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Dry Machining: Short Review

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Abstract: ***Machining is the process of converting raw material into a finished product using a cutting tool to remove material from the workpiece. In this process, coolant is used to eliminate heat generated between the tool and workpiece and for lubrication purposes. Manufacturers globally are researching alternative techniques to eliminate coolant. The major component of manufacturing cost is spent on the purchase, storage, handling, usage, treatment and safe disposal of the coolant. Lots of efforts have been made to increase machining productivity. The cost involves with the machining coolant is higher which constitutes 7% to 17% of total manufacturing cost[1]. In a developed and industrialized nation, the cost of utilization and disposition is in billion dollars. Also, the chemical contents in the coolant and its mist causing adverse effects on the environment and the workers who are in contact with the manufacturing process. Dry machining is the future trend in the machining process to eliminate this use of coolant. This paper provides the basis of dry machining to have an idea about the successful implementation of the technique.***

Keywords: Dry Machining, Coolant, Cost and Hazard, Tool material, tool coatings

I. INTRODUCTION

The conventional machining process involves the use of coolant. But the usage of coolant in the machining operation is not affordable in cost and not suitable for the health and environment. The use of coolant in machining is for dissipating heat which is generated between tool and workpiece in the shear zone during the operation. During the machining process there is also friction between the tool and workpiece and to reduce this coolant plays an important role as a lubricant. Also, coolant cools the tool and workpiece to increase the tool life and prevent temperature distortion respectively.

II. ENVIRONMENTAL AND FINANCIAL CONSEQUENCES OF COOLANT

Coolant became important in the machining of some metals because these metals are very difficult to be machined without coolant. The cost of treatment and disposition of coolant is increasing significantly as the environmental laws and regulations increase considerably. The chemical substance such as chlorinated paraffin which under heat and high temperature converted into dioxin is harmful to the worker who is directly in contact with the coolant.

III. DISADVANTAGES OF CUTTING FLUID

A. Environmental Reason

If the enclosure of the working is improper and ventilated systems are not equipped then the oil mist and the smoke can be harmful to the workers who are in the working area of the machining process with the coolant. The use of coolant sometimes causes an oily film on the work surface which requires cleaning with the solvents. Also, the oily surfaces are quite hard to clean for workers.

B. Economical Reason

The cost of coolant is high due to its handling and disposal because of strict laws and regulations i.e. 7% to 17% of total manufacturing cost[1].

IV. CONCEPT OF DRY MACHINING

Like any other machining process, dry machining is also a metal removing operation without the use of coolant which is high in overall cost and harmful to the health of the worker and environment. The only one thing that goes against the dry machining is during the machining the machine zone temperature goes up to 1000 ºC at high speed and while cutting hard materials.

The important factor in dry machining is a tool. Normal tools and coated tools can be used in the dry machining technique. Normal tools like CBN i.e. Cubic Boron Nitride, HSS (High-speed steel) tools, ceramic and aluminium ceramic tools are used in the dry machining operation in absence of coolant. The life of the coated tool is longer than an ordinary cutting tool and these coatings are effective. The coated tools are very well insulated and lubricated for the purpose of metal removal. These coatings are of Diamond, TiN and TiAlN (Titanium Aluminium Nitride). These coatings are in the form of layers on the tools in nanometres which serves the purpose of lubrication between the tool and work, insulation to heat and wear resistance.

Diamond coating is superior as compared to other coating materials. For the dry cutting of cast iron CBN and ceramic tools are used where steels are cut dry by using TiN coated tools. There are materials such as superalloys and titanium which are hard and difficult to cut without coolant in the machining process can be cut by the cryogenic machining process.

V. DRY MACHINING CHALLENGE

Machining is comprised of four different concerns, different types of machining operations involved to get desired work, the material of the workpiece to be cut, cutting tool and coolant requirements. Operations such as boring and milling can be done with the help of dry machining as they are considered as open-faced operations. That means while dry cutting the chips generated during the machining can be carried away without any special arrangement. Also, the heat generated during these operations easily gets dissipated in the atmosphere. But, in case of drilling and tapping this scenario change because chips generated during operations remains between the tool and workpiece which can create damage to the tool as there are no arrangements to removal chips.

A. Techniques to improve dry machining:

1) *Tool Material:* Shear deformation is the mechanism that causes the removal of material from the workpiece with the help of the cutting tool. These cutting tools are having specific geometries such as clearance angles which ensure that the only cutting tool edge should touch the workpiece, not the entire tool surface. These tools are classified into a single point and multipoint cutting tools. A single point cutting tool has only one cutting edge. Common operations like turning, shaping can be done using a single-point cutting tool. Multipoint cutting tools are generally used in milling, drilling, and grinding. The material used for the cutting tool should be harder than the material of the workpiece. And should also be capable of withstanding the heat generated during the machining.
2) *Tool Coatings:* Tool coatings is a need of the dry machining, as the metal removal rate increases the requirement of resistant to heat or heat insulation is increases simultaneously for the cutting tool. During the high cutting feed rate and faster cut the heat produced is much higher due to the low surface hardness and friction in the high speed steel cutting tools and workpiece. The requirement of heat resistant cutting tool replaced high speed cutting tools with carbide, ceramic and hard materials coatings on the cutting tool. For faster cuts and long life of the cutting tools, titanium nitride is used which resists corrosion of the cutting tool and provide high surface hardness to high speed steel tools. Tools coated with carbide are more efficient that the HSS tools.
3) *Chip Removal Using Air Spindle:* This process of chip removal is effective because this can be done without stopping the production operation. It save the power require for compressed air. It also ensure that there will be no wetting zone due to coolant dripping and chips. Spindle of the machine need not to be shut down for cleaning which significantly benefits in profits to the industry. And, it also keeps working environment clean and silent.

VI. ADVANTAGES OF DRY MACHINING

There are numerous advantages of dry machining if it is successfully implemented in manufacturing process. Firstly, dry machining completely eliminate harmful coolant which is dangerous to health. As mentioned, coolant constitutes major part in manufacturing cost, dry machining eliminates the total cost involve in the purchase, handling, usage, treatment and disposal of coolant. Good surface finish can be achieved using high cutting speeds and overall production efficiency increase along with the cleaned working condition.

VII. LIMITATIONS OF DRY MACHINING

The main challenge with the dry machining is the surface finish of the workpiece, feed rate of the machining and the speeds. To ensure these parameters coolant is needed in the machining operation. The gap between the machining with dry machining and machining with coolant is significant. Hun sicker revealed that Caterpillar has tried dry machining in a number of machining operations during the past 20 years [2]. The new tool coatings have been helpful but still the problem exists that machining cannot be done dry at the rate needed to achieve the productivity found with using metalworking fluids [2]. Due to machining there is also a chances that the chips can be thrown away with the speed and can be harmful to the workers around the working are.

VIII. DRY MACHINING FUTURE

It is very clear that in the next coming years dry machining and near dry machining cannot replace conventional wet machining completely. But dry machining and near dry machining ca**n** definitely give us alternative to some specific applications. Special tool materials and tool coatings can be a challenges in front of manufacturing industry to implement this technique. It will be very beneficial to the environment and health if the new type of biodegradable coolant can be used for the machining purpose [3].

IX. CONCLUSION

From this short review of dry machining, we can conclude that dry machining is the machining without the coolant. Dry machining requires special arrangements of cooling but sometimes it can be implemented without these arrangements. These arrangements are for tools to improve its life span and workpiece to improve the surface finish. These arrangements doesn't have any adverse effects on the health of the worker or the environment. Also, the chip removal can be done by special modification with the tool and the workpiece.

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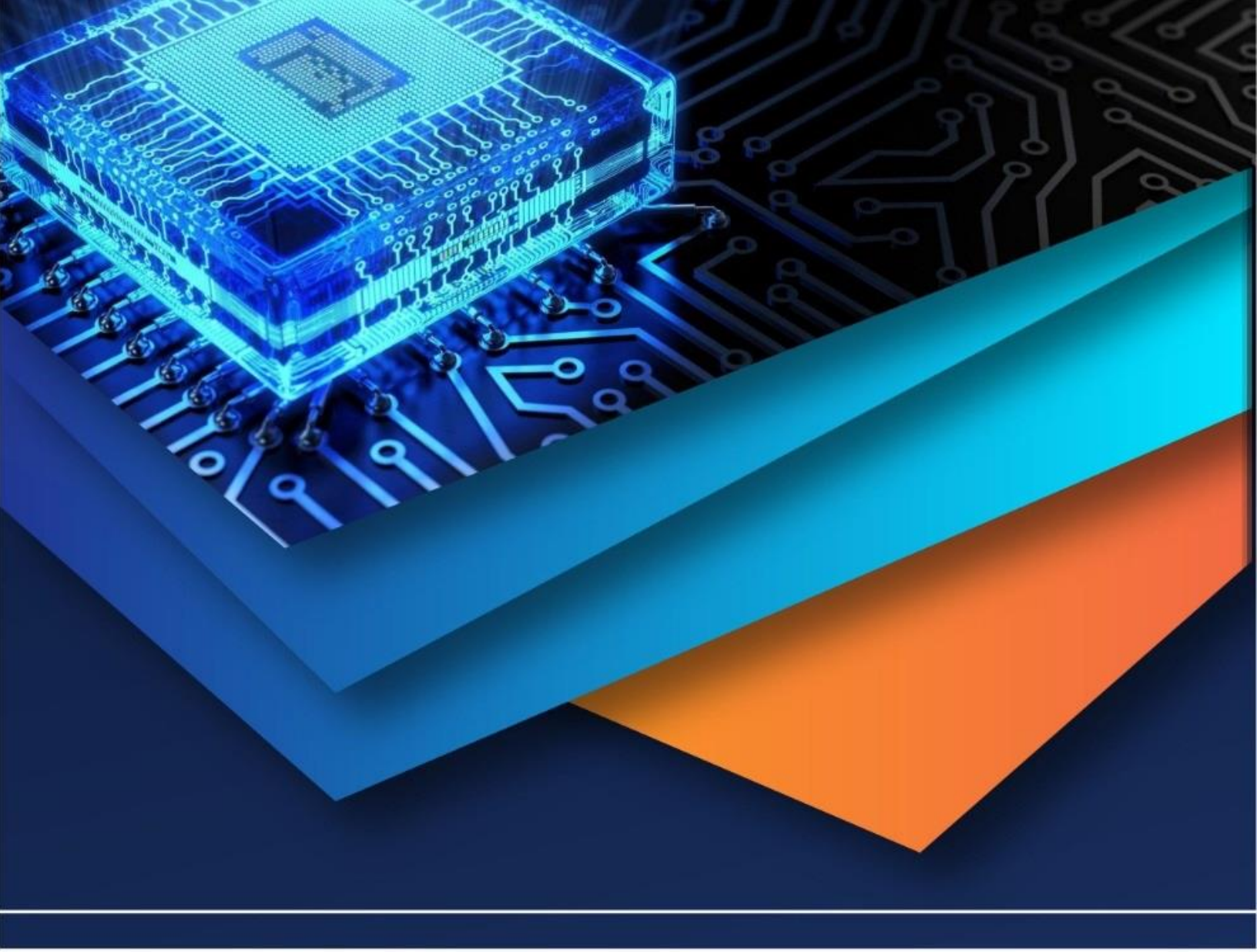

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