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Investigation of microstructure and deep cryogenic temperature properties on Aluminum 6061-T6 material by wear test

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ABSTRACT
The point of this paper is to center around the impact of profound cryogenic treatment on the microstructure, mechanical and wear properties of Al 6061. The main goal was to comprehend how much wear conduct has indicated change with aluminum grades being dealt with cryogenically on the examples. To direct wear test Aluminum trial examination has been done on aluminumamalgams with cryogenic coolants. The cryogenic coolant has expanded the wear protection properties of aluminum up to 25% when contrasted with wear of non- cryogenically treated aluminum. The cryogenic treatment was completed under three unique timings for three distinctive rpm's under differing loads. The paper additionally thinks about the smaller scale auxiliary changes under these differing conditions. The test examination of the paper reasons that cryogenically treated aluminum demonstrates increment in wear protection of about 25%.

Keywords: *Deep Cryogenic Treatment, Wear, Microstructure.*

1. Introduction

"Cryogenics" is taken from two Greek words– "kryos" which signifies 'ice' or solidifying, and "genic" which means to 'create' or produced. Innovatively, it implies the investigation and utilization of materials (or different prerequisites) at low temperatures. The utilization of cryogenic treatment to enhance mechanical properties of materials has been created from the finish of the Sixties. A cryogenic treatment is the way toward treating work pieces to cryogenic temperatures i.e. beneath −190 °C (−310 °F) to evacuate lingering stresses and enhance wear protection on steels. Cryogenic treatment is a low temperature treatment process broadly utilized as a part of late years to upgrade the material properties without giving up different properties in the meantime.

Cryogenics assumes a huge part in upgrading the mechanical properties of compounds. It additionally expands the protection from stretch erosion which is of prime worry in wind designing application. Cryogenic solidifying is a cryogenic warmth treating process where the material is cooled to roughly −185 °C (−301 °F), ordinarily utilizing fluid nitrogen. It can profoundly affect the mechanical properties of aluminum and different metals. Silicon is the most critical single alloying component utilized as a part of greater part of Aluminum throwing amalgams. Yuan-Zhi ZHU [1], in his article has clarified how AlFeSi molecule is appropriated on close to the aluminum surfaces heterogeneously. It demonstrates how these groups of hard particles instigate crack. The creation alone does not influence the property but rather likewise the grain measure as talked about by Fabio [2] in his paper where the effect of Al-Si blend is examined. Impact of aluminum with Zirconium is examined by Yi Meng [3], where it builds the Ultimate rigidity of the amalgam. Magnesium is an alloying material of aluminum. Change of weariness attributes by including it with aluminum is talked about by Zuqi Hu [4]. Hardness is an essential parameter required in mechanical applications, hardness property is expanded by including copper and magnesium with aluminum by Nafsin [5] and the paper likewise talks about the effect of hardness on the misshapening of articles. Dunia Abdul Saheb [6], in his paper shows the aluminum silicon carbide and aluminum graphite to build the hardness altogether. With a specific end goal to expand the UTS, hardness, torsional quality and effect quality Al 6061 combination/TiO_2 is utilized by Kataiah [7]. In all the above diaries the mechanical property change of aluminum is achieved by utilizing metal composites. However, a similar property change

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could be realized by treatment of aluminum cryogenically.

It is discovered that Cryogenic Heat Treatment (CHT) influences the remaining pressure, mechanical properties, and precipitation of the Al 6061 compound in his paper Dae-Hoon Ko [8]. K. N. Pande [9] in his paper has clarified the cryogenic treatment of Polyamide at various temperatures (- 80, - 140 and - 185 oC) for stipulated day and age (4, 8, 12, 16, 20 and 24 h) in the cryostat. Mechanical properties like wear execution and tractable properties are assessed and found to have huge upgrades.

The cryogenic medications are given to enhance the mechanical properties. This paper by P. Nageswara Rao [10], talks about the hot rolling and frosty moving after cryogenic treatment. D. Frolich [11], in his paper clarifies the effect of applying cryogenic cooling, in realizing misshapening actuated α′-martensite in the (−196 °C) on microstructure and mechanical properties of AZ91 magnesium combination, Dry sliding wear tests were likewise connected and the wear protection of the amalgam enhanced astoundingly after profound cryogenic treatment. Kaveh [12], in his paper clarifies the profound cryogenic treatment of Thornton [13], The outcomes demonstrate a change in the wear rate of dim cast iron of 9.1 – 81.4% because of profound cryogenic treatment where huge wear has happened, in spite of the fact that there was no noteworthy surface layer expands the wear protection, contrasted with dry turned AISI 347, change in the mass hardness, network hardness or in the microstructure of the material under optical perception. Numerous examinations have been done on the component of cryogenic treatment of non-ferrous metals, for example, aluminum combinations [14, 15].

Despite the fact that numerous works have been completed already on different materials, this paper manages and Aluminum 6061 T6. These materials were taken into contemplations and dissected the wear properties remembering the utilizations of wear and tear that occurs in vehicle parts in unique conditions. Aluminum has a one of a kind mix of appealing properties, for example, its low weight, consumption protection, and simple support of definite item, have guaranteed that this metal and its compounds will be being used for quite a while. Subsequently, a cryogenic investigation has been done in this paper for these two evaluations of aluminum.

2. Experimental Procedure

2.1 Deep Cryogenic Treatment of Materials:

The cryogenic cooling approaches in material machining can be characterized into four gatherings as indicated by use of the cooling, backhanded cryogenic cooling or cryogenic device back cooling or conductive remote cooling and cryogenic fly or surge cooling by infusing the cryogenic liquid into the cutting zone. After cryogenic treatment, composites indicated bring down instrument wear rate.

The fluid nitrogen was gathered in a compartment of 20 liters limit and a weight pump of 2 lit/min limit was fitted to the holder. The spout of 3 mm measurement tip was associated with the half inch estimate plastic pipe and the opposite end of this pipe was fitted to the time was recorded for machining of 50 mm length by an accuracy stop watch. Cryogenic pre cooling of the workpiece or cutting apparatus, cryogenic chip. The weightpumpas appeared in Figure (1).

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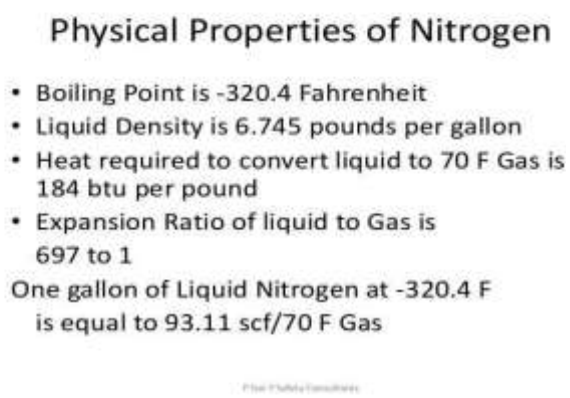

3. Experimental Result and Discussions

3.1 Wear Test:

The use of cryogenic treatment in enhancing mechanical properties of materials, particularly wear protection, has won as of late (Das et al., 2010a; Tyshchenko et al., 2010; Mohan Lal et al., 2001; Vimal et al

3.1.1 Pin On Disk Wear Test: Dry sliding wear test The measure of wear in any segment will, all in all, rely on various factors, for example, connected load, testing machine attributes, sliding velocity, sliding separation, condition and material properties. In this test, materials are tried in sets under ostensibly non-rough conditions. Before testing, the surface of the examples was cleaned by utilizing 1000 coarseness paper. Care was taken and the test surfaces were level and cleaned metallographically before testing. The measure of the stick is 10 mm in breadth and 30 mm long though the circle is 165 mm in distance across (En 31 plate 58-60 HRC) and thickness of 10 mm. The case profundity of 1 mm is given for both the test example. The stick is situated opposite and constrained against the spinning circle example with a required load. So the wear track on the plate is a circle, including different wear passes on a similar track. The variable speed engine in the machine makes the circle example spin about the plate focus and the plane of the circle is held on a level plane.

The dry test was led for the examples in three distinct burdens [Table 1] for examples treated with and without cryogenically treated pieces. The speed and load ranges were resolved considering the limit of the wear testing machine and the base measure of wear misfortune which could be estimated utilizing the measuring balance. The most extreme limit of the measuring balance utilized for estimating the wear misfortune is 250 g with an exactness of 0.001 g.

Table 1**:** Wear Rate under 500,1000 and 1500 rpm conducted at different loads for various duration.

RPM	**500**	**500**	**1000**	**1000**	**1500**	**800**
	With Cryogenic Treatment	**Without Cryogenic Treatment**	**With Cryogenic Treatment**	**Without Cryogenic Treatment**	**With Cryogenic Treatment**	**Without Cryogenic Treatment**
Hrs	*8*	*8*	*24*	*24*	*48*	*48*
Load 1	5.85	50	52	45	46.6	40
Load 2	73	68	72	61	64	55
Load 3	83	72	87	75	98	85

After each test the mass loss of stick was considered as the wear. Amid the test the temperature of the stick and circle interface was expanded extensively. In light of the preparatory examinations on the machine, wear test parameters were arrived, which are wear track breadth 10– 140 mm, sliding velocity extend 0.26– 12 m/s, circle turn speed.100 – 2000 rpm, and ordinary load up to 200 N. Subsequently tests were completed for three unique burdens (10, 20, and 30 N), for four distinct examples conditions all cryogenically treated [Al 6061 T6, Al 6061 T6] at three diverse rpm's (500, 1000, 1500). Wear comes about are acquired by directing test for a chose rpm and load. Every example was tried for length of 600 s before touching base at the weight reduction. The wear rate of each stick was figured from the weight reduction amid this test length. The measure of wear is dictated by estimating the example length when the tests.

A round and hollow example of size 10 mm breadth and 30 mm length was arranged and stacked in a PC interfaced stick on - circle wear testing rig. Preceding testing, the surface of the examples was cleaned metallographically by utilizing 1000 coarseness paper before testing. Care was taken that the test's end surfaces were level. The turning plate was made of EN 31 steel and hardness of 58-60 HRC. Destroy tests were conveyed at 25 °C room temperature and 60 % relative stickiness for 10 minutes. Wear misfortune was estimated by utilizing programming.

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Wear is a procedure of expulsion of material from either of two strong surfaces in strong state contact. Wear is dynamic harm, including material misfortune, happens at first glance because of relative movement between the surfaces. As the wear is a surface evacuation marvel and happens for the most part at external surfaces, it is more fitting and efficient to make surface change of existing compounds than utilizing the wear safe combinations. Dry sliding wear tests for various number of examples were led by utilizing a stick on-plate machine

Figure (2): Pin-on disc machine.

In any case, the well used surface turns out to be harsh at the overwhelming heap of 30 N, that is, evident plastic disfigurement and delamination went with a lot of breaks and cracked layers. Specifically, the ragged surface shows high hardness contrasted and the unworn surface demonstrating work solidifying. As the heaps increment, the composite bear higher contact pressure and result in plastic twisting.

3.1.2 Wear rate:

The wear rate is a standout amongst the most vital variables that control the life of a material in numerous building applications. In the Pin on circle wear test, wear rate can be characterized as the normal thickness expelled per cycle from the earliest starting point of the test to a specific number of cycles. That is, the hardness of the both compound and composites is impacted by the disengagement development in the substructure because of cryogenic treatment. The higher opportunity fixation is acquired by bringing down the temperature. This advances the bunching procedure and results in a better size of precipitation. The heap and rpm picked was most elevated among the three examples considered.

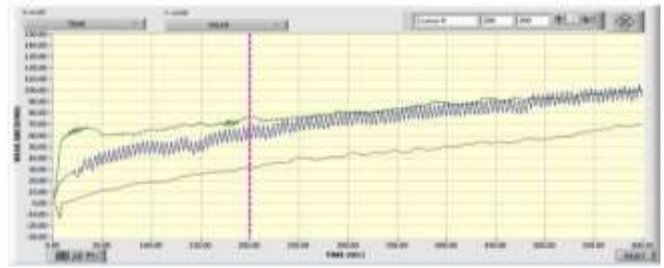

Fig 3(a): Wear test results taken for Al 6061 T6 specimen with and without cryogenic treatment.

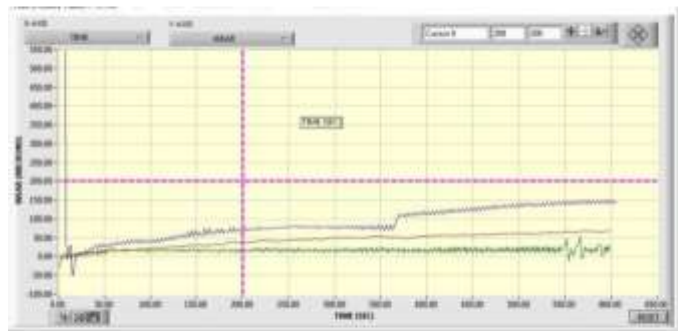

Fig 3(b): Wear test results taken for Al 6061 T6 specimen with and without cryogenic treatment.

One of the perusing among the few perusing and its demonstrates a diminishment in wear if the example is covered as in Figure (3a). At 600th Second the maximum wear is 70 microns for an example treated cryogenically. Be that as it may, the wear is 40 microns for an example covered with NiCoW. The outcomes because of cryogenic treatment demonstrates a sport diminishment of about 42% of wear. Figure (3b) demonstrates the wear comes about contrasted and examples without cryogenic treatment that gives a wear consequence of 120 microns. The change in wear rate is far higher than in cryogenic treatment. Effect of wear on course is managed in the papers [16 - 19].

4. Microstructural Investigation

The Aluminum example of two evaluations Al 6061T6 were cryogenically treated for 8 hrs, 24 hrs and 48 hrs, hardness and wear tried at heaps of 1, 2, 3 kg at velocities of 500, 1000, 1500 rpm. The microstructures of the examining electron magnifying lens (SEM) of the example in Figure (4a-d) gives the microstructure of the cryogenically treated aluminum example. The treated surface worn surface was broke down by a filtering electron magnifying instrument (SEM) with vitality dispersive X-beam (EDX) spectrometer.

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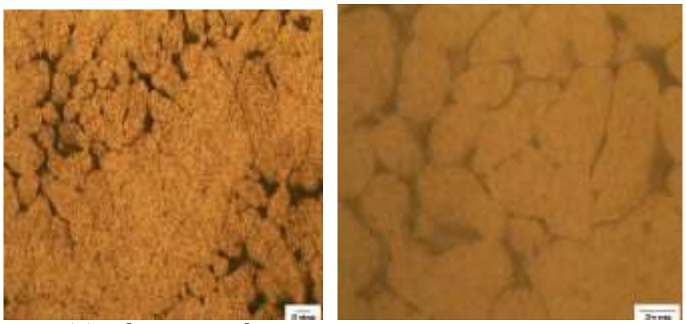

Fig 4(a):Al 6061 without cryogenic treatment
4(b): Al 6061 with cryogenic treatment

The Al composite with cryogenic encounters small scale slicing wear because of the scraped area among ill tempers of the contact surfaces. From the Images of SEM for 6061 T6 it is discovered that the cryogenically treated aluminum tests demonstrate the material with more noteworthy smallness and subsequently better surface wrap up. It is more composed and flawless in light of the fact that the atoms get improved amid cryogenic treatment.

5. Conclusions

1. The impact of cryogenic treatment on the hardness of Aluminum composite was considered in the present paper. The wear change is watched for each expansion of eight hours of cryogenic treatment. This expansion in wear protection is basically caused because of disengagement in particles and increment in thickness because of cooling at - 196°C.

2. During the cryogenic treatment the lower the temperature and longer the splashing time, the outcomes demonstrate an expansion in hardness with increment in the cryogenic treatment hours and better wear protection properties.

References

[1] M. V. Zernin, A. V. Mishin, N. N. Rybkin, S. V. Shil'ko, Journal of Friction and Wear 35/5 (2014) 396 – 406.

[2] V. M. Aleksandrov, E. A. Gubareva, Journal of Friction and Wear, 28/3 (2007) 239 – 245.

[3] M. V. Chernets, Journal of Friction and Wear 36/2 (2015) 163 – 169.

[4] M. V. Chernets, Journal of Friction and Wear 36/2 (2015) 163 – 169.

[5] G. S. Kataiah, D. P.Girish, International Journal of Pharmaceutical Studies and Research IJPSR/Vol. I/ Issue I/July-September, (2010) 17 – 25.

[6] Dae-Hoon Ko, Dae-Cheol Ko, Hak-Jin Lim, Jung-Min Lee, Byung-Min Kim, Journal of Mechanical Science and Technology, 27/7 (2013) 1949 – 1955.

[7] K. N. Pande, D. R. Peshwe, Anupama Kumar, Trans. Indian Inst. Met. 65/3 (2012) 313 – 319.

[8] P. Nageswara rao, R. Jayaganthan, Materials & Design 39 (2012) 226 – 233.

[9] D. Frölich, B. Magyar, B. Sauer, P. Mayer, B. Kirsch, J. C. Aurich, R. Skorupski, M. Smaga, T. Beck, D. Eifler, Wear 328–329 (2015) 123 – 131.

[10] Kaveh Meshinchi Asl, Alireza Tari, Farzad Khomamizadeh, Materials Science and Engineering A 523/1–2 (2009) 27 – 31.

[11] R. Thornton, T. Slatter, A. H. Jones, R. Lewis, Wear 271/9-10 (2011) 2386 – 2395.

[12] J. J. Wang, X. X. Xue, Z. Q. Yang, H. Zhang, Y. Zhou, Adv. Mat. Res. 1646 (2011) 1646 – 1650.

[13] Q. C. Wang, Y. L. Ke, J. Zhejiang Univ. Sci. A. 37 (2003) 748 – 754.

[14] Yuan-zhi Zhu, Qiang Wan, Bing-liang Li, Feng Zhou, Ya-feng Zhang, Transactions of Non Ferrous Metals Society of China, 24/2 (2014) 477 - 483.

[15] Fabio Grosselle, Giulio Timelli, Franco Bonollo, Material Science and Engineering A, 527/15 (2010) 3536 – 3545.

[16] Yi Meng, Jianzhong Cui, Zhihao Zhao, Lizi He, Materials Characterization 92 (2014) 138 - 148.

[17] Zuqi Hu, Li Wan, Shusen Wu, Han Wu, Xueqiang Liu, Materials & Design 46 (2013) 451 - 456.

[18] N. Nafsin, H. M. M. A. Rashed, International Journal of Engineering and Advanced Technology *(IJEAT)* ISSN: 2249-8958, 2/5 (2013).

[19] Dunia Abdul Saheb, ARPN Journal of Engineering and Applied Sciences 6/10 (2011).