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The Effect of Lubrication on Tribological Properties of Bearing Materials Using Pin on Disc: A Review

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Abstract: A bearing is interposed between two surfaces in relative motion to minimize the friction. In generally used bearing materials like steels or its alloys depends on the continuous presence of a very thin –millionths of an inch-film of lubricant. Due to restricted lubricant flow or long run increase excessive temperature etc. These are the several reasons of failure of the bearing and this rate of failure of the bearing can be avoided by proper selection of bearing materials and lubricating system. The materials are processed to achieve desirable properties to maximize bearing performance and life. Wet condition lubricants are oils, which produce an oil film between two mating parts i.e. reduce wear and friction. Dry lubricants are materials which, despite being in a solid phase are able to reduce friction between two surfaces against each other without need a liquid oil medium.

Over the years, the author has evaluated an P1n-on-d1sk tribometer will be described and discussed as will experimental methods for evaluating Wet conditions and Dry conditions. When evaluating what solid lubrication and hydrodynamic lubrication should be used for a specific application, the only sure way to determine how well it will perform.

Keywords: Pin-On-Disc, wet lubrication, dry lubrication

I. INTRODUCTION

Bearings are used to prevent friction between parts during relative movement. The purpose of lubrication is to reduce friction, wear and heating of machine parts moving relative to each other. The control of the friction and wear in movable pieces of the machine is a critical element to face in the industry.

Types of lubrication: Five forms of lubrication can be categorized are:

A. Hydrodynamic lubrication
B. Hydrostatic lubrication
C. Elasto Hydrodynamic lubrication
D. Boundary lubrication
E. Solid film lubrication

These above five lubrication systems the most lubrication systems are Hydrodynamic lubrication and solid film lubrication.

Hydrodynamic lubrication (or) full-film: In this type, the surfaces of the bearing are separated by a relatively thick film of lubricant (to prevent metal to metal contact). The film pressure is created by the moving surface forcing the lubricant into a wedge shaped zone, therefore creating a pressure that separates the sliding surfaces. Solid film lubrication: In this type self-lubricating solid materials such as graphite are used in the bearing. This is used when bearing must operate at very high temperature.

The Pin-on –disk device is one of the equipment most used in Tribology. This tribometer serves for the investigation and simulation of friction and wear processes under sliding conditions. It can be operated for solid friction without lubrication and for boundary lubrication with liquid lubricants. Thus both material and lubricant tests can be executed. In Pin-On-Disc equipment one part (either pin (or) Disc) is stable another part (either pin (or) Disc) is rotating. So in wet lubrication initially boundary lubrication will form after its Start rotating hydrodynamic lubrication is form.It was observed by several researchers that the variation of friction depends on interfacial conditions such as normal load, geometry, relative surface motion, sliding velocity, surface roughness of the rubbing surfaces, type of material, system rigidity, temperature, relive humidity, lubrication and vibration. Among these factors normal load and sliding velocity are the two major factors that play a significant role of variation of wear and friction.

II. WET (OR) HYDRODYNAMIC LUBRICATION CONDITIONS

S. Baskar & G. Sriram (2014) investigated, the friction and wear behaviour of journal bearing material using a pin-on–disc test under wet conditions (Hydrodynamic lubrication) where the pin is Brass and the disc is EN31 hardened with three different lubricating oils i.e. Synthetic lubricating oil (SAE 20W40), chemically modified rapeseed oil, chemically modified rapeseed oil with nano Cuo. Tests were carried out at maximum load and different sliding speeds. After the test chemically modified rapeseed oil with nano Cuo has a lower friction coefficient and high wear resistance [1]. Rameshkumar, T. et.al. [2] Studied the friction behavior and wear properties of Aluminium-tin alloy by means of pin-on –disc tribometer. Experiments were carried under wet conditions using Al-Tin alloy pin and high carbon, high chromium steel disc with engine oil 20W40. Oil was heated to temperature of 80ºc. Results have shown that the Al-alloy has less wear compared to pure aluminium. Azman et.al. [3] Studied friction behaviour and wear property of a refined bleached and deodorized (RBD) and Zinc dialkyl-dithiophosphate (ZDDP) under SAE15W50 oil conditions using a pin-on –disc tribometer. In this study, Aluminium A1100-Tin alloy pin and SKD11 tool steel disc have been used. Test were carried out at different conditions and RBD palm stearin with 5wt%ZDDP additive showed less coefficient of friction than that of SAE15W50.

Amit Kumar Jain & Amit Suhane (2014) found that the lubricants have a very important role to play in every type of industry in reducing friction and wear between two relative moving parts. The study represents an investigation of tribological characteristics of non –edible vegetable oils as bio lubricant and Tribological properties were studied by means of pin-on –disc tribometer under two environmental conditions i.e. refined castor oil and its blend with Mahua oil where pin is plain carbon steel and disc is mild steel. The coefficient of friction was found to be less than 0.02, on an average 90% reduction was identified which in turn is expected to reduce maintenance costs of a machine. It is also observed that that the decreased coefficient leads to minimize the gradual degradation that a machine exposed to during its operation. This reduction of wear average 45 to 63% in the case of metal parts thus helps in increasing the mechanical operating efficiency and application design life. [4]. Sanjay Kumar and S. S. Sen (2014) concluded that friction and wear are the most important parameters to decide the performance of any bearing. In this work, the tribological behaviour analysis for the convention material i.e. Nickel, Nickel chrome, molybdenum Disulfide, PTFE,and Nylon is done. The friction behaviour and wear property of a coating material sample was studied by means of pin-on –disc tribometer. Tests were carried under wet conditions (with engine oil 20W40 (HP) After the test, it was identified that the molybdenum Disulfide (MoS_2) is the best suitable for bearing application. [5]

Kabir, M. A et.al. (2008) studied friction behaviour and wear properties of canola oil and boric acid mixture as a lubricant using pin-on- disc tribometer. In this study, a pin in spherical shape made of copper and disc Aluminium materials under different lubricant conditions (canola oil and canola oil and boric acid mixture) have been used. The test results have shown that the canola oil mixed with boric acid powder found with high viscosity. It is an excellent potential for use as lubricants in industrial applications [6]. Manu Varghese et.al. (2012) study, analysis of coconut oil as a lubricant has been carried out in the perspective of its tribological behaviour using a pin-on-disc tribometer. The variations of its friction-reduction and antiwear properties are analysed. Viscosity of oil is also seen to increase with an increase in concentration of nanoparticles. The kinematic and dynamic viscosities are slightly increased by the addition of nanoparticles in coconut oil at an optimum concentration of Cuo nanoparticles; the coefficient of friction and the specific wear rate are found to be the lowest. The optimum concentration of nanoparticles in this lubricant causes the roughness of the worn pin surface to reduce to a low value after sliding. Wear scar obtained in the presence of nano oil is smoother compared to that with bare coconut oil. When the level of nanoparticles increases above the optimum level, friction coefficient and wear rate are seen to increase. [7]

Noorawzi et.al (2016) presents an experimental analysis of the tribological study of friction behavior and wear property of an Aluminium alloy material were studied by means of pin-on–disc tribometer test were carried under wet conditions (Hydrodynamic lubrication) where the pin is Aluminium and the disc is SKD11 alloy tool steel. A test was carried out in different conditions using Double fractionated palm oil (DFPO), Hydraulic oil and Engine oil-SAE40. After the test the Co. efficient of friction rise when sliding speed and load were high. The DFPO lubricant showed the best performance in terms of its ability to maintain its properties; it can be recommended that the new alternative lubricant as the base lubricant is better for mechanical applications for overcoming friction and wear problems [8].Suhane, et.al (2013) investigates the prospects of Mahua oil based lubricant for maintenance applications. Mahua oil blends with conventional gear oil (90T) in different ratios. Frictional behavior and wear property of Aluminium-tin alloy were studied by means of pin-on –disc tribometer test were carried under wet conditions (Hydrodynamic lubrication) where the pin is plain carbon steel and the disc is mild steel with Mahua oil blended with 90T.Test were carried out in different conditions. After test addition of Mahua oil blended with 90T oil has good wear reducing traits apart from environmental benefits. [9]

Andersson, Peter (1992) taken several material combinations lubricated with water, were investigated by performing pin-on –disc tribometer test were carried under wet conditions (Hydrodynamic lubrication).The materials were alumina, Zirconia-toughened alumina (ZTA), magnesia-partially-stabilized Zirconia (psz), silicon carbide (Sic) and stainless steel. The best performance under conditions of hydrodynamic lubrication was found for the all-alumina sliding pair. The reaction products were dissolved in the water and the sliding surfaces formed were smooth enough to make fluid film lubrication is possible [10]. Kharde,et.al (2011) worked with the experimental investigation of tribological properties of GF-filled polymer composites considering three velocities and loads. The test has been carried out for three materials, PTFE + 15% GF, PTFE + 25%GF and PTFE + 35% GF in wet (oil) and adding additive as graphite (5% wt)in oil. SAE 20W40 oil is used for the test. Friction and wear tests of PTFE composite against a counter surface of EN8 with surface finish of 0.56µm are carried out at ambient conditions using a pin-on-disc tribometer. PTFE increases with glass fiber fillers and composites have good friction and wear behavior at higher speeds, so it can be more effectively used for high speed applications. Also the wear of the PTFE composites can be decreased by using oil and oil with graphite lubrication [11].Shanta, et.al (2011) conducted their experiments on mixtures of SAE 15W40 oil, which were contaminated by known percentages of the bio diesels from canola oil, peanut oil, soybean oil, The friction behavior and where property were studied by means of pin-on –disc tribometer test were carried under wet conditions (Hydrodynamic lubrication) where the pin is AISI 316 stainless steel and the disc is AISI 1018 with a mixture of oils. Tests were carried out in different conditions. After the test this result of this work suggests that any degree of mineral oil dilution by the tested biodiesel can reduce the wear protection properties of the engine oil. [12]

Khashaba et.al (2013) proposed polymeric composites are consisting of polyethylene (PE), polypropylene (PP) and polystyrene (PS) and filled with fibers of polytetra fluoroethylene, and (PTFE) in concentration up to 25 wt. % as well as different types of natural oils such as (corn oil, olive oil, paraffin oil, glycerin oil, castor oil and sunflower oil) in concentration up to 10 wt. %. The frictional behaviour of the proposed composites and wear resistance is investigated at different values of applied load. Using pin-on-disc wear tester it consists of a rotary horizontal steel disc driven by variable speed motor. The bearing steel pin (AISI 52100) is held in the specimen holder. The friction of PP and PE specimens free of oil slightly increased with increasing PTFE content [13].Shahabuddin et.al (2013) investigates the friction and wear Characteristics of Jatropha oil based bio lubricant by using Pin on Disc Wear Testing Machine under load of 30N, a high rotating speed of 2000 RPM and one hour operation time. In this study, SEA 40 was used as a reference base lubricant. As a bio lubricant various blends like 10%, 20%, 30%, 40% and 50% of Jatropha oil were mixed with the base lubricant (SEA 40). The experiment was conducted using Aluminium pins and cast iron disc, which was lubricated with those of bio lubricants. According to the experimental result, it can be recommended that the addition of 10% Jatropha oil in the base lubricant is the optimum for the automotive application as it showed best overall performance in terms of wear, coefficient of friction, viscosity, rise in temperature etc. [14]ingh, Yashvir (2016) outlines the friction and wear characteristics of Pongamia oil (PO) contaminated bio-lubricant by using a pin-on-disc tribometer. Experimental results showed that the lubrication regime that occurred during the test was hydrodynamic lubrication. The addition of PO in the base lubricant acted as a very good lubricant additive which reduced the friction and wear during the test [15].Vijay R, et.al (2014) Machine components and mechanism pairs depend on high-quality lubricants to enable Withstanding high temperatures and extreme pressure (EP). Nanoparticles used a soil additives have been recently investigated the tribological properties were evaluated using the pin on disk tribometer under various load conditions and wet lubrication. The Tribological properties of the lubricating ability of SiO2 nanoparticles as an Additive in the SN-500 base oil. Friction reduction, high load carrying capacity and antiwear can be achieved if nanoparticles are present in SN-500 base oil under increasingly serve conditions such as load, speed and time. [16]

Sandip B. Chaudhari et.al (2013) studied the wear rate of each material i.e. plain PTFE, 25%carbon filled PTFE, 25%bronze filled PTFE and 25%glass filled PTFE have been calculated under wet conditions (hydrodynamic lubrication). so Pin-On-Disk apparatus is used for the experimental work which must provide lubrication facility. For the present work has been followed Analysis of variance (ANOVA) technique where the number of variables studied simultaneously. After the test it was found that addition of filler materials such as bronze, glass and carbon to PTFE causes an increase in hardness and wear resistance, while the co-efficient of friction is slightly increased [17].Pisal,Ajinkya S, and D S Chavan (2014) carried their experiment on Pin on Disc Tribometer and the tests were performed under wet conditions with varying load, speed and varying concentration of nanoparticles in engine oil. Base oil with Cuo nanoparticles improved tribological properties in terms of load carrying capacity, anti-wear and friction reduction than the base oil without nanoparticles [18]. Senhadji et.al(2016) carried out their work in order to compare the frictional and wear behaviour under mixed lubrication of two pins using Pin on Disk experiment under wet lubrication bronze and brass, sliding on a steel disc It is found that under the same conditions, brass has a very high wear coefficient compared to that of bronze [19]. Vijay Kumar S. Jatti (2015) examined the tribological behaviour of titanium oxide Nano particles as additives in mineral based multi grade engine oil. All tests were carried out under variable load and concentration of nanoparticles in lubricating oil. The friction and wear experiments were performed using pin-on-disc tribometer under wet conditions (Hydrodynamic lubrication). It was demonstrated that the nanoparticles as additives in lubrication can effectively improve the lubricating properties. This was because the nanoparticles go in to the friction zone with the flow of lubricant, and then sliding friction changed to rolling friction with a result of the reduction of friction co. efficient [20].

III. DRY (OR) SOLID LUBRICATION CONDITIONS

S. M. H. AHMER1, L. S. JAN, et.al (2016) measured the friction coefficient, wear rate, and wear coefficient of the aluminium metal surface at room temperature (≈300 K) with a pin-on-disk machine at a fixed load of 196.2 N under dry condition. Aluminium pin vs. Helix oil-on-steel disk (AHS) and (2) aluminium pin vs. 10% Polytron plus 90% helix oil-on-steel disk (APS) It can be asserted that Polytron is an effective antiwear additive in the Helix base oil and can intrinsically reduce friction and wear by orders of magnitude [21]. P. N. L. Pavani et.al (2013) worked on graphite flakes acts as solid lubricant& when load is applied, these layers slide over another &provide lubrication. PTFE+Graphite is well known for its self-lubricating properties and widely employed in applications. Frictional behavior and wear property of self-lubricating materials were studied by means of pin-on –disc tribometer test were carried under dry conditions (solid lubrication) where the pin is gray cast iron (GCI) and Gary cast iron (GCI) disc &PTFE+Graphite pin &AISI 1045 steel disk under different conditions. Later linear regression models are developed using input and output variables for both GCI pin on GCI disc and PTFE filled with Graphite pin on AISI 1040 steel disc [22].

G.H. Farrahi et.al (2014) experimented investigations on metal-metal couple show that austenitic stainless steels have favourable and auspicious sliding properties at cryogenic temperatures. This research provides the wear parameters of austenitic stain less steel AISI type 316 in cryogenic environment .For this purpose two sets of test environment are prepared, room temperature (273K) and 77K using pin on disk cryogenic simulator. Disk material is austenitic stainless steel AISI type 316 has a brilliant steel SAE 52100 This investigation shows that AISI type 316 has a brilliant sliding resistance which makes this group of metals to use widely in cryogenic applications [23]. Unal, H et.al (2004) studied and explored the influence of test speed and load values on the friction and wear behaviour of pure PTFE, glass fibre reinforced PTFE, bronze and carbon filled PTFE polymers. Friction and wear test using AISI 440C stainless steel disc were carried out on a pin-on-disc arrangement and at dry conditions (solid lubrication). Tribological tests were at room temperature, under different loads and different speeds. After test friction co-efficient of pure PTFE and its composites decreases when applied load increases. Pure PTFE is characterized by high wear because of its small mechanical properties. Therefore, the reinforcement PTFE with glass fibres improves the load carrying capability that lowers the wear rate of the PTFE [24].

S. M.Yadav et.al (2012) used a pin-on-disk test apparatus to investigate the dry sliding wear characteristics of the pure PTFE (Poly tetra fluoro ethylene) and their composites. The disc used is EN-32 steel The experiments were conducted with the influence of applied load (L),sliding speed(S)and sliding distance(D)on dry sliding (solid lubricating) of pure PTFE,25%Glass particle+PTFE,40% Bronze particle +PTFE composites under study. After test Glass and Bronze particles as fillers increases the wear resistance of the material. However, significant improvement in wear resistance is observed by the incorporation of Bronze particles [25]. Benabdallah, Habib S(2006) Polyoxymethylene, polyamide, polyamide, poly propylene, Poly(vinyl chloride), polytetrafluoroethylene,and polyethylene, were investigated using pin-on-disk configuration .A designed pin-on-disk tribometer was used to conduct the friction and wear testing as well as acoustic emissions measurements. Seven different thermoplastics were rubbed against SAE 52100 polished surface, under a wide range of operating conditions. Based on the obtained results, the wear volume can be reasonably well correlated to operating Parameters like sliding distance, speed, and contact pressure [26]. D. Pansar et.al (2015) worked on effect of load and sliding velocity on friction and wear of materials made of PTFE and PTFE composites with filler materials such as 25% carbon, 35% carbon, 40% bronze, 15% glass fibre, 15% glass fibre + 5% MoS_2 have studied. The experimental work has performed on pin-on-disc friction and wear test Wear studies against AISI 304C stainless steel disc counter face under various loads and sliding speeds, material used in this study were ranked as follows for their wear performance. 15% Glass Fibre + 5% MoS_2 > 35% Carbon > 25% Carbon >15% Glass Fibre> 40% Bronze > Pure PTFE. 15% Glass Fibre + 5% MoS_2 exhibited best wear performance and can be considered as a good tribo-material between materials used in this study [27]. Fusaro, Robert L. (1986) done experiments with hundreds of possible films which might be used for that particular application; thus 1t 1s advisable to evaluate the films first on an Pin on Disk tribometer to determine the best candidates to test 1n the final end use application. Many factors, such as load, speed, temperature, atmosphere, geometry, etc. can affect the performance of a solid lubricant film.[28]

Davim, J. (2009) made a comparative study of wear and friction on PEEK, PEEK-CF30 (wt %) and PEEKGF30 (wt %) against steel, at long dry sliding. experiments was performed on a pin-on-disc machine, under dry lubrication and ambient temperature. PEEK-CF30 presented the lesser friction coefficient followed by PEEK. PEEK-GF30 presented the higher friction coefficient throughout all sliding distance. Both PEEK-CF30 and PEEK-GF30 have presented an excellent wear resistance relatively to PEEK while PEEK-CF30 presented the best tribological behaviour [29]. P. N. Patil (2016) friction and wear, tests will carried out using single pin type "Pin-on-disc friction and wear monitor the machine consists of Steel disc this machine also facilitates study of friction and wear characteristics in sliding contacts under desired conditions. Sliding occurs between the stationary pin and a rotating disc. Normal load, rotational speed and It wear track diameter can be varied to suit the test conditions. Experiment will be performed on pin on disc machine, and studied the behavior of wear of composition on bronze, MoS_2 with different compositions on PTFE [30].

Bagale et.al (2013) studied the effects of load, velocity of sliding and sliding distance on sliding friction and sliding wear of polymer material made of polytetrafluoroethylene, and (PTFE) and PTFE composites with filler materials such as 40% bronze and 40% carbon. The experimental work is performed on pin-on-disc apparatus. The highest wear resistance was found for 40% carbon filled PTFE followed by 40% bronze filled PTFE [31]. Parthasarathi, N L et.al (2013) Worked on dry lubrication pin-on-disc sliding wear tests were carried out on AISI Type 316 L (N) austenitic stainless steel up to 550ºC at constant load and sliding speed. AISI 316 L (N) Hemispherical pins of were mated against discs of the same material. Coefficient of friction increased with increase in temperature [32].

Patare, Prasad M. (2014) conducted friction and wear tests using a pin-on-disc apparatus. the friction and wear properties of 15% glass fibre and 25% glass fibre filled PTFE (Polytetrafluoroethylene, and) composites under dry friction conditions were studied results shows that wear rate of PTFE reduced by addition of glass fibre and tribological properties also improved [33].Marwaha et.al (2013) studied wear and frictional properties of metal matrix hybrid composites by performing dry sliding wear test using pin on disc wear test apparatus the specimens to be tested are taken in the form of a pin is Al alloy base matrix reinforced with silicon carbide (10%) and graphite (5%) particles was fabricated by stir casting process and are allowed to slide against a heat treated steel disc. For dry sliding wear test the disc is rotated in varying speed and applied the different load on pin based, and varying Sliding distance [34].Mohammad Asaduzzaman chowdhury et.al (2013) carried experiments using Pin on Disk mild steel Smooth and Rough Mild Steel Counter faces pins slides on SS 304 disc the presence of normal load and sliding velocity under dry lubrication conditions. The values of friction coefficient Decrease with the increase in normal load while friction coefficients increase with the increase in sliding velocity [35].Ranganath, M S et.al (2014) explored the friction and wear behaviors using Pin on Disk tribometer under dry conditions. The tribological properties as coefficient of friction and specific wear rate of Cylindrical Aluminium pin (Al-6061) of diameter 10 mm and the mild steel disc are investigated [36].

Mohammad Asaduzzaman Chowdhury et.al (2013) studied friction coefficient and wear rate of stainless steel 202 (SS 202) sliding against mild steel are investigated experimentally using a pin on disc apparatus. Experiments are carried out when smooth or rough SS 304 pin slides on SS 202 disc. Experiments are conducted at normal load, sliding velocity and relative humidity Variations of friction coefficient with the duration of rubbing at different normal loads and sliding velocities are investigated after tests friction coefficient decreases with the increase in normal load. On the other hand, it is also found that friction coefficient increases with the increase in sliding velocity. Moreover, wear rate increases with the increase in normal load and sliding velocity [37].Athani, Mohamadaziz et.al (2016) done experimental investigations of Manganese (Mn) on as cast Al-25Mg2Si-2Cu-4Mn alloy. Wear test is done on pin on disc wear testing machine under constant speed condition at room temperature and dry condition. The rotating disc is made up of low carbon alloy steel (EN-32 Steel) and pin material is Mn .This Wear test conclusion For lower values of load and speed the coefficient of friction are maximum, it reduces as the speed is increased. Higher load values the volumetric wear rate is higher with respect to speed [38].

Aadarsh Mishra (2014) conducted pin on disk sliding friction tests on the titanium alloy (Ti-6Al-4V). Alloy disks were slide against the bearing ball composed of stainless steels. The test conducted under different loads and dry condition. Titanium oxide acts as a solid lubricant. When the sliding speed is higher the coefficient of friction and wear rate are lower for steel the wear rate is the least. Micro structural study confirms that Ti alloys have the tendency to transfer material to their counter face and there are possible tribological reactions when the sliding speed is lower than the coefficient of friction was observed to be high with lager fluctuation and higher wear rate [39].Bharath, T et.al (2016) observed that Aluminium has better mechanical properties, good corrosion resistance, wear resistance and having light weight compared to other metals. The change in behaviour of hybrid aluminium by varying percentage (10%) of Silicon carbide and Aluminium oxide composites and compare the test results with pure aluminium-7075. The wear test has performed on these samples by using pin on disc apparatus wear test will be carried on all the samples at various speeds and loads under dry condition. Aluminium7075 with 10% of Sic and 10% of Al2O3 has a maximum hardness and increased wear resistance compared to Al7075 [40].

Patil, Tushar A et.al(2016) conducted experiments on base material is HSS(high speed steel) and various coating are to be done on this base material, specially low friction coating material like TIALN, ALCRN, TIN, TICN are used in thesis and to analyze all these materials. Experimental set up of friction and wear controller machine is used, pins with high speed steel as a base material and coated with respective wear resistant material are to be tested on this machine wear test will be carried on all the samples at various speeds and loads under dry condition Coating of high speed steel with various low friction material increases its hardness and finally it also increases the wear resistance [41].Said, Larbi et.al (2000) investigated the influence of graphite powder addition to an unsaturated polyester type polymer (32% styrene content in mass) on the mechanical and tribological properties. For this purpose, The wear tests were carried out on a dry type pin on disk tribometer with varying loads and speeds for three different compositions (0, 1 and 2% graphite).. The disk is made of quenched and annealed C48 steel. Before the rubbing process, the discs were subjected to polishing in order to obtain approximately the same initial surface roughness. The results show that the addition of graphite powder improves the tribological properties; a noticeable decrease of the coefficient of friction, the mass loss and the wear rate are achieved with the increase of the graphite powder percentage for all sliding speeds and loads [42].Odi-owei et.al (2016) investigated the friction coefficient and wear rate of carbon steel specimens contact with Titanium Nitride of PVD coating on a steel substrate was carried out under unlubricated conditions on a pin-on-disc tribometer. Experiments were conducted with the specimens in the form of a pin sliding against a TiN disc. Variations of friction coefficient, wear rate and time to reach steady state friction were investigated at different sliding speeds and normal loads. Friction coefficient decreased with increasing rubbing duration and decreasing sliding speed, while wear rate increased with increasing rubbing duration [43].Y Ren Jeng (1990) done experiments verification of lubrication theories of surface roughness. A pin on disk tribometer is used to measure the friction of the samples.to study the effects of roughness height and lay orientation on friction. Samples with different rib let tapes mounted longitudinally and transversely were tested .finally the results show that lower roughness height yields lower friction, and that transverse roughness has lower friction than longitudinal roughness. The surface roughness effects become increasing significant as the film thickness decreases [44].

Li, Xinmin (2004) presented the tribological performance of standard gear material (EN 16MnCr5)and two kinds of powder metallurgy (PM) gear material (Distaloy AQ + 0.2% C and Astaloy 85Mo +0.2% C) with and without tribofilm formed by a pre-treatment were evaluated. Specimens treated with the pre-treatment are subjected to pin-on-disc tests under hydrodynamic lubrication conditions. The friction and wear performance of the two different gear materials with the pre-treatment formed tribo-film were compared to RS-RS (EN 16MnCr5 material disc and pin combination) for reference. It was found that the pre-treatment decreases the friction coefficient and enhances the wear resistance of pins because of the tribofilm formed. The tribo-film caused good running-in due to the existing off and Fe and W oxides. Mo-Mo (Astaloy 85Mo + 0.2% C material disc and pin combination) and Mo-RS (Astaloy 85Mo + 0.2% C disc and EN 16MnCr5 pin combination) showed statistically significant higher wear resistance [45].Mahesha,et.al (2016) work is to investigate the dry sliding wear behaviour of AISI 630 hardened by precipitation hardening. The sliding wear tests were conducted with the use of a pin-on-disc tribometer by considering three factors normal load, sliding distances and sliding velocity under Dry sliding wear behaviour of the 17-4PH stainless steel under different loads, sliding distance and sliding velocity have been successfully analysed .Smaller the better S/N (signal to voice) ratio has been selected, since wear rate has to be reduced in the material. From the S/N ratio response for wear volume loss it is observed that, the load most significant factor that affects the wear volume loss and specific wear rate followed by the sliding velocity and sliding distance [46].Sharma (2012) investigate the sliding friction and wear behaviour of Titanium Alloy (Ti-6AL-4v)by using pin –on –disc tribometer test were carried under dry conditions (solid lubrication) where pin is Titanium Alloy (Ti-6AL-4v)and disc is EN-31Steel.Test were carried out at different conditions wear rate of the Titanium Alloy (Ti-6AL-4v) decreases with increasing sliding velocity and decreasing the normal load .The Average co. efficient of friction is decreases as the normal load increases[47].

Tahir, et.al(2015) investigated the effect of temperature on the tribological properties of Palm Kernel by using pin-on –disk tribometer test were carried under dry conditions(solid lubrication)where pin is Palm Kernel and disc is Activated carbon-epoxy test were carried out applying temperature range is 27ºcto 150ºc ,at constant sliding speed, applied load, and sliding distance. Both co. efficient of friction and wear rate of the composite increased with operating temperatures [48]. Kagnaya, T (2009) work carried out with some results of a research work that study relationship between wear and temperature in the case of pin –on –disc tribometer. Topic of the paper is focused on the estimation of the pin on disc contact temperature by coupling experimental measurements Friction experiments were carried under dry conditions (solid lubrication) where pin is WC-60and disc is AISI 1045 Grade. A large sliding velocity range is considered in this study. The friction between two surfaces induces an increase of temperature in the contact. This temperature considerably influences mechanical behaviour and physic-chemical properties of surfaces in the friction contact [49].

IV. DRY AND WET CONDITIONS

Singh (2014) evaluated the wear rate of evaluate the wear rate of different journal bearings materials (brass and white metal) under similar conditions. The materials are tested in dry and wet lubrication (solid lubrication and hydrodynamic lubrication) under similar operating conditions .For the purpose we use pin-on disk apparatus. Where pins material is brass, white metal and copper. And disk is EN8 (common for three materials). Tests were carried out in different conditions. Where 20W40 (HP) is used in the wet conditions for lubricating purpose. After the test, under lubrication conditions brass material have no wear for first 80 minutes after some wear is found and white metal have abrasive wear and frictional force is decreases between them. In dry conditions (same working conditions) wear rate of white metal is more compared to brass and higher frictional force is observed in case of brass [50]. Navale, R. A (2016) studied consider effect of various conditions to compare the friction and wear behaviour of polymer composites with surface texturing on mating surface under different loads at varying velocity by using pin on disc tribometer. The test will be carried out for composite materials like polyamide composites and PTFE composites and HDPE polyblends in dry and wet lubrication (solid lubrication and hydrodynamic lubrication) conditions. In this pin material is polyamide composites and PTFE composites and HDPE polyblends. Disc material is AISI SS 304 stainless steel disc have surface textured pattern. The tests were carried out in ambient conditions. Frictional heat has significant effect on the tribological behaviour of polymer-polymer combinations under dry friction, external oil lubrication reduces the frictional heat during sliding process, and hence decreases the friction and wear. The higher wear of PA66 under oil lubrication may due to mechanical strength reduction because of the oil diffusion in to the surface layer [51].

V. TEST SETUP PIN ON DISC (POD) WEAR TESTING MACHINE

Tribological characteristics of a wide range of materials under conditions of various normal loads can be determined by the POD machine. A stationary pin mounted on a pin holder is brought into contact against a rotating disc at a specified speed. Pin slides in the presence of lubricating oil, introducing frictional force between the pin and disc (Figure 1).

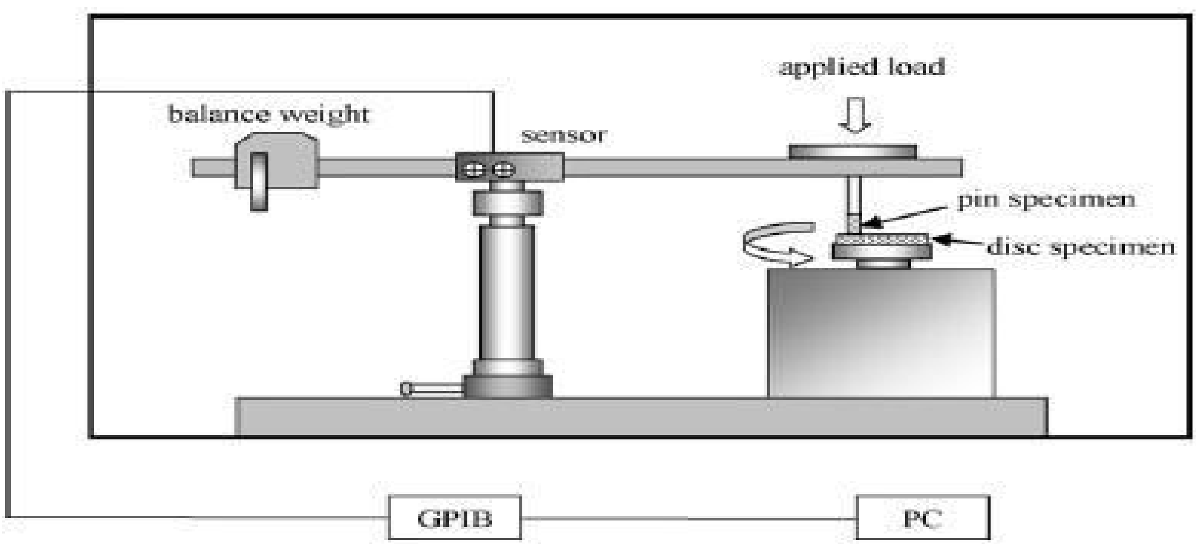

Figure-1 Pin-On Disk [1]

A. Test Specimen

The typical pin specimen is cylindrical in shape. Typical cylindrical pin specimen diameter is 6mm, 8mm,10 mm and length is 30 mm. The surface of the pin is finished because rough surfaces make wear measurement difficult. Material used for making pins for testing the disk material on which the pin slides.

B. Test Parameters

1) Normal Load: Values of the force in Newton’s at the wearing contact.
2) Speed: The relative sliding speed between the contacting surfaces in metres per second.

3) Time: Running time of experiment in minutes.
4) Track Radius: The path generated is circle, so the specimen pin can be positioned over disc.
5) Flow Rate: Flow of oil on the disk. A constant flow of oil is maintained for this experimental study to achieve a film between the contacting surfaces. (Weather used lubricating oil)

C. Output Parameters

1) Wear Rate (mm3/Nm): Material removal rate per unit parameter due to wear.
2) Frictional Force (N): Force exerted by a surface on a relative moving object across it.
3) Coefficient of Friction: A dimensional less quantity indicating the frictional force between the two relative bodies.
4) Sliding Distance: It is the linear distance travelled by the pin over the plate within given time interval if free from the tool holder. Sliding distance evaluates the wear rate. Sliding distance does not vary with load, time, flow rate etc. It varies only with speed.
5) Sliding Velocity: Sliding velocity denotes velocity with which the pin slides over the plate.

VI. CONCLUSIONS

The researchers' investigated friction and wear behavior of so many materials as there is a need to study the undesirable effectobserved in the performance and life of machinery components. This review was carried out to study the friction and wear behavior of different materials using Pin-On-Disc tribometer under wet and dry lubrication conditions. In wet conditions, a lubricant is used. In this Hydrodynamic lubrication film is formed. Most of the studies were found on petroleum based and vegetable oil lubricants and combination (or) mixing of both oils at different concentrations. Due to these conditions, initially materials have shown less wear but after certain time wear rate were found and in case of some white materials abrasive wear take place and reduced the friction force. Under high temperatures, the viscosity of lubricant decreases then increases the wear rate. Application of external lubrication is always suggested under high loads and for closed systems. But for certain systems it is not convenient. Then self-lubricating materials i.e. the material itself act as a self-lubricant can be used. In this most of the experiments were conducted using various polymer materials, it is in pure form the wear rate is more and coefficient of friction is less. So there will be an improvement in the wear resistance of polymer composites (like PTFE+Graphite, carbon, Mos_2 etc). But co. efficient of friction slightly increases.

Finally authors would like conclude that dry lubrication is used for low and medium loads. To get lower wear rates and frictional forces application of vegetable oils is preferable as they are anti-pollutant lubricants. Under maximum working conditions application of lubricant is not suggestible, where self-lubricating materials can be used.

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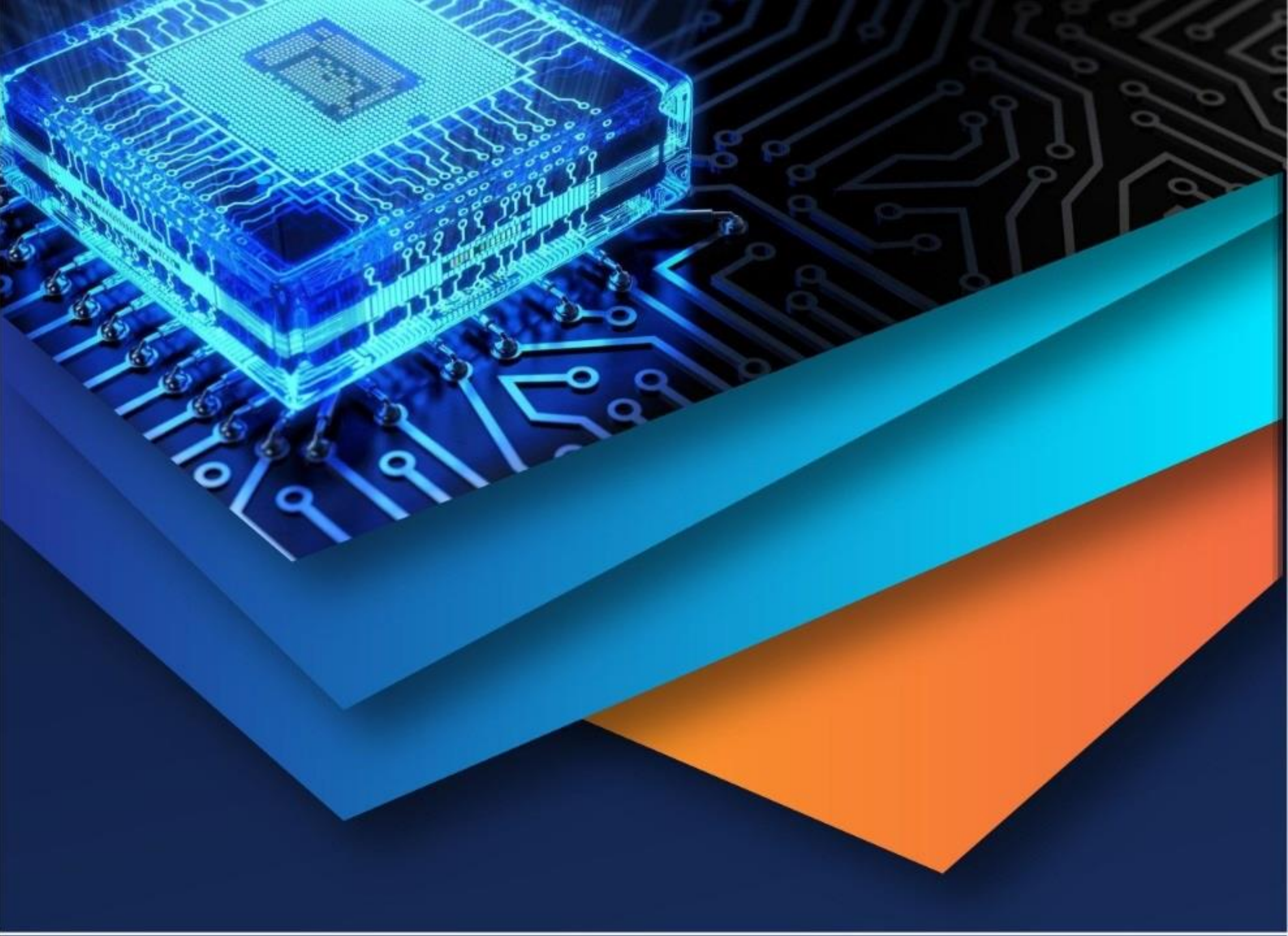

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