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STATE OF THE ART ON TECHNIQUES (METHODS) EMPLOYED FOR MEASUREMENT OF TEMPERATURE IN THE METAL CUTTING PROCESS

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Abstract;-This paper highlights the review of various research conducted intemperature measurement during metal cutting. Temperature measurement was done on different metal cutting environment such as Dry, MQL, NFMQL etc.– from the exhaustive literature review conducted by various authors it can be found that minimum quantity lubrication is helpful in reducing the temperature generation during metal cutting. Furthermore, the contact type measurement based on wire thermocouple was better for measurement on temperature in past. But due to advancement in technology the non-contact type temperature measurement is better due to measurement of temperature at very complex intricates shapes.

Introduction: -

The machining of several materials like steels, cast iron titanium alloys, aluminium alloys generated enormous amount of heat due to the effect of high cutting speed and feed. Shaw et al. explained that the energy supplied to the machining process is converted in to the heat due to the plastic deformation of the shearing plane. Tool removes the material in the form of chip and these chips slides on the rake face of the tool. The heat is generated and distributed among the tool, work piece and chip and rest in the environment. Some of the heat is also generated on the tertiary plane where tool's relief face touches the machined surface. The heat generated in the shearing plane decrease the tool life but increase the productivity [2],[21],[22]. Some different tool wear mechanism such as abrasion,adhesion also depends on temperature.

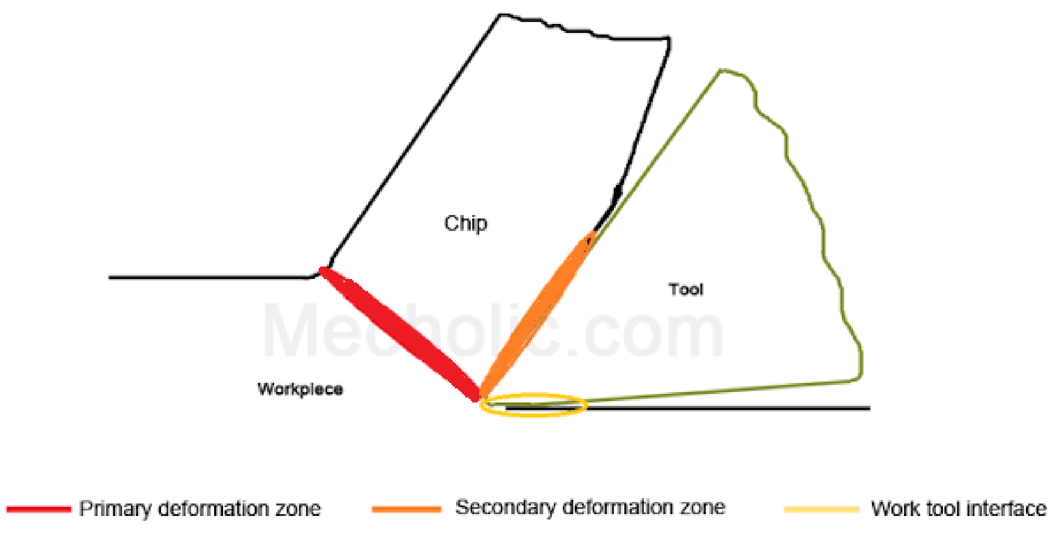

Fig1: Different heat zone during machining

To reduce the temperature during the machining process we used cutting fluids but cutting fluids also have its negative impacts.it may produce health problems because of toxicity present in it. the excess use of cutting fluid also increase the total production cost.to overcome the cost problem some researcher investigated the use of cutting fluid with high compressed air in the form of mist but it also creates health problem due to toxins. Varadarajanetal. [23] developedaindigenousset-upwhich had minimize the drawback of MQL by supplying cutting fluid in high-velocity, narrow, pulsed jet form [6].

Various common techniques are used for temperature measurements are thermograph, pyrometer, thermoelectric and calorimeter, but most commonare thermo elements. [3].

Literature Survey

Lincoln et al. [1] investigated the temperature of work piece when tapping of hardened steel AISIH13 (100×40×14mm). Tapsused were TiAlNcoated of 1.5mm pitch and straight flute. Experiment was done in dry condition, MQL condition and flooded system. The experiment is done with parameters Hole diameter is 8.6mm, V_c = 3 m/min, N = 95rpm, f =143 mm/min. In the experiment three thermocouple of copper constantan are used for temperature measurement in radial direction and 0.1mm distance from hole. The Experiment resultsshowedminimum peak temperature obtainedthrough flooded machining system, followed by MQL, and dry.

Federico et al. [2] revealed turning of AISI 4340 byapplying coated carbide tool and machining was done at high speed. Tool employed was multilayer coated carbide with TiCN-Al_2O_3-TiN layers of 9μm.The work material hasD=50mm and L=200mm. The experiment parameters are V_c = 150-200m/min, f= 0.7-0.17mm/rev and DOC =0.2-0.4 mm. Measurement of temperature was done through thermocouple (K type) at the distance of 0.2 mm from the rake face. The results showed thatenhancement in temperature was significantly at rake face on changing depth of cut. It occurs due to change in contact length.

Rodrigo et al. [3] investigated generated in temperature while drilling of the titanium Ti6Al4V alloy by employing coated and uncoated carbide tool under the condition of MQL. Experiment consist of a work piece of Ti6Al4V with dimension 200mmx150 mmx20mm and drilling the holes of 8.5 mm diameter. The V_c = 10-50m/min, f=0.1-0.2mm.Temperature is measured with the help of thermocouple 0.2 mm from theholewall and 5 mm distance from the edges.

TKeizu et al. [4] investigated the distribution of temperature in compacted graphite iron work pieceduring MQL deep hole drilling and distribution of temperature in the w/p is predicted by the FEM. The experiment setup consists of a w/p of CGI D=20mm and L=200mm and having tool of 2-flute uncoated carbide drill of D=10 mmhaving30-degree helix, 118-degree point angle, 120-degree chisel angle V_c= 25-75 m/min and f = 0.15 mm. The maximum temperature was observed on the chisel edge near the centre of hole instead of the outer surface of hole.

Dhar et al. [5] investigatedthe influence of MQLwhile turning AISI 1040 steel. In experiment setup turning of a 125 mm diameter and 760m long reed of AISI 1040 steel. Cutting tool of carbide and V_c= 72-164m/min f= of 0.1-0.2mm/m and depth of cut 1.5mm. The results show that the application of MQL reduced in chip reduction co efficient due to reduction in friction reduction in temperature and also reduce in cutting force by 5-18 degree. Surface finish and dimension accuracy increase as minimization of wear and dullness of tool takes place.

Thepsonthi et al. [6] investigated influence of minimum cutting fluid during high speed milling of hardened steel on employing carbide mills. The experiment consists of a block of 50mm×100mm× 250mm and carbide tool of 12mm. Experiment variables are V_c =125, 150, 175 m/min, f= 0.01, 0.02 mm/tooth. The result shows that during pulsed mode enhancement in surface roughness was takes place with the increase in cutting velocity but in dry and flood mode it decreases. During pulsed jet flank wear was least and highest in flood mode. Cutting forces was lower in pulse jet than flood and dry mode.

Leshock and Shin [7] investigated temperature generation by thermo couple technique. The experiment consists of 4140 steel or Inconel 718 and tool is Kennametal K313 carbide. The experiment variables are doc 0.5- 1.27 mm, f= 0.07–0.175 mm/rev, and V_c= 1.168–2.997 m/s. The experiment result showed a correlation to find the best fit temperature of tool – chip interface T_{avg} = 1700 V.5 d0.2 f0.4. The results show that feed has a stronger effect on temperature. Depth of cut is shown to affect the tool rake temp but very less in amount. Flank wear has no effect on temperature butstrongly affected by crater wear.

Dhar et. al.[8]investigated on effect of MQL on tool wear, surface roughness and dimensional deviation in turning AISI 4340 steel. Experiments had been carried out by a plain turning rod of 125mm diameter and 760mm rod of AISI 4340 steel. The cutting temperature, tool wear and surface roughness is measured under dry, wet and MQL condition. The experiments variable is V_c =63 to 128 m/min f= 0.1–0.2 mm/rev, DOC 1–1.5mm. The experiment showed that at MQL at low velocity more effective than high speed and enabled in reduction of 5% in temperature.MQL provide reduced tool wear improved tool life and better surface finish as compared to dry and wet.

Rahim at al. [9]Investigated on supercritical carbon di oxide (SCCO2) performance as a sustainable cooling technique. Experimental set up consist of AISI 1045 medium carbon steel rod of 150 mm diameter, uncoated carbide tool was selected as a cutting tool. Supercritical CO_2 (T_{cr} = 31.2°C and P_{cr} = 7.38MPa). MQL the machining variables are V_c = 350–550 m/min, f = 0.08–0.12 mm/rev and DOC = 2mm.Temperature is measured by FLIR thermal imager. The experimental results show reduction of cutting temperature 15–30%, reduction in cutting force for SCCO2 than MQL.

Dhar et al.[10] studiedeffects of minimum quantity of lubrication on cutting temperature, chip and dimensional accuracy in turning AISI-1040 steel. The experiment consists of AISI-1040 steel rod of diameter 110 mm and length 620mm which is plain turned by a tungsten uncoated tool under the dry, wet and minimum quantity lubricant (MQL) condition. The $V_c$varies from 64-130 m/min and f =0.1-0.2mm/rev. A standard K-type thermocouple is used for measuring the temperature at the tool work junction. The result shows that MQL is better than other two conventional cutting fluid. It reduces the cutting temperature and increase the tool–chip interaction which helps in maintain the sharpness of the cutting edges of the tool. This also leads in reduction of tool wear which increases the dimensional accuracy.

Huang et al.[11] investigated on the robust design of using Nano fluid/MQL in micro drilling operation. The experiment consists of a work piece of 7075-T6 of dimension (52mmx52mmx10mm) of aluminium alloy. The drill bit used for drilling of diameter 200μm and flute length 1 mm feed rate is 8 μm/rev. The experiment was done in the condition of dry, MQL and MQL with Nano particle of diamonds. The results show that the less temperature achieves in MQL with Nano particle followed by MQL and dry condition.it is possible due to the high conductivity of Nano particle.

Boradeand Kadam [12]investigated on the comparison of main effect of vegetable oil and Al_2O_3 Nano fluid used with MQL on surface roughness and temperature. The experiment used a work piece of material EN353case hardening steel in the form of 30mm diameter and length of 80mm. The insert selected for this process was CBN 7025. Vegetable oil is used as cutting fluid in MQL and Al_2O_3 as Nano fluid. The N was 800-1200 rpm, f =0.05-0.09 mm/rev and DOC =0.05-0.09 mm. The temperature is measured by Infrared thermometer. The experiment results show that the temperature reduced significantly by using Nano fluid due to high thermal conductivity.

Yanbin et al. [13] experimentally investigated MoS_2/CNT Nano fluid lubrication performance under minimal quantity lubrication in NI based alloy grinding. the experiment set up consist of abrasive grinding wheel of 300mmx20mmx76.2mm and a Ni-based alloy 40 mmx30mmx30mm. The grinding speed is 30m/s, depth of cut 10μm.The Nano fluids are used MoS_2, CNTs and MoS_2/CNT hybrid. The experiment results show that the pure MoS_2 results in great reduction in grinding forces and surface roughness followed by MoS_2/CNT hybrid Nano particle then pure CNT.

Khan and Dhar [14]evaluated cutting performance ofvegetable oil based minimum quantity lubricant in terms of surface finish, cutting force, tool wear and cutting zone temperature during turning of AISI- 1060 steel. The experiment set up consist of a lathe machine, work piece of AISI-1060 steel of size 125mm diameter and 760 mm length. The experiment variables are V_c = 72-164 m/min and *f*=0.1-0.2 mm/rev; DOC remains constant during the process of 1.5mm. The experiment results show that the application of MQL vegetable oil reduces the cutting temperature by increasing tool chip interaction. It also helps in reducing the tool wear, increase the surface finish compared to dry machining of steel.

Haded et al. [15]investigated on the temperature and energy partition in minimum quantity grinding process. The experiment set up consist of a CNC universal surface grinding machine having vitrified Al_2O_3 and resin bond CBN wheels. The work piece was 100Cr6 bearing steel with L = 60mm and 8mm in width. The work piece temperature was measured using a Chromel-aumel thermocouple. In the experiment wheel speed is 30m/s, work speed 200mm/min and DOC = 30μm. the experiment results show that the temperature rises in the work piece under the MQL condition Is lower than others.

Morgan et al.[16] investigated on temperature in fine grinding with minimum quantity lubrication (MQL). The experiment was done under three condition dry grinding, low pressure fluid and MQL condition. The temperature is measured by a single pole thermocouple. The experiment was done on steels grades of EN8, M2 and EN31. The experiment variables are cutting wheel speed 25-45 m/s. work speed 6.5-15m/min and depth of cut 5-25μm. The experiment results show that the temperature rise in EN31 under the wet condition is lower than MQL due to cleaning by large volume but in M2 steel wet and MQL giving similar result in temperature. In EN8MQL gives most effective result and lower temperature is measured in it.

Tai et al. [17] investigated generation of temperature in cast iron Deep-Hole drilling under air pressure Minimum quantity lubrication environment. Experiment consist of a work piece of nodular cast iron of 40mm diameter and 210mm in length and a drill was done of length 200mm. Torque is measured by five thermocouples of E-type. The drilling variables are spindle speed 1600-2400 rpm, feed 0.15-0.2 mm/rev and air pressure. The experiment results show that the work piece temperature increased due to chip accumulation which is done due to less momentum provide by feed and spindle speed. If there is no chip clogging, then there no variation by high air pressure in MQL.

Li, and Shih [18]investigated on the tool temperature in titanium drilling. The experiment set up consist of a CNC vertical machining centre and a work piece of D =38 mm and a drill of 9.92 mm of Kennametal. The experiments were conducted at the three speed *N* = 780,1570, and 2350 rpm. The feed remains fixed of 0.025mm. Four E type thermocouple are used for measuring the temperature. The experiments result show that the peak temperature occurs at the cutting edge near the drill margin and lowest at the chisel edge.

Sullivan andCotterell[19] investigated on work piece temperature measurement in machining of aluminium alloy. The experimental set up consist of an aluminium alloy tube of grade 6082-T6. It has outer diameter of 150mm and thickness 5mmK type thermocouple is used for measure contact temperature and infrared thermal imagine camera is used for surface temperature measurement. The experiment result shows that increase in the cutting speed and feed decreased the work piece temperature because of most of the heat carried by the chips.

Coz et al. [20] investigated on the measuring the temperature of rotating cutting tools: Application to MQL and dry milling of aerospace alloy. The experiment consists of two materials one with MQL drilling which was Ti6Al4V titanium alloy and other was dry milling of aluminium alloy AA7075. The experiment condition is V_c = 30m/min and *f* =0.12 rev mm/rev for drilling and V_c =700m/min and *f*= 0.2 mm/tooth for milling. The tool temperature is measured with a different methodology using thermocouple and data collection and acquisition is done by wireless system in tool holder. The result shows that the temperature rises in the tool is very high as compared to work piece.

Conclusion

On the basis of the reviewing the literature,we find some conclusions.

1. The temperature generated in the different machining process is higher in dry machining and lesser in the case of applying MQL.
2. Machiningwith MQL with low velocity is more effective than high velocity[8].
3. It has been observed that MQL is not effective in some cases like tapping because all the space is filled by tap itself[1].
4. Use of Nano particles with cutting fluid gives best cooling rate because of high thermal conductivity of Nano particles.

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