and then we will remove the different faces of the tool at different angles to get the final shape of the tool. The model is then opened in ANSYS with the igs data exchange file format so that it can be readable in ANSYS 14.0 workbench. The required material properties, meshing in finite parts, and boundary conditions are given to the tool to ensure the right analysis for the given tool. The last step is to compute the results and obtain the final results in form of deformation, stress, shear stress and strain values. Which are then compared to get the best material for making the single point cutting tool.

3.2 Tool Dimensions:

Bake rake angle: 10◦
Side Rake angle: 7◦
End relief angle: 7◦
End cutting Edge Angle: 15◦
Side Cutting Edge Angle: 15◦
Nose Radius: 0.5 mm

3.3 Material Properties:

Table 3.1 Material Properties of Single point cutting tool

Sr. No.	Material	Young's Modulus	Density	Poisson's Ratio
1	High speed steel	200000 M Pa	8138 Kg/m^3	0.3
2	High carbon steel	190000 M Pa	7850 Kg/m^3	0.26
3	Cubic boron nitride	180000 M Pa	7000 Kg/m^3	0.25

IV. MODELING AND SIMULATION:

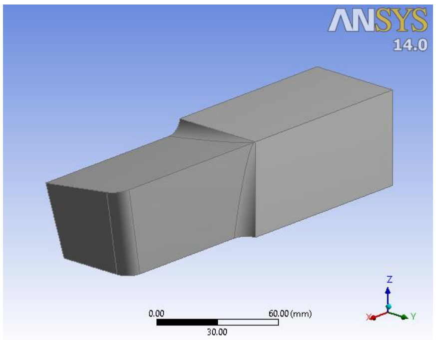

Figure 4.1 SPCT model as imported in ANSYS workbench

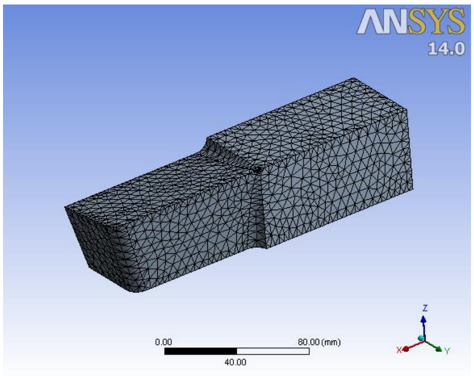

Figure 4.2 Meshed model of SPCT

Figure 4.2 represents the meshed model of the single point cutting tool with octree-tetrahedron mesh element using the by default fine mesh element. This is done in order to make the part finite so that it can be made deformable if this is not done then the ANSYS will traet the whole body as rigid part and further analysis cannot be performed on it.

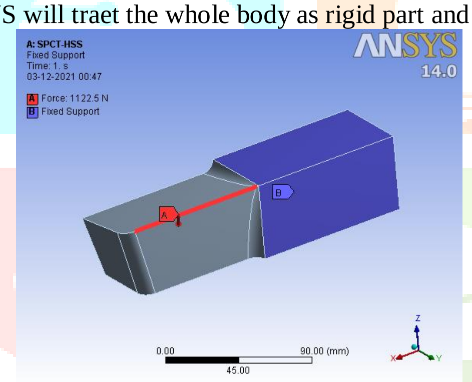

Figure 4.3 SPCT Boundary Conditions

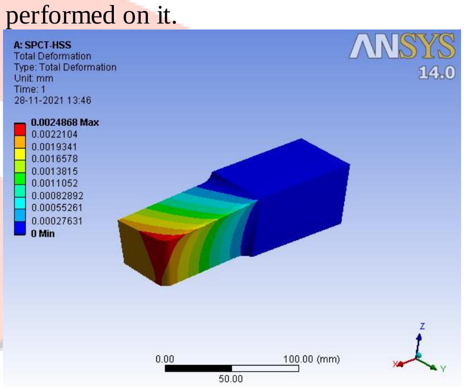

Figure 4.4: Deformation in HSS tool

Figure 4.3 represents the boundary conditions of the front end of the tool and the shank of the tool. The shank end is fully fixed and the forces are applied in all the three components (x, y and z) to ensure the actual loading on the edge of the single point cutting too.

Once the preprocessing part that is the model is created, material is defined, meshing is done and all the boundary conditions are defined then the processing of the computation work is obtained using the ANSYS analysis solver here we need to defile the output data required from the solver.

In present analysis we have drawn the deformation, von mises stress, shear stress and shear strain for all the three materials namely high speed steel, high carbon steel, and Cubic boron nitride.

Figure 4.4 represents the deformation in high speed steel tool for the single point cutting tool and is found to be 0.0024868 mm.

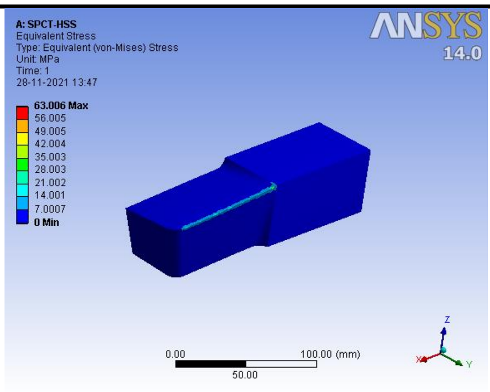

Figure 4.5: Von mises stress in HSS tool

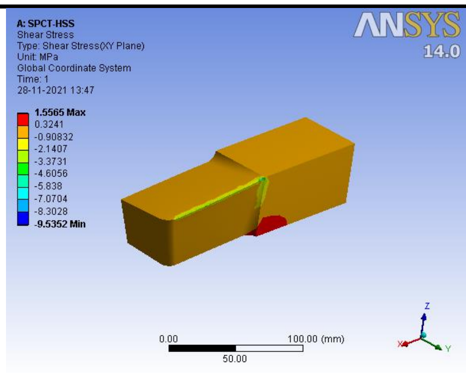

Figure 4.6 Shear stress in HSS tool

Figure 4.5 represents the von mises stresses induced in the HSS material tool and the maximum stress is found to be 63.006 M Pa.

Figure 4.6 represents the shear stress induced in the HSS tool for the single point cutting tool and the maximum value of shear stress is found to be 1.5565 M Pa.

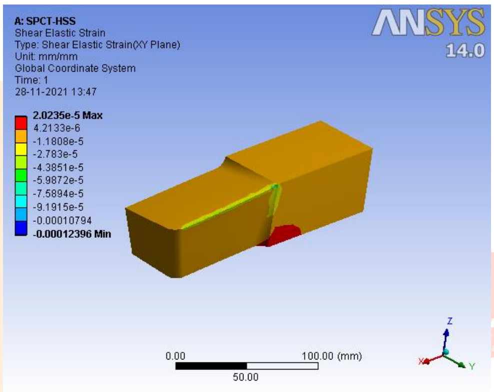

Figure 4.7: Elastic strain in HSS tool

Figure 4.7 represents the shear elastic strain induced in the HSS tool for the single point cutting tool and the maximum value of shear elastic strain is found to be 2.0235 x 10^{-5} mm/mm.

Similarly the analysis is repeated for high carbon steel and cubic boron nitride as tool material.

V. RESULTS AND DISCUSSIONS:

5.1 Results:

The results obtained from the computer aided simulation of single point cutting tools with different materials are shown in the following table.

Table 5.1. Result Table

Sr. No.	Tool Material	Deformation	Von mises stress	Shear stress	Elastic shear strain
1	HSS	0.0024868 mm	63.006 M Pa	1.5565 M Pa	2.0235 x 10^{-5} M Pa
2	HCS	0.0026061 mm	64.297 M Pa	1.5930 M Pa	2.1129 x 10^{-5} M Pa
3	CBN	0.0027495 mm	64.657 M Pa	1.6323 M Pa	2.2671 x 10^{-5} M Pa

5.2 Discussion:

From the present analysis the following things can be drawn:

1. The deformation for the same load of 1122.5 N (300 N, 600 N and 900 N in x, y and z directions) the deformation of HSS tool is minimum and the deformation in CBN is maximum.

2. The generated Von-mises stress or equivalent stress is also minimum in HSS whereas it is maximum in case of CBN.

3. The generated shear stress is again found to be minimum in HSS tool material whereas it is maximum in case of CBN as tool material.

4. Lastly we have also obtained the values for elastic shear strain which also reflects the same observation as in the above three points that the minimum strain is developed in HSS tool and maximum is obtained for CBN tool material.

VI. CONCLUSION AND FUTURE SCOPE

6.1 Conclusion:

From the above results and discussions we can conclude that the tool materials taken into consideration can be ranked as per the fixed loading conditions and induced shear strain, Von mises stresses and shear stress values are found to be minimum in case of high speed steel as tool material and is grater in case of high carbon steel tool and is even greater in case of cubic boron nitride.

So we can rank the tool materials as follows:

High Speed Steel > High Carbon Steel > Cubic Boron Nitride

6.2 Future Scope:

In future a lot of more work can be carried out in the same type of analysis on an single point cutting tool which can be as follows:

1. One can change the tool geometry as per his/her convenience as per the work piece on which you want to carry out the cutting operations.
2. The loading conditions can also be varied for harder work piece materials.
3. The different kind of tool materials and alloying elements can be selected to see how they behave under the same boundary conditions.
4. The meshing for the front end of the tool can be varied as per the cutting angles where more load is imparted on the tool one can go for even fine meshing.

The different computational software's can be used to compute the results and can be compared with the presented results to see that which computational environment will be suited for this kind of analysis.

REFERENCES

[1] Nagarajan, A., & Sangeetha, T. S. (2015). Analysis of coated single point cutting tool. International Journal of Engineering Technologies in Engineering Research, 2, 5-9.

[2] Sowjanya, S., Sreeramulu, D., & Rao, C. J. (2015). Experimental and numerical investigation of tool life of single point cutting tool during turning process. Indian Journal of Science and Technology, 8(28), 1-8.

[3] Wang, M. H., You, S. Y., Wang, F. N., & Liu, Q. (2019). Effect of dynamic adjustment of diamond tools on nano-cutting behavior of single-crystal silicon. Applied Physics A, 125(3), 176.

[4] Lee, Y. J., Chaudhari, A., Zhang, J., & Wang, H. (2019). Thermally assisted microcutting of calcium fluoride single crystals. In Simulation and experiments of material-oriented ultra-precision machining (pp. 77-102). Springer, Singapore.

[5] Gürbüz, H., Şeker, U., & Kafkas, F. (2020). Effects of cutting tool forms on the surface integrity in turning of AISI 316L stainless steel. Journal of the Faculty of Engineering and Architecture of Gazi University, 35(1), 225-240.

[6] Gupta, M. K., Mia, M., Pruncu, C. I., Kapłonek, W., Nadolny, K., Patra, K., ... & Sharma, V. S. (2019). Parametric optimization and process capability analysis for machining of nickel-based superalloy. The International Journal of Advanced Manufacturing Technology, 102(9), 3995-4009.

[7] Gangadhar, N., Kumar, H., Narendranath, S., & Sugumaran, V. (2018). Condition monitoring of single point cutting tools based on machine learning approach. Int J Acoust Vib, 23, 131-137.

[8] Li, Y., Daniel, W. J., & Meehan, P. A. (2017). Deformation analysis in single-point incremental forming through finite element simulation. The International Journal of Advanced Manufacturing Technology, 88(1-4), 255-267.