TEMPERATURE MEASUREMENT OF A CUTTING TOOL IN TURNING PROCESS BY USING TOOL WORK THERMOCOUPLE

Sushil D. Ghodam[1]

[1]*M. Tech Student, Production Engineering, Government college of Engineering, Amravati, (M. S) India*

Abstract

Temperature at the cutting point of the tool is a crucial parameter in the control of the machining process. Due to advancement in the machining processes, a special attention has been given on the life of a tool. To achieve this, the best way is to apply the coating to the tool. In this study, coated and uncoated tungsten carbide tools were used and temperature occurred during machining were measured. Among the number of temperature measuring methods, the tool-work thermocouple technique is used as it is easy to install and inexpensive as compared to other methods. The procedure for the working of Tool-work thermocouple and method of calibration is described in this paper.

Keywords: *Temperature measurement, tool-work thermocouple, CVD coating*

---

1. INTRODUCTION

The importance of knowledge of temperature measurement at the cutting point of the turning tool occurred due to the changes in the cutting condition is well known due to severe effects on the tool and work piece materials properties [1, 3]. During machining heat is generated at the cutting point from three sources i.e. primary, secondary and tertiary zones [5].

The chip, tool and work piece help to remove this heat from the cutting zones. Figure 1 schematically shows this dissipation of heat. The increase in temperature at cutting point of the tool is mainly due to secondary shear zone, but primary shear zone also contribute towards the temperature rise of the cutting tool and indirectly affects the temperature distribution on the tool rake face [11, 14].

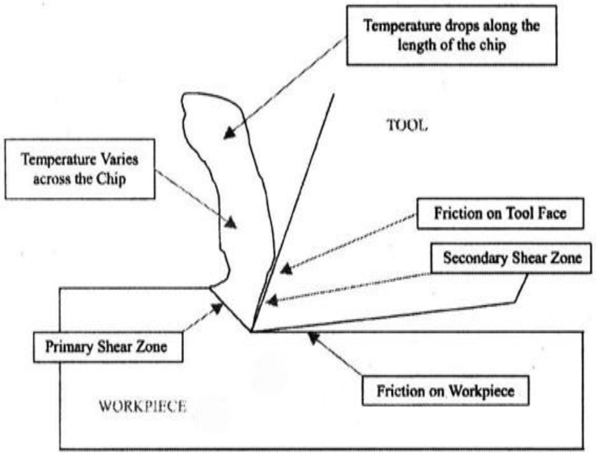

Fig 1 Dissipation of heat in machining

W. Grzesik *et al*. obtained some results of extensive experimental investigations of the thermal interactions between the coating/substrate and the moving surface of the chip. Semi orthogonal cutting when bar turning medium carbon steel and an austenitic stainless steel was carried out. Both flat-faced and grooved inserts coated with TiC, TiC/TiN, and TiC/Al2O3/TiN was tested. A standard K-type thermocouple embedded in the work piece was used to convert measured emf's to the interfacial temperatures. In addition, the chip rake contact length and the area of contact were determined by using computer processing of scanned contact images. The minimum steady-state temperature at the interface between the moving chip and the coating substrate system was explained in terms of the heat flux intensity and the thermal properties of both components of a unique closed tribo-system [3].

Abhijeet Amritkar *et al*. designed and developed a calibration set-up in order to establish a relationship between obtained emf during machining and the cutting temperature. Also, the most simplest and economical technique of temperature measurement i.e. tool-work thermocouple setup was developed for the measurement of the cutting temperature in machining [13].

2. EXPERIMENTAL DETAILS

2.1 Experimental Setup

In this experiment, the HMT heavy duty lathe LTM-20 were used to conduct the tests without using any coolant. A commercially available CVD coated turning insert CNMG 120408 PR 4225 were used to compare the temperature obtained at uncoated tool inserts. The machining was performed using work piece EN8 alloy steel (250 mm long and 45 mm diameter).

The Tool-Work thermocouple was used to measure the temperature at the cutting point of the tool. The tool-work thermocouple is work on the principle of seebeck effect which states that if there is a temperature difference between any two junctions then there will be a development of emf in between the two junctions. The principle of this method is shown in figure 2.

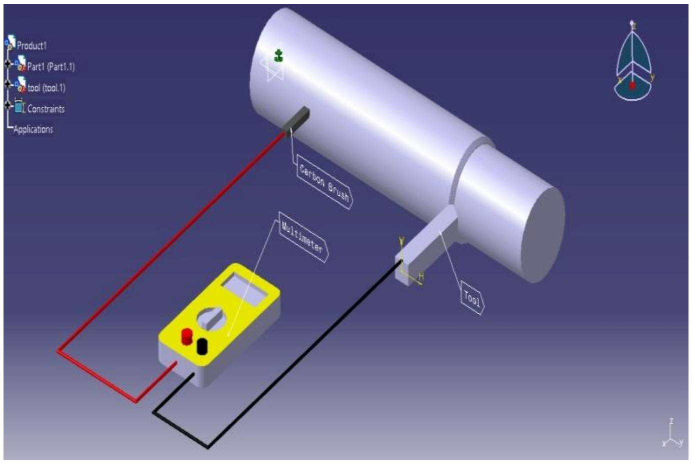

Fig 2 Setup of Tool-Work Thermocouple

In this experiment, turning insert and work piece were insulated from the lathe machine by using mica as an insulating. Cold end of the inserts and work piece were connected to the millivolt meter and carbon brush is used to connect the millivolt meter to the work piece as the work piece in turning is rotating. Figure 3 shows the experimental set-up of the too-work thermocouple for measuring thr average temperature at the tool tip.

Fig 3 Experimental set-up of tool work thermocouple

In this work, calibration of the tool work thermocouple was carried out by using a heating coil. This set-up is similar to one used by Abhijeet Amritkar *et al* [13], in which workpiece was directly calibrated with the tool. Figure 4 shows the calibration set-up for tool-work thermocouple.

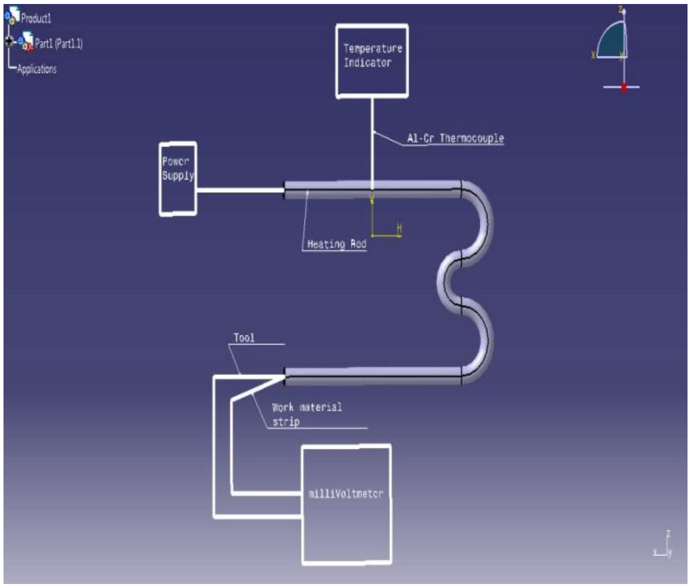

Fig 4 Calibration set up for tool-work thermocouple

In this set-up, Junction of tool and workpiece was connected to the milliVoltmeter and also K-type Alumel-Chromel thermocouple was connected to the heating rod. The temperature indicator was used to display the temperature of heating rod sensed by the Al-Cr thermocouple.

3. EXPERIMENTAL RESULTS

The objective of this experiment was to compare the temperature generated during machining at uncoated and CVD coated tungsten carbide cutting tool. The machining tests were conducted by varying the cutting speed and feed rate whereas depth if cut was kept constant i.e. 1mm. The cutting speed used for machining was 35.32, 59.34, 100.32 and 169.56 m/min whereas feed rates were 0.83, 1.04, 1.25 and 1.65 mm/rev. The calibration curve i.e. Temperature Vs. millivoltage graph obtained for uncoated and coated tool inserts is shown in figure 5(a) and 5(b) respectively.

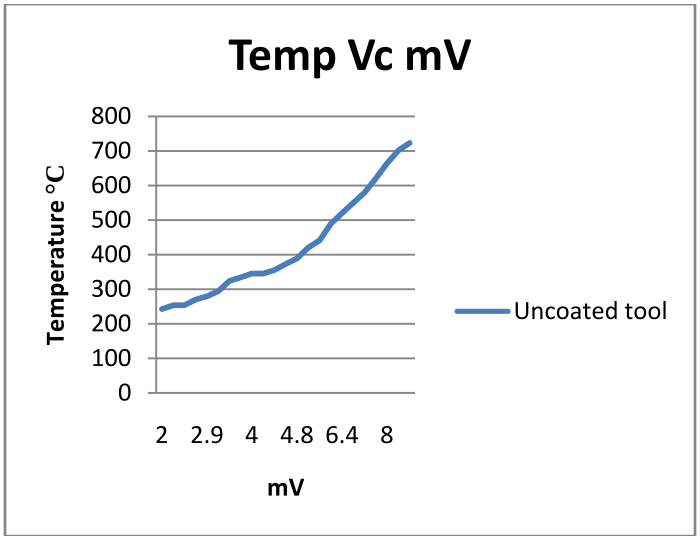

Fig 5(a) Temperature Vs. milliVoltage graph for uncoated tool

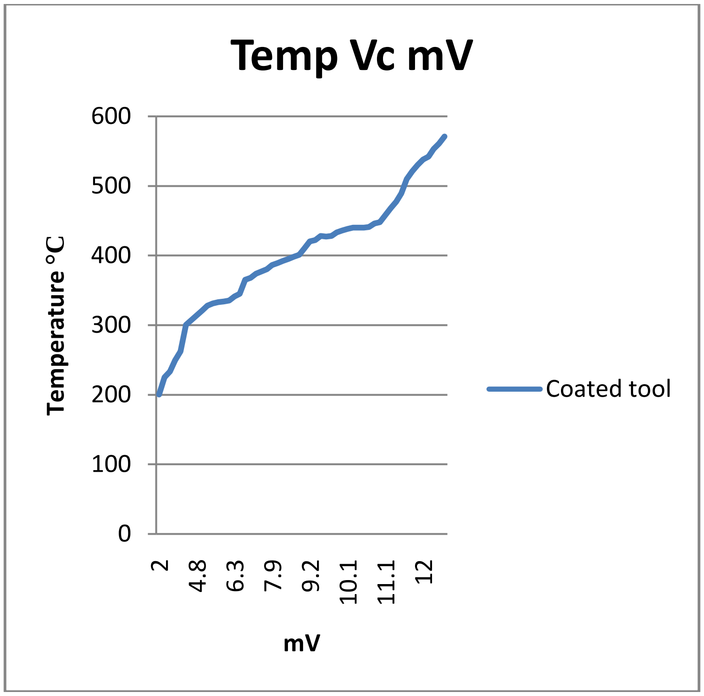

Fig 5(b) Temperature Vs. milliVoltage graph for coated tool

Figure 6 shows the change in temperature in cutting zone of uncoated and CVD coated turning tool according to the feed rate for the machining at 35.32 m/min respectively. As feed rate increases from 0.83 to 1.65 mm/rev, the temperature at the uncoated tool is increases at high amount as compared to the coated tool.

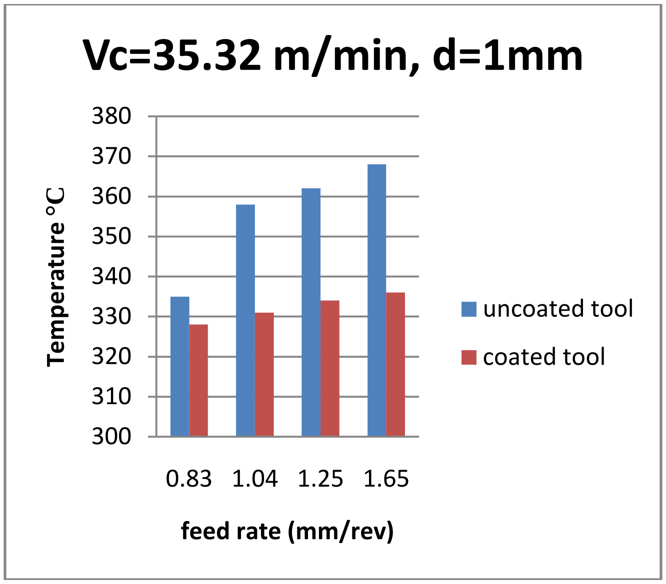

Fig 6 Effect of feed rate on cutting temperature

Similar results were found for the cutting speeds 59.34, 100.32, 169.56 m/min which is shown in figure 7, figure8, and figure 9 respectively.

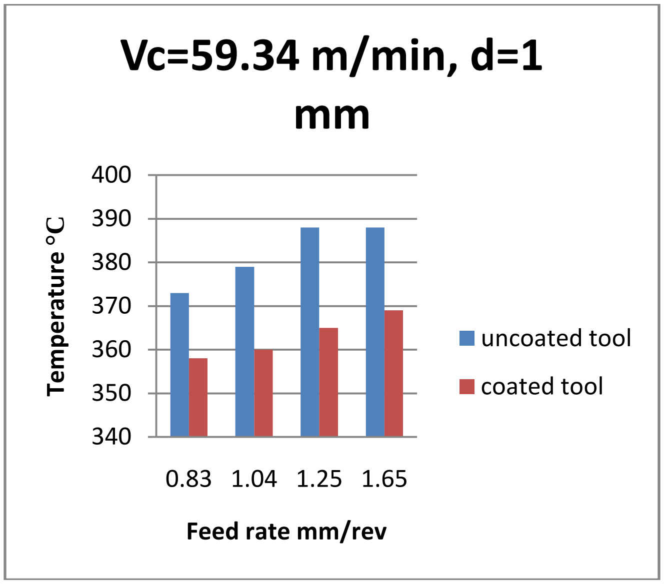

Fig 7 Effect of feed rate on cutting temperature

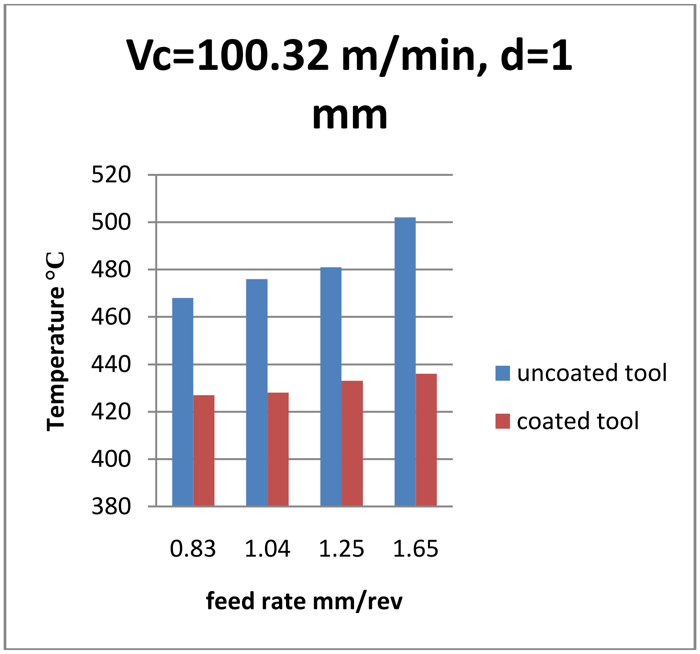

Fig 8 Effect of feed rate on cutting temperature

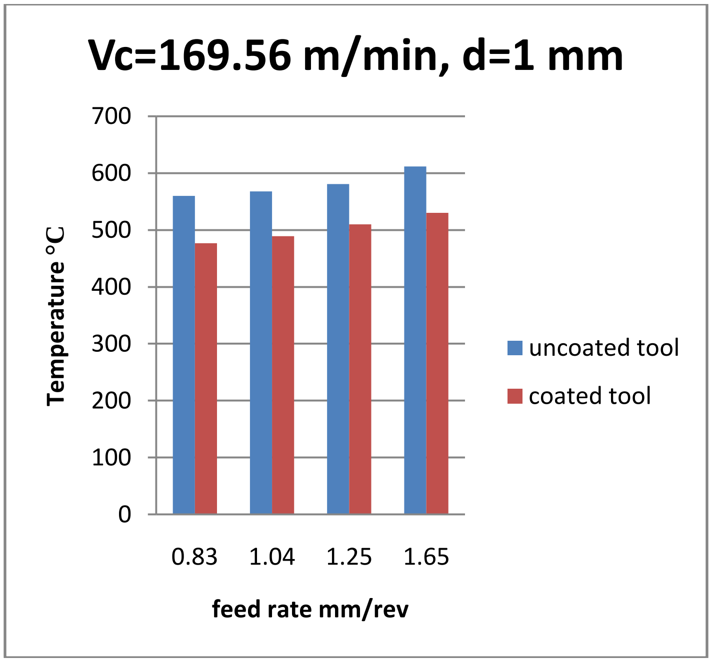

Fig 9 Effect of feed rate on cutting temperature

The maximum temperature difference between coated and uncoated tool was occurred at a cutting speed of 169.56 m/min. At f = 1.65 mm/rev, Vc =169.56 the temperature at the coated tool was found to be 82 °C less than the uncoated tool. The temperature occurred at different cutting speeds for coated and uncoated tool by keeping f =1.65 mm/rev and d = 1mm is shown in figure 10.

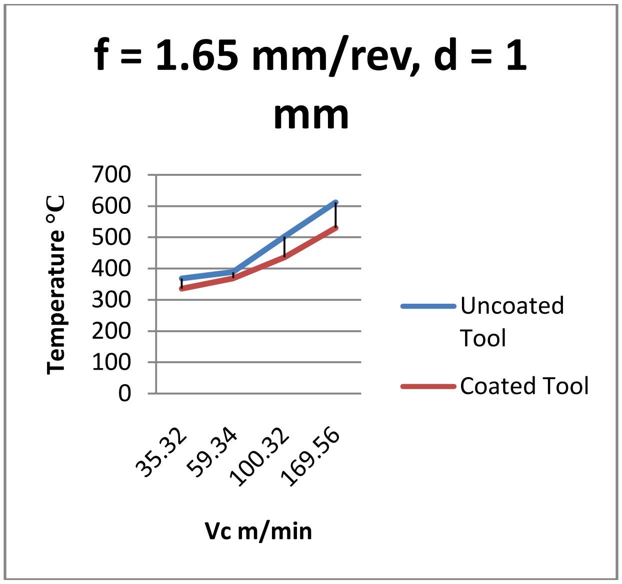

Fig 10 Effects of cutting speeds on cutting temperature

4. CONCLUSIONS

- The Tool-Work thermocouple is the best way to obtain the temperature at the tool rake face as it is easy to install and inexpensive as compared to other methods.
- With the increase in a cutting speed or a feed rate, the temperature at the tool rake face also increases as found in the machining tests
- Due to the advancement in machining processes, generation of high temperature at the tool rake face takes place. This generation of heat can be resisted by using a coated tool. Reduction in the temperature of the tool improves the tool strength and also improves the surface roughness of work piece.
- From the experimental data, it is found that as compared to uncoated tool the coating of the tool increases the life of a tool for the same cutting velocity or for the same tool life, coated tool can be used at higher cutting speed as compared to uncoated tool.

REFERENCES

[1]. X. L. Liu, D. H. Wen, Z. J. Li, L. Xiao, F. G. Yan, 2002, “Cutting temperature and tool wear of hard turning hardened bearing steel”, Journal of Materials Processing Technology 129, pp 200-206.
[2]. S. K. Choudhary, G. Bartarya, 2003, “Role of temperature and surface finish in predicting tool wear using neural network and design of experiments”, International Journal of Machine Tools & Manufacture 43, pp. 747-753
[3]. W. Grzesik, P. Nieslony, 2000, “Thermal Characterization of the Chip-Tool Interface when using coated turning Inserts”, Journal of Manufacturing Processes Vol. 2/No. 2

[4]. Josef Mayr, Jerzy Jedrzejewski, Eckart Uhlmann, 2012, “Thermal Issues in Machine Tools”, Manufacturing Technology 61, pp. 771-791.
[5]. Pradip Mujumdar, R. Jayaramachandran, S. Ganesan, 2005, “Finite element analysis of temperature rise in metal cutting processes”, Applied Thermal Engineering 25, pp. 2152-2168
[6]. W. Grzesik, P. Nieslony, M. Bartoszuk, 2005, “Finite element modeling of temperature distribution in the cutting zone in turning processes with differently coated tool”, Journal of Materials Processing Technology 164-165, pp. 1204-1211
[7]. W. Grzesik, P. Nieslony, M. Bartoszuk, 2004, “Finite difference analysis of the thermal behavior of coated tools in orthogonal cutting of steels”, International Journal of Machine Tools & Manufacture 44, pp. 1451-1462.
[8]. Sarat Babu Singamneni, 2005, “A mixed solution for the three-dimensional temperature distribution in turning inserts using finite and boundary element techniques”, Journal of Materials Processing Technology 166, pp. 98-106.
[9]. A.Molinari, R. Cheriguene, H. Miguelez, 2012, “Contact variables and thermal effects at the tool-chip interface in orthogonal cutting”, International Journal of Solids and Structures 49, pp. 3774-3796.
[10]. X. J. Ren, Q. X. Yang, R. D. James, L. Wang, 2004, “Cutting temperatures in hard turning chromium hardfacing with PCBN tooling”, Journal of Materials Processing Technology 147, pp. 38-44
[11]. N.A. Abukhshim, P.T. Mativenga, M.A. Sheikh, 2005, “Investigation of heat partition in high speed turning of high strength alloy steel”, International Journal of Machine Tools & Manufacture 45, pp. 1687-1695.
[12]. F. Boud, 2007, “Bar diameter as an influencing factor on temperature in turning”, International journal of Machine tools & manufacture 47, pp. 223-228.
[13]. Abhijeet Amritkar, Chandra Prakash, Atul Kulkarni, 2012, “development of temperature measurement setup for machining”, World journal of science and technology 2, pp. 15-19.
[14]. L. B. Abhang, M. Hameedullah, 2012, “Chip-Tool interface temperature prediction model for turning process”, International journal of Engineering science and technology 2, pp. 382-393.
[15]. Lathiya Dharmeshkumar, Viswakarma Ajay, 2012, “Temperature rise distribution due to combined effects of shear plane heat source and the tool-chip interface frictional heat source”, International Journal of Advanced Engineering technology, pp. 63-66
[16]. Onyechi Pius, Oluwadare, Benjamin S., Obuka Nnaemeka, 2013, “Analytical Modelling of Temperature Distribution in Metal Cutting: Finite element approach”, pp. 17-33
[17]. Dr. A. G. Matani, 2013, “Effective energy conservation techniques in industries”, International Journal of Mechanical Engineering & Technology (IJMET), pp. 74- 78
[18]. Dr AG Matani, 2013, “Curricula Challenges of Technical and Management Education Institution”, International Journal of Management (IJM), 4(1), pp. 56-60