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Effect of Titanium Nitride and Zirconium Nitride Coatings in Single Point Cutting Tool

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ABSTRACT:

Single point cutting tool have just a one cutting point through which they perform different sort of capacities, for example, Turning, boaring, and Shaping operation. These instruments are utilized in machine, Boring, and shaper machines.

Here in this project the analysis is performed on ANSYS software and the modeling of the tool is done on CATIA software. To separate cases were studied whit coating material of ZrN and TIN having 5 micron of coating layer. The base material used for the tool is HSS. FEM Analytical calculation was done for all the cases and parameter like stress and deformation at constant loading condition were studied. The result showed TIN to be the best coating material with improve result out of all the cases.

*Keywords –**Single Point Cutting Tool, ZrN, TIN, ANSYS, CATIA, etc.***

INTRODUCTION

Fundamentally, machining is a semi-completing or completing procedure where the overabundance material is expelled from the preformed spaces as chips in order to grant required or stipulated dimensional and shape exactness and additionally surface finish. It is maybe the most flexible manufacturing process [1]. Moreover, it gives a higher level of geometric multifaceted nature to the work.

Types of cutting tool

There are two types of cutting tool.
a) Single point cutting tool
b) Multiple point cutting tool

Single point cutting tool

A single point cutting tool has just a single cutting edge or point. It comprises of a sharped cutting part called its point and shank. A single point cutting tool utilized for turning, boring, forming and planning tasks, that is, tool utilized on the machines, boring machines, shaper, planner and so forth are single point cutting tool [2].

The various parts of single point cutting tool

- Shank
- Face
- Flank
- Base
- Nose
- Cutting edge

The various angles in cutting tool

- Back rake angle
- Side rake angle
- End relief angle
- Side relief angle
- Side cutting angle
- End cutting angle

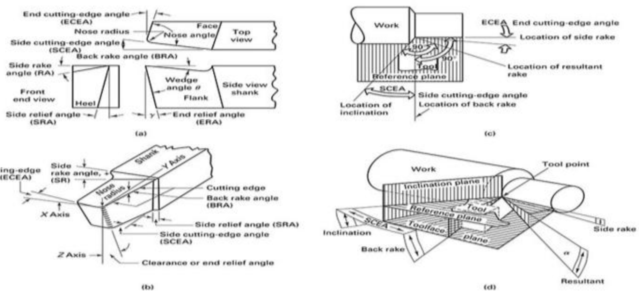

Fig.1: Single point cutting tool

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Literature review

DeepeshGehlot (2017) Cutting technologies are the motors behind manufacturing. Without cutting, none of current item could ever been put into benefit. Growing new materials specifically needs investigation for technique windows in cutting. Immense engineering endeavors brought cutting inside the position where it's nowadays and notwithstanding all bits of declare endeavoring to pronounce, that cutting is superannuated or cutting examination is done it's as yet a noteworthy field of investigation and inclined to quick developments. Considering these certainties display look into work is committed to examinations in cutting tools. For this reason a single point cutting tool was focused on and examinations were made on Vonmises stresses and total deformation considering diverse kinds of tool materials and employment materials. The tool materials were molybdenum high speed steel (Mb HSS) and Cubic Boron Nitride (CBN).

Jeff Rao (2017) The lifetimes and the untimely wear of machining tools affect on manufacturing efficiencies and productivities. A huge extent of machining tool harm can be credited to part wear. Here, titanium aluminum nitride (TiAlN) multi-layered with titanium diboride (TiB2) arranged by PVD (Physical Vapor Deposition) sputtering onto H-13 substrates are contemplated as potential wear-safe coatings for producing bite the dust applications. The TiB2 content has been adjusted and two-arrangements of covering frameworks with a bilayer thickness either not exactly or more noteworthy than 1 _m are examined by tribological and microstructural examination. XRD investigation of the multilayers uncovers the coatings to be predominately ruled by the TiAlN (200) top, with extra pinnacles of TiN (200) and Ti (101) at a TiB2 substance of 9%. Dynamic burdens expanding to 100 N empowered the rubbing coefficients and the covering disappointment at a basic load to be resolved.

Safal A. Shambharkar (2016) This paper features the impact of the temperature and cutting forces created on the tip of the Single Point Cutting Tool (SPCT) while working. In a trial work, temperature estimation is finished by utilizing thermocouple at different profundity of cut and it found that the temperature increments with increment top to bottom of cut. Cutting forces following up on cutting tool are resolved systematically at various profundity of cut. Displaying of single point cutting tool is finished by PRO-Engineer Wildfire-4 programming. The model is then transported in ANSYS programming and meshing is finished. At that point the temperature readings and the forces figured at various profundities of cut are given as a contribution to the product.

AminaZouinaAit-Djafera (2015) The point of this examination is to research the impact of plasma testimony parameters (the weight andthe substrate inclination voltage Vs) on structure, surface morphology, hardness and electrochemical behavior(studied by potentiodynamic polarization and optical magnifying lens (OM) in forceful condition NaCl3.5 wt%) of TiAlN coatings. The coatings were kept by receptive RF magnetron sputtering (13.56 MHz).They were done amid 60 min and their thickness was roughly 1 _m. Auxiliary analysisshown that TiAlN covering solidified in cubic (fcc) and hexagonal (hcp) structure with introductions in(1 0), (1), (2 0), (1 0), (2 0) and (3 1) planes. The kept coatings introduce most extreme hardness(H = 25.75 GPa) and Young's modulus (E = 479.82 GPa) at low weight (20 mTorr) and −60 V of nega-tive substrate predisposition.

D.M.Devia (2014) TixAl1xN coatings were developed utilizing the triode magnetron sputtering procedure shifting the predisposition voltage between - 40 V and - 150V. The impact of inclination voltage on auxiliary and morphological properties was examined by methods for vitality dispersive spectroscopy, x-beam diffraction and nuclear power microscopy systems. As the inclination voltage expanded, an expansion in the Al nuclear rate was watched contending with Ti and delivering auxiliary changes. At low Al fixations, the film exhibited a FCC crystalline structure; by and by, as Al was expanded, the structure introduced a blend of FCC and HCP stages.

Then again, an expansion in predisposition voltage created a decline films thickness because of an increment in impacts. In addition, the grain size and unpleasantness were additionally firmly impacted by predisposition voltage..

Objective

Investigate the effect of ZrN and TIN coating material on single point cutting tool and perfume a comparative study depicting the best material in terms of stress and deformation.

Methodology

In any metal cutting operation in a lathe there acts a force “R” on the tool. This force “R” can be resolved into threecomponents.

Py= in the horizontal plane, perpendicular to the direction of the feed (thrust force);

Px= in horizontal plane against the direction of feed (feed force);

Pz= in vertical plane, perpendicular to both Py and Px (cutting force);

Empirical formula determining the Pz can be expressed as under

$Pz = Cp \times t^x \times S^y \times K$

Where,

Cp= coefficient, characterized by the work material and condition of working such as tool, coolant.

t = depth of cut

S = feed in mm/revolution

K = overall correlation, consisting of actual condition of working and tool angles,

which varies from 0.9 to 1.0.

K= Kc□K□□Kσ□Km

Kc= Correction coefficient for coolant. (Air)

K□□= Correction coefficient depending upon the entering angle. (90^O)

Kσ= correction coefficient depending upon the back rack angle. (8^O)

Km = correction coefficient depending upon the material.

For Depth of cut = 0.2 mm

Feed = 0.286 mm/revolution

Cp= 225

x = 1.00

y = 0.75

Pz= Cp× tx× Sy× K

$= 225 \times 0.2^{1.00} \times 0.286^{0.75} \times 0.935 = 16.45$ N

The components approximately connected by the following expression

Px/ Pz= 0.3

Px= 0.3× Pz= 0.3×16.45 = 4.936

And

Py/Pz= 0.2

Py= 0.2 ×16.45 = 3.29 N

Table 1: Cutting forces at different depth of cut

Cutting forces (N)	Depth Of Cut (mm)				
	0.2	0.5	1.0	2.0	2.5
Px	4.936	12.339	24.68	49.36	61.70
Py	3.29	8.226	16.45	32.91	41.130
Pz	16.45	41.13	82.275	164.55	205

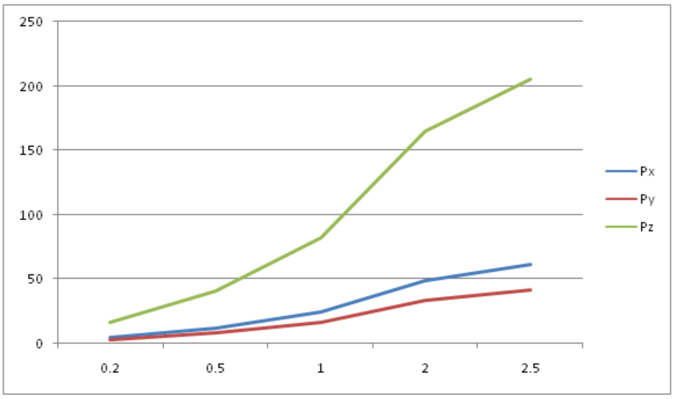

Fig. 2: Graph of components of cutting forces vs. depth of cut

Material properties

HSS (High speed steel) is use to design analysis of Single point cutting tool due to height strength property. The HSS coated with ZrN and TIN [3].

Table 2: Material property of single point cutting tool

Material	Density(Kg/m3)	Young modulus (MPa)	Poisson's ratio
HSS	8160	2.1×10^5	0.3
TIN	7287	6.4×10^5	0.325
ZrN	7090	5.1×10^5	0.25

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Fixed support

The two face of single point cutting tool are fixed.

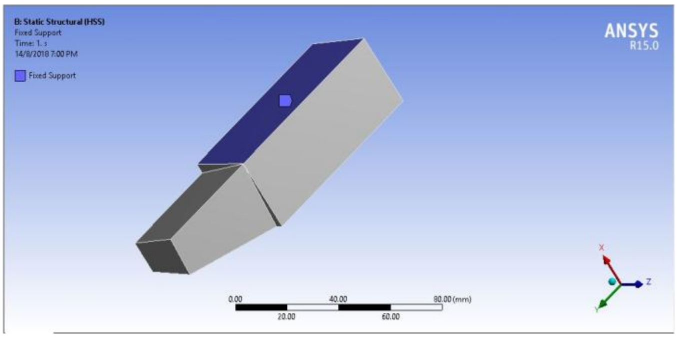


Fig. 3: Apply fixed support

Force

The components approximately connected by the following expression

- Px / Pz = 0.3
- Px = 0.3× Pz = 0.3×16.45 = 4.936
- And
- Py /Pz = 0.2
- Py = 0.2 ×16.45 = 3.29 N

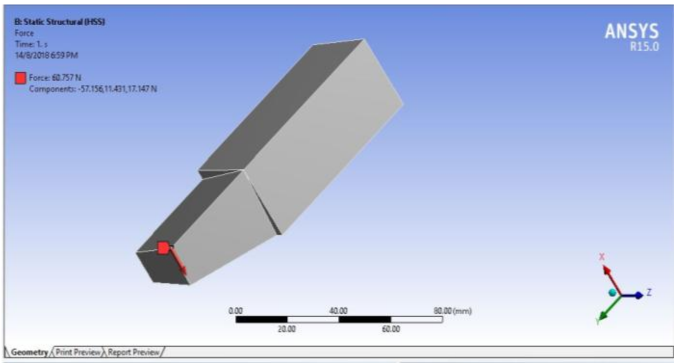
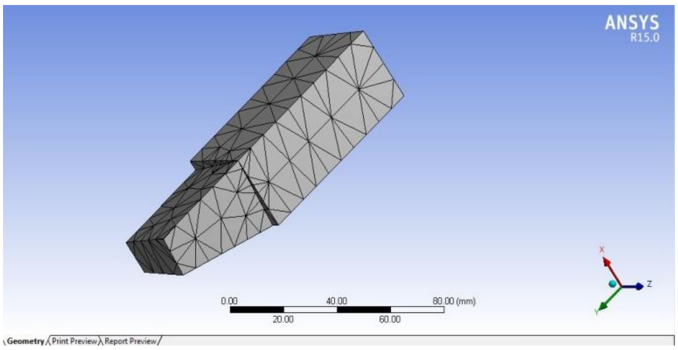


Fig. 4: Apply force in single point cutting tool

Meshing

This model is then imported in ANSYS software for meshing and analysis [4].



Fig, 5: Meshing of single point cutting tool

Result

Case -1 Simple HSS tool

Deformation

The maximum deformation are found in simple HSS tool is 0.0020101mm

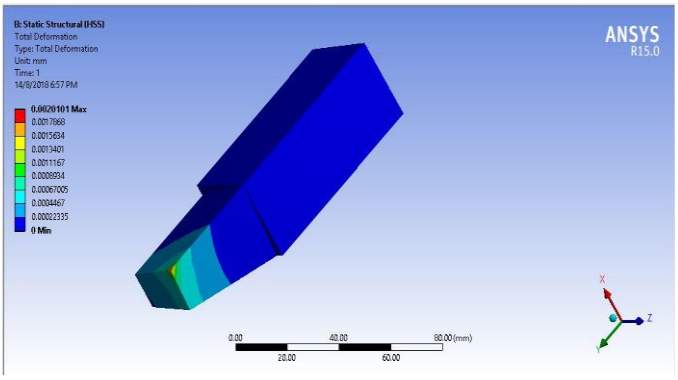


Fig. 6: Deformation in case -1

Stress

The equivalent stress is found in 69.013 Mpa.

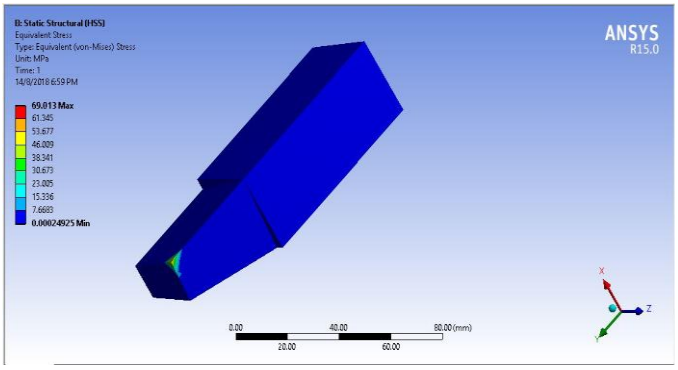


Fig. 7: Equivalent stress in case -1

Case -2 HSS tool and ZRn coating

Deformation

The maximum deformation are found in simple case -2 is 0.0016538mm

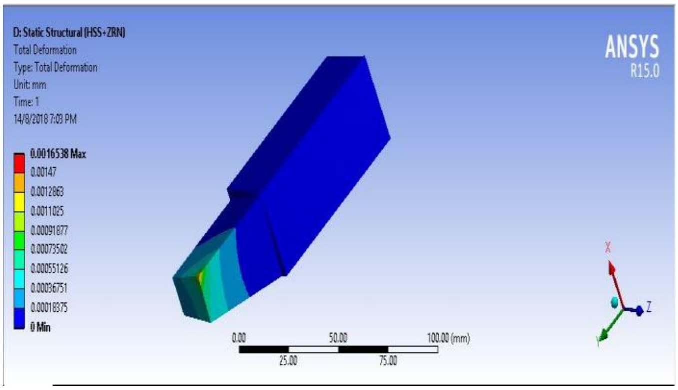


Fig. 8: Deformation in case -2

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Stress

The equivalent stress is found in 52.879 Mpa.

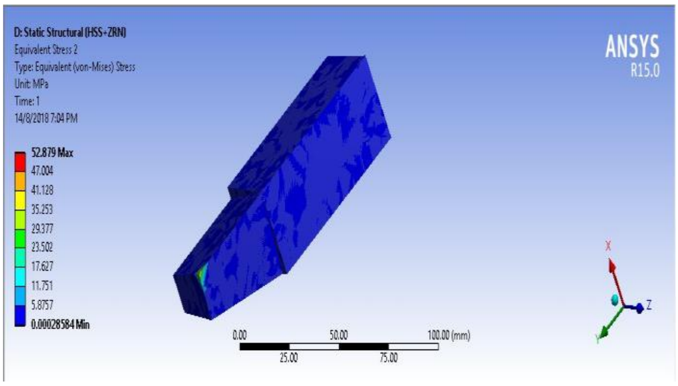

Fig. 9: Equivalent stress in case -2

Case -3 HSS tool and TIN coating

Deformation

The maximum deformation are found in simple case -3 is 0.0016492mm

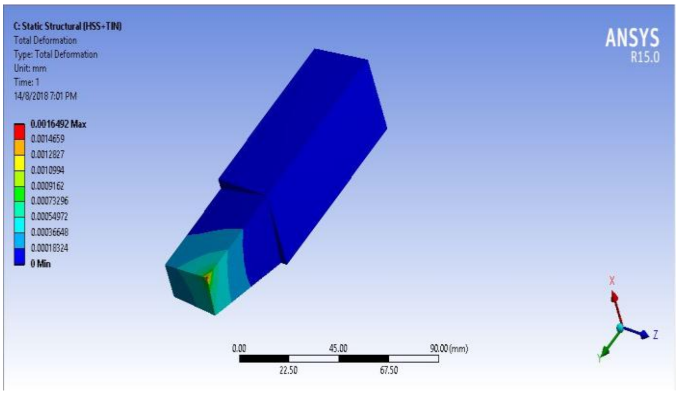

Fig. 10: Deformation in case -3

Stress

The equivalent stress is found in 52.581 Mpa.

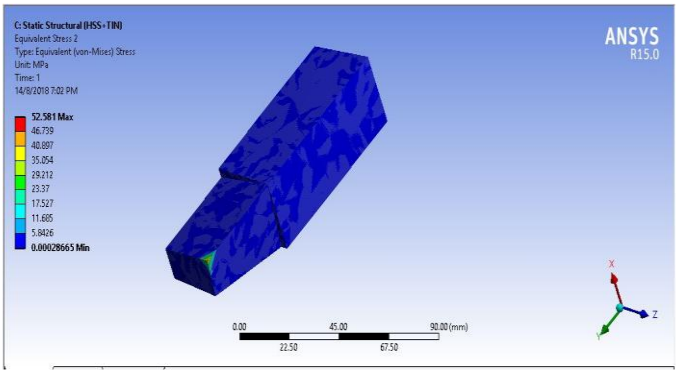

Fig. 11:Equivalent stress in case -3

Table 3: All case comparison table

Case	Deformation (mm)	Stress (MPa)
1	0.0020101	69.013
2	0.0016538	52.879
3	0.0016492	52.581

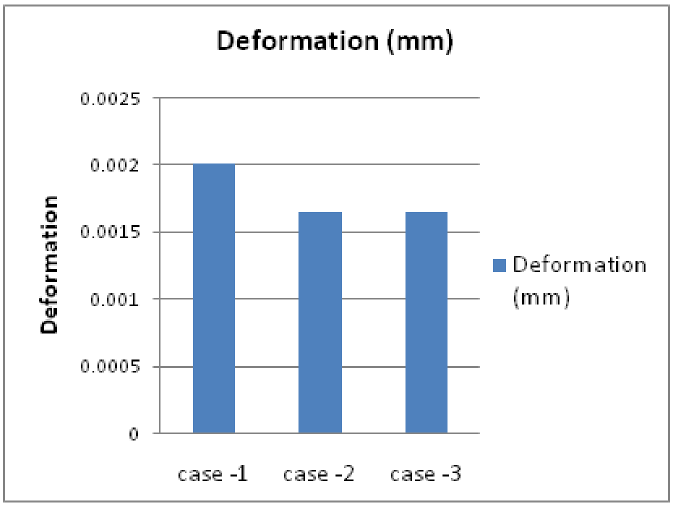

Fig. 12: Deformation graph

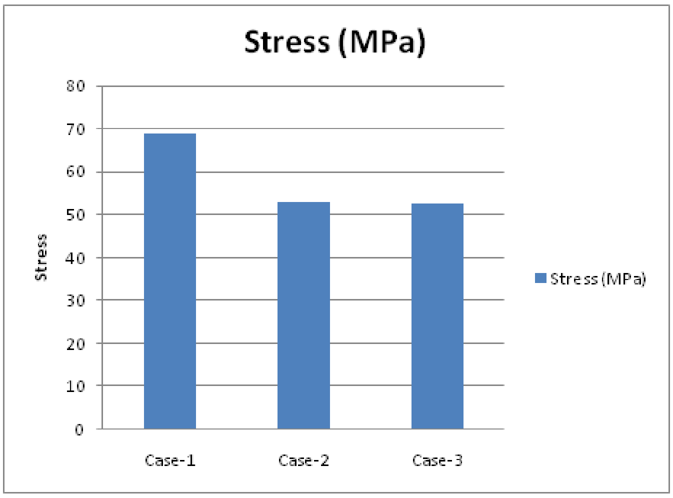

Fig. 13: Stress graph

Conclusion

It has been shown that in above analysis the minimum deformation and stress are found in HSS tool coated with TIN (Titanium Aluminium Nitride). The stress generated in the case of TIN coating was 52.581MPa and total deformation is 0.0016492mm. And the in the case of without any coating the stress was 69.013 MPa and deformation is 0.0020101mm. Hence it is concluded that TIN coating [5] is better material in the above experiment.

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