International Journal *of*

APPLIED ENGINEERING RESEARCH

ISSN 0973-4562

Volume 9,
Number 24,
2014

Editor-in-Chief
Prof. Ir Dr Mohd Sapuan Salit

RIP Research India Publications
http://www.ripublication.com

Homepage: http://www.ripublication.com/ijaer.htm

Print ISSN-0973-4562
Online ISSN-1087-1090

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International Journal of Applied Engineering Research

Country	India
Subject Area	Engineering
Subject Category	Engineering (miscellaneous)
Publisher	Research India Publications
Publication type	Journals
ISSN	09734562
Coverage	2011-ongoing

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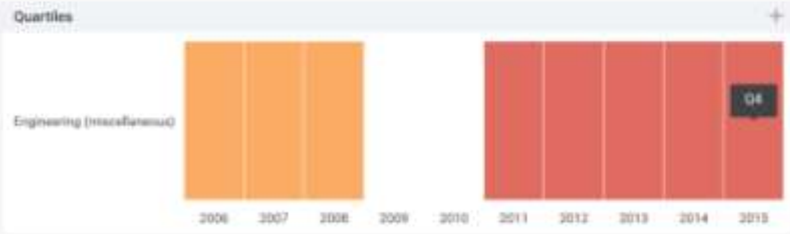

International Journal of Applied Engineering Research
ISSN 0973-4562 Volume 9, Number 24 (2014) pp. 30643-30650

http://www.ripublication.com

Impact of Cryogenic Treatment and Temper to carbide toollife on turning process for Al T-6061

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Abstract

Generally to overcome the problem of cutting tool wear use coolant on metal cutting process for decrease the friction or use coating for cutting tool. Nowadays many industry develop the using of cryogenic treatment to improve wear resistance of cutting tool, for carbide toollifelonger. Target of this research is to evaluate impact of cryogenic treatment and temper to carbide toollife. Method in this research use cryogenic treatment process continued with temper process ofcarbide tool. Carbide cutting tool as result of this process implementedon turning process for Aluminiumalloy T-6061 with cutting depth (a) variation are 0,1 mm; 0,5mm and 1 mm, while cutting speed (Vc) 70 m/minute and constant feeding motion (f) 0,1 mm/rotation, without coolant. Research analyst use analytical method and perception with digital microscope and hardness test with Rockwell. The research result are :1. The greater of cutting depth(a), then wear of cutting tool edge (Vb) be greater, and tool life (T) be shorter.2. Result of cryogenic treatment for 48 hoursat cutting depth(a) 1mm, cutting speed(Vc) 70 m/minute and feeding motion (f) 0,1 mm/rotation, the toollifeincrease 28%. At the same condition with cryogenic treatment for 48 hoursand temper at 150^{0}C for 1 hour the toollife increase to 105%. 3. For the cryogenic treatment at cutting depth(a) 1mm the Taylor equation of tool life$VT^{0,35}$ = 103,6707 and for the cryogenic treatment and temper at the same cutting depth condition the Taylor equation of tool life $VT^{0,2}$ = 95,06642

Keyword: carbide tool, cryogenic treatment, tool life, temper, wearof cutting tool edge

INTRODUCTION

Cutting metal process especially on turning process, friction that happened between cutting tool and workpiece will generate heat highly, so it will make wear of cutting tool faster.This matter affect tosurface roughness growth higher and decreases in tool lifeand also the quality of product progressively lower. Generally to solve the wear problem of cutting tool used coolanton metal cutting for decrease the friction or use coating for cutting tool. Nowadays many industry develop usage of cryogenic treatment to improve wear resistance of cutting tool, gear, and others (Thamizhmanii S. et al., 2011; Ramji B.R. et al., 2010; Kollmer K.P, 2007), so the lifetime of cutting tool become longer.It can save resharpingcost and replace time of cutting tool. Cryogenic treatment isa cooling process of materials as steel, stainless steel and others from room temperature to -320^{0}F (-196^{0}C)then hold at that temperature for several time(soaking time) and continued with warmness until room temperature (Singh S. et al, 2012 and Ramji B.R. et al., 2010). Rajendra K. et al. (2007) classifying that there are two type of materials treatment belowroom temperature, theyare subzero or cold treatment and cryogenic treatment. Subzero treatment done at -145^{0}C(-230^{0}F) and cryogenic treatment doneat -195^{0}C in liquid nitrogen.

Biranchi N.S. (2011) show that after cryogenic treatment on cemented carbide inserts will produce fine carbide particles so it will improve hardness and wear resistance. This matter supported by result of Ramji B.R. et al., (2010), research show cryogenic treatment for Carbide Inserts used on turning process of grey cast iron can improve wear resistance to 31%.

Research that doneby Amber Pawlik, et al. (2004) show for every carbide cutting tool and workpiece material that used issteel of AISI 1148 to get the tool life data and machining condition, machining process variable with spindle rotation that variation become 3 level with cutting motion (f) and cuttingdepth(a) constant, equation of Taylor formula from the research is obtained $V.T^{0,2574} = 521,4$.

Research that doneby Budiman, H and Richard (2007), showed that the tool life and wearof carbide cutting tool for turning process of steel alloy ASSAB 760, with high cutting speed (Vc = 170,816 m/minute), obtained that shortest tool life is 14,756 minute, and the longestis 140,33 minute that happened at lower cutting speed (Vc = 54,259 m/minute). Taylor equation from research is obtained $VT^{0,378} = 379$

Result of research that done by Sudjatmikoet al.(2011), determining the tool life and wear of carbide tool for turning process of Alumunium T- 6061, with analytical method and graph obtained that exponent value (n)lifetime of cutting tool(n=0.3) and constant of tool life (C_T) = 112,5723, at high cutting speed (optimum) Vc = 69,12 m/minute, with shortest time (t_c) = 12 minute, with cutting depth (a) = 0,70 mm, Taylor equation of tool life $VT^{0.3} = 112,5723$.

MATERIALS AND METHODS

Workpiece that used atresearch is AlumuniumT–6061, Carbide tool that used is carbide with chemical composition 1,25% C; 4,0% Cr; 3,6% Mo; 3,2% V; 9,3% W; and 10,0% Co (BOHLER Steel Manual). Dimension of turning cutting tool is 12 x 12 x 150 mm.

Experiment

a. Cooling in liquid nitrogen and hold (soaking) with time variation 2 hours, 24 hours and 48 hours. Then continue with tempering process at 150^0C hold (soaking)for1 hour, then cooled on the air until room temperature.

b. Experiment procedure on machining process

Initial experiment for verification and determine of variable level range machining process.

1. Preparing for setting of turning process data (CNC programming)
2. Material preparing of AlumuniumT -6061 with length = 100mm and diameter = 22mm, grippedat main spindle.
3. Cutting tool paired on tool post, and arranged so cutting toolperpendicular to spindle axes.
4. Do the turning process accordance to determined variable (tables 1), with cutting length (l_t) = 60 mm
5. Stop turning process to note cutting time (t_c) using stop watch for 6 minute and measure the edge wear(V_B) use Digital Microscope Tips Using Measurement Function (Dino-Lite)

Variables of process and its value

In this experiment variable that determined its value level to be inquired are cutting speed (V_c) and constant cutting speed (f), while cutting depth (a) be variation. Experiment tabulation design and its value level and for data experiment, can be seen at Tables 1.

Tables 1.Data Design of machining process cutting condition to measure weathering of edge cutting tool (V_B)

No	Untreated/ treated		Cutting Speed, Vc (m/minute)	Feeding motion, f (mm/rotation)	Cutting depth, a (mm)	Edge cutting tool wear V_B (mm)	Cutting time tc (mnt)
1	untreated		70	0.1	0.10		6
					0.50		6
					1.00		6
2	Treated cooling in liquid nitrogen , soaking (hour)	2	70	0.1	0.10		6
					0.50		6
					1.00		6
		24	70	0.1	0.10		6
					0.50		6
					1.00		6
		48	70	0.1	0.10		6
					0.50		6
					1.00		6

3	Treated Cooling in liquid nitrogen , soaking (hour) and temper 150^0C for 1 hour	2	70	0.1	0.10		6
					0.50		6
					1.00		6
		24	70	0.1	0.10		6
					0.50		6
					1.00		6
		48	70	0.1	0.10		6
					0.50		6
					1.00		6

RESULT AND DISCUSSION

Based on Tables 2 the relation of cutting tool edge wear (V_B) and tool life (T) at any condition show that greater of cutting depth (a) so the wear of cutting tool edge (V_B) will be greater and lifetime of cutting tool (T) will be lower. But at cutting tool condition that cooled in nitrogen liquid with soaking for 24 hours at cutting depth a=1mm show that cutting tool lifetime is bigger than at cutting depth a=0,5mm. The similar matter is also happened at nitrogen cooling treatment (treated) with soaking 24 hours + temper at 150^0C for 1 hour, at cutting depth a=0,5mm, showed that tool life is bigger than at cutting depth a=0,1mm.

Tables 2. Wear of cutting tool edge, V_B with toollife, T and Taylor Equation at various condition with feeding motion f = 0,1 mm/rotation and cutting speed Vc= 70 m/minute

Condition	Cutting depth, a (mm)	Wear of edge cutting tool, V_B (mm)	Tool life, T (mnt)	Taylor Equation
Untreated	0.1	0.06	6.123	$VT^{0,5}$= 127.6879
	0.5	0.16	5.671	$VT^{0,5}$= 120.6405
	1.0	0.24	5.464	$VT^{0,5}$= 115.6598
Nitrogen cooling with soaking 2 hours	0.1	0.05	7.119	$VT^{0,45}$= 124.8107
	0.5	0.13	6.492	$VT^{0,45}$= 117.5495
	1.0	0.14	5.681	$VT^{0,45}$= 108.1239
Nitrogen cooling with Soaking 24 hours	0.1	0.03	7.756	$VT^{0,4}$= 117.0903
	0.5	0.07	6.759	$VT^{0,4}$= 108.7966
	1.0	0.14	7.059	$VT^{0,4}$= 108.1239
Nitrogen cooling with soaking 48hours	0.1	0.01	7.020	$VT^{0,35}$= 102.0659
	0.5	0.04	7.272	$VT^{0,35}$= 101.4461
	1.0	0.10	8.275	$VT^{0,35}$= 103.6707
Nitrogen cooling with soaking	0.1	0.03	15.354	$VT^{0,3}$= 117.0903
	0.5	0.05	11.109	$VT^{0,3}$= 104.3156

2 hours + temper at150^{0}C for 1hour	1.0	0.07	10.144	$VT^{0,3}$= 99.15009
Nitrogen cooling with soaking 24 hours + temper at150^{0}C for 1hour	0.1	0.02	21.648	$VT^{0,25}$= 111.3037
	0.5	0.08	22.744	$VT^{0,25}$= 110.6278
	1.0	0.12	21.110	$VT^{0,25}$= 106.0605
Nitrogen cooling with soaking 48 hours + temper at 150^{0}C for 1hour	0.1	0.01	30.278	$VT^{0,2}$= 102.0659
	0.5	0.03	26.906	$VT^{0,2}$= 97.86292
	1.0	0.05	26.181	$VT^{0,2}$= 95.06642

Source : result of data processing

Tables 2 show the wear of cutting tool edge (V_B) at untreated condition is bigger than nitrogen cooling treatment specimen with any kind of soaking at same cutting depth (a = 0.1mm; 0.5mm; 1mm). Same thing shown at nitrogen cooling treatment with any various of soaking (holding for 2 hours; 24 hours ; 48 hours) at same cutting depth (a = 0.1mm; 0.5mm; 1mm), that wear of cutting tool edge (V_B) is bigger than nitrogen cooling treated + tempering at 150$_0$C for 1 hour. Its opposite for tool life on untreated condition, nitrogen cooling treated and nitrogen cooling+ tempering treatment.(see Tables 2).

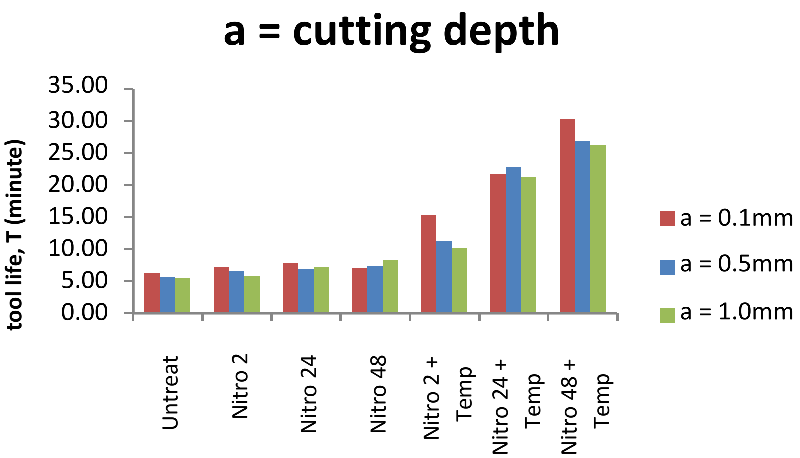

Figure 1. The tool lifeon various condition at various cutting depth with constant cutting speed (Vc) and feeding motion (f)

Figure 1. show the longer of soaking at nitrogen cooling process even at nitrogen cooling process + temper, the carbide tool life will longer at any cutting

depth, and its opposite the bigger of cutting depth so the carbide tool life will be shorter. Carbide tool with nitrogen cooling process + temper will have longer tool life or its T value is bigger (Figure 1).

Based on table 3 it show the highest hardness number is HRc79.7 for cutting tool that treated nitrogen cooling with soaking for 48 hours , continued by temper at 150$_0$ C for 1 hour.The hardness number increase about 2.97% compare to nitrogen cooling treatment with same soaking without temper. The hardness increase about 3.96% for 24 hours soaking, whereas for 2 hours soaking the hardness increase 2.41%. The hardness number for carbide cutting tool without treatment is HRc 71. It show that there is hardness increasing for carbide cutting tool about 5.07% and 8.87% for nitrogen cooling treatment with soaking variation 2 hours and 48 hours. Addition for temper process, the hardness number increase 7.6% and 12.3% with soaking variation 2 hours and 48 hours. The higher of carbide cutting tool hardness will higher the life time of cutting tool. It showed that carbide cutting tool with cutting depth a = 0.1mm, feeding speed Vc = 70 m/s and feeding motion f = 0.1 mm/rotation that treated by nitrogen cooling and temper process has the least wear of edge cutting tool Vb = 0.01 (Table 3) with highest hardness number HRc79.7 and the longest life time T = 30.278 minute (Table 2).

Tables 3 Result of hardness testingfor carbide tool without treatment (untreated) and cutting tool with nitrogen cooling treatment (treated) and also nitrogen cooling + temper process

No	Condition		Hardness, HRc			Mean of Hardness, HRc
			1	2	3	
1	Untreated		70	72	71	71
2	treated Cooling at liquid nitrogen , soaking (hour)	2	74	75	75	74,6
		24	75	76	76	75,7
		48	77	78	77	77,4
3	treated Cooling at liquid nitrogen , soaking (hour) and temper 150^{0}C 1 hour	2	76	77	76	76,4
		24	78	79	79	78,7
		48	79	80	80	79,7

Based on Taylor equation of tool life at cutting speed Vc=70 m/minute, cutting depth a=1mm, feeding motion f = 0,1 mm/rotation the tool life with cryogenic treatment will improve to 28%. Its look like experiment that done by Ramji B.R. et al, (2010) show that cryogenic treatment of Carbide Inserts used for turning process of grey cast iron can increase the wear resistance to 31 %. Its also done by Thamizhmanii S. et al, (2011) researched Cemented carbide tools coat by physical vapour deposition (PVD) used for turning process of Inconel 718 with high speed and feeding motion. Cutting tool with cryogenic treatment have longer tool life than untreated specimen.

The carbide tool life used for turning process of Aluminium 6061 as result of cryogenic treatment and temper, its increase to 105%. This result is much greater than research done by Rupinder Singh, and Kamaljit Singh (2010), which is show turning process of crank shaft with carbide tool at cutting speed Vc 250 m/minute, the carbide tool life increase to 22,2 % after cryogenic treatment and temper. Its because of materials that turned is harder.

CONCLUSION

1. The carbide tool lifeused for turning process of Aluminium 6061 as result of cryogenic treatment increase to 28% compared with untreatedcutting tool.
2. The carbide tool life used for turning process of Aluminium 6061 as result of cryogenic treatment and temper increase to 105% compared with untreated cutting tool.
3. Taylor equation of tool life without treatment, $VT_{0,5}$ = 115,6598
4. Taylor equation of toollife with cryogenic treatment, $VT_{0,35}$ = 103,6707
5. Taylor equation of toollife with cryogenic treatment and temper, $VT_{0,2}$ = 95,0664
6. The greater of cutting depth hence wear of edge cutting tool be greater and its carbide tool life will shorter.

ACKNOWLEDGEMENTS

I would like to express my very great appreciation to DP2M DIKTI for their sponsored for this research .

Special and deeply thank I dedicate to operator in the Manufacture and Metallurgy Laboratory of Mechanical Engineering –Universityof MerdekaMalang for their assistance.

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