SIMULATION STUDY ON SINGLE POINT CUTTING TOOL WITH INCORPORATED TRANSPIRATION COOLING

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Introduction

The basic requirement of a manufacturing industry is higher production rate with required quality and low cost. This can be achieved by high cutting speed and efficient cooling of the tool. Increasing the cutting speed will subsequently increase tool wear and shorten tool life which affects the dimensional accuracy and surface integrity of the tool. To overcome this problem it is important to study the temperature distribution and heat flux generated. In metal cutting process which requires considerable efforts to find temperature distribution and heat flux generated and often not suitable in manufacturing conditions, hence computational and analytical methods are used. The precise prediction of temperature distribution on the cutting tool is still a very challenging task.

Scope of the Project

The scope of this project is to increase the tool life by increasing the cooling or by reducing the temperature gradient of the tool through passing coolant. We are also going to introduce transpiration cooling method in the tool and check if it is more effective compared to the traditional cooling method.

Methodology

Literature Survey :

- Many research articles and scholars were collected regarding dry machining and Coolant flow analysis.
- All the required values such as material properties and different methods to carry out the analysis were noted.

Paper Validation:

- Among all the papers, the most relevant papers for the analysis were chosen for validation and for result verification.
- After simulating multiple methods as mentioned in different papers, the results with less deviation from the paper was chosen for validation as well as for result verification.

Performing Dry Machining:

- Dry machining analysis was performed using ABAQUS CAE software.
- Titanium Alloy (Ti-6Al-2Mo-2Cr) and Carbide were used as materials for workpiece and tool respectively. A Johnson Cook Model was developed for formulating the results.

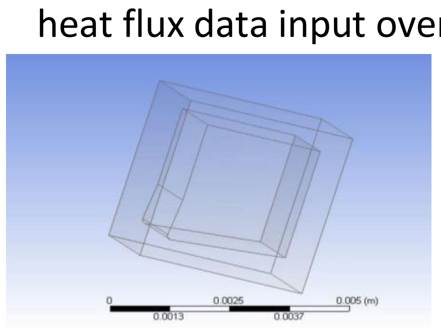
$$\sigma = \left[A + B\varepsilon^{n}\left(\frac{1}{\exp(\varepsilon^{a})}\right)\right]\left[1 + C\ln^{-}_{\circ}\right]\left[1-\left(\frac{T-T^{\circ}}{\mathrm{Tm}-T^{\circ}}\right)^{m}\right]$$

Johnson Cook Equation

- Important steps of the analysis involves meshing ,load definition and boundary condition.Transient Heat Flux data and Temperature data of the tool were taken as results form the analysis.

Coolant analysis(without Transpiration cooling model) using CFD:

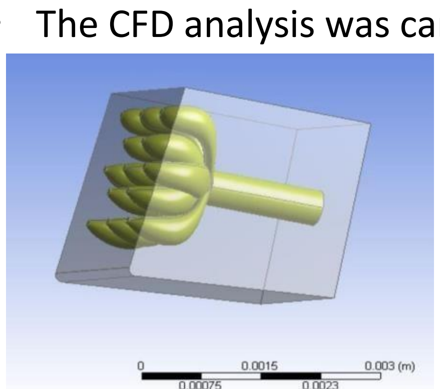
- CFD analysis was carried using ANSYS software. This analysis involved direct application of coolant(**Water – Oil emulsion**) over the tool.
- The important steps of this analysis include domain definition and transient heat flux data input over the tool.



Boundary Layer thickness for the tool surface was calculated considering Turbulent flow for the coolant.

Transpiration Cooling Analysis using CFD:

- The CFD analysis was carried out using ANSYS software.



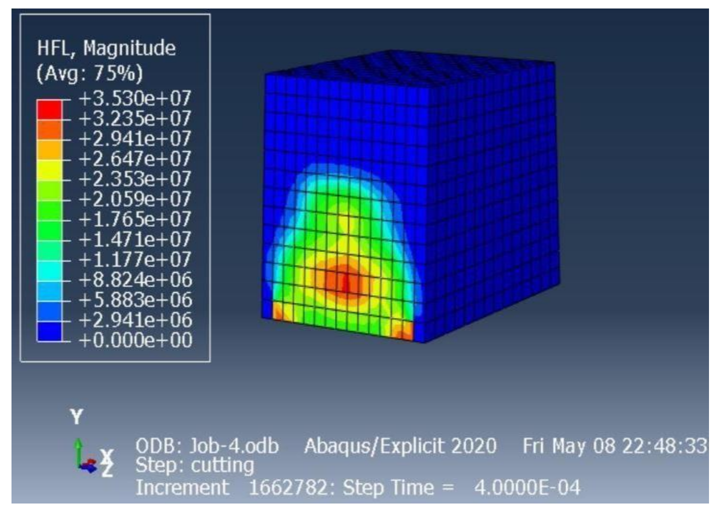
A tool model was developed incorporating the Transpiration cooling system. Coolant was passed from the back surface and was made to come out from the rake surface of the tool.

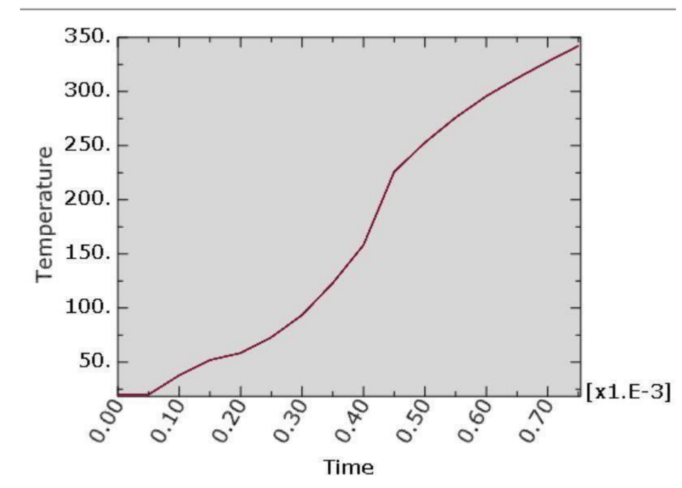
Result Comparison:

- Both the final temperatures of the tool were compared, and the most efficient cooling method was found out.

Results

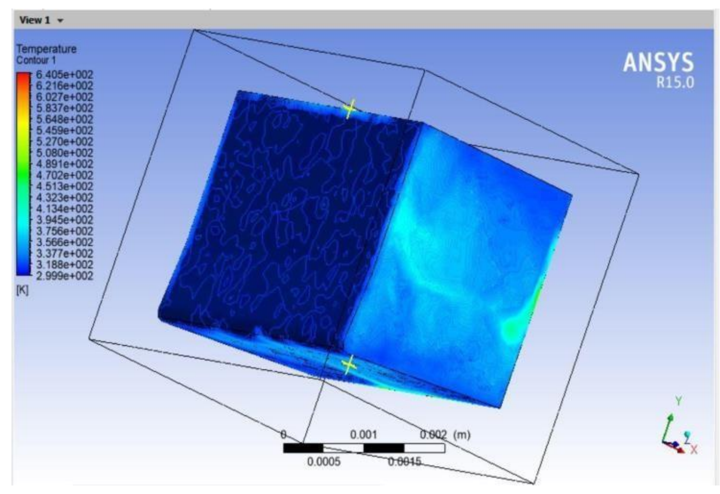
Dry machining Results:

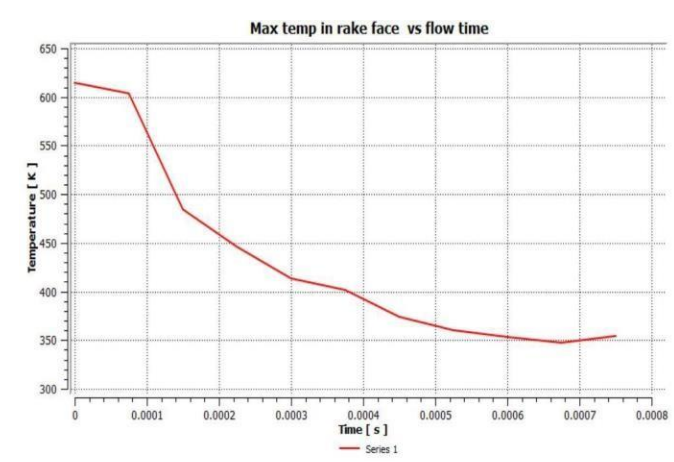




The Transient Heat Flux data obtained for the tool during cutting process(ABAQUS).

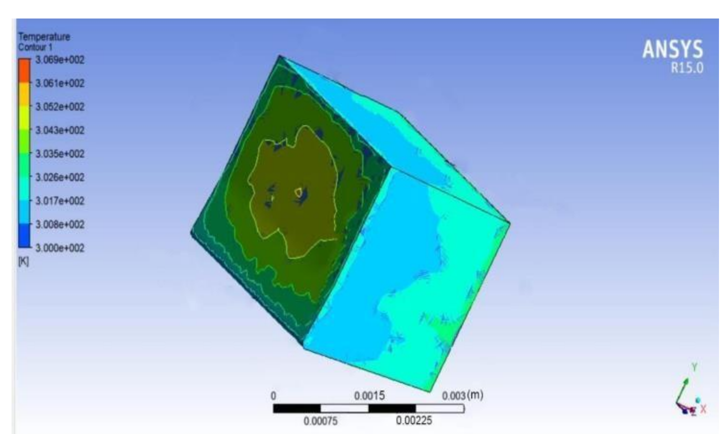
Coolant Analysis(without Transpiration Cooling model) Results:

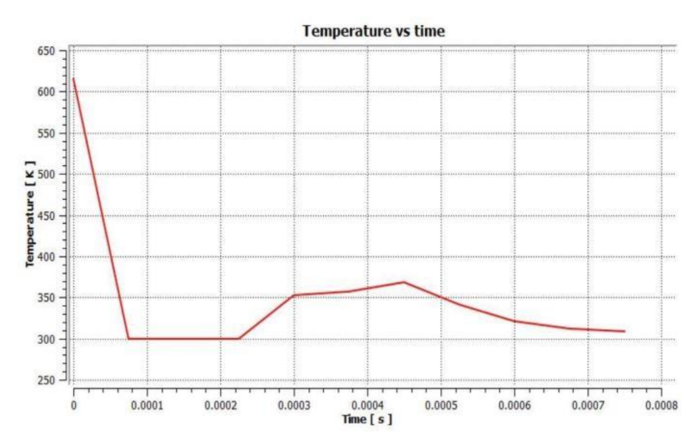




The Temperature data of the tool, obtained from coolant analysis using CFD(ANSYS).

Transpiration Cooling Analysis Results:





The Temperature data of the tool after Transpiration Cooling Analysis(ANSYS).

Result Comparison

- All the temperature results were taken for a machining time of 0.00075 sec.
- The final temperature after each cooling process are the reductions in temperature from the initial Dry machining temperature.

	Maximum Temperature after simulation	Difference in Max temperature after cooling	Percentage Decrease(%)
Dry Machining	615K	-	-
Direct Cooling	350K	265K	43.09
Transpiration Cooling	300K	315K	51.22

Conclusion

- The percentage temperature change with the transpiration cooling model has an extra 8% of cooling the tool when compared with the other model. These results prove that transpiration cooling has an additional cooling advantage over the traditional cooling method.
- Using Ansys Fluent software is a great advantage as it gives the prompt results at very less computational time and also being a user friendly operator.
- The further improvement in results can be done by optimizing the transpiration cooling geometry, which will be one of the future scope in this study.

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Acknowledgments

We would like to extend our sincere gratitude to our guide Dr.Ashok K and our mentor Dr.Muralidharan B for supporting us and sharing insightful directions and suggestions over the course of our project.