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Study on HDPE Components with Abrasive Wear in Rotation for Industrial Applications- A Review

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Abstract:

Abrasion wear is one of the most common failure mechanisms of moving machine elements. Because of their mechanical and tribological ability, engineering polymer composites can be chosen to replace metal parts in certain applications (e.g. bearings). Increasingly newer polymer composites are appearing and data on their tribological behaviors are incomplete, it is not so easy to choose from this wide wide selection of choices (mechanical properties, price, etc.). In the present study two groups of polymer composites In many fields of industry, abrasion and erosion processes are dominant wear mechanisms that reduce lifetime of costly machine parts. Wear resistance against abrasion and/or impact or the ability to withstand other complex mechanical actions are often required. In order to quantify the specific properties of material that are applied in such fields, several test methods are in use. A certain discrepancy can be seen between the systems approach and the aim to get information about suitability of materials for practical applications simply from specific material tests. This paper gives an overview over a selection of relevant test equipment and procedures. In addition, some examples are given for advanced studies on materials behavior combining tribological test, material analyses respectively materialography and mathematical methods in order to support – for selected cases.

Keywords **— hard facing materials, abrasive wear, impact, test methods, morphology, wear modeling**

1.0 Introduction:

Abrasion is the most common type of wear in industrial practice. It occurs when the micro-roughness of the harder counter body ploughs through the softness of the counter surface. Material is removed by micro cutting or micro cracking and wears results by sharp and rigid particles or peaks of roughness. Wear gaps are created by the scratches of the surface. The particles that leave the gap are called the wear. Abrasive wear can occur in all places, where rigid particles can go between the sliding surfaces roughness is high, or the hardness of the sliding elements is very different, or if the machine works with abrasive material. Briscoe and Sinhala mentioned that cohesive wear results from surface and subsurface deformations, caused by the harder asperities of the counter face. Abrasion and fatigue wear processes are termed, ‘cohesive wear’.

Abrasive Wear:

Abrasive wear occurs whenever a solid component is loaded to particles of a material that have equal or greater hardness. A common example of this problem is the wear of shovels on earth-moving machinery. The extent of abrasive wear is far larger than may be observed. Any material, even if the bulk of it is very soft, may cause abrasive wear if hard particles are present. For example, an organic material, such as sugar cane, is associated with abrasive wear of cane cutters and shredders because of the small fraction of silica present in the plant fibers A major obstacle in the prevention and control of abrasive wear is that the term ‘abrasive wear’ does not precisely describe the wear mechanisms involved. There are, in fact, almost always several different mechanisms of wear acting in concert, all of which have different characteristics.

High Stress Grinding Abrasion: This type of abrasive wear occurs during the progressive fragmentation or grinding of the abrasive which was initially of small size and takes place on the surfaces employed to grind the abrasive. The wear is believed to be caused by concentrated compressive stress at the point of abrasive contact and to result from plastic flowing and fatiguing of ductile constituents and cracking of hard constituents of the metal surface. The use of the words “high stress” in this classification is intended to imply that the crushing strength of the abrasive is exceeded.

Low Stress Scratching Abrasion or Erosion: The result of this type of abrasive wear is scratching of the metal surface, and the scratches are usually minute. The stress imposed on the abrasive particle does not exceed the crushing strength of the abrasive. Abrasive counterparts or particles are grooving the functional surfaces of machine components or parts, like

Rotary platform double-head abrader:

This type of setup is primarily used for tests under mild abrasion conditions and commonly known as the TABER Rotary Platform Abrader This “abrader” was already developed in the 1930’s in order to provide accelerated wear testing as it has been used for research and development, quality and process control, and generally for material evaluation. Several test procedures have been introduced into industrial, national, and international standards, e The Taber Abrader generates a combination of rolling and rubbing to cause wear to the tested material or surface, respectively, being in contact with bonded abrasive particles Abrasives are applied in wearing rollers (abrading wheels) of different composition (hard particles and binder). Test specimens disks are spun on a turntable and are abraded by a pair of abrading wheels for a specified number of cycles under a specified load. The test method specifies that the change in haze of the test specimen be determined as a measure of abrasion resistance. It is more common, however, to see abrasion resistance reported as the change in mass of the test specimen or change in mass per number of cycles. Mass change is due to material loss from abrasion. Thus wear is normally quantified as cumulative mass loss of the plate mating against the wheels, or as a “Taber Wear Index” (mass loss relating to 1000 cycles) typically after a test run of several 1000 cycles, with a typical test load (wheel load) of 10.2 N (corresponding to a mass of 1000 g).

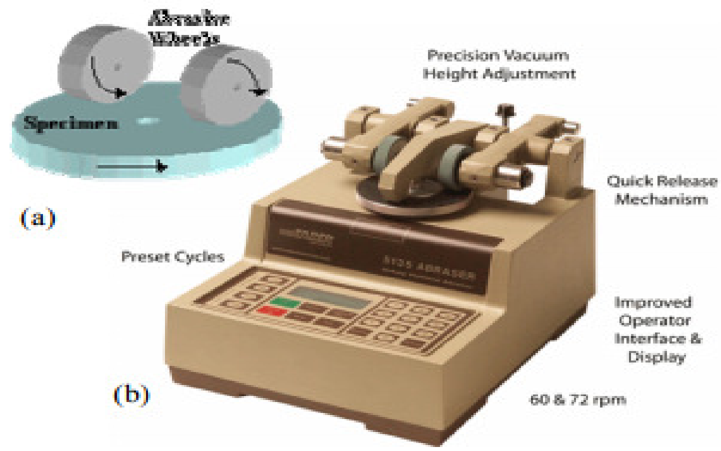

Figure: 1.1. Rotary Platform Abraders: (a) test principle and (b) test setup

The main objectives of our investigations are:

2.0 Objectives:

- Comparison of friction and wear behaviour of different HDPE Components in connection with mechanical properties,
- To select the proper polymer for a given operational condition
- Presentation of a special abrasion test system, with one way motion and conformal contact,
- Determination of optimal operational conditions of the selected polymers.
- To study the properties such as mechanical strength, wear resistance and fatigue

3.0 Literature review:

[1] László Zsidai (2016) to compare the tribological properties of composites and to investigate the effect of different additives and mechanical properties. The tests were prepared using the pin on plane (band) model system and tested on different loads (11.5 N and 23 N), where the abrasion mating surface was emery cloth. Polymer has a more efficient effect on the fri ction at higher load, but it does not have any individual effect **[2] M.S. Priyana, P. Hariharan (2014)** to develop a theoretical model and associated wear mode map to identify the regimes in which two body abrasion (grooving abrasion) and three body abrasion (rolling abrasion) dominate in the micro-abrasive wear test (also known as the ball cratering wear test). This test is generally considered to be a three body wear test abrasive volume fractions and the rolling mechanism dominated at low loads and high abrasive volume fractions. For the grooving wear mechanism, wear volume is proportional to the normal load **[3] Wani Khalid Shafi1, Ankush Raina (2018)** tribology has also helped in developing lubricants which are eco-friendly and sustainable. The research has shown that the use of bio lubrication in different industrial applications can protect the environment. Developments of bio lubricants as cutting fluids have also been suggested. This reduces the emissions to a greater extent and provides a source of renewable energy. Further researches are going on the development of new materials and overcoming the difficulties in biodegradable lubricants so that they can be used widely **[4] Milan Brožek (2017)** Wear intensity was assessed by the volume, weight and length losses of the tested samples. From the results of the carried out tests it follows that the wear resistance of different woods is different. It was proved that the wear resistance of different woods depends on the abrasive particles size, too. Also the technical-economical evaluation was part of the carried out tests. it is possible to recommend beech. The other tested woods are either not so wear-resistant **[5] Winkelmann, H., Varga, M., Badisch,(2012)** the critical drop energy without breakout of the edge can be detected for the different materials (alloys, welding deposits, etc.) investigated. The impact leaves a dent on the sample, which is firmly fixed so they cannot dodge during impact. The samples' deformation due to the impact is analyzed, primarily by quantifying the length (diameter) and depth of the indent. From the latter the angle of the deformed area (impacted zone) can be calculated which provides information about the relation between elastic and plastic deformation of the material **[6] Taylor, C.M., (1998)** the various rotating elements like shafts etc. Journal bearings are used for supporting the cylindrical rotating shafts. A special feature of journal bearings is that it makes metal to metal contact only in two conditions, one at the start of rotation and other at the end of rotation. Only in these two conditions, wear of journal bearings takes place. At all other instants, there is a hydrostatic lift between shaft and bearing which is created by pressurized fluid which we supplied externally. In Hydrostatic lift, shaft is slightly lifted from its original position and it rotates at its new position and does not make any contact with bearing so no wear of bearing takes place. **[7] Yano, A., Hirayama, Y., Sakanishi (2007)** The most important component where most of the fuel energy is lost in automobiles is engine. The energy is lost as heat to the surroundings the energy is also lost as friction. The engines are also the parts which are most responsible for the environmental pollution by releasing hydrocarbons, NOx emissions and other pollutants. It has been observed that around 60% of the fuel energy is lost as heat in which 30% is lost as exhaust and 30% for cooling the cylinder. 15% is lost as mechanical losses and only 25% of the energy provides the brake power **[8] Erhan, S.Z., Sharma, B.K. and Perez (2006)** The amount of hazardous emissions released by the mineral oil The judicious use of the non renewable resources is also a main area of concern. Research is being conducting for finding a replacement of the mineral oils. The study shows vegetable oils are the potential candidates for the replacement of mineral oils as cutting fluids. Vegetable oil possesses all the properties necessary for functioning as a cutting fluid lubricant. The Area of concern for vegetable oils is their oxidation stability. The vegetable oils tend to oxidize when operated under high temperatures **[9] R.M. Voitik(2010),** The examination of the tribosystem should include also the inspection and measurement of the wear scars. The shape, morphology, and location of the wear scars provide important information generally needed to characterize the tribo system and the wear process. Quantifying the amount of wear, particularly in terms of depth, generally is useful as well. The magnitude of the wear can support the characterization of the wear behavior and aid in the identification of a solution when used in conjunction with various models and analytical relationships. A generally good practice in examining wear scars is to examine them using several different methods, such as visual, low-power optical, and scanning electron microscopy (SEM) **[10] Mohd Shadab Khan (2016)** Wear by abrasion is form of wear caused by contact between a particle and solid material. Abrasive wear is the loss of material by the passage of hard particles over a surface. Abrasion in particular is rapid and severe forms of wear and can result in significant costs if not adequately controlled. These differences extend to the practical consideration of materials selection for wear resistance due to the different microscopic mechanisms of wear occurring in abrasion wear test of pure graphite or say more than 90% graphite in an engineering materials Therefore my work of objective is to find out abrasive wear characteristics & tribological behavior of graphite with help of specified apparatus **[11] Mani Deep et.al (2010)** An experimental investigation is carried out by to study the effect of normal load, weight fraction of graphite and abrading distance on the abrasive wear behavior of graphite reinforced polymer. Wear studies are carried out using PIN ON DISC APPARATUS. Weight loss of composites during abrasion has been examined as a function of sliding distance, normal load and weight fraction of graphite. Specimens with varying weight fraction of 10, 15, 20, 25, 30 of graphite have been taken and wear test is conducted using pin on disc apparatus under dry contact conditions. **[12] Srinivas Lakshmi et.al (2012)** The abrasive wear and frictional properties of graphite micro particle filled polyamide matrix composites are investigated by In this experiment the composites with varying weight fractions of graphite have been prepared by melt mixing technique. Wear tests were conducted using a pin on disc apparatus under dry contact conditions. The wear tests showed that graphite fillers improved the wear resistance and reduced coefficient of the friction

4.0 **RESULTS AND DISCUSSIONS:**

References	**Study**	**conclusions**
Wani Khalid Shafi, Ankush Raina (2018)	tribology has also helped in developing lubricants which are eco-friendly and sustainable.	This reduces the emissions to a greater extent and provides a source of renewable energy
M.S. Priyana, P. Hariharan (2014)	To develop a theoretical model and associated wear mode map to identify the regimes in which two body abrasion	the rolling mechanism dominated at low loads and high abrasive volume fractions
Mani Deep et.al (2010)	The effect of normal load, weight fraction of graphite and abrading distance on the abrasive wear behavior of graphite reinforced polymer.	Weight loss of composites during abrasion has been examined as a function of sliding distance, normal load and weight fraction of graphite.
László Zsidai (2016)	the tribological properties of composites and to investigate the effect of different additives and mechanical properties	Polymer has a more efficient effect on the fri ction at higher load, but it does not have any individual effect
Mohd Shadab Khan (2016)	Wear by abrasion is form of wear	the different microscopic

	caused by contact between a particle and solid material. Abrasive wear is the loss of material by the passage of hard particles over a surface	mechanisms of wear occurring in abrasion wear test of pure graphite or say more than 90% graphite in an engineering materials

To adapt this equipment to different industrial applications, the screws, which perform most of the work of transporting, conveying, mixing, compressing, or shearing of raw materials, have been designed to be totally modular. The screw segments are stacked one beside another on a splinted shaft. Their composition can be rapidly modified depending on the products to be processed and the final product desired. The adequately prepared suspension was gravity cast into a metal die. Both the composite castings obtained in this way and the comparative castings produced of the pure matrix alloy were examined for the abrasive wear behavior. Photo macrographs of the sliding surfaces of the examined composites were taken, and also the hardness measurements were carried out. It was found that even a small addition of particles influences positively the tribological properties of the examined composite materials, protecting the abraded surface from the destructive action of silicon carbide particles. The work presents also the results of hardness measurements which confirm that the composite material hardness increases with an increase in the volume fraction of hard reinforcing particles.

5.0 Conclusions:

Based on the results of the unique experiments, the following conclusions can help and improve the further tribotesting of polymers, the selection of proper material and design. For practical use we can mention by our results, that the polyamide composites are suitable as machine elements in normal abrasive applications, as they resist again abrasion wear. However, if there are any extreme demands, for example: high mechanical properties, temperature resistance and excellent chemical resistance etc., Characterization of materials subject to abrasion/ erosion processes conditions must be based on adequate experimental methods. Such methods make use of various special tribometers; some of them are commercially available. The tests have to be accompanied by material graphic analyses. "Classical" methods should be complemented by advanced modeling techniques and mathematical tools that enable correlation of wear properties and characteristic material properties for wear protection materials.

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