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Determination of friction coefficient and wear behaviour of AL6061-T6 at varying sliding speed against 100cr Steel

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Abstract
The tribological behaviour of Al 6061 at a constant load and varying sliding speeds was investigated experimentally using CSM made pin on disc high temperature Tribometer apparatus. The tests were carried out using at a constant load of 2N and varying sliding speeds of 2 $cmsec^{-1}$, 4 $cmsec^{-1}$, 6 $cmsec^{-1}$ and 8$cmsec^{-1}$ respectively. Another test were carried out at a constant load of 2N, constant sliding speed of 2cmsec-1 and temperature of 100 ºC temperature. Effect of different sliding speed on rubbing surface was investigated. Optical microscope were used in order to study the wear Track of the samples. The depth of penetration of 100Cr steel ball into the disc at all speeds and temperature was noted. It has been found that friction coefficient decrease with the increase of sliding velocity and it increases with the increase of temperature.

Keywords: Al 6061, Tribological behaviour, coefficient of friction, wear rate

1. Introduction
Wear exist in almost in all engineering systems involving contacting motion and in most cases it determine the service life of the systems. Aluminium is the most abundant metal found on the earth. It have good corrosion resistant and and have a good formability and weldability [1]. Numerous investigations have been carried out by different researchers in the past few years and they found that tribological properties depend on different parameters like Normal load, sliding velocity, sliding distance, surface roughness, temperature, chemical compositions of materials, geometry of contracting surface, vibrations, environment, lubrication etc. Very few of the parameters involved during wear process have been considered as a factors during investigations that is the reason of little progress have been made towards modeling of wear process. Among the different parameters sliding velocity and temperature plays an important role for coefficient of friction variation. Amanov *et al*. [2] shown in his investigation that friction coefficient and wear rate of ultrasonic nanocrystalline surface modification (UNSM) treated specimen of Al6061-T6 reduced by 25 % and 20 % respectively compared with UNSM free specimen. Wilson *et al*. [3] tested the high temperature dry sliding wear behaviour of Al (A356)/SiC, Al (A356)/(SiC+ Graphite) and Al(6061)/Al2O3 composite and reported addition of ceramic particles enhances the seizure resistance of the composite at higher temperature compared to pure alloy. Shipway *et al*. [4] in his investigation with Al-4Cu/TiC, Al (A356)/TiC, and Al (pure)/TiC composite reported that the influence of load and TiC content on the dry sliding wear behavior. Al 6063 is mainly used for architectural fabrication, window and door frames, pipe and tubing and aluminium furniture. Sivaprasad *et al*. [5] examined the wear characteristics of the as-cast Al (6063)/Tib2 in-situ composite and reported that the abrasive wear rate of the composite decreases with increase in weight percent of Tib2 particles and wear resistance decreases with increase in load. He also revealed that as weight percent of Tib2 particles increases the volume losses decreases and with increase in distance traversed the volume losses increases. Al 6063 is highly weldable using tungsten inert gas welding. Kumar *et al*. [6] in his experiment with Al6061T6 reinforced with silicon carbide and alumina oxide particles (10%weight percentage of SiC and Al2O3 particles) and found that sliding distance has the highest tribological influence followed by applied load and sliding speed respectively. Moreno-Valle *et al*. [1] also demonstrated that the severe plastic deformation (SPD) method can be successfully utilized for grain refinement of Al alloys down to an ultra-fine scale. Surface mechanical attrition treatment (SMAT) was also developed to increase the strength and for the improvement of the tribological properties of metals [7-10] and alloys [11-14] by creating a nanocrystalline structure harnessing shot peening and milling ball impact processes. Amanov *et al*. studied a comparative [2] specimens and found that the effects of the UNSM technique were advantageous for improving the accelerated fatigue nature and some mechanical properties of Al6061–T6 alloy. It was also found that the fatigue lifetime of the UNSM-treated specimens significantly prolonged and the S–N curve shifted by about 30% towards higher stress levels compared to that of the UNSM-free specimen, which may be attributed to the improved mechanical properties and generated NCSL. Through description and theoretical background of the UNSM technique can be found in publications [15, 16]. The objective of the present investigation is to evaluate the dry sliding metal to metal behavior of Al 6063 against a steel ball. The effect of applied load and varying sliding speed on the dry sliding metal-metal wear and friction behaviour of aluminium alloys was investigated using a CSM made pin-on-disk tribometer.

The wear track left on the sample was observed under an optical microscope to determine the wear track widths shown in Fig. 4-7. From the graph obtained from the tests the depth of penetration was also noted.

Table 1: Chemical composition of AL6061

Elements	Percentage
Si	0.2-0.6 %
Fe	0.35 %
Cu	0.1 %
MN	0.1 %
Mg	0.45-0.9 %
Cr	0.1 %
Zn	0.1 %
Ti	0.1 %
Others	0.15 %
Al	Remainder

2. Experimental Setup and Methodology

The equipment used for this investigation was a pin-on-disk tribometer (CSM Tribometer). The pin used is actually a ball of diameter 6mm.The wear track radius is set varied for all grades of aluminium. The test samples are first finished by emery paper of grit size of 600, 1000, 1200 and 2000 respectively. Dry sliding test were then run on the samples keeping the load constant at 2N and varying the sliding speed from 2 cm/sec to 8 cm/sec. The sliding distance for each sliding test is kept fixed at 30 m. The temperature during the tests was 20-25^{0}C and relative humidity was 72%. The test duration varied according to the sliding speeds. For every sample test the instrument was calibrated and for each parameters variation is made by the computer which was attached with the tribometer which gives the value for friction coefficient and wear penetration upon each successful test.

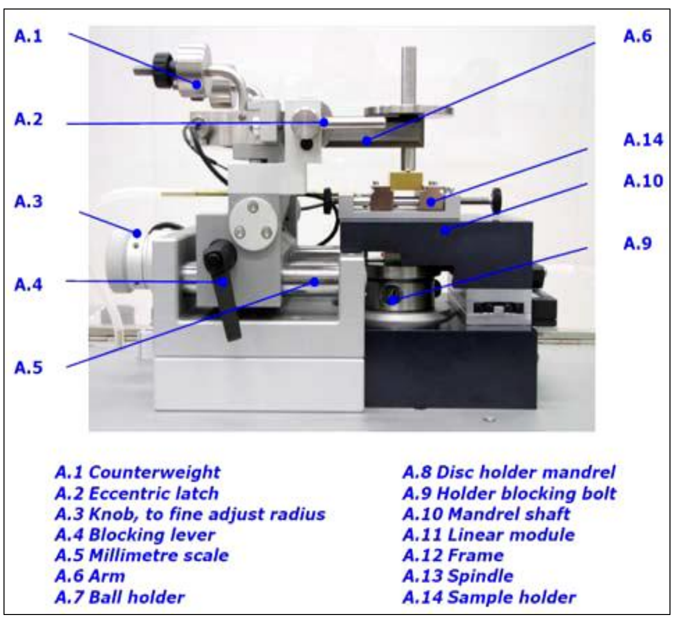

Fig 3: Schematic Diagram of Pin on Disk Tribometer

3. Results and Discussion

Sliding distance (m) vs. Coefficient of friction graph was plotted showing the relation between the coefficient of friction and different sliding speeds for Al 6063. From Fig. 2 it can be seen the coefficient of friction for Al 6063 at different sliding speed and sliding distance. At all speeds it can be seen that initially there is a sharp increase in the coefficient of friction which can be attributed to the ball trying to overcome the static friction right when the sliding starts. It can also be said that when sliding starts the load gets applied on the sample in a sudden manner causing the two sliding surfaces to interlock with each other increasing the friction between the two surfaces. After the initial steep increase, the coefficient of friction can be observed decreasing gradually for all speeds except at 8cm/sec. This can be attributed to a variety of reasons. One of them might be that during sliding, as the two surfaces rub against each other, adhesive wear may take place causing particles to break off from the surface of the sample and adhere to the surface of the ball. This might lead to sudden increases or decrease in the coefficient of friction as can be evident by the zig-zag pattern of the lines in the graph. But as these particles increase in amount they begin to get flattened against the surfaces and slowly start forming an oxide layer which reduces the contact between the two surfaces and hence the gradual decrease in the coefficient of friction. Also again the oxide layer that was formed may break down due to sliding resulting in the formation of more particles. This cycle of particle formation and subsequent oxide layer formation might be the reason for the coefficient of friction being uniform or stable towards the end of the sliding tests.

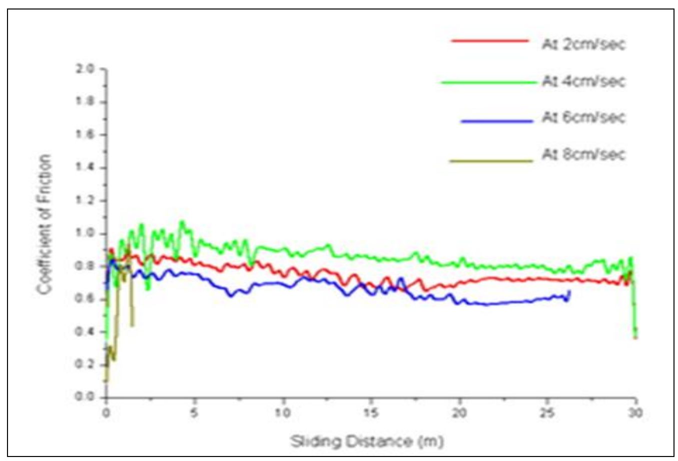

Fig 2: Variation of Coefficient of friction Vs Sliding speed at different speed

Another observation that can be made from the Fig. 2 that Al 6063 at 6cm/sec shows the lowest coefficient of friction. The reason for this might be that at higher speeds the sliding surfaces come in contact with each other for a lesser amount of time compared to the contact time at lower speeds. As such the momentum due to the comparatively higher sliding velocity would overcome the frictional force generated and hence, reduced coefficient of friction.

Also from the graph it can be seen that coefficient of friction tests on Al6063 at 8cm/sec could be carried out only partially as evident from the graph showing the coefficient of friction only up to a distance of approximately 2.5m after this distance the coefficient of friction exceeds threshold friction and the tests stops. This can be attributed to the fact that the coefficient of friction during testing could have exceeded the threshold coefficient of friction set in the tribometer software. The reason for this cannot be determined until and scanning electron microscope (SEM) analysis is carried out. Fig. 3 shows the wear rate for Al6063 at different speed. Wear rate of Al6063 running at 6 cm/s is minimum which can be clearly seen in Fig. 3 since the coefficient of friction is minimum for sample running at 6 cm/s sliding speed. Wear rate is maximum for sample with test of 8 cm/s sliding speed which can be evident from Fig. 2 that coefficient of friction for this speed may go higher than the threshold value of friction. Sample at 4 cm/s test shows higher wear rate and is clear from Fig. 3 because of higher coefficient of friction shown in Fig. 2. Sample running at speed of 2 cm/s has the intermediate wear rate as can be seen in Fig. 3 and is also evident from the coefficient of friction value from Fig. 2.

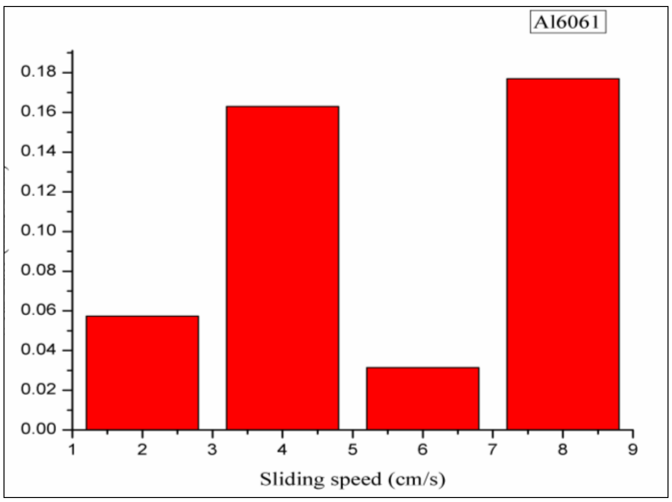

Fig 3: Wear rate of Al6063 at different speed

Fig. 4(a-d) show the various track widths on the Al 6063 sample at 2cm/sec obtained from optical microscope. The track width can be obtained by adding the 4 track widths obtained and dividing by 4. From this value, the wear rate can be calculated.

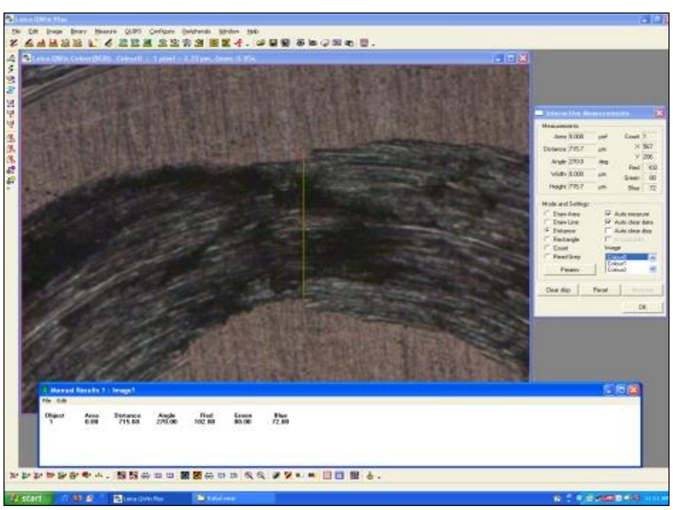

Fig 4a: Track widths on the Al 6063 at 2cm/sec

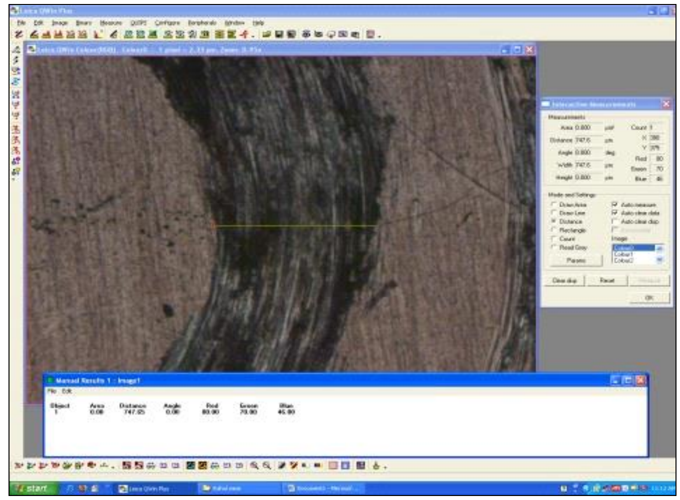

Fig 4b: Track widths on the Al 6063 at 2cm/sec

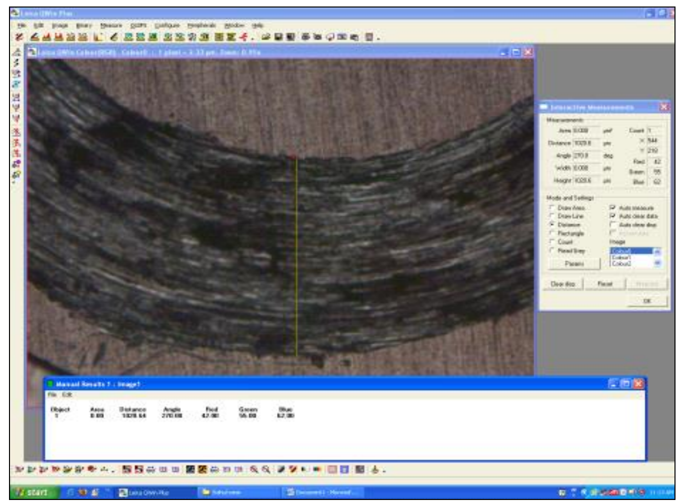

Fig 4c: Track widths on the Al 6063 at 2cm/sec

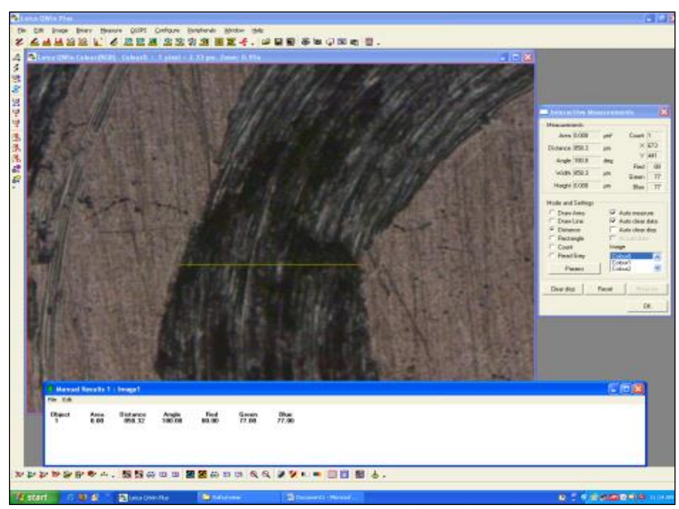

Fig 4d: Track widths on the Al 6063 at 2cm/sec

Fig. 5(a-d) show the various track widths on the Al 6063 sample at 4cm/sec obtained from optical microscope. The track width can be obtained by adding the 4 track widths obtained and dividing by 4. From this value, the wear rate can be calculated flow.

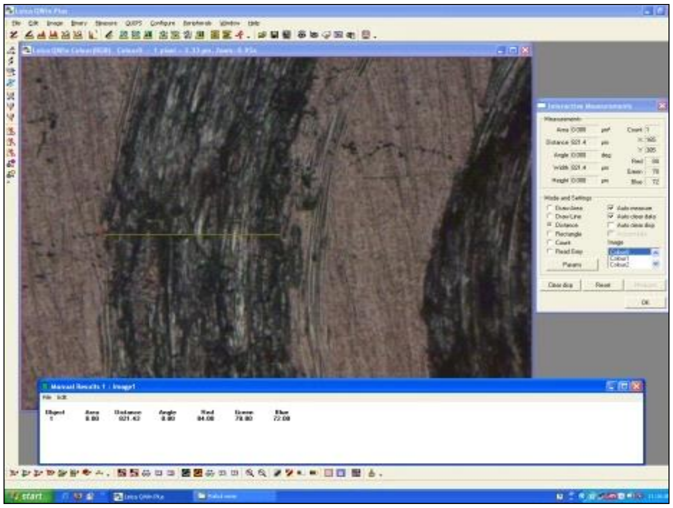

Fig 5a: Track widths on the Al 6063 at 4cm/sec

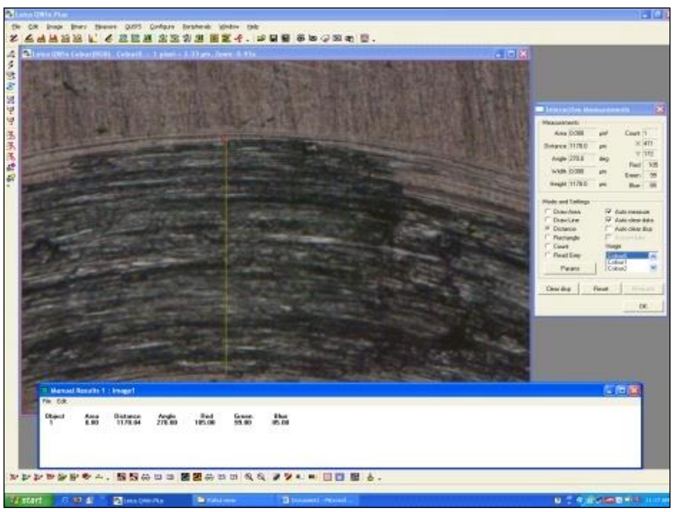

Fig 5b: Track widths on the Al 6063 at 4cm/sec

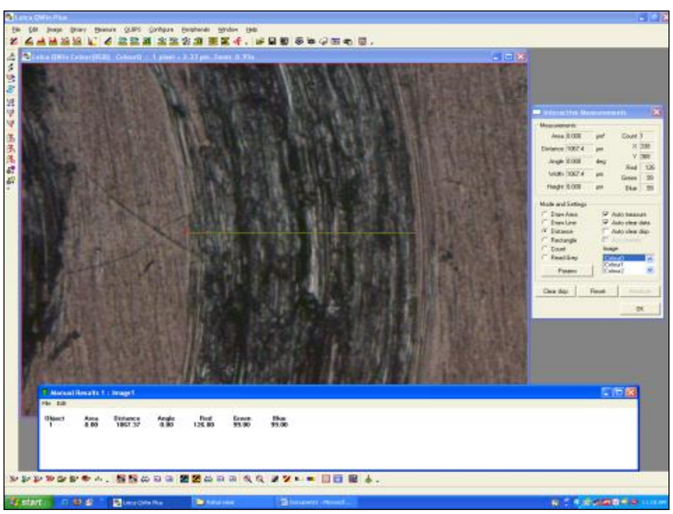

Fig 5c: Track widths on the Al 6063 at 4cm/sec

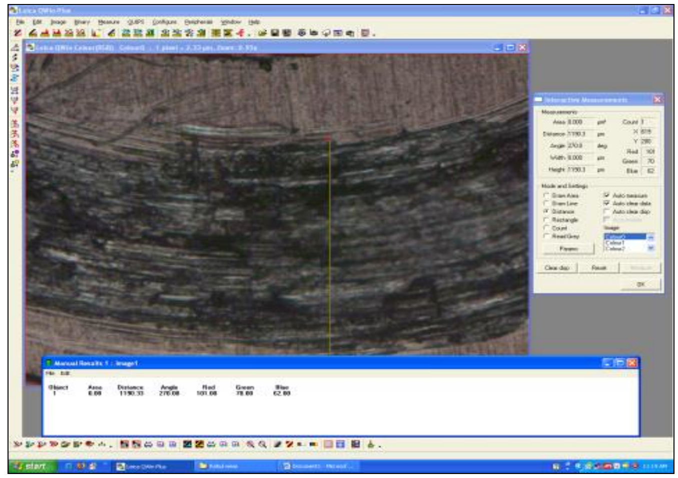

Fig 5d: Track widths on the Al 6063 at 4cm/sec

Fig. 6(a-d) show the various track widths on the Al 6063 sample at 6cm/sec obtained from optical microscope. The track width can be obtained by adding the 4 track widths obtained and dividing by 4. From this value, the wear rate can be calculated.

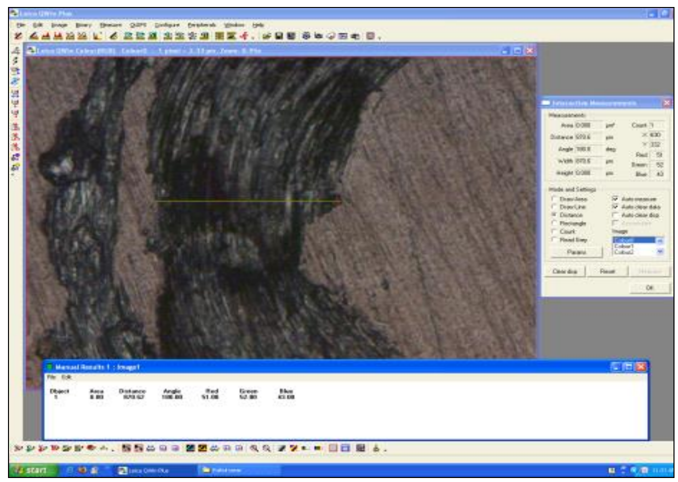

Fig 6a: Track widths on the Al 6063 at 6cm/sec

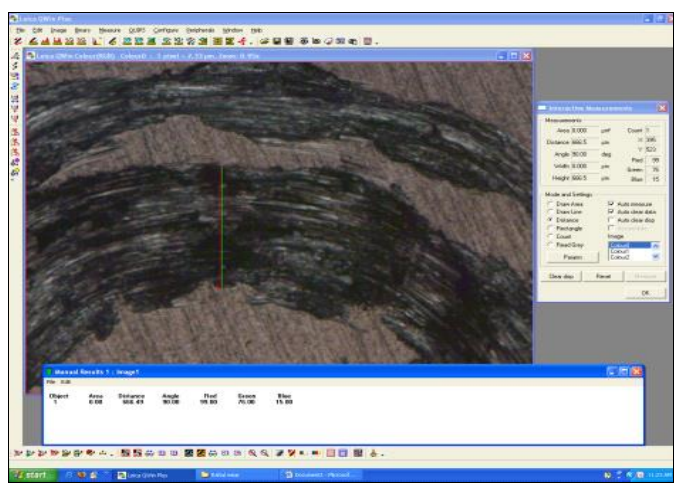

Fig 6b: Track widths on the Al 6063 at 6cm/sec

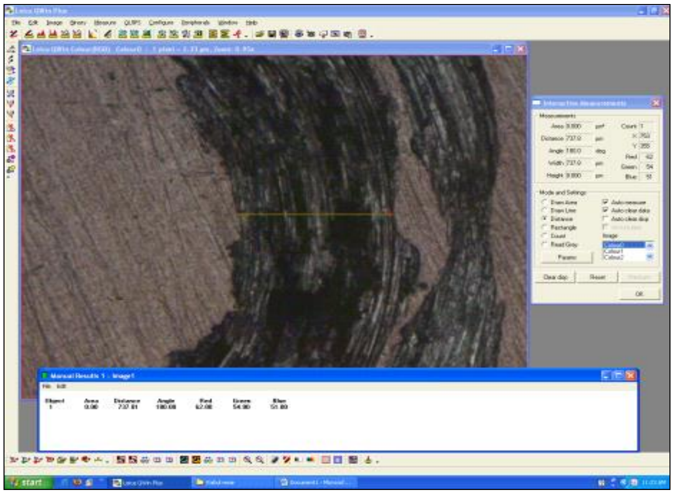

Fig 6c: Track widths on the Al 6063 at 6cm/sec

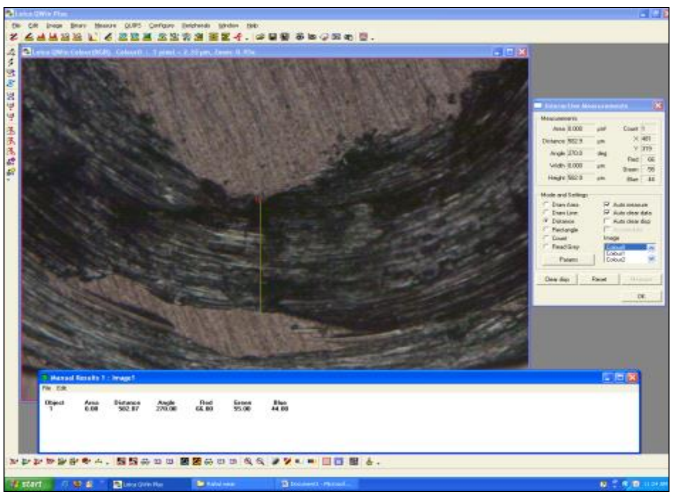

Fig 6d: Track widths on the Al 6063 at 6cm/sec

Fig. 7(a-d) show the various track widths on the Al 6063 sample at 8cm/sec obtained from optical microscope. The track width can be obtained by adding the 4 track widths obtained and dividing by 4. From this value, the wear rate can be calculated.

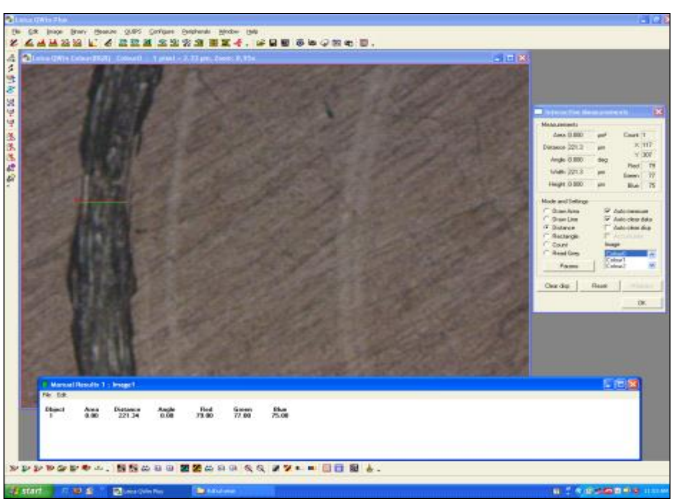

Fig 7a: Track widths on the Al 6063 at 8cm/sec

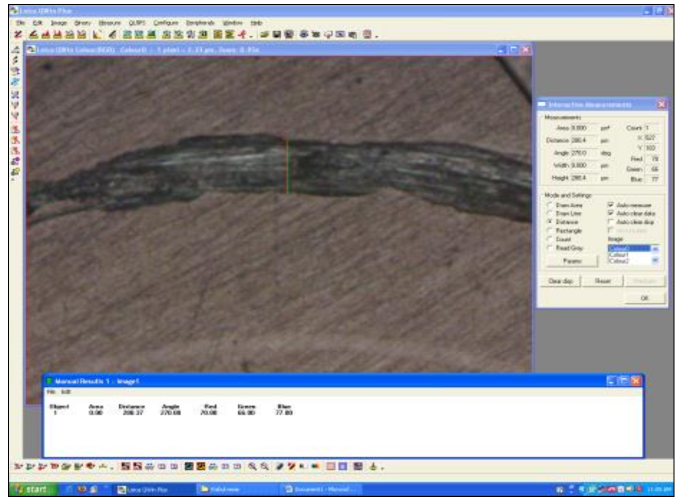

Fig 7b: Track widths on the Al 6063 at 8cm/sec

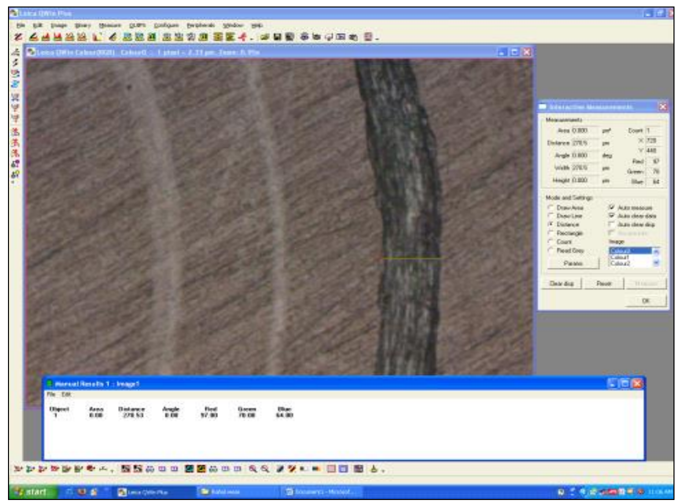

Fig 7c: Track widths on the Al 6063 at 8cm/sec

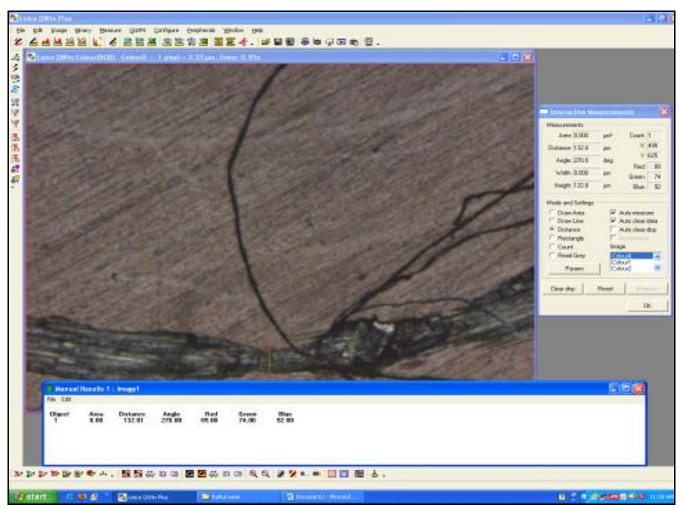

Fig 7d: Track widths on the Al 6063 at 8cm/sec

4. Conclusions

Al 6063-T6 grade aluminium was successfully tested for friction coefficient and wear rate for the different speed. It was found that at higher value of linear speed friction coefficient reduces and wear rate also reduces compared to lower speed. Sample with speed of 6cm/s shows the lowest frictional coefficient and wear rate.

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6. References

1. Moreno-Valle E, Sabirov I, Perez-Prado M, Murashkin MY, Bobruk E, Valiev R. Effect of the grain refinement via severe plastic deformation on strength properties and deformation behavior of an Al6061 alloy at room and cryogenic temperatures, Materials Letters. 2011; 65:2917-2919.
2. Amanov S, Sasaki D, Kim E, Penkov OV, Pyun YS. Improvement of the tribological properties of Al6061–T6 alloy under dry sliding conditions, Tribology International. 2013; 64:24-32.
3. Wilson S, Alpas A. Effect of temperature on the sliding wear performance of Al alloys and Al matrix composites, *Wear. 1996;* 196:270-278.
4. Shipway P, Kennedy A, Wilkes A. Sliding wear behaviour of aluminium-based metal matrix composites produced by a novel liquid route, *Wear. 1998;* 216:160-171.
5. Sivaprasad K, Babu SK, Natarajan S, Narayanasamy R, Kumar BA, Dinesh G. Study on abrasive and erosive wear behaviour of Al 6063/TiB 2 in situ composites, Materials Science and Engineering: A. 2008; 498, 495-500.
6. Kumar V, Mishra AK, Roy B. Application of Taguchi Technique to Optimize Tribological Behaviour of Al6061T6/SiC/Al2O3 Metal Matrix Composite.
7. Lu K, Lu J. Nanostructured surface layer on metallic materials induced by surface mechanical attrition treatment, Materials Science and Engineering. 2004; 375:38-45.
8. Tao N, Wang Z, Tong W, Sui M, Lu J, Lu K. An investigation of surface nanocrystallization mechanism in Fe induced by surface mechanical attrition treatment, *Acta Materialia. 2002*; 50:4603-4616.
9. Jian L. Surface nanocrystallization (SNC) of metallic materials-presentation of the concept behind a new approach, J Mater Sci Technol. 1999; 15:193.
10. Zhang Y, Han Z, Wang K, Lu K. Friction and wear behaviors of nanocrystalline surface layer of pure copper, *Wear*. 2006; 260:942-948.
11. Zhang H, Hei Z, Liu G, Lu J, Lu K. Formation of nanostructured surface layer on AISI 304 stainless steel by means of surface mechanical attrition treatment, *Acta Materialia*. 2003; 51:1871-1881.
12. Wu X, Tao N, Hong Y, Liu G, Xu B, Lu J. *et al*. Strain-induced grain refinement of cobalt during surface mechanical attrition treatment, *Acta Materialia*. 2005: 53:681-691.
13. Yong X, Liu G, Lu K, Lu J. Characterization and properties of nanostructured surface layer in a low carbon steel subjected to surface mechanical attrition, Journal of Materials Science and Technology. 2003; 19:1-4.
14. Sun H, Shi YN, Zhang MX, and K. Lu. Plastic strain-induced grain refinement in the nanometer scale in a Mg alloy, *Acta Materialia*. 2007; 55:975-982.
15. Amanov I, Cho Y, Pyoun C, Lee Park I. Micro-dimpled surface by ultrasonic nanocrystal surface modification and its tribological effects, Wear. 2012; 286:136-144.
16. Amanov IS, Cho DE, Ki Pyun YD YS. Fretting wear and friction reduction of CP titanium and Ti–6Al–4V alloy by ultrasonic nanocrystalline surface modification, Surface and Coatings Technology. 2012; 207:135-142.