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Finite Element Analysis of Single Point Cutting Tool Under Cryogenic Cooling

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ABSTRACT: This paper presents the review on experimentation and validation on single point cutting tool under cryogenic cooling. The cooling application in machining operation plays a very important role. Feed rate and depth of cut at cutting point can be used to control the machining process. Temperature at the tip of the cutting tool increase when the depth of cut and cutting speed increases. The temperature at tip is measured by the infrared thermometer. in this review, the cryogenic coolant is used for cooling in machining process where liquid nitrogen is used as a cryogenic coolant to reduce the temperature in the cutting zone, hence the strength and hardness of the cutting tool remains high and also the temperature dependent tool wear reduced .Cutting temperature and normal forces are measured at the tip of tool is been determined analytically.

Keywords: Single Point Cutting Tool, Temperature, ANSYS, PTC Creo, Stresses.

1. INTRODUCTION:

During machining process, to reduce the heat generated and tool wear progression cutting fluids are used. It is observed that implementation of oil-based coolants has inefficient due to its poor accessibility to small areas and has low capability to reduce the cutting temperature and it is not environmentally friendly. So to overcome these problems, cryogenic cooling is used.

In this paper, the structural analysis of the single point cutting tool under conventional cooling and cryogenic cooling is carried out with help experimental setup. The results obtained by experimentation are compared and deformation as well as stress generated in tool is obtained by finite analysis results.

2. EXPERIMENTAL DETAILS:

During the experimental set, the flow rate for cryogenic media was controlled and regulated at 0.3 l/min while pressure was set at 2 bars.

The cryogenic modular system is a customized design to deliver LN2 to the machining process. It can be attached and detached from commercial tool holder, with two major cryogenic media delivery channels to the rake and flank faces of the cutting tools. Tool wear was caused by heat generated and shear stress in primary and secondary shear zones. It can be observed that there was a significant heat affected zone on the flank face under oil-based coolant condition while it was much lesser in cryogenic cooling. Additionally, a significant BUE was observed after 3.5 minutes at 110 m/min under oil-based coolant while no BUE was observed in cryogenic cooling case. The heat generation going to be increased with cutting time and leads to strong build up edge and chip formation. At the same time, it was found that cryogenic cooling reduced wear rates compared to oil-based coolant condition for both cutting speeds. Cryogenic cooling provided a better accessibility and lubricity of coolant compared to oil-based type, which will result in longer tool life.

3. OBSERVATION TABLE:

Table No. 1 Readings for Conventional Cooling

Sr. No	Speed (RPM)	Feed Rate (mm/rev)	Depth of Cut (mm)	Temp (°C)
1	**500**	**0.2**	1.0	57.3
			0.5	51.2
2	**350**	**0.2**	1.0	46.5
			0.5	42.6

Table No. 2 Readings for Cryogenic Cooling

Sr. No	Speed (RPM)	Feed Rate (mm/rev)	Depth of Cut (mm)	Temp (°C)
1.	500	0.2	1.0	39.2
			0.5	36.4
2.	350	0.2	1.0	33.1
			0.5	29.9

4. MODELLING OF SINGLE POINT CUTTING TOOL:

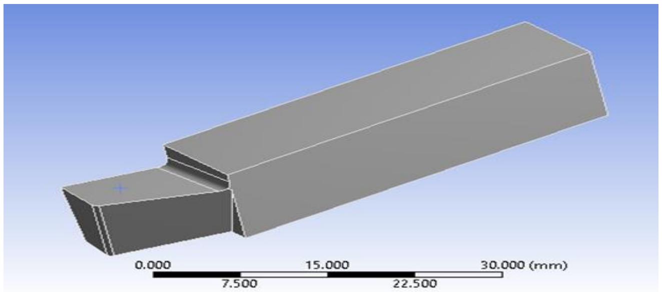

Fig.1: PTC Creo Model of single point cutting tool Imported in IGES Format in ANSYS for Analysis.

5. ANALYSIS OF CUTTING TOOL

5.1. STEADY STATE THERMAL ANALYSIS OF CUTTING TOOL

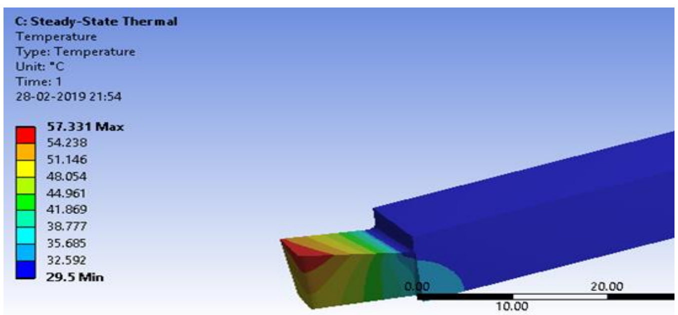

Fig.2: Under Conventional Cooling.

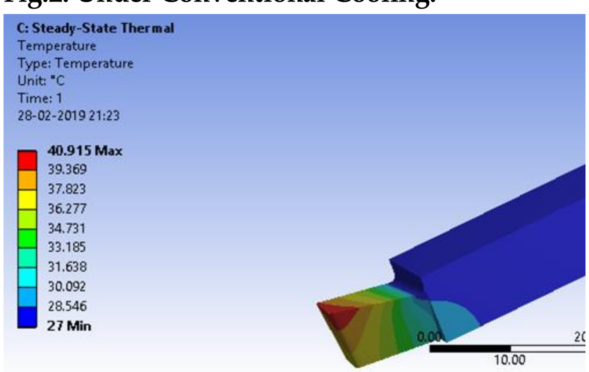

Fig.3: Under Cryogenic Cooling.

5.2. STRUCTURAL ANALYSIS OF SINGLE POINT CUTTING TOOL

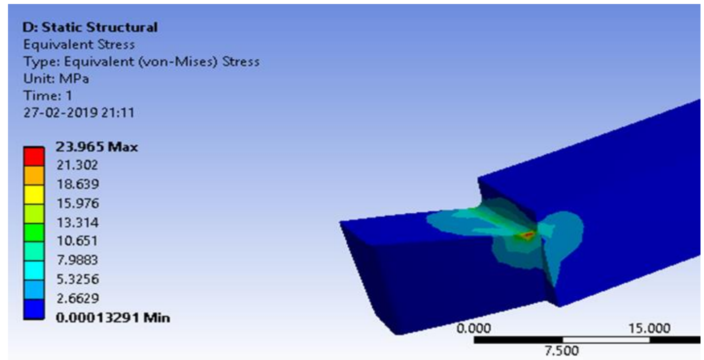

Fig.4: Temperature Distribution on Cutting Tool Using Conventional Cooling.

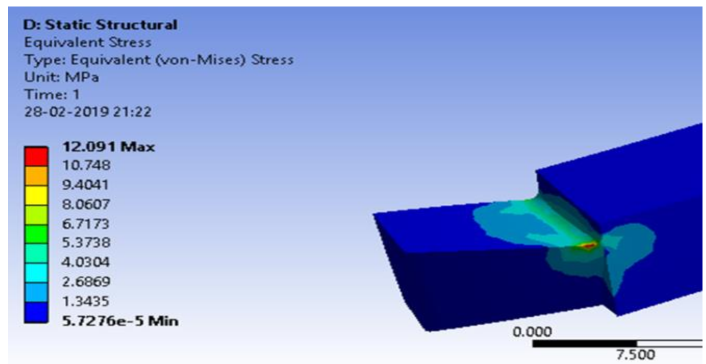

Fig.3: Temperature Distribution on Cutting Tool Using Cryogenic Cooling.

4. RESULTS:

Table No. 3 Comparison Results

Sr. No.	Stress (MPa)	
	Conventional Cooling	Cryogenic Cooling
1	23.96	12.091

5. CONCLUSIONS:

This paper has presented the investigation that as compared to conventional cooling, cryogenic cooling is feasible by using LN2. Due to the cryogenic cooling used during machining there is extremely low temperature which reduces chemical reactivity between cutting tool materials and the workpiece which results in increase in tool life. Efficiency in cooling is improved by cryogenic media, hence reduced friction between chip-tool interfaces, results in tool wear reduction.

6. REFERENCES

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