Experimental Investigation Of Cryogenic Machining Of EN-19 Steel

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Abstract- Machining is a major manufacturing process in the industry, heat is generated during the chip formation process. which escalates the temperature of the cutting tool and accelerates tool wear. Conventionally, cutting fluid is used to cool and lubricate the cutting process, thereby reducing tool wear and lengthening tool life. So that we can use the cryogenic maching technique where Cryogenic machining technique is a machining process where the traditional fluid lubro-cooling liquid (an emulsion of oil into water) is replaced by a jet of either liquid nitrogen (LN2) or pre-compressed carbon dioxide (CO2).It is useful to preserve the integrity and quality of the machined surfaces in finish machining operations. In this paper conventional machining technique is replaced by cryogenic machining.

Keywords- **Cryogenic machining, Liquid nitrogen, EN-19 steel**

I.Introduction

EN-19 steel is hard material. It is used for camshaft & shaft manufacturing of diesel engine.Due to conventional machining life of camshaft get reduced because of microdamage (microcracks) produced on the camshaft surface & it is also difficult to machine.so cryogenics machining is introduced to machining of EN-19 to improve machinability and overcome microdamage problem. This EN-19 is hard material have hardness 50 HRC. Machining to EN-19 is difficult by conventional machining because of low material removal rate ,low surface finish and high tool wear rate because of that cryogenics machining technique is used for machining of EN-19.From experimental study of cryogenics machining it is used to increase machinability. In the cryogenics machining where the traditional flood lubro-cooling liquid (an emulsion of oil into water) is replaced by a jet of either liquid nitrogen (LN2).It is useful to preserve the integrity and quality of the machined surfaces in finish machining operations. Cryogenic Machining Technology utilizes vacuum jacketed feed lines to deliver small flow rates of liquid nitrogen (LN2) through the machine, through the spindle (or turret), and through the tool near the cutting edge. At this point, the LN2 is allowed to evaporate and cool the cutting edge to -321° F. [1]

In the past, cryogenic machining was difficult and costly. Methods focused on spraying the liquid nitrogen at the tool. Spraying the tool required a large high-flow rate. This allowed the nitrogen to mostly evaporate before reaching the cutting surface and ultimately reduced its cooling capacity. These drawbacks made cryogenic machining both costly and nearly impossible to implement for larger products. Today 5ME patented Cryogenic Machining Technology utilizes vacuum jacketed feed lines to deliver small flow rates of liquid nitrogen (LN2) through the machine, through the spindle (or turret), and through the tool near the cutting edge [2].

II.Cryogenic cooling approaches:

A)Cryogenic pre-cooling the workpiece:

the workpiece and chip cooling method, the aim is to cool workpiece or chip to change properties of material from ductile to brittle because, the ductile chip material can become brittle when the chip temperature is lowered . Chip formation and its effect on productivity in metal cutting have been However, these methods may be impractical in the production line and negatively increase the cutting force and the abrasion, in addition, they can cause dimensional change of the workpiece and, particularly high liquid nitrogen consumption can be required uneconomically [7].

B) Cryogenic spraying and jet cooling:

The objective in this method is to cool cutting zone, particularly tool–chip interface with liquid nitrogen by using nozzles. LN2 consumption and thus production cost could be high by general flooding or spraying of the coolant to the general cutting area in a machining operation.

C) Indirect cryogenic cooling:

This method was also called as cryogenic tool back cooling and conductive remote cooling. In this distinctive cryogenic cooling approach, the aim is to cool the cutting point through heat conduction from a LN2 chamber located at the tool face or the tool holder. In other words, LN2 is not repulsed to the tool or workpiece.

D) Cryogenic treatment:

Cryogenic treatment is a process similar to heat treatment. In this method, samples are cooled down to cryogenic temperature and maintained at this temperature for a long time and then heated back to room temperature to improve wear resistance and dimensional stability of them . For example, Hong et al. performed a treatment method of tools cryogenically as follows: inserts are placed in a chamber; temperature is gradually lowered over a period of 6h from room temperature to about 1841C; temperature is then held steady for about 18h; temperature is gradually raised over a period of 6h to room temperature and inserts are tempered. Steps followed by Silva et al. for the cryogenic treatment were: tools were conventionally quenched and tempered lasting a total of 43h; cooling to 1961C (20h); heating to +1961C.

III. Experimental Set up

The experimental setup can be manufacture in college. The machining experiments were run on a Mori Seiki NL1500™ CNC Retrofetting lathe equipped with a cooling line assembled for the cryogenic cooling. The liquid nitrogen is stored in a non-conventional high pressure LN2 storage Dewar (Cryocan) equipped with security valves and pressure regulator. A high vacuum insulated pipe carries the cutting fluid to the cutting zone. Previous researches on cryogenic turning have proved higher cooling efficiency of LN2 if multiple cooling directions are adopted simultaneously [3]. According to the literature findings, the proposed experimental set-up consists of two flows of LN2 directed onto the rake and flank faces by means of external copper nozzles with an internal diameter of 0.9 mm. The position and the direction of the nozzles with respect to the tool faces were optimized after several rough turning trials conducted on wrought Ti6Al4V workpieces [10]. The supplying pressure was set equal to 1.5 bars, resulting in a mass flow of 0.9 kg/min. The adopted insert was a finishing TiAlN coated tungsten carbide insert DNMG 150608 (substrate composition: 93% WC and 7% Co) supplied by Sandvik–Coromants, with a radius of 0.8 mm, rake and clearance angles are of 71 and 01, respectively [4]. Both the insert grade and micro geometry were chosen on the basis of the tool manufacturer's advices for machining EN-19. The adopted tool holder for both dry and cryogenic machining was a Sandviks PCLNR/L with an approach angle Kr of 751.The L27 number of experimental combinations done on machine. The 90 mm bars are used for machining [5]. The schematic diagram of cryogenic machining set up in which liquid nitrogen is compressed in the compressor, the picture of compressor.The liquid nitrogen goes through drier & phase of LN changes. Then pressurized nitrogen in liquid form stored in the tank & carried out upto cutting zone using nozzle.

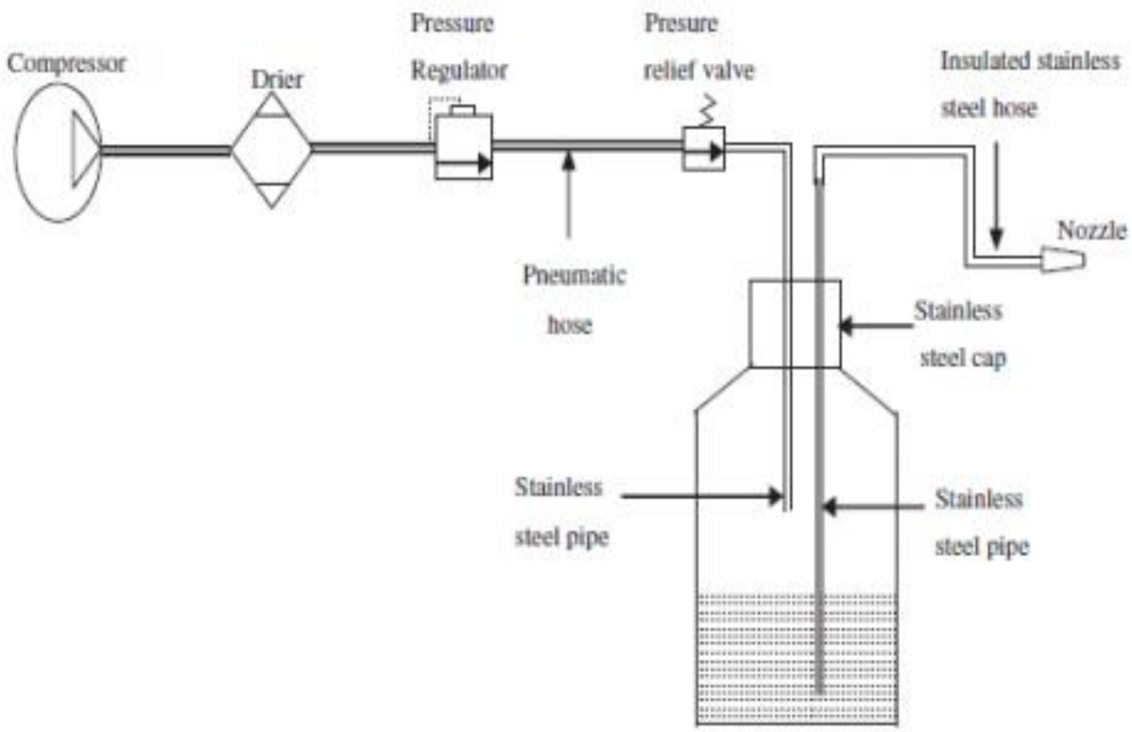

Fig. 3.1 Schematic diagram of cryogenic machining setup

The schematic digram of cryogenic machining setup is shown in above figure, in the figure there are many numbers of various mountings mount on the copper pipe and which are connected to the cryogenic can. The can is filled with the liquid nitrogen (LN2)

Fig. 3.1 Actual cryogenic machining set-up

IV.Design Of Experiment

Design of experiments (DOE) is a systematic method to determine the relationship between factors affecting a process and the output of that process. In other words, it is used to find cause-and-effect relationships. This information is needed to manage process inputs in order to optimize the output. An understanding of DOE first requires knowledge of some statistical tools and experimentation concepts. Although a DOE can be analyzed in many software programs, it is important for practitioners to understand basic DOE concepts for proper application. [8]

A) *Controllable input factors*, or x factors, are those input parameters that can be modified in an experiment or process. For example, in cooking rice, these factors include the quantity and quality of the rice and the quantity of water used for boiling.
B) Uncontrollable input factors are those parameters that cannot be changed. In the rice-cooking example, this may be the temperature in the kitchen. These factors need to be recognized to understand how they may affect the response.
C) Responses, or output measures, are the elements of the process outcome that gave the desired effect. In the cooking example, the taste and texture of the rice are the responses.
The controllable input factors can be modified to optimize the output. The relationship between the factors and responses are shown

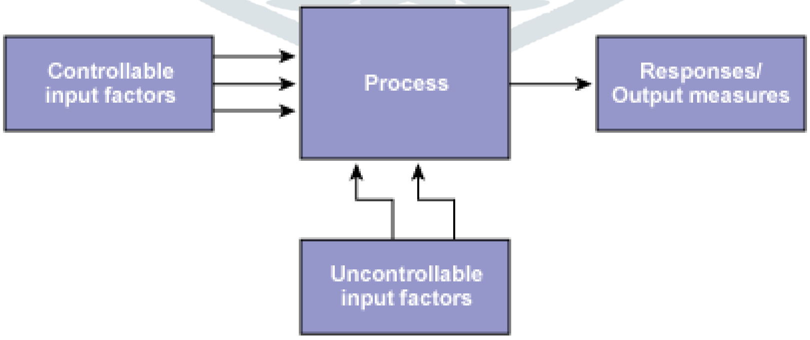

Fig. 4.1 Process Factors and Responses

There are three levels I,e Speed, Feed, Depth of Cut And Three factors I,e Material removal rate (MRR), Sourface Roghness, Tool wear rate. With the help of this levels and factors with sandvik catalogue we get the values of speed, feed and depth of cut.

Table 4.1 Level's from sandvik catalouge

Speed	Feed	DOC
300	0.1	0.5
600	0.15	0.75
900	0.2	1

With this three levels and factors the DOE can be designed. For design of experiment Minitab 17 software used with taguchi method for the DOE. L27 orthogonal array used for the experimental runs [9].

Table 4.2 Design Of Experiment

speed	feed	DOC	Sr. No
300	0.10	0.50	1
300	0.10	0.75	2
300	0.10	1.00	3
300	0.15	0.50	4
300	0.15	0.75	5
300	0.15	1.00	6
300	0.20	0.50	7
300	0.20	0.75	8
300	0.20	1.00	9
600	0.10	0.50	10
600	0.10	0.75	11
600	0.10	1.00	12
600	0.15	0.50	13
600	0.15	0.75	14
600	0.15	1.00	15
600	0.20	0.50	16
600	0.20	0.75	17
600	0.20	1.00	18
900	0.10	0.50	19
900	0.10	0.75	20
900	0.10	1.00	21
900	0.15	0.50	22
900	0.15	0.75	23
900	0.15	1.00	24
900	0.20	0.50	25
900	0.20	0.75	26
900	0.20	1.00	27

V. Conclusions

The traditional machining process generates a lots of heat during machining of hard material. which escalates the temperature of the cutting tool and accelerates tool wear rate so to minimize the tool wear and to increase the material removal rate of hard EN-19 steel material the cryogenic machining process is used. Also the traditional cutting fluids is harmful and environmental contaminated so liquid nitrogen is used as it don't affect on environment.

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