Feasibility of Application of Solid Lubricants in Machining Process: A review

M.A.Makhesana[1], K.M.Patel[2]

[1]Department of Mechanical Engineering, Institute of Technology, Nirma University, Ahmedabad India.
[2]Department of Mechanical Engineering, Institute of Technology, Nirma University, Ahmedabad India.
mayur.makhesana@nirmauni.ac.in

ABSTRACT - To control the high heat generation and its effects during machining, the liquid lubrication has been used traditionally; but there are more problems associated with the health of person and environmental pollution with the use of cutting fluids. So now it is the demand of time and situation that the use of cutting fluid should be minimize or if possible eliminate its use and find out some other means or alternative instead of cutting fluid can be a topic of research in machining. To overcome the difficulties with the cutting fluids one concept is use of solid lubricants while machining and it will control the process temperature and so as heat generated. Solid lubricant, if employed properly, could control the machining zone temperature effectively by intensive removal of heat from the machining zone.

Keywords- Solid Lubricants, Machining, Grinding

1. Introduction:

During a machining process, the plastic deformation of the work piece occurs because of the friction generated between the surface of work piece and tool and as a result of friction significant amount of heat is generated in process. The heat generated will raise the temperature of the cutting tip of the tool; and work piece surface which results in poor surface quality of material after machining.. So the quality of machined work piece is directly affected by the amount of heat generated during the process. To overcome this difficulty lubrication or cooling is provided by the application of cutting fluids in machining zone.

But the policies of government for controlling the pollution and nowadays increased consumer focus on use of products that are more environment conscious leads the industries to eliminate or minimize the use of these cutting fluids. Attanasio *et al* (2006). Moreover, it has also been reported Vikram *et al* (2007) that cutting fluids can affect seriously to the health of people and also the environment in some ways. So in case of the cutting fluids it resulted that the companies are concentrating to maintenance of cutting fluid so the wastage can be reduced and the useful life of cutting fluid can be extended and so it reduces health related problems.Tan *et al* (2002). Though the technology is available for treatment of cutting fluid some another research is need to be carry out to eliminate the use of it.

The study of various methods of machining has become keen topic of research in recent times since it has acquired a prominent role as one of the primary processes in manufacturing industry. Turning is one such machining process which is most commonly used in industry because of its ability to have faster metal removal giving reasonably good surface quality. Surface roughness is one of the important factors for assessing the quality of machined material because the other properties like resistance to fatigue, surface friction will be affected by quality of surface roughness. Further it is also deciding the machinebility of the material.

Grinding is a precision machining process which is widely used in the manufacture of components requiring fine tolerances and smooth finishes. Cutting fluids are used in grinding for a variety of reasons such as improving wheel life, reducing workpiece thermal deformation, improving surface finish and flushing away chips. Large fluid delivery and cooling systems are evident in production plants. Grinding is recognized as one of the most environmentally unfriendly manufacturing processes. An extensive amount of mist is generated during grinding, and the problem is exacerbated by the use of high wheel speeds. From measurements of the mist concentration and droplet size distribution on the shop floor for grinding, it was concluded that the mist generation rate in grinding is often an order of magnitude higher than that in turning. Millions of workers are engaged in daily manufacturing operations worldwide. However, the health hazards to machine operators and other nearby workers who breathe in this hazardous mist are often overlooked. The inherent high cost of disposal or recycling of the grinding fluid is often accepted as a necessary cost of doing business. As environmental regulations get stricter, the cost of disposal or recycling continues to go up.

Government regulation, environmental protection, public awareness, and the need for cost-reduction have all promoted the development of new environmentally conscious machining processes. The main obstacle to replace or eliminate cutting fluids is that the energy generated in the machining process and dissipated as heat causes elevated temperatures, thermal damage, and dimensional inaccuracies. Cutting fluids are a critical factor in controlling these undesirable effects, mainly by providing lubrication and cooling. Lubrication reduces the machining power and the associated heat generation, while also enhancing surface quality and reducing wheel wear. Cooling by the fluid removes heat from the tool and the workpiece.

One alternative to large cutting fluids practice is the dry machining, without using any cutting fluid, minimum quantity lubrication or by using solid lubricants.

2. Literature Review:

If the solid lubricants are applied properly in machining it can be one of the feasible option to eliminate the use of cutting fluid. Many researchers have tried using solid lubricants and minimum quantity solid lubricant concept for machining by replacing conventional cutting fluid.

In this field, an optimized method of the application of solid lubricants named electrostatic solid lubrication experimental setup was envisaged which can supply the solid lubricants at machining zone with slow flow rate and high velocity jet. They have measured the performance of process by considering thrust force, rate of tool wear, chip thickness, diameter of hole and surface finish of material by putting the other conditions constant. They have also compared the results of without the use of any lubricant and wet machining. The experimental results showed that the solid lubricants were more effective in reducing of the cutting zone temperature as compared to dry machining and machining with fluid lubricants. It was also noted that it improves the chip and tool interaction. The selection of solid lubricant should be proper and economical. This concept will provide competition to conventional cutting fluid being used in present. Reddy *et al* (2010)

Barczak *et al* (2010) have studied and compared three various cooling methods: conventional flood cooling, dry grinding and grinding with minimum quantity lubrication. Common steels EN8, M2 and EN31 were ground with a general purpose alumina wheel. The results reported by them showed that minimum quantity lubrication can deliver better performance than flood cooling for the considered parameters and conditions. The parameters were: power, specific forces (tangential and normal force), grinding temperature and surface roughness of workpiece.

The researchers have used the minimum quantity lubrication in grinding process and proposed a new method to find out grinding temperatures and the energy distribution in the surface of material being machined. The same methodology can be used for other grinding operations. They have used the embedded thermocouple for the measurement of temperature distribution in the subsurface of 100Cr6 hardened steel work pieces during grinding with without lubrication, with MQL and with fluid lubricants. Hadad and Sadeghi (2012).

The suitability of minimum quantity lubrication was assessed in micro grinding for the parameters surface roughness and tool life. And the effect of various parameters of grinding and lubrication was analyzied. Some experiments on dry grinding were also conducted. It is observed that the minimum quantity lubrication in micro grinding process improves the surface roughness and tool life. Experimental results shows that the if good surface finish and longer tool life is required than the chip removal should be also smooth and efficient at the grinding zone in process. The application of a small amount of cutting oil in MQL can significantly extend the tool life. In that analysis the tool life increases seven times than dry grinding in MQL. Kuan-Ming Li and Cheng-Peng Lin (2012).

Dilbag Singh and rao (2008) has identified the molybdenum disulphide as a solid lubricant for bearing steels and it was found the reduced friction and better surface finish of materials. Researchers have conducted the experiments for the hard turning of the bearing steel material to analyze the effect of molybdenum disulphide lubricant on surface roughness. It was reported the considerable improvement in quality and performance of bearing steel as compared to dry machining and machining with conventional lubricants.

In another work the concept of minimum quantity lubrication was used by adding 10% of boric acid by weight with SAE 40 base oil. In different machining situations the value of cutting force, cutting temp, chip thickness and surface roughness are studied for lubrication. The results indicate that there is a considerable improvement in machining performance with MQL assisted machining compared to dry machining. Abhang and Hameedullah (2010).

The machining without lubrication, cryogenic cooling, minimum quantity lubrication and use of solid lubricants are some of the ways to eliminate the use of cutting fluid in this time when more weightage is given on environment pollution. If there is advancement in cutting tool material than it was reported that dry machining can replace the cutting fluid. Sreejith, and Ngoi (200). It was also found that Dry machining reduces the power consumption and results in fine surface than turning with cutting fluid at specified cutting conditions Diniz, and Micaroni (2002).

It was also reported that the increase in the performance of process can be done by applying minimum quantity of lubrication instead of dry and wet lubrication for various parameters considered. Varadarajan *et al* (2002). Li and Liang (2006) has also studied the effect of various values of the parameters on temperature of cutting zone for almost dry machining. Researchers are also working in the area to develop environment friendly lubrication system by using minimum quantity of lubricant, such as MoS2 powder, grease-based graphite mixed with water and SAE 20 oil in various proportions instead of fluid lubricants Lathkar, and Bas (2000).

It was also investigated that the use of liquid nitrogen jets results in good surface finish, low cutting temperature, reduction in tool wear and also provides good dimensional accuracy as compared to dry machining or machining with fluid lubricants for various grades of steels Paul *et al* (2002).

Machining by liquid nitrogen provided longer tool life by modifying the tool holder and more resistance to wear as compared to dry machining Ahmed *et al* (2007).Venugopal, and Rao (2004) has also used the graphite as a solid lubricant in grinding process which resulted the decrease in heat generation. And it was noted that the entire improvement in the process because of graphite. The value measured for various process parameters were observed and reported to be reduced as compared to the values with normal lubrication. .

Deng et al (2005) has shown that the friction coefficient at the tool–chip interface in dry cutting of hardened steel and the cast iron with Al_2O_3/TiC/CaF_2 ceramic tool was reduced compared to that of Al_2O_3/TiC tool without CaF_2 solid lubricant. In ceramic grinding the graphite as a solid lubricant was used in paste form between wheel and work piece and the feasibility of it was checked in various grinding conditions. Shaji and Radhakrishnan (2003). The effective role of graphite as solid lubricant was evident from the process results related to frictional factors. The grinding performance was also increased when graphite and molybdenum disulfide were used as solid lubricants in machining for various basic process parameters. Agarwal and Rao (2007).

Mukhopadhyay *et al* (2007) has checked the possibility of the application of solid lubricants for machining of AISI 1040 steel material. They found reduced chip thickness ratio and value of surface roughness by using uncoated cemented carbide inserts. They have also reported the increased machinability of material and quality of work.

3. Future scope for work:

It can be identified the behaviour of minimum quantity lubrication with solid lubricants in machining process. And it can be also develop an understanding of the MQSL within the machining process and suitable feeding mechanism for solid lubricants for the process. Further it can be investigated the feasibility of an optical non-invasive method of determining the surface finish, process temperature, cutting forces and tool wear rate.

Conclusion:

In order to look into the aspects of obtaining better surface quality, investigations were carried out by introducing various solid lubricants in machining process with a newly designed experimental setup. Minimum quantity lubricant can be reduced the chip-tool interface temperature and Surface finish can be also improved mainly due to significant reduction wear and damage at the tool tip.

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