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A Review on Cryogenic Machining of EN 31 Steel: A Comparison with Dry Machining

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ABSTRACT: As now a day, the demand of machining process is increasing as increased in manufacturing technology. Tool failure is natural as the increase in manufacturing process. This problem is overcome by introducing cutting fluids. Some fluids are very hazardous to the environment. So, according to the problem new machining techniques are consider like dry machining and cryogenic machining. This paper presents the difference between dry and cryogenic machining.

Keywords: Cryogenic cooling Tool wear Surface roughness Cutting forces

I. INTRODUCTION

Machining process is one of the oldest types of process that is being used to machine many kinds of material in the world. It is also known as material removal process. One of the examples of machining process is turning process. Turning is the most widely used machining process that may result in high precision and quality and increase productivity. Machining by turning involves the use of a lathe machine and is used primarily to produce cylindrical or conical parts. It is valuable to increase tool life, to improve surface roughness, to reduce cutting forces and material removal rate in turning operations. In machining operation the main by product is heat energy and cutting temperature. Such high temperature causes dimensional deviation in the work piece. Generally, such problems are tried to be controlled by profuse cooling with soluble oil. But, conventional cooling is not that effective and hazardous to the environment. Recently work been done on cryogenic cooling by liquid nitrogen (LN2) on some steel of industrial use. Cryogenic cooling provided less cutting forces, reduced cutting temperature, and better surface finish and improve tool life.

II. LITERATURE REVIEW

In this present work, a new type of cooling approach is used i.e. cryogenic machining in which the liquid nitrogen is used as a coolant. The experiment investigation done by Hongshane (2001) on cryogenic cooling of titanium alloy (Ti-6Al-4V). The study finds that the combination of these two micro nozzles provide the most effective cooling while using liquid nitrogen flow rate. Their work shows that tool life increases up to 5 times the state of the machining [1].

Kamruzzman (2010) studied on the effect of high pressure coolant jet in machining of 42Cr Mo4 steel by uncoated carbide inserts. They have deal with an experimental investigation on the effect of high pressure coolant on temperature, tool wear, surface roughness and dimensional deviation [3].

Nalbant Muammer, 2010 studied on Effect of cryogenic cooling in milling process of AISI 304 stainless steel. The effects of cryogenic cooling on cutting forces in the milling process of AISI 304 stainless steel were investigated. Cryogenic cooling and cutting speed are found to be effective on cutting forces. Cutting forces and torque in cryogenic milling are higher than those in dry milling. Cutting force is increased as the cutting speed is increased [2]. Biceka, 2010 studied on a Cryogenic machining as an alternative turning process of normalized and hardened AISI 52100 bearing steel. This article presents the results of turning hardened and normalized bearing steel AISI 52100 (DIN 100Cr6), comparing conventional flood and dry with cryogenic machining [7].

Turning results show drastic improvements in tool lifetime (up to 370%) for cryogenic machining of normalized bearing steel 100Cr6 and reduction of thermal residual stress inducements in case of hardened bearing steel 100Cr6, while tool life is also extended.

Bermingham, 2011 studied on new observations on tool life, cutting forces and chip morphology in cryogenic machining Ti-6Al-4V. Liquid nitrogen is a safe, clean, non-toxic coolant that requires no expensive disposal and can substantially improve tool life. This work investigates the effectiveness of the cryogenic coolant during turning of Ti-6Al-4V at a constant speed and material removal rate (125m/min, 48.5cm^3/min) with different combinations of feed rate and depth of cut. It is found that the greatest improvement in tool life using cryogenic coolant occurs for conditions of high feed rate and low depth of cut combinations. Cryogenic coolant is effective in extracting heat from the cutting zone [5-6].

PuBiceka 2011 studied on Enhanced surface integrity of AZ31B Mg alloy by cryogenic machining towards improved functional performance of machined components. In this study, the influence of dry and cryogenic machining (liquid nitrogen was sprayed on the machined surface during machining) using different cutting edge radius tools on surface integrity was investigated. Surface integrity in terms of the following:(1) improved surface finish; (2) significant grain refinement from 12 mm to 31nm in the featureless surface layer(3) large intensity of (0002) basal plane on the machined surface; (4) 10 times larger compressive areas in residual stress profiles. This study suggests that cryogenic machining may also enhance the surface integrity of the work piece and improve the performance of machined components.

III. OBJECTIVE

As seen from the literature, the cryogenic cooling suggests many advantages and disadvantages in machining processes. In order to achieve minimum tool wear, good surface quality and minimum cutting forces the cutting conditions should be carefully selected with and appropriate conditions. So that during machining a new tool material is to be developed with lower coefficient of friction and high heat resistance. The main objective of the current work is to study the effect of LN2 as the coolant in machining EN 31 steel and to compare it with dry machining and wet machining.

IV. CONCEPT

A. Dry Machining

To make a basis for comparing the tool wear, surface roughness, tool forces and cutting temperature for cryogenic machining, dry machining was performed. In dry machining, the experiments were performed without uses of any coolant. Dry machining is considered a more sustainable process than machining with cutting fluid. In dry turning the cutting forces required are lower than wet machining. To enrich surface roughness in dry machining coated carbide tool is required for cutting. This carbide coated play an important role in tool life and machining performance.

B. Wet Machining Process

In wet machining process involves use of cutting fluid. High cutting zone temperature is conventionally tried to be controlled by employing flood cooling by soluble oil. In high speed-feed machining conventionally applied cutting fluids fail to penetrate the chip tool interface and thus cannot remove heat effectively. But application of conventional cutting fluids creates several techno-environmental problems like environmental pollution, water pollution and soil contamination during disposal requirement of extra floor space and additional system for pumping, storage, filtration, recycling, chilling, etc.

C. Cryogenic Cooling

Cryogenics is the phenomenon and effect at very low temperature. It is originally derived from Greek word ‘Kryos’ means ‘frost’ and ‘genic’ means ‘production’. In cryogenic cooling liquid nitrogen is used which reduce heat is generated as compared to internal cooling system, which overall improves the machining behavior of product.

The techniques of cryogenics is generated during second world war when scientists realize that cool metal to low temperature become metal more resistive to wear. Ed Busch founded the first commercial cryogenic processing industry in 1966.

Cryogenic Process. Cryogenic machining is the process of cooling the cutting tool and work piece during machining process. This process is about delivering liquid nitrogen instead of soluble oil. When nitrogen delivered to the cutting region it immediately turn into vapor state leaving residue to damage the part, machine tool, chips or operator. This makes it completely eco-friendly process.

Fig. 1. Cryogenic machining operation.

V. CUTTING INSERTS

The tool is selected accordingly the work material and machining properties. To perform effective cutting, the tool selection of proper cutting tool is very essential. As dry machining does not require lubricant, the mainly used coated cutting tool is TiAlN, TiN and other tools.

Insert coated properties	
I.	Lower friction
II.	Higher adhesion
III.	Higher resistance to wear and cracking
IV.	Acting a diffuser barrier
V.	Higher hot hardness and impact resistance

VI. CRYOGENIC SET UP

Cryogenic set up consist of Compressor, Liquid nitrogen cylinder, Drier, Floe meter, Flexible nozzle, Stainless steel houses.

VII. WORKING

In both the types of processes the working is similar only the difference is the in cryogenic coolant. In dry machining the special coated carbide tools are used. The coated tools are bad conductor of heat so, that high temperature distortion is less on the tool. As in cryogenic machining liquid nitrogen is used. Heat absorbed instantly and temperature region is very less. So, high surface finish can be achieved.

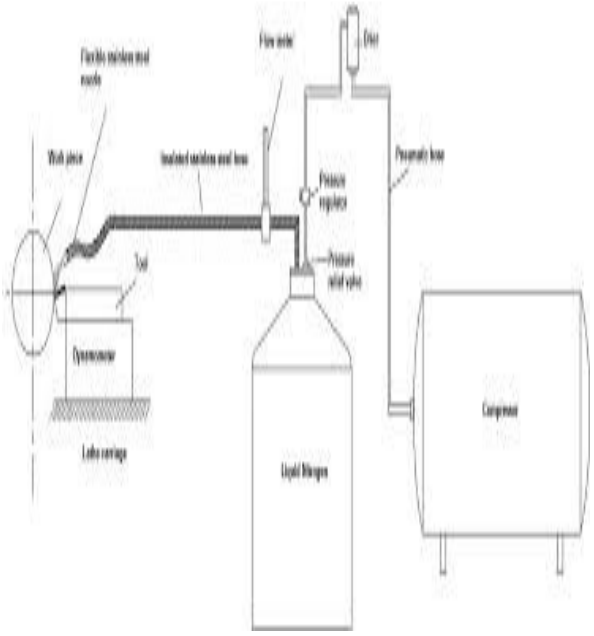
VIII. ADVANTAGES

A. Dry Machining

1. Increased productivity.
2. Increased in flexibility.
3. Reductions in machine tool cost.
4. No pollution of the atmosphere and water

B. Cryogenic Machining

1. Increased in cutting speed without increasing wear of tool.
2. Increase in productivity.
3. Increase in tool life.
4. Environment friendly and safer method.



IX. LIMITATION

A. Dry Machining
1. High wear rate.
2. Shorter tool life.
3 cause high temperature.

B. Cryogenic Machining
1. Costly coolant (nitrogen)
2. High maintenance cost

X. ANALYSIS

A. Dry Machining
Surface roughness is the main phenomenon in this type of machining techniques rather than using different machining process use of dry and cryogenic machining to recover the resources.
(i) By varying the parameter like speed, feed etc. we can study the influence of surface roughness, accuracy during work piece manufacturing.
(ii) Heavy noise created during machining process.

B. Cryogenic Machining
(i) Cryogenic machining is eco-friendly.
(i) When gas other than liquid nitrogen is used as a cutting fluid it helps to reduce cutting force.

XI. CONCLUSION

We have presented overview of dry machining and cryogenic machining. This paper contributes the understanding of cryogenic machining by liquid nitrogen. Normally both the concept is eco-friendly and good surface finish is obtained.

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