Influence of Cryogenic LN2 coolant on Chip morphology in Machining 7075 Aluminium alloy

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Abstract

This paper dealt with experimental investigations on chip morphology in machining of 7075 aluminium alloy, using Cryogenic Liquid Nitrogen (LN2) as a coolant.. The chip thickness, chip form and morphology were taken in machining 7075 Al alloy with conventional coolant and cryogenic liquid nitrogen coolant for comparison. The thickness of metal chip reduced when Cryogenic Liquid Nitrogen is used compare to conventional coolant by 6 to 20%.. The surface finish is increased in Cryogenic machining conditions about 15 to 23% compared to conventional coolant machining conditions.

Keywords: *7075 aluminium alloy; LN2 cooling; chip thickness; surface roughness;*

1.Introduction

Aluminium is the second most structural metal available noted for its density. Aluminium and its alloy are predominantly used in the transportation industry, food industry, chemical industry and electrical industry etc. Al-Zinc alloys are considered as important material of the industry, due to excellent mechanical properties over other aluminium wrought alloys. The Aluminium- Zinc 7075 alloy is widely used in automobile and aeronautical industries due to its better mechanical properties.

Machining of Aluminium alloys generate Built Up Edge formation (BUE), which is affecting the surface finish (Jeelani and Musial,1986; Dae andDong,1998).When the cutting velocity is increased, the tendency of BUE vanishes, due to high cutting temperature and reduction in cutting force (Oishi and Mirror,1996)

The conventional liquid lubricants are utilized in machining operations to develop surface finish values of the work-piece and life of the cutting tool . They also useful in reduction of temperature and metal particles during machining operation. Though the use of conventional cutting fluids is effective, it has several harmful effects. The cutting fluids used in machining industries contain chemical constituents harmful to environment . These coolants are arduous to dispose of and can cause deleterious diseases to the machinist. When Minimum Quantity Lubrication conditions were used in machining 6061 alloy, the material adhesion on the tool surface experienced nose and flank wear (Sree-jith,2008). The dry machining in turning Aluminium alloys result-ing higher temperature in the cutting zone and Built Up Edge formation. This also leads to high dimensional inaccuracies and excessive tool wear [Sreejith,2000].

An environment friendly coolant viz, cryogenic liquid nitrogen is used to overcome these difficulties. Cryogenic LN2 is used by many researchers to carry out experiments for machining other materials, and produced better results in reduction of cutting forces, machining temperature, tool wear and surface roughness (Dhar et al.,2008; Paul et al.,2001; Hong et al.,2001). It was also experimented that when low temperature

LN2 was utilized as a lubricant in machining of AISI 4045 Steel and Ti-6Al-4V alloy, the performance parameters such as cutting temperature, cutting force, tool wear and surface roughness, got reduced. (Dhananchezian and Pradeep Kumar,2011; Dilip Jerold and Pradeep Kumar,2012; Muthuraman and Arunkumar,2017). The various researchers utilized gases and water vapour also as lubricants and carried out research in machining various metals(Çakir et al.,2004; Liu et al.,2005).

2.Experimental procedure

Al-Zinc 7075 alloy was widely used in Aeroapce and Automobile Industries due its excellent strength and high percentage zinc content(5.1 to 6.1). So 7075 alloy was considered as workpiece material. A bar with 75 mm diameter and 300 mm length was used for the experimental work.The same machining conditions are considered for the wet and cryogenic machining work.

The objective of this experiment is to investigate influence of chip form when LN2 is used as a cutting fluid, and compare it with that of the conventional coolant in the turning of the 7075 Al alloy. The different combination of experiments with above process varaibles were performed by the turning operation on a High speed automatic lathe (NAGMATI175).

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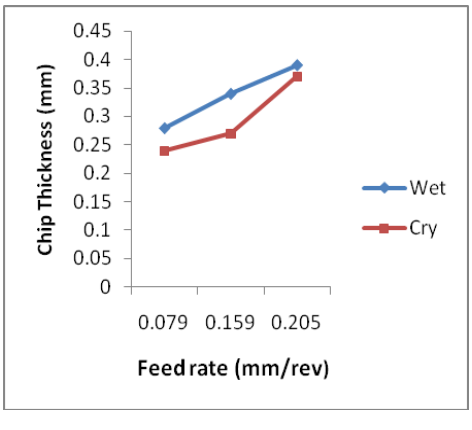
3.Results and Discussion

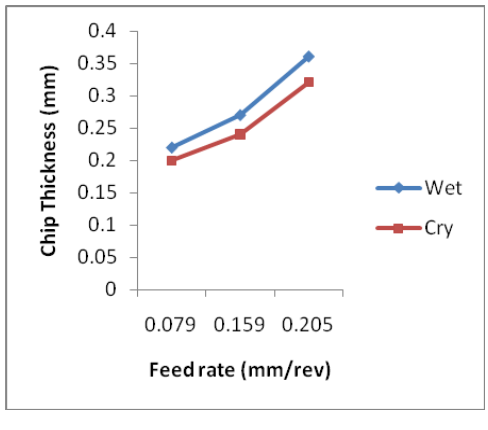
3.1.Chip thickness

Generally, coolant used for machining should also help for chip control It can be noted that conventional coolant used is failed to remove metal chips from the tool insert. This chips accumulated in insert leading to change of tool nomenclature which is affecting surface roughness. When pressurized cryogenic liquid nitrogen were applied, it was found that chip breakability and chip control was improved better.

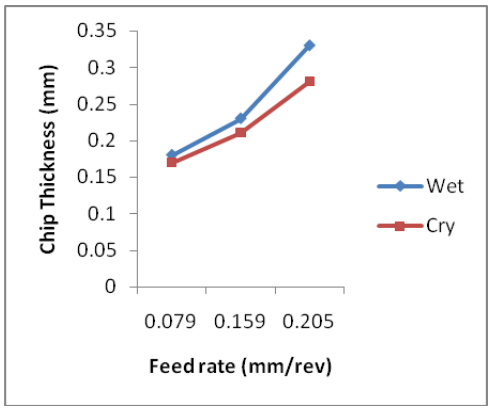
The chip colour was like silvery white while machining Al/SiC composites, when cryogenic LN2 was applied and it was grey colour when conventional coolant was used. The chip thickness was less when cryogenic LN2 coolant was used. It was observed that, when speed increases ,chip thickness decreases and when feed rate increases, chip thickness increases. Generally, the conventional coolant reducing cutting temperature by heat convection . Cryogenic LN2 coolant penetrated between tool-work piece, there by reducing cutting temperature by better lubricating action



(a)



(b)



(c)

Figure. 1 Variation of the chip thickness with different feed rates in machining 7075 Al alloy under different machining conditions a) 51 m/min b) 118 m/min c) 181 m/min

It was observed that the breakability of chip was good in cryogenic LN2 machining compare to wet machining conditions. The cutting temperature also reduced on application of cryogenic LN2 compared with conventional coolant. This is due to application of cryogenic LN2 liquid and gaseous form which penetrated well in cutting zone compare to convention cutting fluid. As a result, the lubricating layer of the cryogenic coolant reduced chip thickness due to less friction and adhesion between the tool and metal chip.

The application of cryogenic LN2 decreased the chip thickness in the range of about 5-20 % compared to wet machining conditions. The nature of chips obtained in machining 7075 Al alloy using cryogenic LN2 was favorable than conventional machining environments. The metal chips images collected under different machining conditions are shown in Table 1

3.2 Chip images

It was noted that chip breakability was good at constant speed and feed. The chips grumbled into a small pieces or few turns in cryogenic conditions also observed. The thickness of chips obtained in wet machining conditions is more difficult to break compare to cryogenic machining conditions. The long and curled chips were collected at cutting velocity of 51 m/min and feed rate of 0.159 rev/min. However when feed rate was increased by keeping the same cutting velocity, short tubular chips were collected caused difficulties in breaking metal chips.

The short tubular chips with lesser thickness chips were collected, when cryogenic LN_2 coolant was used. This is favoured the problem free machining. It was also noted that chip breakability was found to be better in cryogenic LN_2 machining environments at higher cutting velocity of 181 m /min. This is due to the reason that cryogenic LN_2 coolant when impinged between tool and workpiece gets into gaseous form which is penetrating well ,thus friction reducd ,thereby helping the chip for easy to break.. The chip thickness was found to be less in cryogenic LN_2 machining conditions compared to conventional machining environments.

Table.1 Chip images of machined alloy under wet and cryogenic machining Conditions

Speed (m/min)	Feed (mm/rev)	Wet	Cryogenic LN_2
51	0.079		
	0.159		
	0.205		
118	0.079		
	0.159		
	0.205		
181	0.079		
	0.159		
	0.205		

The surface roughness values measured using Talysurf surface roughness tester.It was found that cryogenic LN2 coolant reduced surface roughness values compared to conventional machining conditions. This is because of less friction and adhesion effect of the metal chips over the tool. It is also noted that this improved cushioning effect between chip tool interface and higher tool hardness which reduced surface roughness values. It was observed that application of cryogenic LN2 developed better surface finish values compared to conventional machining conditions in the range of 15– 23%

Conclusions

The following observations can be arrived, based on experimental work of machining Al-Zinc 7075 alloy with wet and cryogenic LN2 coolant :

1. The chip thickness and its form studied in both wet and cryogenic machining environments.
2. The chip thickness reduced by about 6–20% in cryogenic LN_2 condition compared to conventional machining condition.
3. The surface roughness and BUE reduced on application of cryogenic LN_2 coolant compared to conventional machining condition.

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