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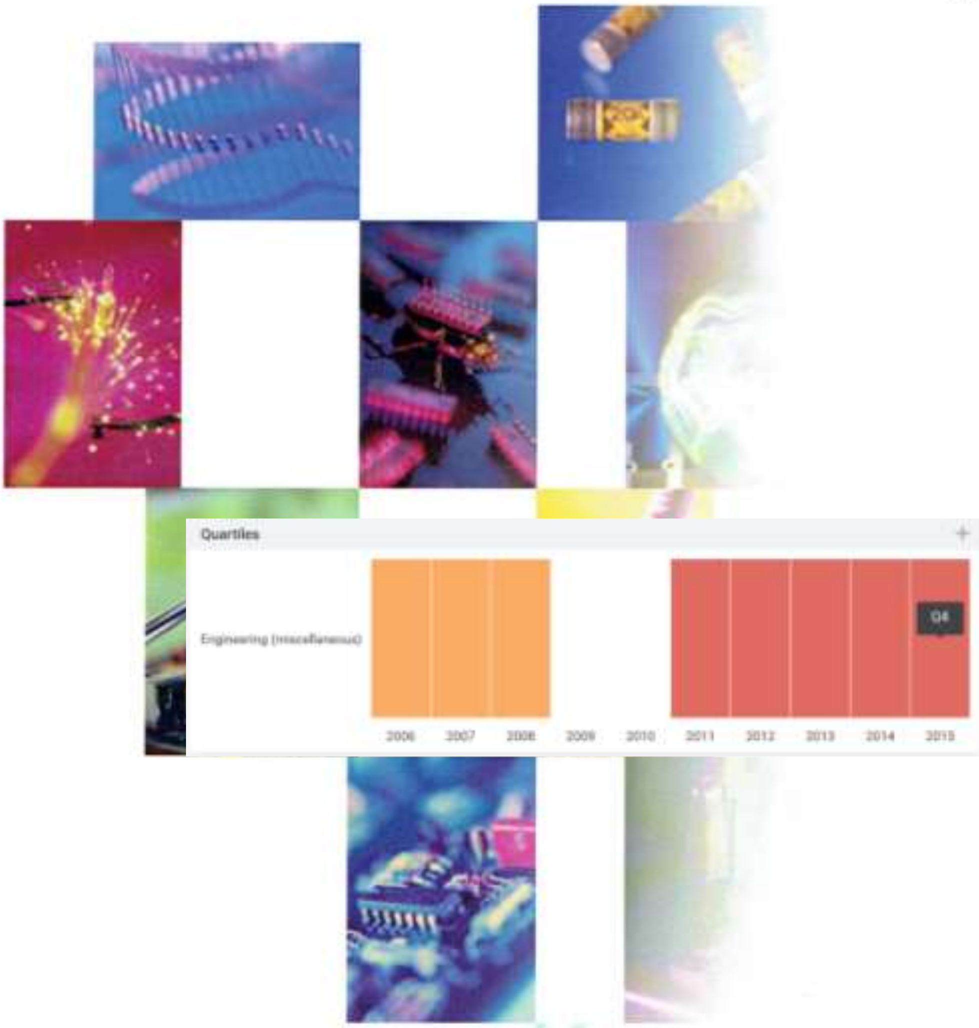

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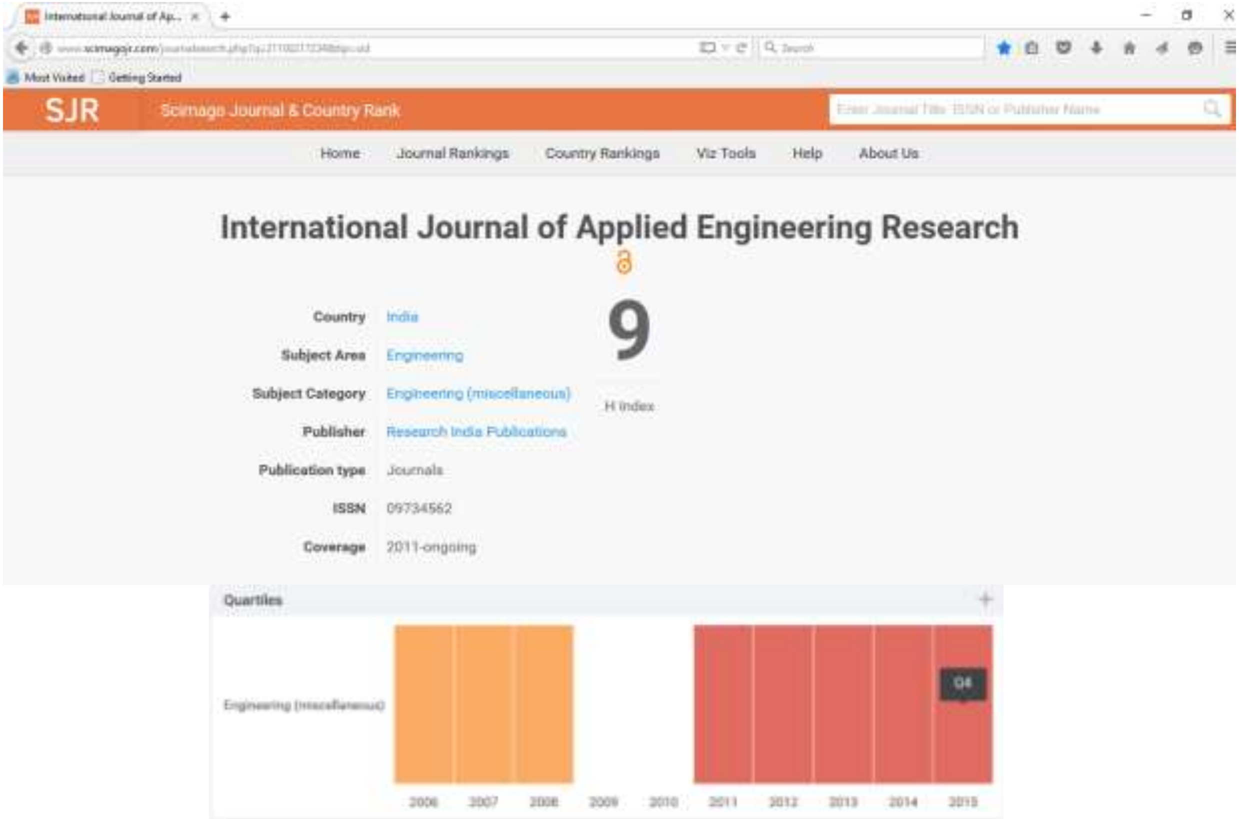
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Impact evaluation of Cryogenic Treatment to wear characteristics of ADI cutting tool

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Abstract
Nowadays, there are many industries develop the using of cryogenic treatment to improve wear resistance of cutting tool. Target of the research is to evaluate impact of cryogenic treatment method to wear resistance characteristic of ADI (Austemper Ductile Iron) cutting tools. ADI cutting tools of cryogenic treatment implemented for turning process of aluminium alloy material T-6061with cutting depth (a) variation 0. 1mm; 0. 5mm; and 1mm, while cutting speed (Vc) 70 m/min and constant feeding motion (f) 0. 1 mm/rotation without coolant. Analysis of this experiment uses analytic method and microscope digital observation. The finding of experiment are (1) BUE (Built Up Edge)deposit of Al material on untreated ADI cutting tool be thicker with increase of cutting depth (a). (2) BUE deposit of Al material be thinner on cryogenic treatment ADI cutting tool with increase of soaking time. (3) Wear on rake surface be worse with increase of cutting depth (a). (4) ADI cutting tool as a result of cryogenic treatment with soaking time for 48 hours, cutting speed (Vc) 70 m/min, feed motion (f) 0. 1 mm/rotation and cutting depth (a) 1mm, show the wearing of cutting tool edge decrease until 77% compare than cutting tool without cryogenic treatment. (5) Wearing of cutting tool edge be smaller with increase of soaking time on cryogenic treatment process so wear resistance be higher.

Key words: *cryogenic treatment*, wearing of cutting tool edge, ADI (*Austemper Ductile Iron*) cutting tool.

INTRODUCTION

There is a friction on turning process between cutting tool and work piece that cause of heat so the wearing of cutting tool will be done then shorter the tool life. Generally its used to coolant to decrease of friction or coating on cutting tool to solve this problem on metal cutting process. Cryogenic treatment developed by industry to increase wear resistance of cutting tool, gear etc. (Thamizhmanii, S. *et al*, 2011; Ramji B. R. *et al*, 2010; Kollmer K. P, 2007) so the tool life will be longer. It can save resharping cost of tool and time to change the cutting tool.

Cryogenic treatment is a coolant process of steel, stainless steel and the other metal from room temperature to-320$_0$F (-196$_0$C) then hold at that temperature with soaking time for some time then continue with warming process until room temperature (Singh, S. *et al*, 2012 dan Ramji B. R. *et al*, 2010). Rajendra K. et al (2007) classified there are 2 kinds of under room temperature treatment, subzero or cold treatment and cryogenic treatment. Subzero treatment held on-145$_0$C (-230$_0$F) and cryogenic treatment held on-195$_0$C in liquid nitrogen.

Society of Manufacturing Engineers (SME), 2012 explain the effect ofcryogenic treatment on ADI cutting tool to mechanics properties(hardness HRc 41, 4), it be increase of hardness 10. 4% compare than ADI material without cryogenic treatment (hardness HRc 37. 5). This is supported by the experiment result of Yazdani S. and, Ardestani M. (2007) that show the effect of subzero cooling on ADI to hardness properties increase HB 66 (19. 6%) compare than before treatment process HB 337. Chang-Yong Kang et al (2009), show the effect of subzero treatment to hardness of ADI more increase 18%.

The result of experiment that be done (Suprapto, A. *et al*, 2014A), show the carbide tool lifefor turning process of Alumunium T-6061, with cryogenic treatment at condition cutting speed (Vc) 70 m/min, feed motion (f) 0, 1 mm/rotation and cutting depth(a) 1mm, tool life Taylorequation $VT_{0,050}$= 115, 6598 and for cryogenic treatment and temperat the same condition, tool life Taylorequation $VT_{0,035}$= 103, 6707 it be increase of tool lifeas 105% compare to cutting tool without treatment.

To follow up the experiment that be done by Suprapto, A. *et al*, 2014A, determined carbide tool lifefor turning machine of Alumunium T-6061. The result of experiment isimpact evaluation ofcryogenic treatmentto wear characteristics ADI cutting tool implemented on turning process of material Aluminium T-6061 with variation of cutting depth (a), and constant of feed motion (f) and cutting speed (Vc).

EXPERIMENT METHOD

Cryogenic treatmentexperimentand machining process

(a). Sample of ADI (Austemper Ductile Iron) cutting tool cooled on nitrogen then hold with variationof soaking time 2 hours (3 sample), 24 hours (3 sample) and 48 hours (3 sample).

(b) Prepare material: Alumunium 6061-T with dimension of length = 100 mm and diameter = 22 mm, hold on the main spindle.

(c). Turning process at condition Vc = 70 m/min and f = 0, 1 mm/rotation and variation of cutting depth a = 0, 1 mm; 0, 5 mm and 1 mm.

(d). Stop turning process to account the cutting time (tc) use stop watch for 6 minute for each process and measure wear of cutting edge(V_B) use Digital Microscope.

(e). Analyses the result of experimental.

RESULT ACHIEVED

According Figure no. 1 result of optical micrographfor cutting condition of Aluminium with cutting speed Vc= 70 m/min, and feed motion f = 0, 1 mm/rotation show that untreated nitrogen cooling sample BUE deposite thicker happened with deeper cutting depth (a): 0, 1 mm ; 0, 5 mm dan 1, 0 mm. Deposit of (BUE) is clear on flank surface. This is supported by experiment result of Agus Suprapto et. al (2014B) that show BUE Aluminium deposit on carbide cutting tool too. Figure 2, 3 and 4 sample with nitrogen cooling soaking for 2 hours, 24 hours and 48 hours, BUE deposite Al on flank surfaceof ADI cutting tool are occur. Deposite BUE of Aluminium will be thickerat bigger cutting depth. At bigger cutting depth so the BUE deposite Aluminium will be thicker on flank surfaceof ADI cutting tool. For nitrogen cooling sample with longer soaking so the BUE deposite at flank surfaceod ADI cutting tool be thinner (Figure4).
Wearing at rake surfacebe worse with deeper cutting depth (Figure 5, 6, 7, and 8). At cutting tool without nitrogen cooling treatment wearing at rake surfaceworse compare than cutting tool with nitrogen cooling treatment (Figure 5 and 6). According to result of experiment the usage of cutting tool on turning process for Aluminium with untreated or treated use nitrogen cooling treatment retrieved that wearing of the cutting tool edge like at Figure 9. Its shows the wearing of cutting tool edge (Vb) on many condition that deeper of cutting depth (a) so the wearing of cutting tool edge (Vb) will be bigger. Its depend on nitrogen cooling treatment. At the same picture is show on untreated condition, the wearing of cutting tool edge (Vb) is bigger than the nitrogen cooling treated cutting tool with variant soaking time at the same cutting depth a = 0. 1 mm, 0. 5 mm and 1 mm.

Figure 1: Optical micrographs flank surface of ADI cutting tool without cooling nitrogen treatmentat turning process condition Vc: 70 mm/min, f: 0. 1 mm/rotationfor Al T-6061 a. Cutting depth a: 0, 1 mm b. Cutting deptha: 0, 5 mm c. Cutting deptha: 1, 0 mm

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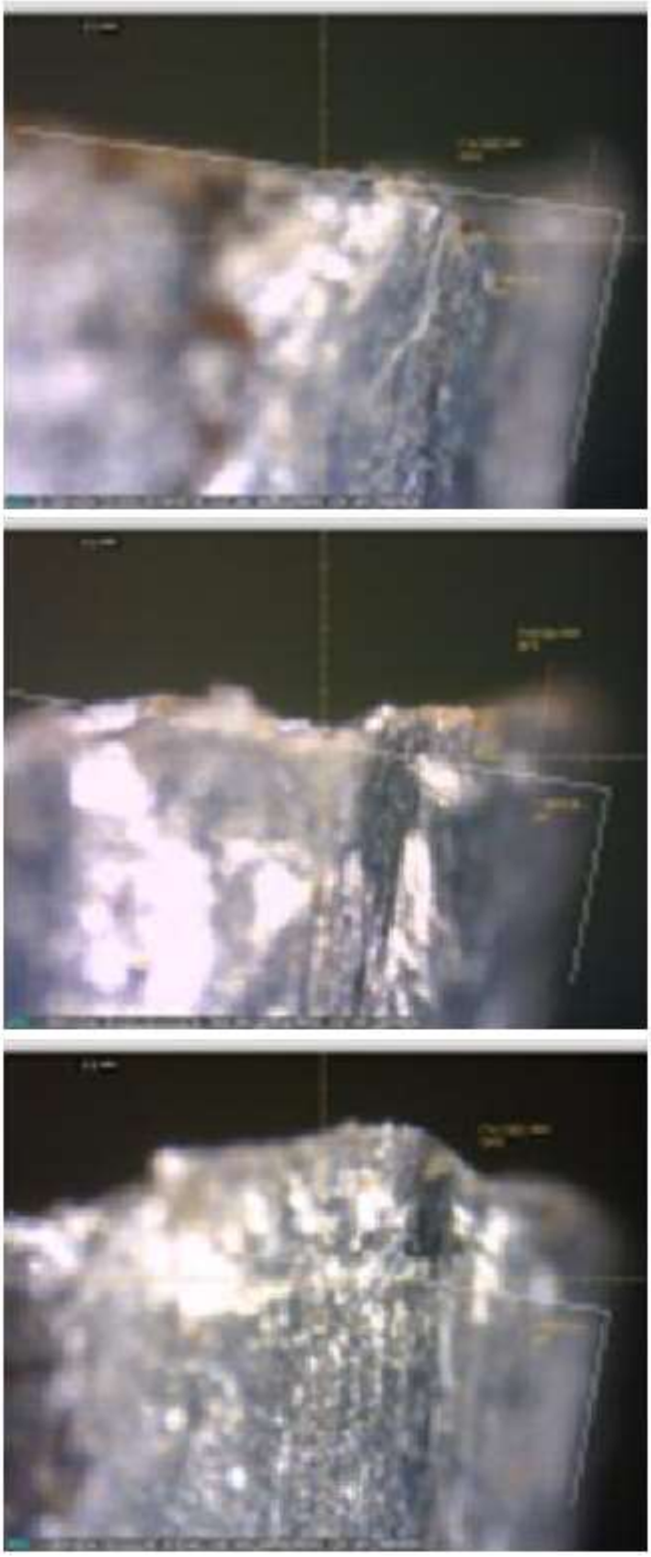

Figure 2: Optical micrographs at flank surface of ADI cutting tool with nitrogen cooling treatment, soaking time 2 hours continued by turning process Vc: 70 mm/min, f: 0. 1 mm/rotation, for Aluminium T-6061. a. Cutting depth a: 0, 1 mm b. Cutting depth a: 0, 5 mm c. Cutting depth a: 1, 0 mm

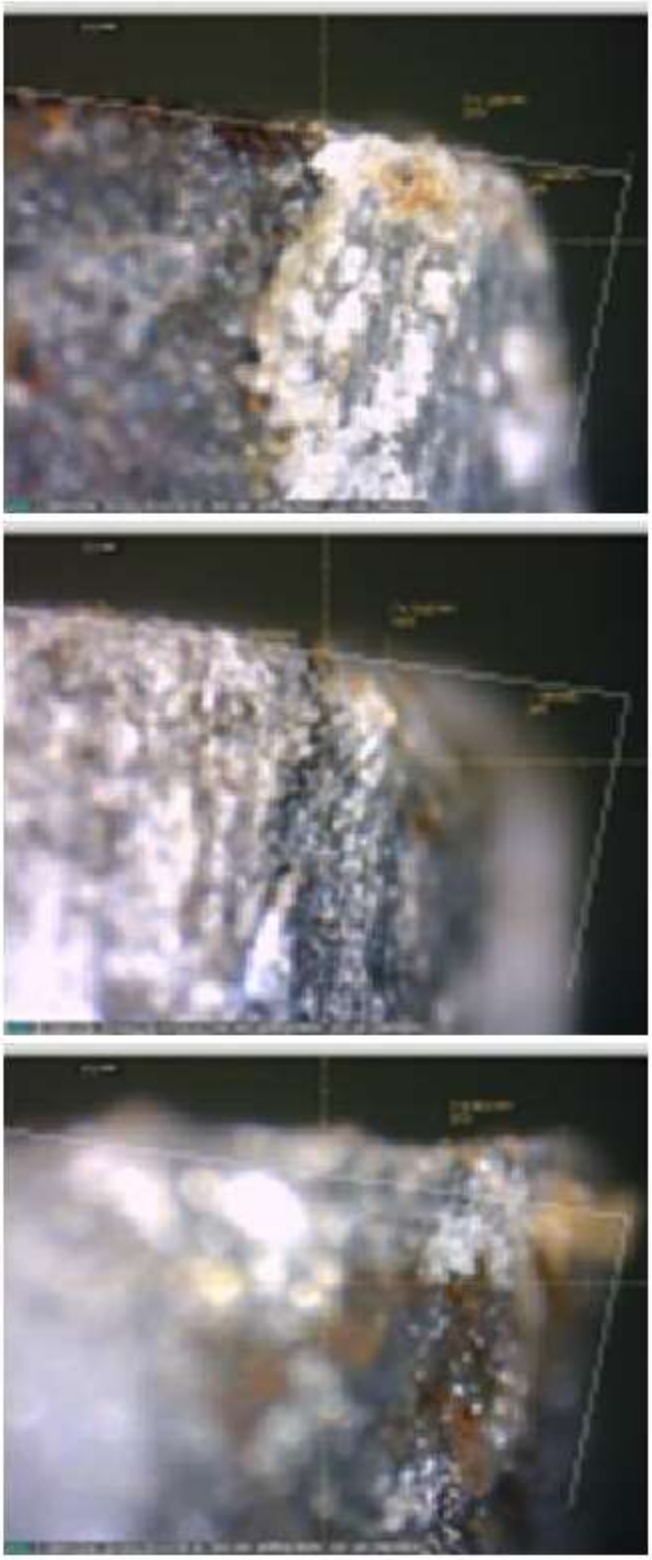

Figure 3: Optical micrographs at flank surface of ADI cutting tool with nitrogen cooling treatment, soaking 24 hours continued by turning process Vc: 70 mm/min, f: 0. 1 mm/rotation, for Al T-6061. a. Cutting depth a: 0, 1 mm b. Cutting depth a: 0, 5 m c. Cutting depth a: 1, 0 mm

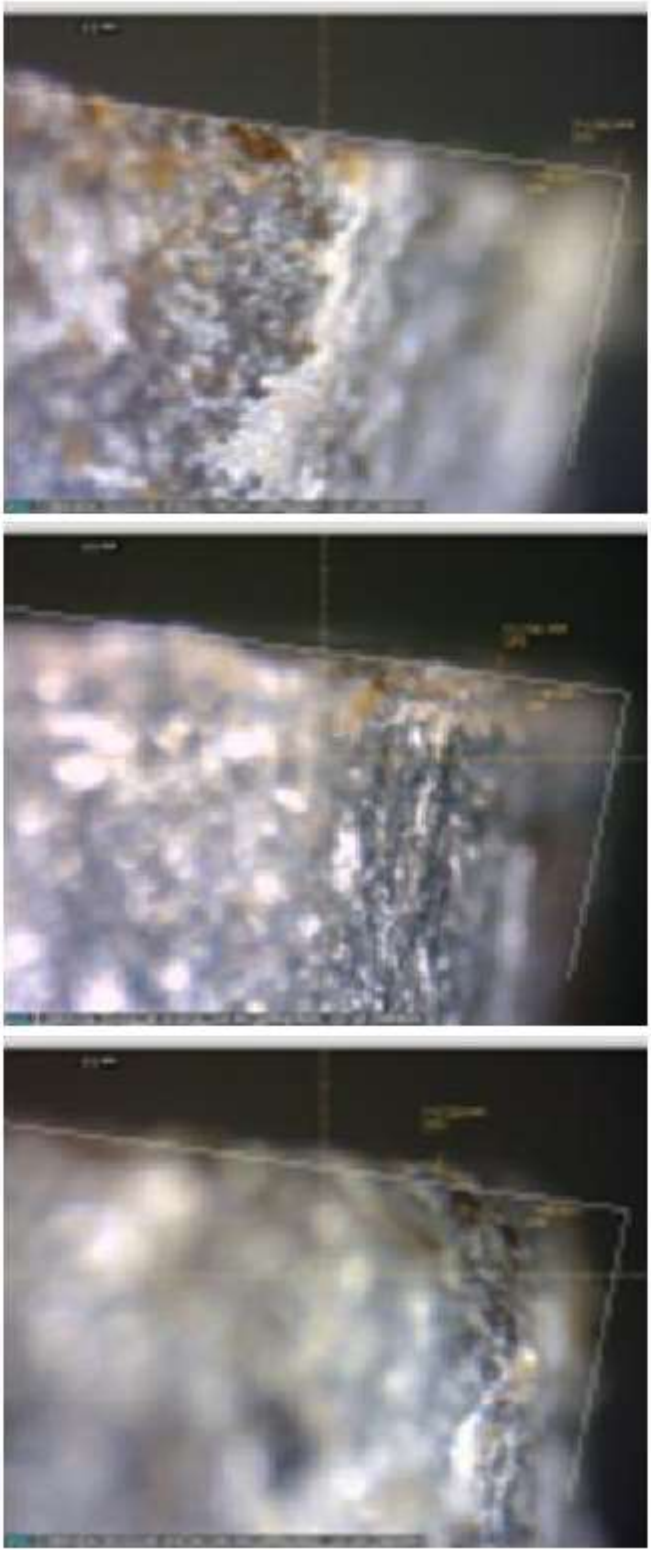

Figure 4: Optical micrographs at flank surface of ADI cutting tool with nitrogen cooling treatment, soaking 48 hours, continued by turning process Vc: 70 mm/min, f: 0. 1 mm/rotation, for Al T-6061 a. Cutting depth a: 0, 1 mm b. Cutting depth a: 0, 5 mm c. Cutting depth a: 1, 0 mm

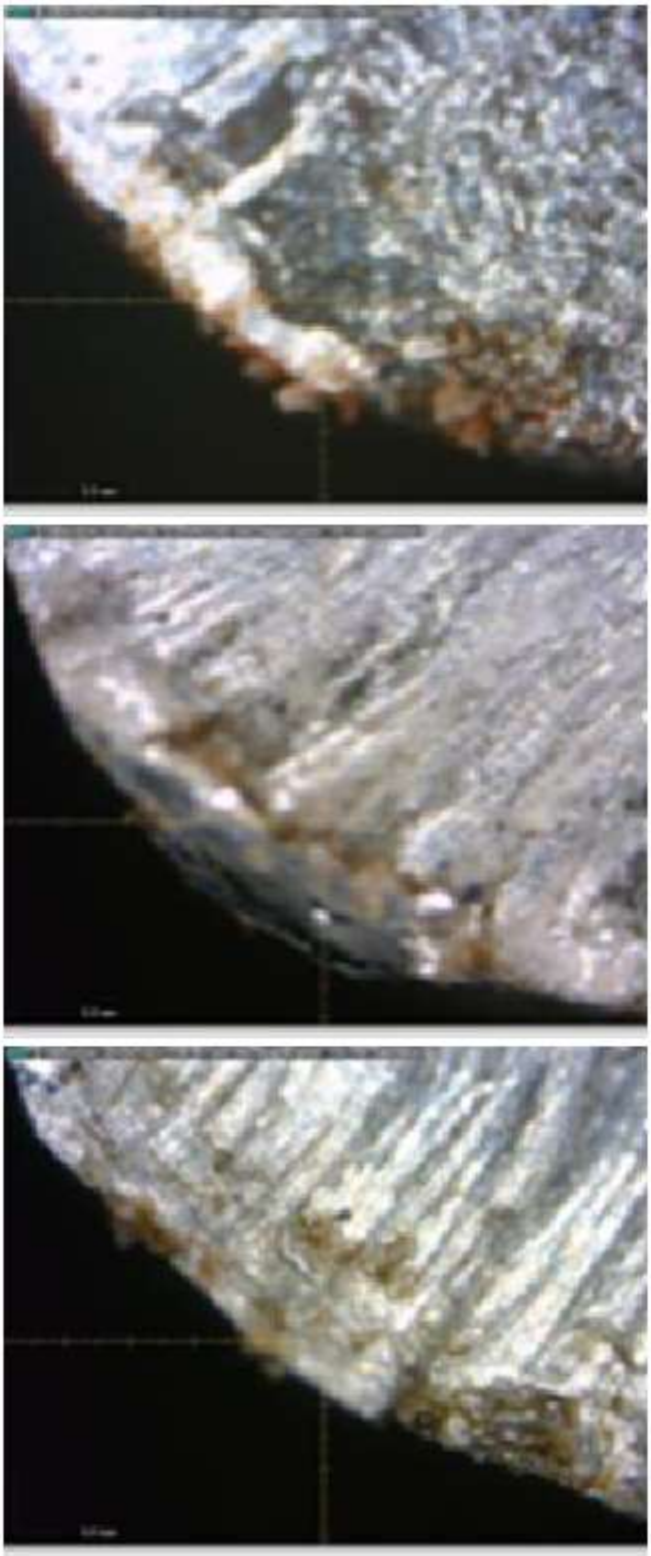

Figure 5: Optical micrographs at rake surface of ADI cutting tool without nitrogen cooling treatment, turning process condition Vc: 70 mm/min, f: 0. 1 mm/rotation, for Al T-6061 a. Cutting depth a: 0, 1 mm b. Cutting depth a: 0, 5 mm c. Cutting depth a: 1, 0 mm

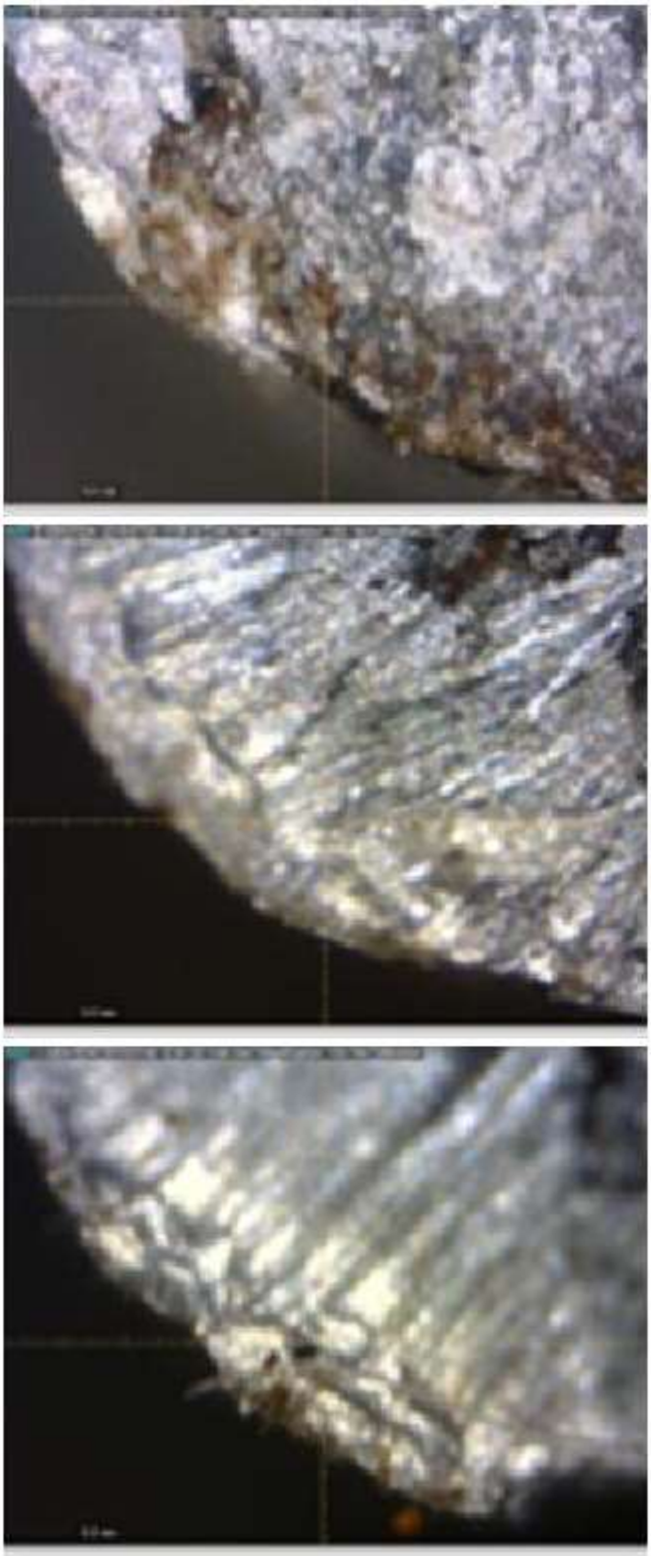

Figure 6: Optical micrographs at rake surface of ADI cutting tool with nitrogen cooling treatment, soaking 2 hours, continued by turning process Vc: 70 mm/min, f: 0. 1 mm/rotation, for Aluminium T-6061 a. Cutting depth a: 0, 1 mm b. Cutting depth a: 0, 5 mm c. Cutting depth a: 1, 0 mm

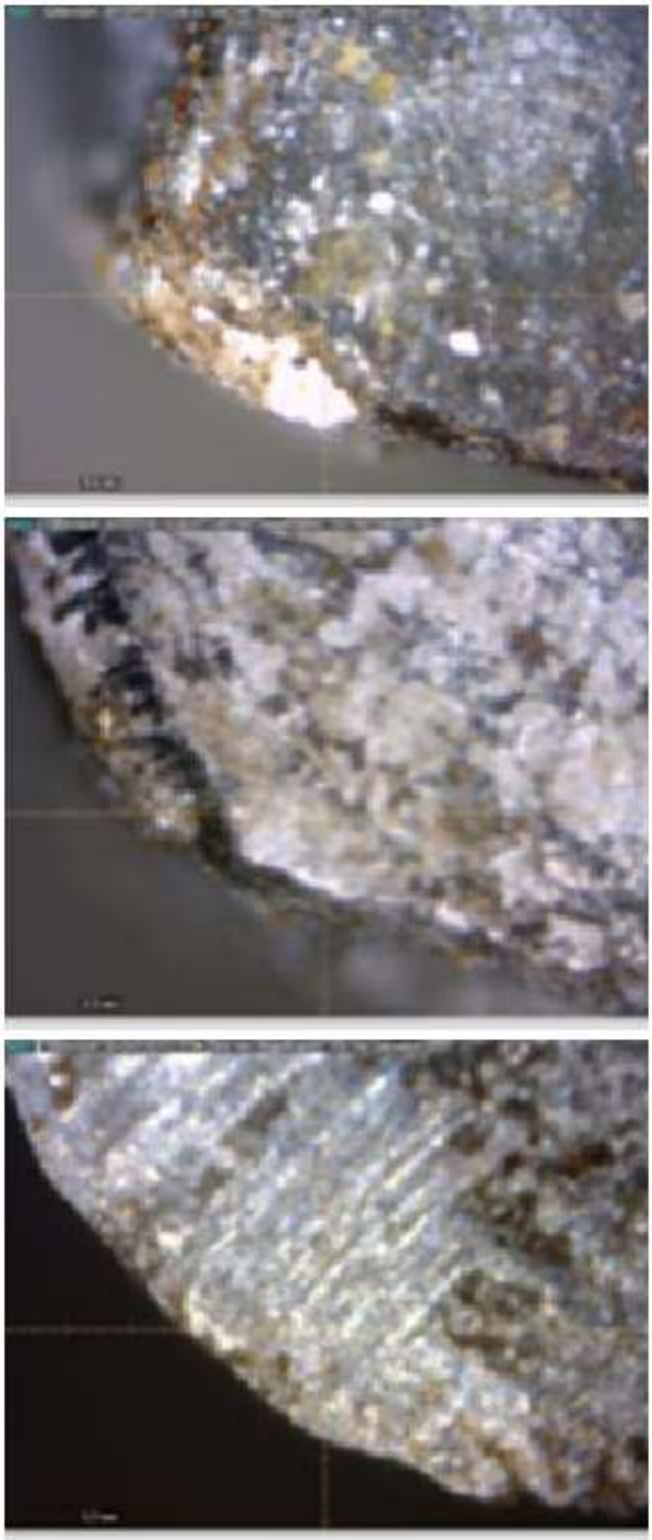

Figure 7: Optical micrographs at rake surface of ADI cutting tool with nitrogen cooling treatment, soaking 24 hours, continued by turning process Vc: 70 mm/min, f: 0. 1 mm/rotation, for Al T-6061 a. Cutting depth a: 0, 1 mm b. Cutting depth a: 0, 5 mm c. Cutting depth a: 1, 0 mm

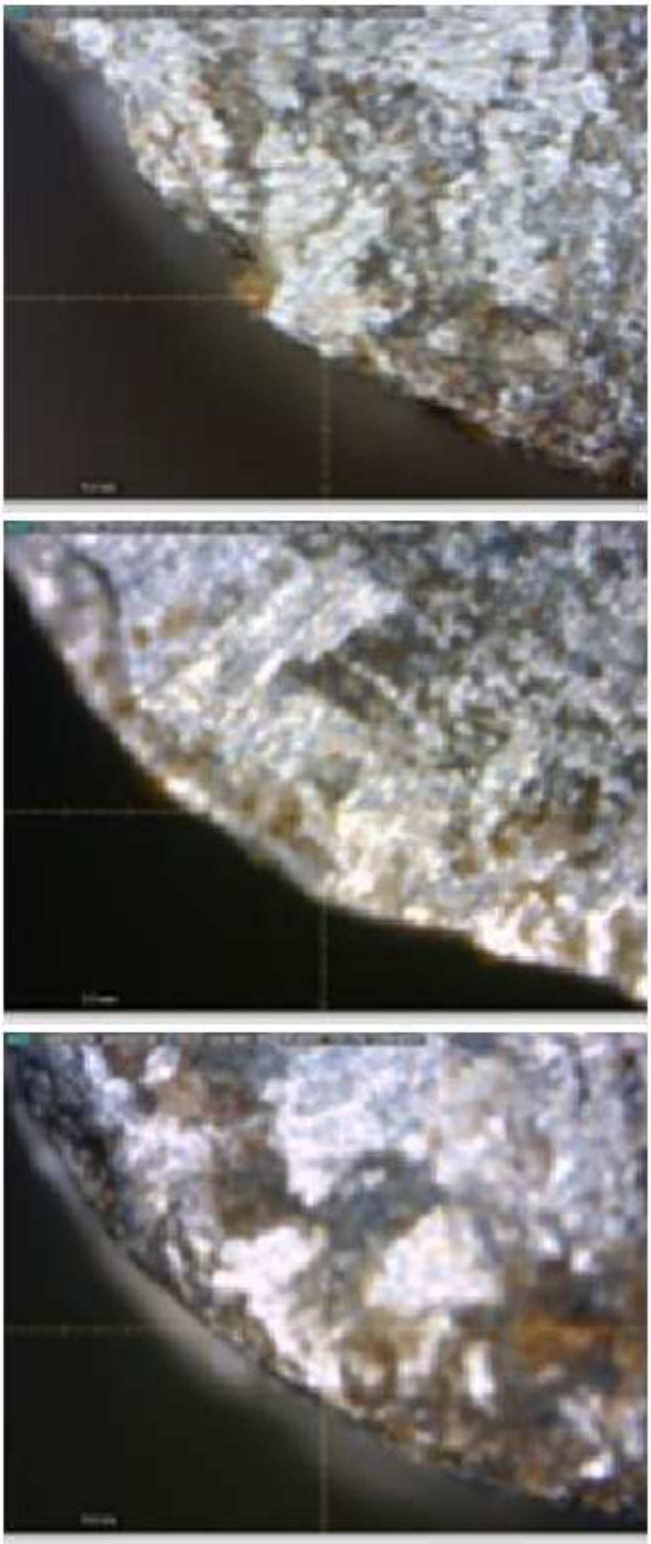

Figure 8: Optical micrographs at rake surface of ADI cutting tool with nitrogen cooling treatment, soaking 48 hours, continued by turning process Vc: 70 mm/min, f: 0. 1 mm/rotation, for Al T-6061 a. Cutting depth a: 0, 1 mm b. Cutting depth a: 0, 5 mm c. Cutting depth a: 1, 0 mm

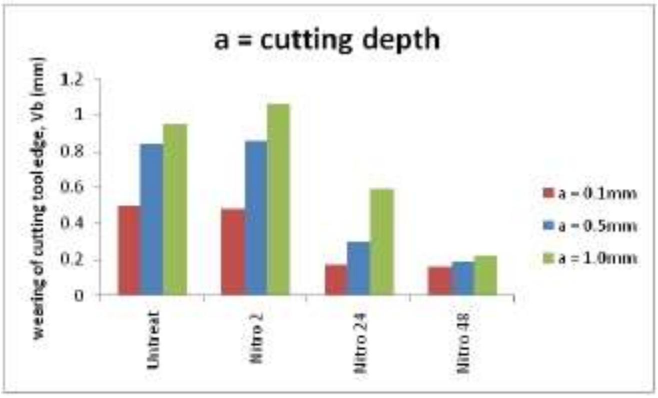

Figure 9: Wearing of edge cutting tool, Vb on varian condition of cutting depth with varian cutting speed Vc and constant feed motion f, for treated and untreated cutting tool (nitrogen cooling) on soaking variation 2 hours, 24 hours and 48 hours.

At condition cutting depth a: 0, 1 mm

For treated cutting tool on nitrogen cooling wit soaking 2 hours with cutting depth a: 0. 1mm, the wearing of cutting tool edge (Vb) is smaller 2% than untreated sample. At the same cutting depth for 24 hours soaking time, the wearing of cutting tool edge (Vb) is smaller 65% than untreated sample. While for 48 hours soaking the wearing of cutting tool edge (Vb) is smaller 67% than 2 hours soaking. So for 48 hours soaking the wearing of cutting tool edge (Vb) is smaller 6% than 24 hours soaking dan smaller 66% than 2 hours soaking.

At condition cutting depth a: 0, 5 mm

At treated condition with nitrogen cooling soaking for 2 hours at cutting depth a: 0. 5 mm, the wearing of cutting tool edge (Vb) is bigger 2% than untreated cutting tool, it ought to smaller. At the same cutting depth, for 24 hours soaking, the wearing of cutting tool edge (Vb) is smaller 64% than untreated. While 48 hours soaking the wearing of cutting tool edge (Vb) is smaller 77% than untreated. For 24 hours soaking, the wearing of cutting tool edge (Vb) is smaller 65% than 2 hours soaking. So for 48 hours soaking, the wearing of cutting tool edge (Vb) is smaller 36% than 24 hours soaking and smaller 77% than 2 hours soaking.

At condition cutting depth a: 1, 0 mm

However for nitrogen cooling treatment with 2 hours soaking at cutting depth a: 1. 0 mm, the wearing of cutting tool edge (Vb) is bigger 11% than untreated, it should be smaller. At the same cutting depth a: 1. 0 mm the wearing of cutting tool edge (Vb)is smaller 38% than untreated. While for 48 hours soaking, the wearing of cutting tool edge (Vb) is smaller 77% than untreated. It shows that wear resistance of treated ADI cutting tool use nitrogen cooling will bigger than untreated. While the effect of longer soaking time is the wearing of cutting tool edge will be smaller so the wear resistance be higher. For 24 hours soaking, the wearing of cutting tool edge (Vb) is smaller 44% than 2 hours soaking. So for 48 hours, the wearing of cutting tool edge (Vb) is smaller 62% than 24 hours soaking and smaller 79% than 2 hours soaking. The

addition of cutting depth to 900% (from a: 0. 1 mm until a:1. 0 mm) for ADI cutting tool without cryogenic treatment, the wearing of cutting tool edge (Vb) increase 92% than treated sample for 48 hours, the wearing of cutting tool edge (Vb) increase 36%. Its shows that the wearing of treated cutting tool edge decrease 60% than untreated.
At cutting speed Vc: 70 m/min with feed motion 0. 1 mm/rotation and cutting depth a: 1. 0 mm, the result of cryogenic treatment show that the wearing of cutting tool edge smaller than untreated. Its show that cryogenic treatment will increase wear resistance of ADI cutting tool on turning process for AL T-6061. This result similar to doneRamji B. R. *et al*, (2010), that cryogenic treatment at carbide insert which used to turning of gray cast iron can increase wear resistance about 31%. So do Thamizhmanii S., et al (2011), researched cemented carbide tools coated with Physical Vapour Deposition (PVD)which used to turning Inconel 718 material at high speed and feed motion, cutting tool with cryogenic treatment have longer long life than untreated.

CONCLUSION

1. BUE deposite of Aluminium be thicker on untreated ADI (Austemper Ductile Iron) cutting tool with deeper cutting depth (a).
2. BUE deposite of Aluminium be thinner on ADI cutting tool with cryogenic treatment at longer of soaking time.
3. Wearing at rake surface be worse with deeper cutting depth (a)
4. ADI cutting tool with cryogenic treatment and soaking for 48 hours, cutting speed Vc = 70 m/min, feed motion f = 0. 1 mm/rotation and cutting depth a = 1 mm show that wearing of cutting tool edge decrease 77% than untreated.
5. Wearing of cutting tool edge decrease with longer soaking time at cryogenic treatment process so the wear resistance will be higher.

REFERENCES

[1] Thamizhmanii S. et al. 2011. *Performance of deep cryogenically treated and non-treated PVD inserts in milling*, Journal of Achievments in Materials and Manufacturing Engineering, Vol. 49, Issue 2, Desember 2011, p. 460-466
[2] Ramji B. R. et al. 2010. *Analysis of Roughness and Flank Wear in Turning Gray Cast Iron Using Cryogenically Treated Cutting Tool*, Research Journal of Applied Sciences, Engineering and Technology 2(5):Maxwell Scientific Organization, ISSN: 2040-7467, 2010, p. 414-417
[3] Kollmer K. P, 2007. *Applications & Developments in the Cryogenic Processing of Materials*, Kollmer-The Technologi Interface. htm. 2/23/2007
[4] Singh S. et al. 2012. *Experimental Analysis of Cryogenic Treatment on Coated Tungsten Carbide Inserts in Turning*, International Journal of Advanced Engineering Technology, E-ISSN 0976-3945, IJAET, Vol. III, Issue I, 2012, p. 290-294
[5] Rajendra K. et al, 2007. *Under standing the effect of cryogenic treatment on M2 Tool Steel Properties*, Heat Treating Progress, 2007, p. 57-60
[6] *Society of Manufacturing Engineers* (SME), 2012. *Deep Cryogenic Treatment of Metal, an Emerging Technology*, DCT WEBINARS SME March 13 2012, Air Liquide, **http://sme. org/ffc/**,
[7] Yazdani S. and, Ardestani M. 2007. *Effect of sub-zero cooling on microstructure and mechanical properties of a low alloyed austempered ductile iron*, China Foundry, Vol 4, No 2, pp 120-123
[8] Chang-Yong Kang et al. 2009. *Effect of Subzero Treatment on the Microstructure and Mechanical Properties of Austempered Ductile Cast Iron*", Materials Transactions, Vol. 50, No. 9 (2009) pp. 2207 to 2211
[9] Agus Suprapto, Agus Iswantoko, dan Ike Widyastuti. 2014A. "*Impact of Cryogenic Treatment and Temper to carbide tool life on turning process for Al T-6061*, International Journal of Applied Engineering Research, ISSN 0973-4562 Volume 9, Number 24 (2014) pp. 30643-30650
[10] Agus Suprapto, Agus Iswantoko, dan Ike Widyastuti. 2014B. *Dampak Cryogenic Treatment dan Temper terhadap Karakteristik Keausan Pahat Karbida pada Pembubutan Al T-6061*, ISBN 2085-2347, Vol-3-2014, Proseding SMM 2014
[11] Singh Rupinder, and Singh Kamaljit. 2010. *Enhancement of Tool Material Machining Characteristics with Cryogenic Treatment: A Review*, Proceedings of the 2010 International Conference on Industrial Engineering and Operations Management Dhaka, Bangladesh, January 9-10, 2010