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Reduction of Tool Wear by Using Aluminium Oxide Nano Particles with Experimental Analysis

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ABSTRACT

The purpose of this paper is to find the cutting forces, cutting temperatures, surface finish and tool wear of the samples of aluminium oxide nano particles are measured during the machining under constant cutting conditions, using HSS. In Al2o3 content are formulated and used in machining. In the present work, cooling abilities of the fluid are assessed by the carrying out machining tests using the fluids with and without nano particles (aluminum Nano tube) inclusions, such as 1%, 2%, and 3% nano particles. The wear test of the cutting tool conducted on pin on disk machine. Hence, it has constantly been the drive to device techniques for reducing friction and temperatures associated with metal cutting. Nano fluids are engineered colloidal suspensions of nano particles (1-100 nm) in a base fluid. The applicability of the fluids as coolants is mainly due to the enhanced thermal conductivity of the fluids due to the solid particle inclusion.

KEYWORDS: Al2o3, Nano fluids, disk machine, thermal conductivity, tool wear and cutting force.

1.0 INTRODUCTION

Nanoscale materials are defined as a set of substances where at least one dimension is less than approximately 100 nanometers. A nanometer is one millionth of a millimeter - approximately 1,00,000 times smaller than the diameter of a human hair. Nanomaterials are of interest because at this scale unique optical, magnetic, electrical and other properties emerge. These emergent properties have the potential for great impacts in electronics, medicine and other fields. The objectives are 1. To prepare high viscosity and low vapour pressure lubricant. 2. To minimize number of oil changes. 3. To improve the performance of lubricant. 4. To increase the machine parts life. 5. To prepare eco friendly lubrication oil. 6. To improve the easy to handling. 7. To reduce the operation time of lubricant. 8. Totally to get more effective Nano lubricant oil.

1.1 THE NEED OF LUBRICANT

The primary purpose of a lubricant is to separate these contacting surfaces and thereby reduce friction and wear. They may in addition, act as a cooling medium or as protection from corrosion.

1.2 ALUMINUM OXIDE NANOPARTICLES

Aluminum oxide is an amphoteric oxide with the chemical formula Al_2O_3. It is commonly referred to as alumina (α-alumina), or corundum in its crystalline form, as well as many other names, reflecting its widespread occurrence in nature and industry. Its most significant use is in the production of aluminum metal, although it is also used as an abrasive owing to its hardness and as a refractory material owing to its high melting point. Pure aluminum is light, nontoxic and non-sparking. It can be easily formed, machined or cast.

Table 1: Properties of Aluminum Oxide Nanoparticles.

Molecular formula	Al_2O_3
Molar mass	101.96 g mol^{-1}
Appearance	white solid
Solubility in water	Insoluble
Density	3.95–4.1 g/cm^3
Melting point	2072 °C
Boiling point	2977 °C
Thermal conductivity	30 $W{\cdot}m^{-1}{\cdot}K^{-1}$

Aluminum oxide is an atmospheric oxide with the chemical formula Al2O3. It is commonly referred to as alumina (α-alumina), or corundum in its crystalline form, as well as many other names, reflecting its widespread occurrence in nature and industry. Its most significant use is in the production of aluminum metal, although it is also used as an abrasive owing to its hardness and as a refractory material owing to its high melting point. Pure aluminum is light, nontoxic and non-sparking. It can be easily formed, machined or cast.

2.0 EXPERIMENTAL PROCEDURE
2.1 MATERIAL SPECIFICATION
Diameter = 6mm.
Length = 20mm.
Volume = $120m^3$.
Chemical formula:
Fe, <0.15% C, 11.0-13.5% Cr, <1.0% Mn, <1.0% Si, <0.04% P, >0.03%S

It contains a minimum of 12% chromium, just sufficient to give corrosion resistance properties.

Table 2: Material Composition.

GRADE		C	Mn	Si	P	S	Cr	Mo	Ni	N
	min	-	-	-	-	-	11.5	-	-	0.75
	max	0.15	1.00	1.00	0.040	0.030	13.5	-	-	0.75

Table 3: Mechanical properties of Aluminum Oxide Nano particles.

Tempering Temperature (ºC)	Tensile Strength (MPa)	Yield Strength0.2% proof (MPa)	Elongation (%in 50mm)	Hardness Brinell (HB)	Impact Charpy V(J)
Annealed	480 min	275min	16min	-	-
316	1240	960	14	325	36
538	985	730	16	321	52
650	755	575	23	225	80

2.2 PHYSICAL PROPERTIES
Density (kg/m3) - 7750
Elastic modulus (GPa) - 200
Mean coefficient of thermal
Expansion (mm/m/ºc0-100ºC - 9.9
Thermal Conductivity (W/m.K) 100ºC - 24.9
Specific Heat (J/kg.K) 100ºC - 460

2.3 PIN ON DISC MACHINE PROCEDURE
The test set up used in this investigation was pin-on-pin wear test apparatus. The test pin 6 mm dia and height 20 mm. The surface of the specimen comes in contact with the mirror finishing surface of hardness 410 SS, the mirror finishing surface used in the present work is an alloy steel pin having dimensions of 6 mm diameter. The test was conducted on a track of 100 mm diameter for a specified test duration, applied load and sliding velocity. First the test specimen surface was prepared as per standard lubricant procedure. The surfaces of both the pin and the pin were cleaned with emery sheet before the test.

The initial weight of the pin assembly was recorded accurately using a digital electronic balance of least count 4.157 g. After fixing both the pin and the pin in their respective positions, the 5kg load to the pin was applied through a pivoted loading lever with a string and pan assembly. The required loads were applied by placing known weights on the pan. The tests were conducted by selecting the test duration applied load and sliding velocity.

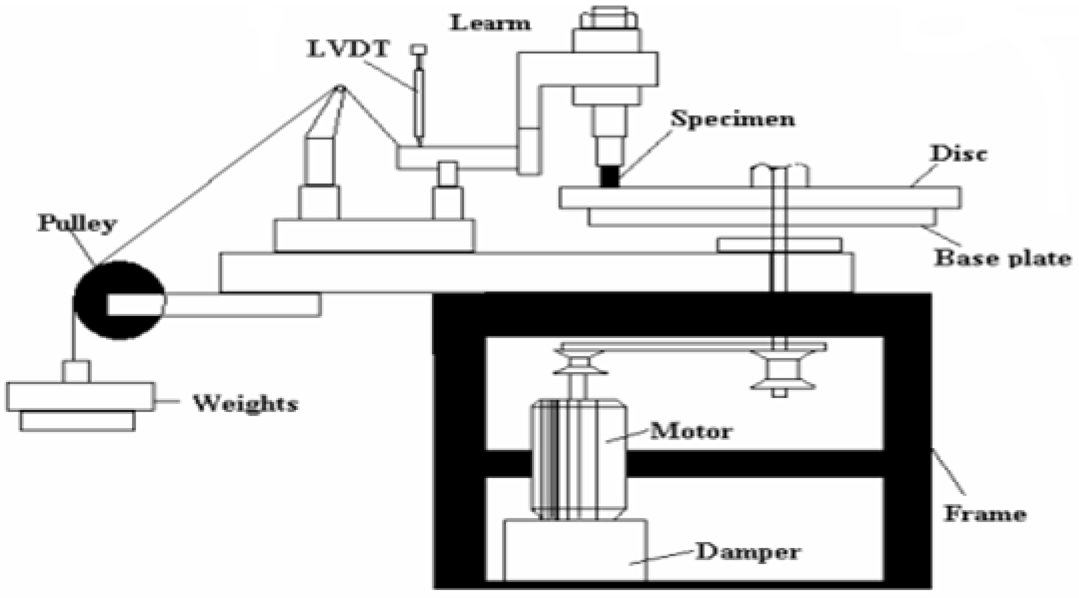

Figure 1: A Experimental Setup of the Pin-on-disc test apparatus

The tests were conducted on with temperature and without temperatures. The end of the test, the pin assembly was again weighed in the same balance and difference was taken as weight loss. The test parameters used in the present study are applied load, sliding velocity and sliding distance. The test load is 5kg is constant to all loads. A minimum of two temperature trials were conducted to ensure repeatability of test data.

The repeatability of wear test runs was established by determining the coefficient of friction which was well within the acceptable limit of 10%. The tests were conducted in five phases, in first phase dry test is take on machine at 40ºc and 200cº.during second phase load value constant, sliding distance is constant and lubricant is added this test. During third phase lubricant with 1% nanoparticles added to this test.

During fourth phase lubricant with 2% nanoparticles added to this test. During final phase lubricant with 3% nanoparticles added this test.

2.4 FORMULAS USED

Wear loss = (wear volume)/ (load * sliding distance), μ = frictional force / (normal force).

3.0 EXPERIMENTAL OBSERVATIONS

Table 4 : Lubricant with Out Al_2O_3

40°C					200°C				
Time	**Wear**	**Time**	**Wear**	**Time**	**Wear**	**Time**	**Wear**	**Time**	**Wear**
0.9800	1.3700	0.9800	1.3700	0.9800	1.3700	0.9800	1.3700	0.9800	1.3700
30.3840	540.6100	30.3840	540.6100	30.3840	540.6100	30.3840	540.6100	30.3840	540.6100
70.5710	555.1100	70.5710	555.1100	70.5710	555.1100	70.5710	555.1100	70.5710	555.1100
110.7560	561.3700	110.7560	561.3700	110.7560	561.3700	110.7560	561.3700	110.7560	561.3700
140.1610	564.2100	140.1610	564.2100	140.1610	564.2100	140.1610	564.2100	140.1610	564.2100

Table 5: Lubricant only.

40°C					200°C				
Time	**Wear**	**Frictional force**	**Coefficient of friction**	**Wear loss**	**Time**	**Wear**	**Frictional force**	**Coefficient of friction**	**Wear loss**
0.9800	0.4300	0.0500	0.0010	0.0877	0.9810	-1.0100	3.2000	0.0652	-0.2059
30.3840	455.210	18.8400	0.3841	92.8053	30.385	629.330	12.420	0.2532	128.303
70.5720	653.630	8.1800	0.1668	133.257	70.571	1115.11	10.760	0.2194	227.341
110.000	734.460	8.2100	0.1674	149.737	110.75	881.070	9.3700	0.1910	179.626
140.164	777.770	6.7000	0.1366	158.566	140.16	968.640	8.5900	0.1751	197.480

Table 6: Lubricant with 1% Nano particles.

40°C					200°C				
Time	Wear	Frictional force	Coefficient of friction	Wear loss	Time	Wear	Frictional force	Coefficient of friction	Wear loss
0.9800	3.1700	7.0200	0.1431	0.6463	0.9800	1.0800	0.0100	0.0002	-0.2202
30.3850	460.2100	6.0700	0.0014	98.395	30.3850	600.900	6.2900	0.1282	155.361
70.5710	421.360	5.6500	0.0133	87.841	70.5720	546.440	5.6000	0.1142	141.985
110.758	400.120	4.7500	0.0153	50.828	110.7580	518.680	5.4700	0.1115	132.636
140.161	350.870	3.7800	0.0159	41.543	140.1640	482.430	5.4000	0.1101	130.516

Table 7: Lubricant with 2% Nano particles.

40°C					200°C				
Time	Wear	Frictional force	Coefficient of friction	Wear loss	Time	Wear	Frictional force	Coefficient of friction	Wear loss
0.9100	224.520	1.3300	0.0271	45.7737	0.9800	-0.4000	0.4100	0.0084	-0.0815
30.0140	412.710	15.110	0.3081	90.077	30.3850	658.290	7.6200	0.1554	146.774
70.9390	400.550	13.300	0.2712	85.388	70.5720	521.360	5.1000	0.1040	126.291
110.046	370.970	12.400	0.2528	78.635	110.758	454.920	4.7800	0.0975	113.520
140.057	340.022	4.2300	0.0862	50.849	140.162	419.910	4.9300	0.1005	98.770

Table 8: Lubricant with 3% Nano particles.

40°C					200°C				
Time	Wear	Frictional force	Coefficient of friction	Wear loss	Time	Wear	Frictional force	Coefficient of friction	Wear loss
0.9810	1.2000	-0.2400	-0.0049	0.2446	0.9800	0.4700	2.8600	0.0583	0.0958
30.3840	450.0600	12.540	0.2557	87.178	30.3830	587.7000	11.640	0.2373	150.041
70.5710	420.770	10.790	0.2200	80.901	70.5700	545.3300	11.100	0.2263	141.952
110.756	345.010	10.330	0.2106	64.082	110.755	490.300	10.780	0.2198	121.074
140.159	310.119	9.2224	0.1880	51.362	140.160	410.370	10.730	0.2188	86.651

3.1 COMPARISON OF EXPERIMENTAL VALUES

Table 9: Comparison of Experimental Values.

Lubricant type	40°C		200°C	
Without lubricant	Wear	564.210	Wear	458.9600
	Frictional force	17.4300	Frictional force	16.3400
	Coefficient of friction	0.3554	Co efficient of friction	0.3331
	Wear loss	115.0275	Wear loss	93.5698
Lubricant only	Wear	777.770	Wear	968.640
	Frictional force	6.7000	Frictional force	8.5900
	Coefficient of friction	0.1366	Coefficient of friction	0.1751
	Wear loss	158.566	Wear loss	197.480
Lubricant with 1% nanoparticles	Wear	350.870	Wear	482.430
	Frictional force	3.7800	Frictional force	5.4000
	Coefficient of friction	0.0159	Coefficient of friction	0.1101
	Wear loss	41.543	Wear loss	130.516
Lubricant with 2% Nanoparticles	Wear	340.022	Wear	419.910
	Frictional force	4.2300	Frictional force	4.9300
	Coefficient of friction	0.0862	Coefficient of friction	0.1005
	Wear loss	50.849	Wear loss	98.770
Lubricant with 3% Nanoparticles	Wear	310.119	Wear	410.370
	Frictional force	9.2224	Frictional force	10.730
	Coefficient of friction	0.1880	Coefficient of friction	0.2188
	Wear loss	51.362	Wear loss	86.651

3.2 Frictional Coefficient Vs Time at 40°c &200°c, under 50 N load and Sliding velocity 2.5 m/s

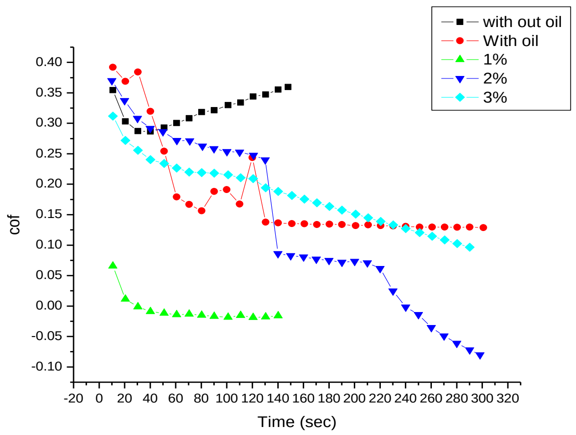

Figure 2: Frictional coefficient Vs Time at 40^{o}c, under 50 N load and Sliding velocity 2.5 m/s.

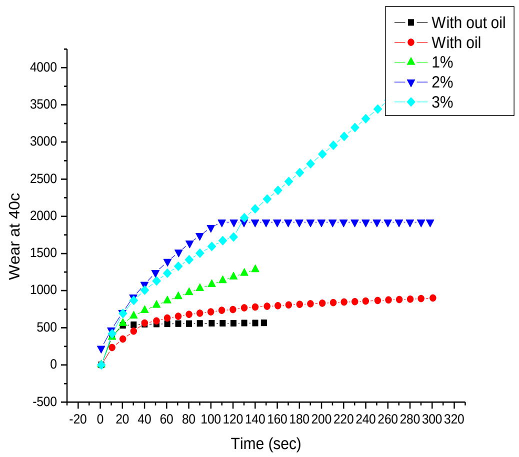

Figure 3: Frictional coefficient Vs Time at 200^{o}c.

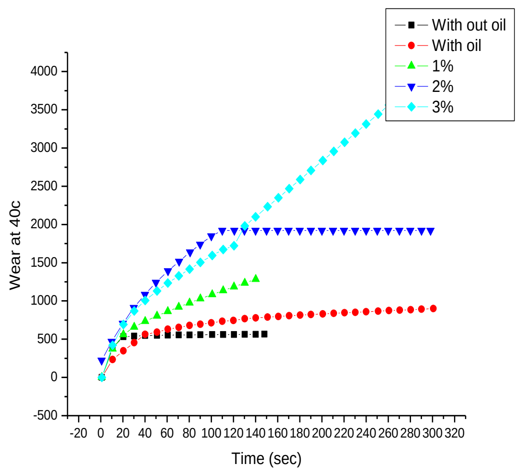

Figure 4: Wear loss Vs Time at 40^{o}c.

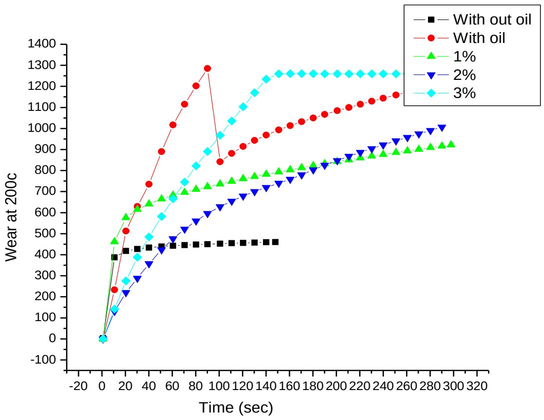

Figure 5: Wear loss Vs Time at 200^{o}c,

3.4 SEM RESULTS :

This test was conducted on a scanning electron microscope at specified test duration sample and wear tested materials are taken. First work piece is fixed on the machine at one stage. Then closed door. The high vacuum is created on the material the material wear areas are showed on image. The results are displayed by computer.

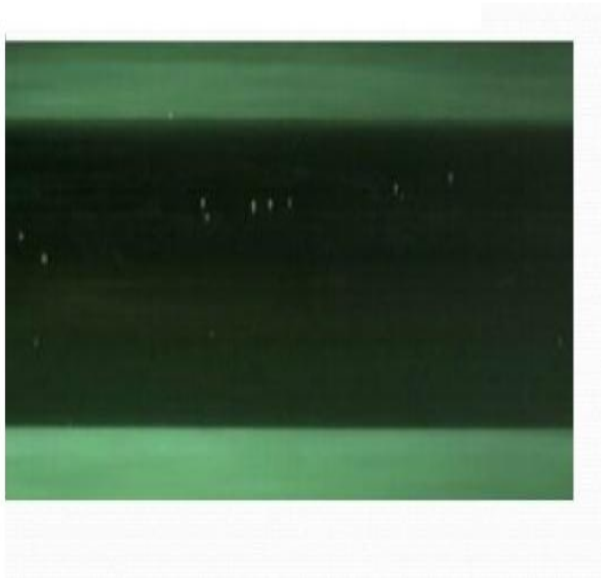

Figure 6: SEM results for without Nanoparticles

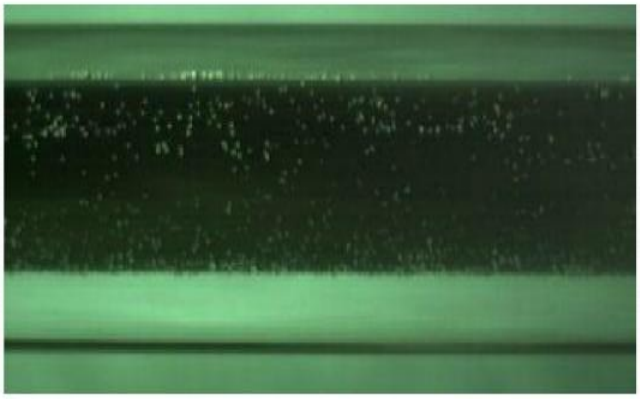

Figure 7: SEM results for 1% Nanoparticles

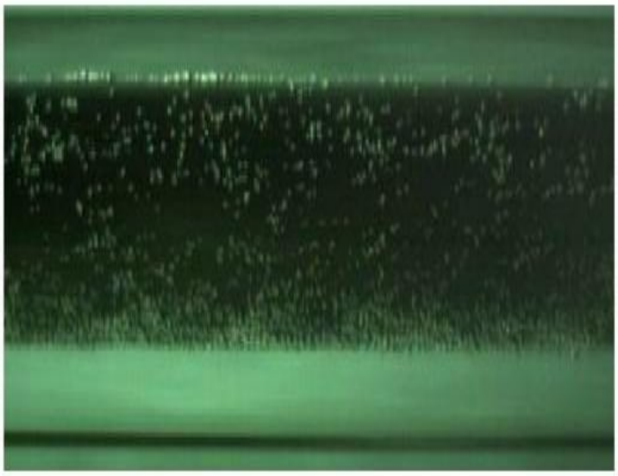

Figure 8: SEM results for 2% Nanoparticles

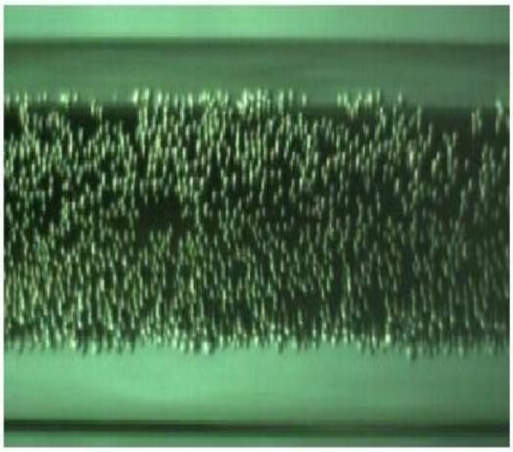

Figure 9: SEM results for 3% Nanoparticles

4.0 CONCLUSION:

Friction coefficient, frictional force is decreased while the test then Wear also decreased by with lubricant and nano particles. Whereas different applied load and sliding distance is kept constant at all stages. During second stage applied load is same, but wear is decreased and sliding distance is kept constant. The third phase wear is decreased and sliding distance is kept constant because the abrasive particles are heated during the operation, while the lubricants passing the abrasive particles are gets cooled, so the abrasive particles gets harden due to heat and cooled process, so the toolwear of the sample pin is less compare with without lubricant,with lubricant, 1% nano particles of with lubricant, 2% nano particles of with lubricant, 3% of nano particles with lubricant.

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