ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Finding Effective Heat Transfer Rate by Cooling Oil Flashing in Cutting Tool

Gopidi Harish Reddy
Ellenki College of Engineering and Technology, JNTU, Hyderabad, Telangana, India.

Smt. K.Aparna
Ellenki College of Engineering and Technology, JNTU, Hyderabad, Telangana, India.

ABSTRACT:
Flash cooling is a method for rapid cooling of vessels or other areas, often by using a gas or mist. Flash cooling system is used for cooling of liquids, utilizing thermo compressors, steam ejectors or vacuum pumps. Tool wear of machine tools and large usage of cutting fluids is one of the major problems in manufacturing. Cutting fluids are used to cool down the tool and have been shown to cause environmental problems in machine shops. Tool life and temperature have an inverse relationship, namely that the higher the temperature at the tool-chip interface is, the lower the tool life will be, and vice-versa

In this thesis the comparison of flash cooling (i.e) by providing holes on the cutting tool for passing fluid from them and external cooling of cutting tool is done by determining the heat transfer rate. 3D models of the shrink fit chuck with flash cooling and external cooling is done in Pro/Engineer.

Thermal and CFD analysis is done to determine the heat transfer rates in Ansys by changing the cooling fluids and also the material of the cutting tool.

I. INTRODUCTION

Flash Coolers are similar to evaporators in that they utilize a vacuum vessel to reduce the temperatures at which the liquid boils. The flash cooler's purpose is not to concentrate products but rather to cool them, by admitting them into a vessel, in which the boiling point has been reduced by the vessel being operated under vacuum. Many liquid products benefit by prompt cooling after thermal processing, either in pasteurizers or evaporators.

The Marriott Walker Corporation offers two types of flash coolers, one for use on conventional liquid products and the other is suitable for use with viscous liquids such as barbeque sauce and soy protein isolate.

Easily pumped liquids can be quickly cooled in flash coolers with tangential, centrifugal inlets. This approach lays the liquid to be cooled in a thin film against the side-wall of the cylindrical vessel and water vapor is immediately "flashed off", providing for prompt cooling of the liquid product.

For viscous products, the Marriott Walker Corporation flash cooler design relies on a solid cone spray nozzle, centrally located within the cylindrical vacuum vessel. The solid cone spray sprays the liquid to be cooled into the dual-diameter vacuum vessel, whose unique configuration results in a cylindrical "curtain of product", which provides for quick and effective flash cooling of the product.

Where cooling duties are particularly rigorous, Marriott Walker flash coolers can be provided in multi-stage configurations, to accomplish the required product cooling task.

Our "vapor-in-tube" surface condensers, used in conjunction with flash coolers, provide for sanitary capture and re-use of condensed flash vapors if circumstances require it.

Traditional explanations for the efficacy of mineral oil in successful flash cooling of a protein crystal correctly point to the removal of excess liquid around

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

the crystal to prevent external ice formation. Based on the physics of the well known Leidenfrost phenomenon, an additional role that mineral oil possibly plays in aiding verification is suggested: that of improving cooling rates for a protein crystal plunged into liquid nitrogen. The full potential of liquid heat transfer when using liquid nitrogen is not realized in conventional cooling techniques due to film boiling that occurs around larger protein crystals. However, a thin layer of an insulating material, such as a mineral oil, around the protein crystal can prevent this vapor film from forming by raising the Leidenfrost temperature. Surface cooling then occurs in the more efficient nucleate boiling regime where liquid nitrogen is in contact with the crystal throughout the quench. Using bare and coated thermocouples, the validity of a predictive Leidenfrost temperature equation for use in liquid-nitrogen plunge cooling of protein crystals is demonstrated When machining at high speeds, air turbulences frequently influence the coolant and prevent it from optimally reaching the cutting tool. Haimer now offers a shrink chuck with the newly developed Cool Flash System, where the coolant wraps itself around the tool like a jacket and protects it against such disturbances. According to a company spokesperson, Haimer is offering these as an option for its shrink chucks that, due to their especially high run-out accuracy, are ideal for high-speed machining.

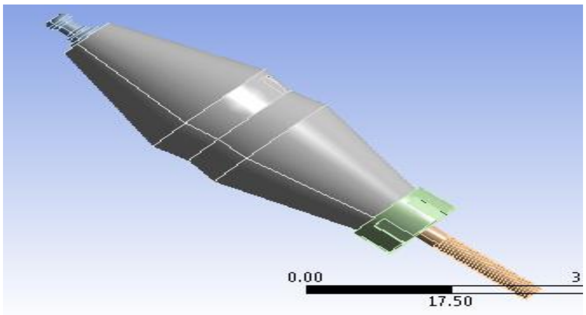
With the Cool Flash System, in a similar manner to the Haimer Cool Jet System for normal machining, the bores have been introduced in the clamping chuck, where the coolant is transported to the face area of the tool holder. In contrast to the Cool Jet System, where the coolant exits the chuck as a spray pattern toward the tool cutting edge, the Cool Flash has the decisive difference at this point: a disc is positioned at the face side of the Cool Flash chuck, which releases a narrow circumferential gap in the direction of the tool. From this small reservoir, it flows over the tool shaft directly as a closed jacket and is, therefore, insensitive against air turbulences. At the end of the shaft area, the coolant is pressed into the flutes, flushes them out and then reaches - even at high speeds - the cutting edges of the tool directly without atomizing, where its cooling effect may develop.

THERMAL ANALYSIS

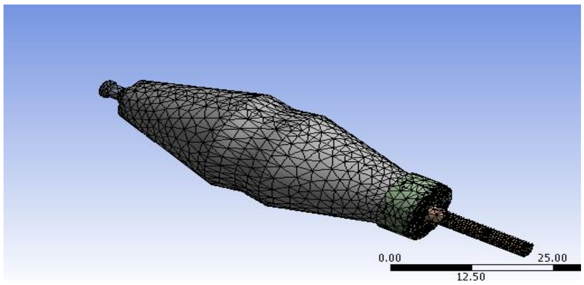
TOOL MATERIAL – HIGH SPEED STEEL

FLASH COOLING

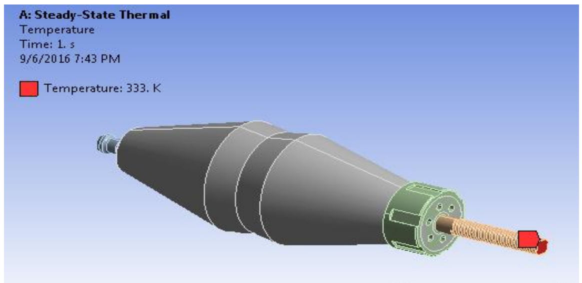
IMPORTED MODEL



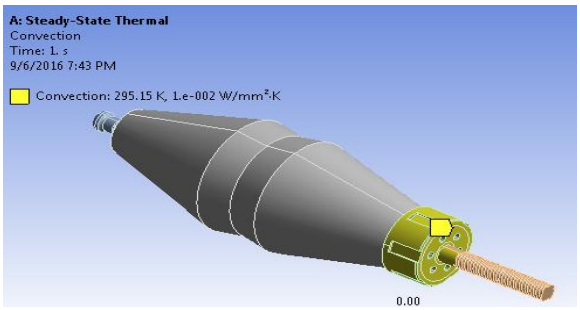
MESHED



TEMPERATURE

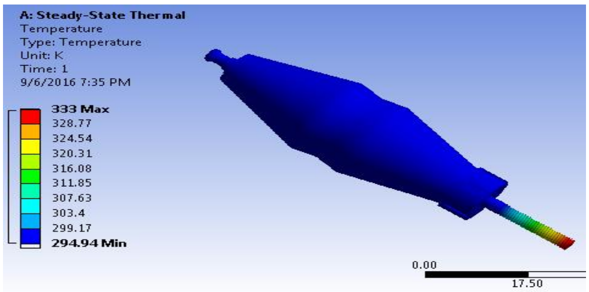


CONVECTION

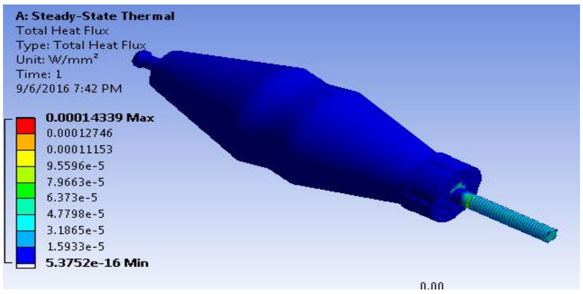


ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

TEMPERATURE

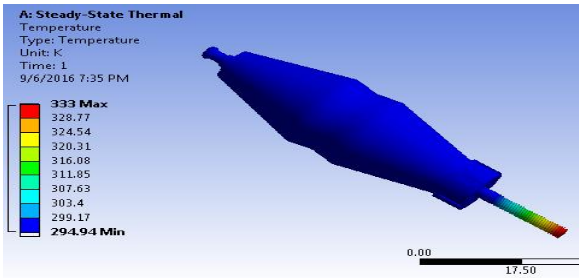


HEAT FLUX

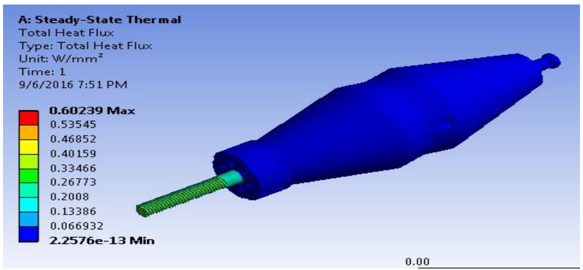


TOOL MATERIAL – TUNGSTEN CARBIDE

TEMPERATURE



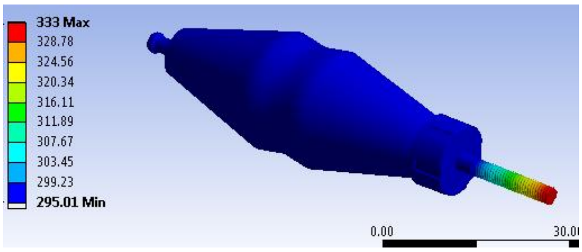
HEAT FLUX



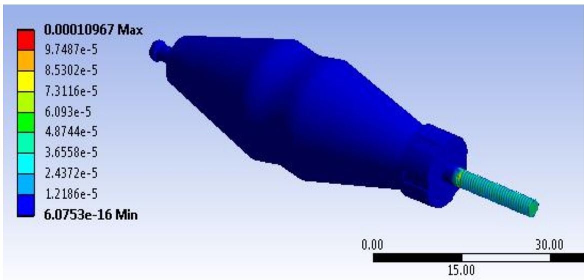
EXTERNAL COOLING

HIGH SPEED STEEL

TEMPERATURE

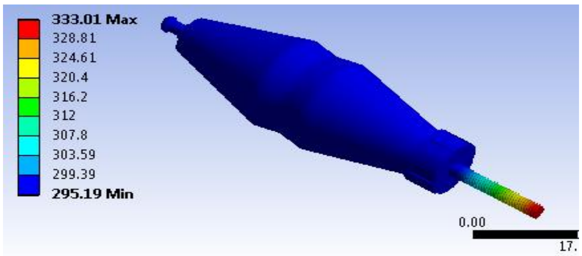


HEAT FLUX

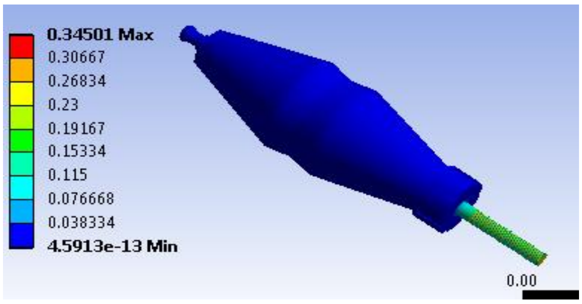


TUNGSTEN CARBIDE

TEMPERATURE

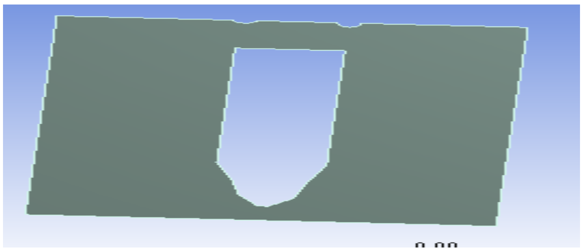


HEAT FLUX

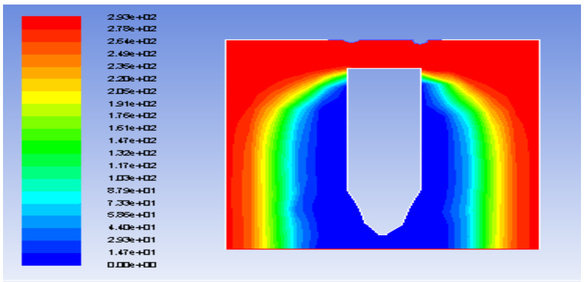


CFD ANALYSIS OF FLASH COOLING FLUID-WATER AT 20 0C

IMPORTED MODEL

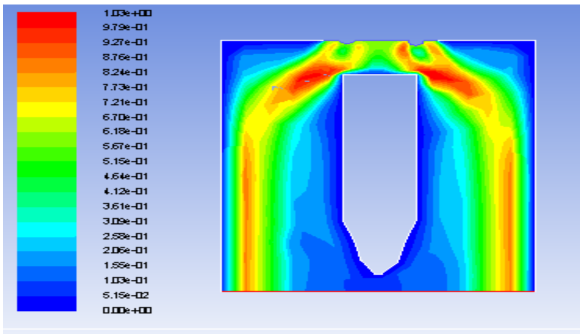


TEMPERATURE

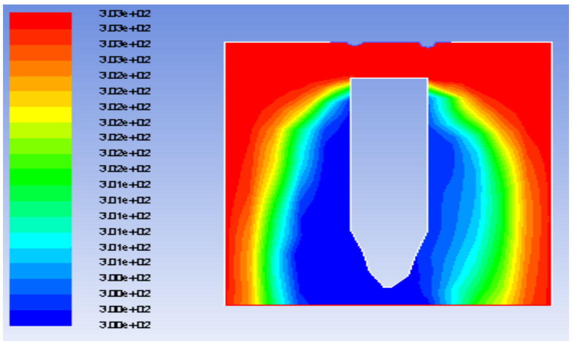


ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

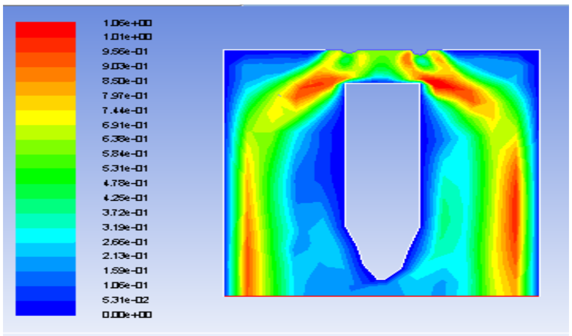
VELOCITY



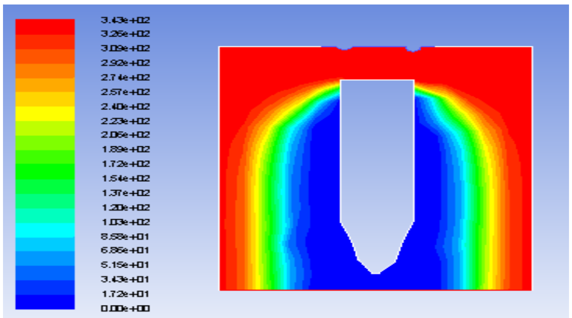
WATER AT 400C TEMPERATURE



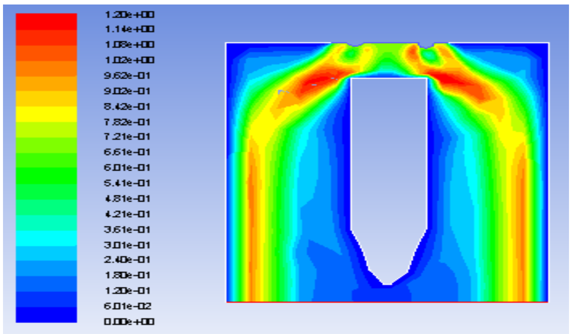
VELOCITY



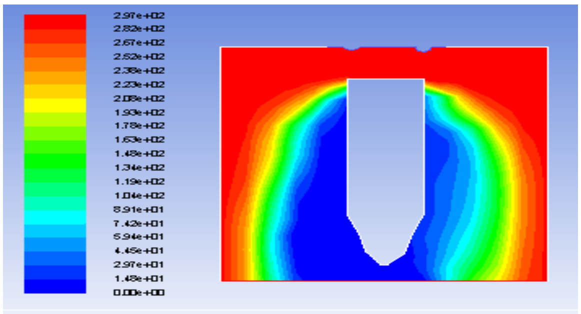
FLUID WATER AT 60 0C TEMPERATURE



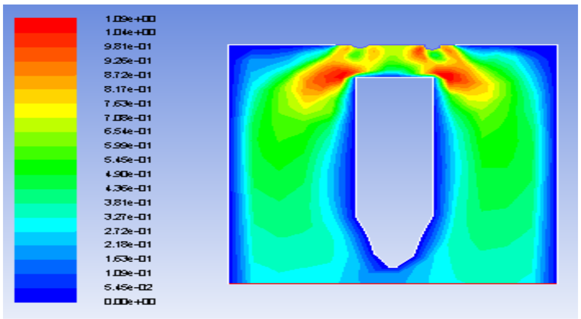
VELOCITY



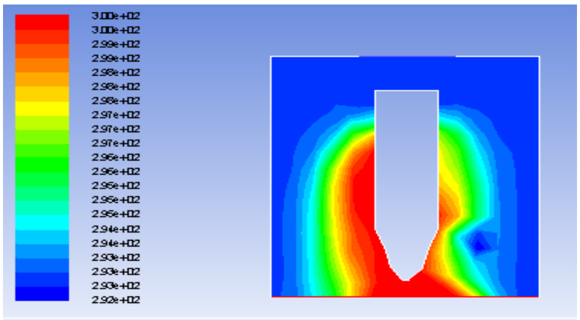
AIR PRESSURE TEMPERATURE



VELOCITY

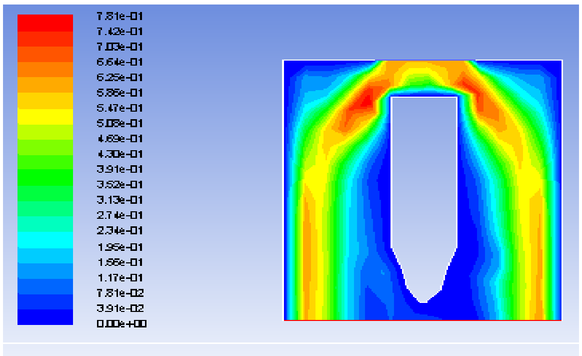


EXTERNAL COOLING WATER AT 200C TEMPERATURE

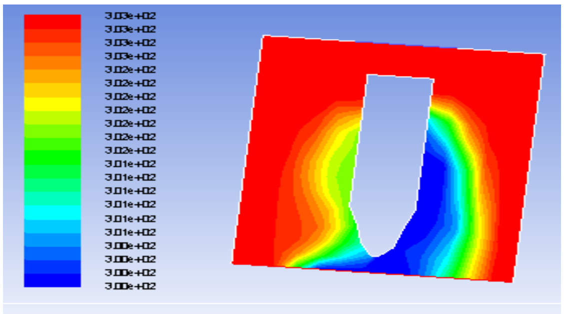


ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

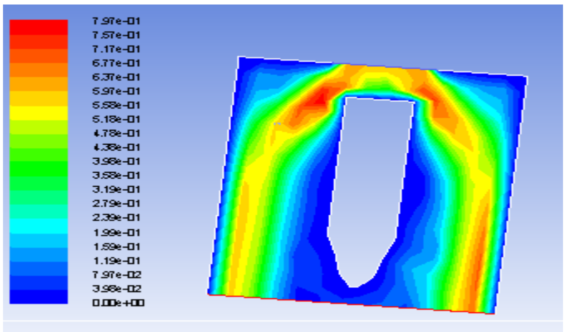
VELOCITY



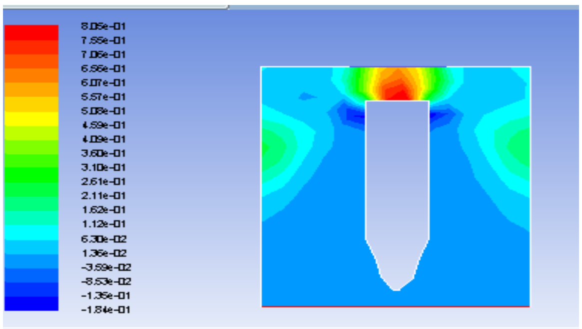
WATER AT 400C
TEMPERATURE



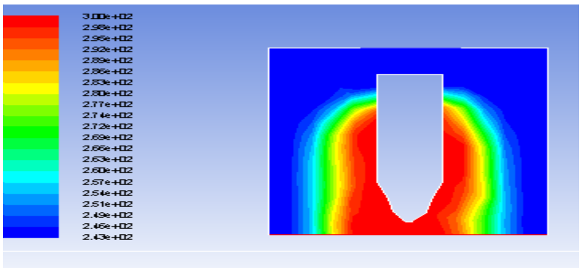
VELOCITY



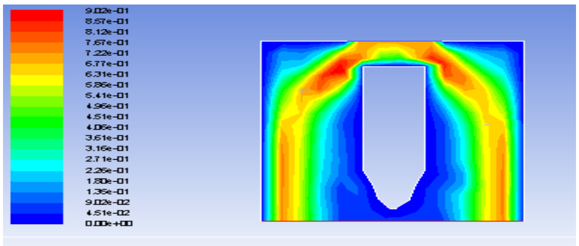
WATER AT 600C
PRESSURE



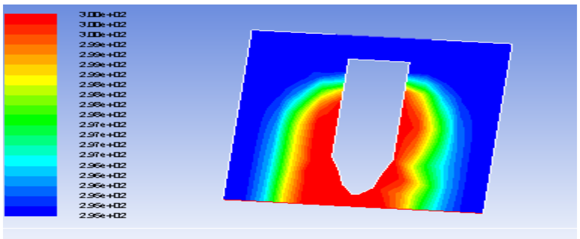
TEMPERATURE



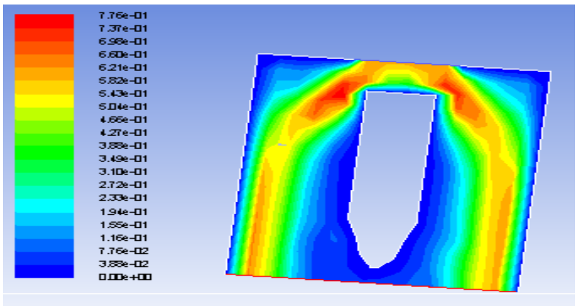
VELOCITY



AIR
TEMPERATURE



VELOCITY



RESULTS AND DISCUSSIONS
THERMAL ANALYSIS –WITH HOLE

Materials	Temperature(K)	Heat flux(W/mm²)
High speed steel	333	0.00014339
Tungsten carbide	333	0.60239

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

THERMAL ANALYSIS –WITH OUT HOLES

Materials	Temperature(K)	Heat flux(W/mm²)
High speed steel	333	0.00010967
Tungsten carbide	333.01	0.34501

CFD ANALYSIS

WITHOUT HOLES

Fluid	Pressure(N/m²)	Temperature(K)	Velocity(m/s)	Heat Transfer Rate (W)
Water at 20⁰	1.37e+00	2.93e+02	1.03e+00	2.4261475
Water at 40⁰	1.41e+00	3.03e+02	1.06e+00	3.5054321
Water at 60⁰	1.87e+00	3.43e+02	1.20e+00	3.2851563

WITH HOLES

Fluid	Pressure(N/m²)	Temperature(K)	Velocity(m/s)	Heat Transfer Rate (W)
Water at 20⁰	5.81e-01	300e+02	7.81e-01	5.0693359
Water at 40⁰	5.89e-01	3.03e+02	7.89e-01	10.908325
Water at 60⁰	8.05e-01	3.00e+02	9.02e-01	14.87207

WITH HOLES – AIR

Fluid	Pressure(N/m²)	Temperature(K)	Velocity(m/s)	Heat Transfer Rate (W)
Air	1.30e+00	2.97e+02	1.09e+00	3.2346802

WITH OUT HOLES – AIR

Fluid	Pressure(N/m²)	Temperature(K)	Velocity(m/s)	Heat Transfer Rate (W)
Air	5.84e-01	300e+02	7.76-01	2.7330933

CONCLUSION

By observing thermal analysis results, the heat flux values are more for flash cooling than external cooling. That is the heat produced while machining is fastly removed by flash cooling than external cooling. For Tungsten Carbide tool, the heat transfer rate is more than that of HSS tool.

By observing the CFD analysis results, the heat transfer rate is more for all fluids when flash cooling is provided than external cooling. By comparing the results for fluids, the water at 60^{0}C removes more heat from cutting fluid than other fluids.

REFRENCES

[1] R. F. Ávila, A. M. Abrão, "The effect of cutting fluids on the machining of hardened AISI 4340 steel," Journal of Materials Processing Technology 2001;119:21-26.

[2] D. U. Braga, A. E. Diniz, G. W. A. Miranda, N. L. Coppini, "Using a minimum quantity of lubricant (MQL) and a diamond coated tool in the drilling of aluminum-silicon alloys," Journal of Materials Processing Technology 2002;122:127-138.

[3] M. Soković, K. Mijanović, "Ecological aspects of cutting fluids and its influence on quantifiable parameters of the cutting processes," Journal of Materials Processing Technology 2001;109:181-189.

[4] J. John, M. Bhattacharya, P. C. Raynor, Emulsions containing vegetable oils for cutting fluid application," Colloids and Surfaces A: Physicochem. Eng. Aspects 2004;237:141-150.

[5] W. Belluco, L. De Chiffre, "Testing of vegetable-based cutting fluids by hole making operations," Lubrication Engineering 2001;57:12-16.

[6] W. Belluco, L. De Chiffre, "Surface integrity and part accuracy in reaming and tapping stainless steel with new vegetable based cutting oils," Tribology International 2002;35:865-870.

[7] L. De Chiffre, W. Belluco, "Investigations of cutting fluid performance using different machining operations," Lubrication Engineering 2002;58:22-29.

[8] W. Belluco, L. De Chiffre, "Performance evaluation of vegetable-based oils in drilling austenitic stainless steel," Journal of Materials Processing Technology 2004;148:171-176.

[9] M. A. Xavior, M. Adithan, "Determining the influence of cutting fluids on tool wear and surface roughness during turning of AISI 304 austenitic stainless steel," Journal of Materials Processing Technology 2009;209:900-909.

[10] E. Kuram, "Investigation of vegetable-based cutting fluids performance in drilling," M.Sc. Thesis, Gebze Institute of Technology, Gebze-Kocaeli, Turkey, (in Turkish), 2009.

Author Details

Gopidi Harish Reddy received the B.TECH degree in Mechanical Engineering from Bharat Institute of Engineering and Technology,JNTU, Hyderabad, Telangana,India, in 2014 year and pursuing M.TECH in Thermal Engineering from Ellenki College of Engineering and Technology, JNTU, Hyderabad, Telangana, India.

Smt.K.Aparna, M.TECH, Assistant Professor, Ellenki College of Engineering and Technology, JNTU, Hyderabad, Telangana, India.