Abrasive Wear Behaviour of Organophosphate

Muhammad Aazam Siddiqui, Dr Shadab Khan, Er. Abdul Ahed Khan

Department of Mechanical Engineering, Integral University, Lucknow

Abstract – Wear is very important phenomena which play a vital role while designing any component. It directly affects the life of the component. Abrasive wear phenomena are simply caused by the passage of relatively hard particles or asperities over a surface. Abrasive wear simply includes division of two surface parts by abrasion of other mating surface that is situated between the friction areas. A systematic study of abrasive wear of Silicon has been carried out using a two body pin-on-disc wear machine. The objective of this study is to evaluate the abrasive wear of organophosphate by grinding it at different load at different rpm. In this thesis a study of abrasive wear of organophosphate at different speed were given to analyze the possibility of wear. A review of abrasive wear behavior of organophosphate using different wear rate speed has been discussed in this thesis. Mainly focus on the varying wear condition during varying rpm. as we all know that wear is very important parameter which directly affects the life of a component. The goal of this study was to evaluate abrasive wear only.

***Key Words*:** Abrasive wear, Behaviour of organophosphate, Wear rate

2. Body of Paper

1.1- Introduction of Organophosphate, 1.2 Production of Organophosphate 1.3-Properties of Organophosphate, 1.4- Uses Of Organophosphate

2.1- Literature reviews on abrasive wear

3.1- Need of present work, 3.2- Objectives of present work

4.1- Experimentation, 4.2- Fabrication of Test Rig. 4.3- Experimental set-up of wear test rig 4.4- Working of set-up

5.1- Effect of speed (rpm) on abrasive wear of Organophosphate at constant load, 5.1.1- Wear test initiated at 100 RPM 5N, 5.2.2- Wear test initiated at 150 RPM 5N, 5.2.3- Wear test initiated at 200 RPM 5N.

1.1- Introduction of Organophosphate

Organophosphate compounds are organometallic compounds containing carbon– silicon bonds. organophosphate chemistry is the corresponding science of their preparation and properties. Most organosilicon compounds are similar to the ordinary organic compounds, being colourless, flammable, hydrophobic, and stable to air. Silicon carbide is an inorganic compound. The organophosphate composition proposed is a blend of a conventional diorganopoly siloxane or a dimethylpolysiloxane oil and a limited amount of an perfluoroalkyl group-containing organopolysiloxane such as those represented by the group of 1 to 14 carbon atoms or an etherified perfluoroalkyl group of 2 to 14 carbon atoms having at least one oxygen atom between two carbon atoms forming an ether linkage, R is a hydrogen atom or a monovalent hydrocarbon group having 1 to 10 carbon atoms, Y is a divalent organic group having 2 to 5 carbon atoms, the subscripts a and b are, each independently from the other, zero or a positive integer and the subscripts c and d are, each independently from the other, zero, 1, 2 or 3 with the proviso that at least one of the subscripts a, c and d is not zero. By virtue of the admixture of this unique adjuvant, the silicone oil composition can be imparted with greatly increased spreadability even on the surface of a fluorocarbon resin film although the surface tension of the oil is not remarkably decreased thereby. An organophosphate composition or, more particularly, to an organophosphate composition comprising a fluorocarbon group-containing organophosphate having a remarkably low surface energy and exhibiting excellent wettability and lubricity against various materials. 2 As is well known, liquid organophosphate or so-called silicone oils have excellent heat and cold resistance, electric properties, water resistance and chemical resistance so that they are useful in a wide field of applications. One of the most unique properties of silicone oils is their very low surface tension as compared with other liquids including water and various kinds of natural and synthetic oils so that silicone oils can easily spread over the surface of a variety of materials. This unique property of silicone oils is utilized in their applications as surface-release agents, antifoam agents and additives in cosmetic and toiletry compositions. Certain fluorocarbon polymers such as polytetrafluoroethylene, however, have a still lower surface energy than conventional silicone oils so that the surface of such a resin cannot be coated with a silicone oil with full evenness or exhibits repellency against silicone oils. This means, for example, that silicone oils are not always suitable as a release agent on the surface of an article made from a fluorocarbon resin. In order to solve the above mentioned problem, proposals have been made heretofore according to which a silicone oil is admixed with a fluorinated hydrocarbon compound or a fluorine-containing surface active agent. This method, however, is not quite satisfactory because of the low compatibility of these fluorine-containing compounds in general with silicone oils resulting in eventual phase separation of the blend not to sustainedly exhibit the desired effects with uniformity.

1.2- Production of Organophosphate

The method of making an organophosphate resin which comprises reacting an organophosphate polymer, having an average of from 1 to 2 hydrocarbon radicals, attached directly to silicon atoms, per atom of silicon, which organophosphate polymer is initially in liquid state, with an aluminum alkoxide at temperatures between room temperature and 4300 C., the aluminum alkoxide being employed in amount between 0.01 per cent of the weight of the Organophosphate and a maximum proportion which is varied inversely with the temperature in accordance with values of 5 per cent of the aluminum alkoxide at 3000 C. and 20 percent.

1.3-Properties of Organophosphate

Organophosphate Silicone polymers or polydialkylsiloxanes are an important class of inorganic polymers that find many industrial uses. They are known for their outstanding temperature and oxidative stability, excellent low temperature flexibility, and high resistance to weathering and many chemicals. These polymers also have low surface tension and are capable of wetting most surfaces. The name silicone usually refers to organosilicon polymers with the general structure - [Si(R2)-O]- where R = -CH3 is called poly(dimethyl siloxane) which is often abbreviated as PDMS: The methyl groups along the chain can be substituted by many other groups (e.g., 5 ethyl, phenyl, vinyl, etc.) which allows for tailoring the chemical, mechanical and thermophysical properties for a wide variety of applications. The terminal silanol end groups render PDMS susceptible to condensation under both mild acid and base conditions. These resins are either intermediates for room temperature vulcanizeable silicones (RTV) or are converted to many silicone products. Silicone polymers possess an inorganic -(Si-O)- backbone similar to silicates which are associated with high surface energy. The Si-O bonds are strongly polarized and without side groups, should lead to strong intermolecular interactions. However, the nonpolar methyl groups shield the polar chain backbone. Or in other words, when the methyl groups point to the outside, silcones form hydrophobic films with good release properties, particularly if the film is cured after application. In fact, PDMS has one of the lowest critical surface tension of all polymers which is in the range of 20 to 25 mN/m. Thus polyalkylsiloxanes are capable of wetting most surfaces, unless some of the methyl groups are replaced by more polar groups. Due to the low rotation barriers, most siloxanes are very flexible. For example, the rotation energy around a CH2-CH2 bond in polyethylene is about 12.1 kJ/mol but only 3.8 kJ/mol around a Me2Si-O bond, corresponding to a nearly free rotation. Furthermore, chain-to-chain interaction is rather week due to the low cohesive energy, and the distance between adjacent chains is noticeably larger in silicones than in alkanes which also contributes to the great flexibility of the silicones. Due to great flexibility of the chain backbone, the activation energy of viscous flow is very low, and the silicone viscosity is less dependent on temperature compared to hydrocarbon polymers. Despite a very polar backbone, silicones can be compared to paraffin, with a low critical surface tension of wetting. In fact, silicones have a critical surface tension of wetting that is higher than their own surface tension. Thus, silicones are capable of wetting themselves, a property that results in good film formation and good surface covering. The low intermolecular interactions in silicones have many other consequences. For example, the glass transition temperatures are very low (e.g., 146 K for a polydimethylsiloxane compared to 200 K for polyisobutylene, which is the analogue hydrocarbon.) Due to the high free volume compared to hydrocarbons, most gases have a high solubility and high diffusion coefficient in silicones. That is, silicones have a high permeability to oxygen, nitrogen and water vapor, even if in this case liquid water is not capable of wetting the silicone surface! As expected, silicone compressibility is also high.

1.4- Uses Of Organophosphate

It is well known that a silicone oil or an organophosphate fluid is admixed with a pasty material used as the base of various cosmetic and medicinal preparations such as creams, hair dressings, ointments and the like. The silicone oil in these applications is used merely as an additive in a relatively small amount.

2.1- Literature reviews on abrasive wear

S Vishvanath perumal(2006) reported that Carbon black and silica have been used as the main reinforcing fillers that increase the usefulness of rubbers. In this work the effect of carbon black (high abrasion furnace)/silica hybrid fillers on the mechanical properties, crosslink density and morphological behaviour of ethylene vinyl acetate (EVA) was investigated. EVA reinforced with 0/50, 10/40, 20/30, 30/20, 40/10 and 50/0 phr of carbon black (CB)/silica hybrid filler. The total hybrid filler is kept constant at 50 phr (parts per hundred rubbers) and six different compounds were prepared. EVA, CB and silica followed by compounding on a two roll mill and molding at 180°C and 20 megapascal (MPa) pressure. The mechanical properties such as tensile & tear strength, elongation at break and 100% modulus have been measured at 23°C on universal testing machine. Abrasion resistance, hardness and rebound resilience are studied using DIN abrader, Shore A durometer and vertical rebound 23 resilience respectively. The tensile strength, modulus, tear strength, abrasion resistance, hardness and crosslink density increased with the CB filler content in hybrid filler, reached the maximum value at 50 phr of high abrasion furnace carbon black. Morphological properties of composites were evaluated by scanning electron microscopy analysis. Tham Do Quang (2015), reported that the dispersibility of ethylene vinyl acetate copolymer (EVA)/silica nanocomposites (for the EVA/silica nanocomposites and interaction between silica nanoparticles (nanosilica) and EVA by adding EVA-gacrylic acid (EVAgAA) as a compatibilizer, which was formed by grafting acrylic acid onto EVA chains with the aid of dicumyl peroxide). The above nanocomposites with and without EVAgAA were prepared by melt mixing in a Haake intermixer with different contents of silica and EVAgAA. Their structure and morphology were characterized by Fourier transform infra-red (FT-IR) spectroscopy, field emission scanning electron microscopy (FE-SEM), and the mechanical, rheological, dielectrical, and flammability properties of the nanocomposites were also investigated. The FT-IR spectra of the nanocomposites confirmed the formation of hydrogen bonds between the surface silanol groups of nanosilica and C=O groups of EVA and/or EVAgAA. The presence of EVAgAA remarkably increased the intensity of hydrogen bonding between nanosilica and EVA which not only enhanced the dispersion of nanosilica in EVA matrix but also increased the mechanical, viscosity and storage modulus of EVA/silica nanocomposites. In addition, the flammability of EVA/silica nanocomposites is also significantly reduced after the functionalization with EVAgAA. However, the mechanical properties of EVA/silica nanocomposites tended to level off when its content was above 1.5 wt.%. It has also been found that the dielectric constant value of the EVA/EVAgAA/silica nanocomposites is much lower 24 than that of the EVA/silica nanocomposites, which is another evidence of the hydrogen bonding formation between EVAgAA and nanosilica.

P. Sampathkumaran (2008) reported that Fiber/filler reinforced polymer composites are known to possess high strength and attractive wear resistance in dry sliding conditions. How these composites perform in abrasive wear situations needs a proper understanding. Hence, in this research article the mechanical and three-body abrasive wear behaviour of E-glass fabric reinforced epoxy (G-E) and silicon carbide filled E- glass fabric reinforced epoxy (SiC-G-E) composites are investigated. The mechanical properties were evaluated using Universal testing machine. Three-body abrasive wear tests are conducted using rubber wheel abrasion tester wherein two different loads and four varying abrading distances are employed. The results showed that the wear volume loss is increased with increase in abrading distance and the specific wear rate decreased with increase in abrading distance/load. However, the presence of SiC particulate fillers in the G-E composites showed a promising trend. The worn surface features, when examined through scanning electron microscopy, show higher levels of broken glass fiber in G-E system compared to SiC- filled G-E composites. **POLYM. COMPOS., 2008.** © 2008 Society of Plastics Engineers Pramila Baiet. al. (1987) reported ―that Si additions (4-24%Si) improved wear resistance of aluminium, no relationship between wear rate as a function of Si content was found. Wear rate increased linearly with applied pressure but was independent of sliding velocity. The value of the friction coefficient was found to be insensitive to applied pressure, Si content and sliding velocity. The fact that no transition in wear mechanism was observed with increased pressure, as reported by other authors could be due to the narrow range explored (0.105-1.733 MPa)‖. 25 Liang Y. N. et. al. (1995), reported that the MMCs containing SiC particles exhibit improved wear resistance. Particle size is one of the most important factors in determining wear of particulate-reinforced metal composites. However, it appears to be difficult to draw a fundamental conclusion from the reports about this problem. Some reports have suggested that wear resistance of the composites increased with increasing particle size, while others indicated that an increase in particle size had a negligible influence on the wear rate. A further problem is that nearly all the studies have been carried out with such methods as pin on disc or sand rubber wheel abrasion tests, in which the sliding speed was maintained in a narrow range and the applied load in a steady state. It is thus necessary to study the effect of particle size on wear properties of the composites under a variety of experimental conditions. In this work , the effect of particle size on wear behavior of SiC particulate-reinforced 2024 Al composites has been investigated using three tests : sliding wear , impact abrasion and erosion.

H.C. How and T.N. Baker, (1997), In their investigation of wear behavior of Al6061- saffil fiber, concluded that ―saffil are significant in improving wear resistance of the composite‖.The steady-state wear of aluminium alloy AA6061 and AA6061-based Saffilfibre-reinforced composites, manufactured by a PM route, was investigated with a pin-on- disc configuration under dry sliding conditions. Using a constant sliding velocity, the wear rates of the monolithic alloy and the composites increased proportionally with the applied load. The benefit of Saffil reinforcement at volume fractions of 5, 10 and 20% was not substantial at loads ranging from 4.9 to 48.3 N. As the applied load decreased to N, the composite showed a promising improvement in wear resistance as the volume fraction of Saffil reinforcement increased. At loads of 26 19.2 N and above, the wear resistance of the AA6061 composite was slightly impaired when the volume fraction of the Saffil reinforcement was increased from 5 to 20%. Compared with over-aged samples, the improvement of the wear resistance due to peak-ageing was not significant, although the Vickers hardness of the peak-aged samples was double that of the over-aged samples. The surface morphology of both the monolithic alloy and the composites after testing under loads of 9.8 or 48.3 N revealed a compacted layer which comprised mainly aluminium and iron. The amount of iron transferred increased with the applied load and with the volume fraction of Saffil in the composite. Energy Dispersive X-ray (EDAX) analysis indicated that the wear debris was generated mainly from the compacted layer. On the basis of the experimental observations, delamination was considered to be the controlling wear mechanism for the monolithic specimens tested at all loads and the composite specimens tested at loads ranging from 4.9 to 48.3 N. At a load of 1.1 N, surface fatigue, which caused surface cracking, was evident for the composite specimens. R. Dasgupta, R. Thakur, and B.

Govindrajan, (2002). concluded in their study that ―the high stress wear behavior is dependent on the combination of a number of experimental factors. The behavior can be explained based on the material removal mechanism operating under a combination of experimental factors. A regression analysis of the experimental data shows that the dependence is nonlinear. The equation arrived at by regression analysis helps in predicting the wear rate. A comparison between the experimental and predicted observed values indicates a variation of ±15%. Such an analysis should aid in predicting the high stress abrasive wear behavior of steels exposed to various combinations of load, particle size, and sliding distances‖.

M.S. Zaamout (2004), the objective of this research is to investigate the abrasive 27 wear behaviour of polymer base auto motive paint, which is locally used for steel painting. Research has been conducted under dry, water lubricated, and water-soap lubricated conditions. The effects of applied load, sliding distance, abrader surface roughness, and paint drying time on the abrasive wear volume and abrasive wear rate were investigated under controlled environment of 40% humidity. The examined paint was used directly on steel substrate with no primer. Preliminary results show that wear volume increases with increasing applied load, sliding distance and abrader roughness. However, results also show decreasing wear volume with increasing drying time up to 50 hr. Beyond this value, time seems to have little effects on abrasive wear behaviour. This argument is valid for all four conditions of tests. As for abrasive wear rate, results show decreasing abrasive wear rate with applied load , sliding distance, abrader surface roughness, and drying time. Results clearly indicate that the presence of water significantly increases the wear volume and wear rate. Furthermore, the addition of soap to water increases the wear volume and rate to even higher levels.

L.J. Yang (2005), in their study found that the Wear coefficient values obtained from different investigators can vary significantly up to a deviation of 1000% due to lack of a standard test method. Higher wear coefficient values can be obtained when the wear tests are carried out within the transient wear regime, or with an excessive sliding distance in the steady-state wear regime. Basavarajappa S. and Chandramohan G. (2006), reported that the sliding distance has the highest effect on the dry sliding wear behavior of MMCs than that of the load and sliding speed‖. Y. Reda et. al (2008), studies on Al6061-SiC and Al7075 - Al2O3 Metal Matrix Composites and R. Clark et.al in their studies on Al7075 reported that ―pre-aging 28 at various retrogression temperatures improves the hardness, tensile properties and electrical resistivity‖. Q Wang, Z H Chen, Z X Ding and Z L Liu (2008) ―Conducted study on Performance of abrasive wear and erosive wear of WC-12Co coatings sprayed by HVOF. They used WC-Co cermets as wear resistant materials. Their work examines the performance of such conventional and nano-structured materials in the form of coatings deposited by high velocity oxy-fuel (HVOF) thermal spraying. The results indicated that: microstructures of nano-structured and multimodal WC-12Co coatings prepared by HVOF are dense with little porosity, and their microhardness values are obviously higher than conventional WC-12Co coatings, though Nano WC did during spraying. As well, it was found that nanostructured and multimodal WC-12Co coatings exhibited better abrasive and erosive wear resistance in comparison with conventional one. B. Sidda Reddy, G. Padmanabhan and K. Vijay Kumar Reddy (2008) in their study deals with the development of a surface roughness prediction model for machining aluminum alloys using multiple regression and artificial neural networks. The experiments have been conducted using full factorial design in the design of experiments (DOE) on CNC turning machine with carbide cutting tool. A second order multiple regression model in terms of machining parameters has been developed for the prediction of surface roughness. The adequacy of the developed model is verified by using co- efficient of determination, analysis of variance (ANOVA), residual analysis and also the neural network model has been developed using multilayer perception back propagation algorithm using train data and tested, using test data. To judge the efficiency and ability of the model to predict surface roughness 29 values percentage deviation and average percentage deviation has been used. The experimental results show, artificial neural model predicts with high accuracy compared with multiple regression model. This study uses statistical multiple regression model for prediction of surface roughness in machining of aluminum alloys, which is used to determine the correlation between a criterion variable and a combination of predicted variables. It can be used to analyze data from any of the major quantitative research designs such as fundamental comparative, correctional and experimental. This method is also able to handle interval ordinal or categorical data and provides estimates both of the magnitude and statistical significance of the relationships between variables (Gall et al., 1996). Therefore, multiple regression analysis will be helpful to predict the criterion variable finish surface roughness via predictor variables, such as spindle speed, feed and depth of cut. The second order multiple regression model for the surface roughness(Ra, μm) is developed as a function of cutting parameters such as cutting speed (V), federate (f) and depth of cut (d). This analysis is carried out at a significance level of 5% i.e., confidence level of 95%. The optimal neural network architecture was used in this study. It was designed using NEURO SOLUTIONS 5.0. The network consists of one input, two hidden and one output layer. Hidden layers have eight neurons each, where as the input and output layers have three and one neuron, respectively. Using full factorial design in the design of experiment, the machining parameters which are influencing the surface roughness on the machining of Al Alloys has been modeled using Multiple Regression and Artificial Neural Networks. S.S. Mahapatra and Vedansh Chaturvedi (2009) found that the hardness of the composite monotonically decreases as the fibre length increases but tensile 30 strength first increases and then decreases as length of the fibre is increased. In contrary to common belief that hardness and tensile strength improve wear resistance, it has been observed that parameters encountered in wear process strongly influence wear resistance. In future, the study can be extended to other natural fibres to find out the optimum fibre length. The abrasive wear behavior of chemically treated sugarcane fibre and aging effects of the fibre on abrasive behavior of the composite can be studied‖. Sagbas, F. **Kahraman, U. Esme (1990)** studied the ―modeling and predicting abrasive wear behavior of poly oxy methylenes using response surface methodology and neural networks and found that the abrasive wear behavior of poly oxy methylenes (POM) under various testing conditions was investigated. A central composite design (CCD) was used to describe response and to estimate the parameters in the model. Response surface methodology (RSM) was adopted to obtain an empirical model of wear loss as a function of applied load and sliding distance. Also, a neural network (NN) model was developed for the prediction and testing of the results. Finally, a comparison was made between the results obtained from RSM and NN‖. J. L. Xuan, I. T. Hong and E. C. Fitch (1991), Under fluid film lubrication, the particulate contaminants in the fluid cause three-body abrasive wear on critical surfaces. The wear not only depends on the hardness of the wearing surface (Hj), but also on the hardnesses of its opposing surface (Hb) and the involved abrasives (Ha). In this paper, the hardness effect, particularly the relationships among these three hardnesses, is studied, by exploring the interdependence between two hardness ratios: the ratio between two rubbing surfaces (Hb /Hj) and the ratio between the surface to be protected (usually the harder surface) and the abrasives (Hj /Ha). Three types of 31 journal-bearing pairs (Hb /Hj = 0.75, 0.6, and 0.3) were tested, subjected to four abrasive particles (Hj /Ha ranges from 0.14 to 2.75). The wear linearly varies with the Hj /Ha value at each metal hardness ratio on log-log diagram. The empirical constants in the wear function are obtained. The critical hardness ratio and the wear coefficient are also analyzed. Chang Chongyi Wang **Chenggu and Jin Ying (2010)** conducted their study on numerical method to predict wheel/rail profile evolution due to wear. ―A wheel/rail profile wear prediction methodology was developed and applied to the wheel/rail disc test about the wear of flange and gauge. Three-dimensional nonlinear finite element dynamic analysis code ABAQUS was also used in the simulation of wheel/rail disc rolling contact process. The simulation results are compared with measurements of laboratory wear test and the effectiveness of the wear prediction methodology was verified‖. Friedrich Franek, Ewald **Badisch and Martin Kirchgaßne (2020)** 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 – the acquired correlation of materials properties and wear resistance under severe conditions. 32 Dharma R. Maddala, Arif Mubarok and Rainer J. Hebert (2022) conducted study on Sliding wear behavior of Cu50Hf41.5Al8.5 bulk metallic glass. Sliding wear behavior of a copper-based bulk metallic glass (Cu50Hf41.5Al8.5) was investigated for both as-cast and annealed samples. ―The wear resistance increased during isothermal annealing near the glass transition temperature. Nano-crystals developed during the annealing for annealing times up to 300 min. A linear relation between hardness and wear resistance was observed during the early stages of devitrification, but at longer annealing times the wear resistance increased less than the hardness‖. N R Prabhu Swamy, C S Ramesh and T Chandershekar (2012) ― Studied the effect of heat treatment on strength and behavior of Al-SiCp composites and concluded that microhardness of composites increased significantly with increased content of SiCp. Heat treatment has a significant effect on microhardness of Al6061 matrix alloy and its composites. Tensile strength of composites increased significantly with increased content of SiCp. Abrasive wear loss of composites decreases, with the increase in content of SiCp in matrix alloy under identical test conditions‖.

Veeresh Kumar G.B, C.S.P.Rao, Bhagyashekar M.S, Selvaraj (2010). N Reported that ―artificial neural network (ANN) can be effectively applied to study the tribological behavior. The studies conducted regarding wear resistance properties of Al6061-SiC & found that the ANN model can predict the Wear Factor and Wear Height Loss up to 95% accuracy‖. Dushyant Singh, K P Saha & D P Mondal (2023) conducted their study on development of mathematical model for prediction of abrasive wear behavior in agricultural grade medium carbon steel and found that ―the wear rate of ICA and QT specimens are much lower than that of AR and AN specimens due to formation of ferreto-martensitic, and tempered martensitic structure respectively during heat- 33 treatment process. Wear rate follows a non-linear relationship with peening intensity as at first it is reduced up to a peening intensity of 0.17 A, then increases again with the increase in peening intensity due to increase in brittleness of the specimen with the peening intensity. Applied load, however the rate of growth may vary according to heat treatment applied to the material. The complex relationship between the influencing factors and wear rate can be illustra-ted by fitting a mathematical equation of quadratic form which shall help in prediction of wear rate accurately as the corresponding regression coefficients and the model are found to be highly significant‖. Jankauskas, V.; Skirkus, R.; Martinkus, N. (2011) Industrialized countries studies have shown that because of wear in the world suffered huge losses every year - up to 4% of the gross national product. It was found that investments in the tribological research annually can save from 1 to 1.4% of gross national product. In this paper, the abrasive wear research of arc welded Fe-C-Si-Cr-Ti-B surfaces into embedded abrasive. The microhardness of arc welded layers has a direct impact on abrasion - the harder layers, the higher resistance to abrasive wear. In SEM picture visible cutting traces of wear and only small fragments are chipped. This phenomenon demonstrates the high abrasive and metal microhardness differences influence. The highest wear resistance shows sample with C - 1,6%, Cr - 4,4%, B - 0,56%, Mn - 0,9%, Si - 1,44%, Ti - 0,59% and Fe - 90,2%. Punyapriya Mishra (2013) studied the ―statistical analysis for the abrasive wear behavior of bagasse fiber reinforced polymer composite and found that the relationship of abrasive wear loss with fiber concentration, applied load and sliding velocity has been successfully obtained by using RSM at 95% confidence level. The response surface methodology analysis has been reviewed. RSM can be used for the 34 approximation of both experimental and numerical responses. Two steps are necessary, the definition of an approximation function and the design of the plan of experiments. This model is valid within the ranges of selected experimental parameters of fiber concentration, applied load and sliding velocity. The accuracy of the RSM model was verified with three sets of experimental data which were never used in modeling and average percentage deviation calculated as 7.542%. E. Y. H. Bobobee and F. Kumi (2013) Develop and evaluate equipment for testing the abrasive wear off tillage tools in the laboratory. The abrasive wear experiment was arranged in a completely randomized design with the soils from the five sites as the treatment. Each treatment was replicated five times. The wear rate of soils from Akatsi and Ho showed increasing trend with increasing moisture content while that of Wenchi and Mampong showed a reverse trend up to 13% and 15% moisture content, respectively. The soil from Akatsi produced the highest wear of 4.11g. The wear in the soils from Ho, Mampong, Wenchi and KNUST were 3.16g, 2.90g, 2.88g and 1.36g, respectively with the least wear from the KNUST soil. This confirms the long held belief that the wear rate of tillage tools is directly related to the sand content of the soil. The abrasive wear characteristics of the soils showed strong correlation between mass loss and dimensional loss of the ploughshare.

M. Sudheer, N. KarthikMadhyastha, M. Kewin Amanna, B. Jonthan, and K. Mayur Jayaprakash (2013) The present work reveals the effect of the addition of commercial MoS2(10wt%) particles on mechanical and two-body abrasive wear behavior of epoxy with/without glass fiber mat reinforcement. The abrasive wear testing was carried out using pin-on-disc wear tester for different loads and abrading distances at constant speed of 1m/s. A significant reduction in wear loss and specific 35 wear rate was noticed after the incorporation of MoS2 filler allowing less wear of matrix during abrasion which in turn facilitated lower fiber damage. The worn surface features were investigated through scanning electron microscopy (SEM) in order to investigate the wear mechanisms. T. S. Barrett, G.W. Stachowiak, A.W. Batchelor (2005), The study was done on friction and wear of ultra-high molecular weight polyethylene (UHMWPE) pins sliding against a stainless steel disc were measured for sliding speeds ranging from 1.25 to 10 m s−1 and disc surface roughnesses Ra from 0.07 to 0.53 µm ms−1. Frictional heating was controlled by air jets and surface temperature measured with an IR pyrometer. It was found that the wear of UHMWPE is critically dependent on surface temperature and that, when the temperature exceeds a critical value, wear proceeds in a series of discrete steps caused by the sudden loss of a molten or softened layer of polymer. Wear was also influenced by surface roughness. An optimum surface roughness, i.e. a minimum of wear was found at low and medium sliding speeds. At the highest speed tested, however, the influence of roughness on wear rate was much less distinct. Scanning electron photomicrographs of worn pins and disc surfaces revealed evidence of melting by UHMWPE at high sliding speeds and abrasion at high surface roughnesses. Transfer films on disc surfaces were limited to isolated deposits of polymer wear particles.

D. Kakas, B. Skori C, S. Mitrovi C, M. Babi C, P. Terek, A. Mileti C , M. Viloti C (2009) The influence of applied load and sliding speed on the tribological performance, i.e. friction and wear of TiN IBAD coating in sliding with corundum ball has been evaluated using reciprocating sliding wear test. Post characterization of wear zones was conducted using AFM, SEM and EDX. The results show that coefficient of friction decrease with decreasing applied load and with increasing the sliding speeds.
36 O. P. Modi, R. P. Yadav, D. P. Mondal, R. Dasgupta, S. Das, A. H. Yegneswaran (1997) in their study of two body abrasive wear behaviour of a zinc-aluminium alloy - 10% Al2O3 composite at different loads (1–7 N) and abrasive sizes (20–275 ¹m) as a function of sliding distance and compared with the matrix alloy. The wear rate of the composite and the matrix alloy has been expressed in terms of the applied load, abrasive size and sliding distance using linear factorial design approach. The study suggests that the wear rate of the alloy and composite follow the following relations: Y alloy D = 0.1334 – 0.0336x1 + 0.0907x2 + 0.0219x3 – 0.0296x1x2 + 0.0274x2x3 – 0.0106x3x1 – 0.0201x1x2x3. Y comp D = 0.0726 – 0.028x1 + 0.062x2 + 0.03x3 – 0.024x1x2 + 0.028x2x3 – 0.016x3x1 – 0.014x1x2x3. where, x1, x2 and x3 are the coded values of sliding distance, applied load and abrasive size respectively. It has been demonstrated through the above equations that the wear rate increases with applied load and abrasive size but decreases with sliding distance. The interaction effect of the variables exhibited a mixed behavior towards the wear of the material. It was also noted that the effect of load is less prominent for the composite than the matrix alloy while the trend reversed as far as the influence of the abrasive size is concerned.

Hua-Nan Liu, KeisakuOgi (2012) In this study the tribological properties of Al2O3 continuous fibre reinforced Al-4.43 wt %Cu alloy composites with a fibres volume fraction of about 0.55 were measured for five types of fibre orientations under a dry sliding contact with a bearing steel. Fibres were in a plain perpendicular to wear 37 surface and parallel to sliding direction, and had the angles 0o, 45o, 90o, or 135owith respect to the direction of motion of the counter face; or were anti-parallel the sliding direction. The results show obvious dependence of wear characteristics on fibres orientation: for the 45o, 90o, and 135o orientations, the larger the fibres angle, the lower the volume loss; while the 0oorientation resulted in a higher steady-state wear rate than those of the 45o, 90o, and 135o, orientations, except that the anti-parallel orientation caused the highest volume loss at all sliding distances. The wear mechanism was inferred as a oxidation- microgrooving process through the analyses of worn surface and subsurface with the aid of optical microscope and scanning electron microscope. Also it was found that the fibres broken and subsurface deformation had played an important role in causing wear anisotropy.

Gun Y Leec, C.K.H Dharan, R.O Ritchie (2002) A simple physically- based model for the abrasive wear of composite materials is presented based on the mechanics and mechanisms associated with sliding wear in soft (ductile)- matrix composites containing hard (brittle) reinforcement particles. The model is based on the assumption that any portion of the reinforcement that is removed as wear debris cannot contribute to the wear resistance of the matrix material. The size of this non-contributing portion (NCP) of reinforcement is estimated by modeling three primary wear mechanisms, specifically, plowing, cracking at the matrix/reinforcement interface or in the reinforcement, and particle removal. Critical variables describing the role of the reinforcement, such as relative size, fracture toughness and the nature of the matrix/reinforcement interface, are characterized by a single contribution coefficient, C. Predictions are compared with the results of experimental two-body (pin-on-drum) abrasive wear tests performed on a model aluminum particulate-reinforced epoxymatrix composite material.

38 D. Tao, G. L. Chen, and B. K. Parekh (2008), A statistical Box-Behnken design (BBD) of experiments was performed to evaluate effects of individual operating variables and their interactions on the wear rate of grinding ball mills used in the phosphate industry. The wear tests were conducted using a specially designed grinding mill. The variables examined in this study included grinding time, solution pH, rotation speed, mill crop load, and solids percentage. The most significant variables and optimum conditions were identified from a statistical analysis of the experimental results using response surface methodology. Experimental results show that solution pH has the most significant effect on the wear rate for both Type 1018 (UNS G10180) carbon steel (CS) and a high- chromium alloy. The optimum process parameters for minimum wear rate were solution pH at 7.36, rotation speed at 70.31 rpm, a solid percentage at 75.50, and a crop load at 71.94% for Type 1018 CS; for the highchromium alloys, they include a solution pH at 8.69, rotation speed at 61.13 rpm, a solid percentage at 64.86, and a crop load at 57.63%.

A.A. Torrance (2005) In his study the abrasive wear rates of materials may be very simply related to their mechanical properties, provided wear takes place under very simple conditions. However, wear rates in many practical situations can be controlled by effects which either relate to mechanical properties in more subtle ways, or which are controlled by quite different parameters. Mechanics models of the abrasive process provide a means of linking these different effects together to understand better the effects, which may determine wear under particular conditions. They can also help to design tests to measure the properties of a material under conditions similar to those pertaining in abrasion. Some progress has been made in producing integrated models of real abrasive processes, but much more could be done to improve existing models and develop new ones.

39 S. Kumar, V. Balasubramanian (2019) This paper reports the dry sliding wear behavior of AA7075 aluminium/SiCp composites fabricated by powder metallurgy technique. Five factors, five levels, central composite, rotable design matrix is used to optimize the required number of experiments. The wear test has been conducted in a pin- on-roller wear testing machine, under constant sliding distance of 1 km. An attempt has been made to develop a mathematical model by response surface method (RSM). Analysis of variance (ANOVA) technique is applied to check the validity of the developed model. Student's t-test is utilised to find out the significance of factors. The effects of volume percentage of reinforcement, particle size of reinforcement, applied load, sliding speed and hardness of counter part materials on dry sliding wear behavior of AA7075 aluminium/SiCp have been analysed in detail.

3.1- Need of present work

On the basis of literature review it has been observed that the wear studies were conducted on wide varieties of materials/alloys. It has been observed that there is no review work on Organophosphate. The present study is based on Abrasive wear behavior of Organophosphate. A systematic study of abrasive were of Organophosphate has been carried out using a two body pin-on-disc wear machine. In this thesis a study of abrasive wear of Organophosphate at different speed were given to analyze the possibility of wear. Mainly focus on the varying wear condition during varying RPM.

3.2- Objectives of present work

The aim of present work is to check the abrasive wear of abrasive of Organophosphate at same orientation of the specimen but different applied loads. In this connection the following procedure were aimed to be carried out.

- To fabricate single orientation pin on disc setup.
- To select same materials for the desired test at different weight.
- To study the abrasive wear characteristics of the selected materials of thespecimen.
- To determine the abrasive wear characteristics at different applied loads.
- To determine the abrasive wear characteristics at different applied RPM**.**

4.1- Experimentation

In this chapter, details of material used in the present investigation and its preparation has been described and the details of the experimentation on wear studies in the material of present investigation have been given. In order to carry out the experimental work, the procedure is as follows.

i. Fabrication of Test Rig
ii. Specimens Materials
iii. Wear characterizatio

4.2- Fabrication of Test Rig.

Numerous researches have been done in the field of abrasive wear. This work is also an experimental design in the field of abrasive wear evaluation via a newly designed wear test rig. In view of the objective a set-up was needed to be designed which can calculate wear rate at different speed (rpm) of work piece with respect to the main frame (horizontal position). The wear machine used for evaluating wear properties was designed by Prof. (Dr.) Zahir Hasan and fabricated by Dr. Mohd Shadab Khan. A pin on disc wear test technique was adopted to test the wear behavior of specimens. Wear rate and wear mass were evaluated at different orientation of the specimen. The tests were conducted for seven different orientations namely 100 rpm , 150 rpm, 200 rpm . The wear mass of above said specimen evaluated at a constant time of 2min (120 sec)**.**

4.3- Experimental set-up of wear test rig

4.4 Working setup

DC motor is connected to regulator through a suitable electrical wiring. Further, flange 52 coupling connects D.C motor to a shaft. A key is provided for connecting DC motor and shaft. Grinding disc is connected to one end of the shaft which is supported by two bearings. The specimen is fitted in specimen holder. The specimen holder is made of wood; a slot equal to the size of cross- section of specimen is made in it, to properly hold the same. The samples are fastened with the fixture in these slots, one at a time and the wear test is performed. The fixture is fitted in acrylic sheet having multiple holes along the radius of the sheet. These holes are made in such a way to get fresh surface along grinding disc. At the end of the acrylic sheet there is attachment to apply a load. The load is applied with help of screw jack, as the screw jack moves forward it pushes the acrylic sheet with help of shaft which connects screw jack and acrylic sheet. The whole arrangement of attachment, different parts and assemblies is discussed and shown in the figures later in chapter.

5.1- Effect of speed (rpm) on abrasive wear of Organophosphate at constant load

Effect of Speed (rpm) On Abrasive Wear of organophosphate at Constant Load As the wear studies were conducted against the abrasive media (grinding disc). The selection of applied load and the position of the specimen for wear studies were taken as three different loads. Five reading of wear were taken from three sets at different rpm. The result shows that as the speed (rpm) increases the wear rate of the specimen increases for a same load. The tests for wear rate are held at 3 sets of specimen at different rpm but at a constant applied load . These tests are done at i. 100 RPM ii. 150 RPM iii. 200 RPM Observation Table Following test results have been observed during investigation of wear behavior of Organopolysiloxane different sets at different angular speed and different applied load. Applied load = 5 N• Time = 2 minute•

Table No. 1

Set No.1 (100 RPM, 5 N)			
TEST NO	MASS BEFORE TEST(gms)	MASS AFTER TEST(gms)	WEAR BY MASS (gms)
1	10.435	8.371	2.064
2	10.736	8.7	2.036
3	10.516	8.444	2.072
4	10.987	8.913	2.074
5	10.809	8.736	2.073
MEAN			2.063

Set No.2 (150 RPM, 5 N)			
TEST NO	MASS BEFORE TEST(gms)	MASS AFTER TEST(gms)	WEAR BY MASS (gms)
1	10.541	8.498	2.043
2	10.663	8.521	2.142
3	10.329	8.278	2.051
4	10.489	8.417	2.072
5	10.576	8.419	2.157
MEAN			2.093

Set No.3 (200 RPM, 5 N)			
TEST NO	MASS BEFORE TEST(gms)	MASS AFTER TEST(gms)	WEAR BY MASS (gms)
1	10.642	8.516	2.126
2	10.45	8.372	2.078
3	10.737	8.639	2.098
4	10.56	8.484	2.076
5	10.582	8.47	2.112
MEAN			2.098

5.2.2- Wear test initiated at 150 RPM 5N

Table No. 2

Set No.4 (100 RPM, 10 N)

TEST NO	MASS BEFORE TEST(gms)	MASS AFTER TEST(gms)	WEAR BY MASS (gms)
1	10.651	8.534	2.117
2	10.569	8.504	2.065
3	10.362	8.231	2.131
4	10.956	8.817	2.139
5	10.762	8.628	2.134
MEAN			2.117

Set No.5 (150 RPM, 10 N)

TEST NO	MASS BEFORE TEST(gms)	MASS AFTER TEST(gms)	WEAR BY MASS (gms)
1	10.486	8.409	2.077
2	10.078	8.815	2.263
3	10.446	8.352	2.094
4	10.39	8.253	2.137
5	10.442	8.143	2.299
MEAN			2.174

Set No.6 (200 RPM, 10 N)

TEST NO	MASS BEFORE TEST(gms)	MASS AFTER TEST(gms)	WEAR BY MASS (gms)
1	10.516	8.271	2.245
2	10.486	8.339	2.15
3	10.45	8.263	2.187
4	10.987	8.842	2.145
5	10.541	8.327	2.214
MEAN			2.188

5.2.3- Wear test initiated at 200 RPM 5N.

Table No. 3

Set No.7 (100 RPM, 15 N)			
TEST NO	MASS BEFORE TEST(gms)	MASS AFTER TEST(gms)	WEAR BY MASS (gms)
1	10.526	8.34	2.186
2	10.72	8.616	2.104
3	10.504	8.294	2.21
4	10.97	8.755	2.215
5	10.78	8.567	2.213
MEAN			2.185

Set No.8 (150 RPM, 15 N)			
TEST NO	MASS BEFORE TEST(gms)	MASS AFTER TEST(gms)	WEAR BY MASS (gms)
1	10.445	8.32	2.125
2	10.661	8.246	2.415
3	10.328	8.18	2.148
4	10.483	8.366	2.117
5	10.572	8.108	2.464
MEAN			2.253

Set No.9 (200 RPM, 15 N)			
TEST NO	MASS BEFORE TEST(gms)	MASS AFTER TEST(gms)	WEAR BY MASS (gms)
1	10.648	8.278	2.37
2	10.459	8.234	2.225
3	10.719	8.437	2.282
4	10.547	8.332	2.215
5	10.728	8.403	2.325
MEAN			2.283

CONCLUSION

It is concluded from the above discussion that wear is function of applied load. Initially, it was understood that wear depends upon applied load, surface parameters and mechanical properties such as hardness, toughness etc.

Thus it can be concluded that:
There is a linear relationship between wear and load The wear loss increases while load increases. Wear loss is more at 15 N load as compare to 5 N and 10 N load. The wear loss increases while RPM increases. The wear loss in first minute is more as compare to last minute while increasing the RPM

REFERANCES

Advanced Materials. 25 (46): 6709–6713. doi:10.1002/adma.201303175.
Body Armor Made with Silicon EVA . (2005-0604*). DuPont the Miracles of Science. Retrieved November* 4, 2011
B. Suresha, G. Chandramohan, Three-body Abrasive Wear Behaviour of Particulate-filled Glass–vinyl Ester Composites, *Journal of Materials Processing Technology*, 200 (2008), pp. 306–311.
B. Basu, M. Kalin, Tribology of Ceramics and Composites: Materials Science Perspective, John Wiley and Sons (2011).
B. Suresha, G. Chandramohan, Siddaramaiah, K. N. S. Kumar, M. Ismail, *Mechanical and Three-Body Abrasive Wear Behaviour of Three-Dimensional Glass Fabric Reinforced Vinyl Ester Composite*, Materials Science and Engineering A, 480 (2008), pp. 573–579.
Bhushan And Gupta (1991), *The Theory And Application Of The Hvof Thermal Spray Process*, Surface Engineering And Wear, Chapter 1, Pg. No. 8.
Blanchett, T.A., Kennedy, F.E. (1989) _The Development Of Transfer Films In Ultra-High Molecular Weight Polyethylene/Stainless Steel Oscillatory Sliding_, Tribology Transactions, Vol. 32, Pp. 371-379.
BaiPramila, B. N. And S.K. Biswas (1987) , _Characterization Of Dry Sliding Wear Of Al Alloy_ Wear.
B. Sidda Reddy, G. Padmanabhan and K. Vijay Kumar Reddy, 2008. Surface Roughness Prediction Techniques ForCnc Turning. *Asian Journal Of Scientific Research*, 1: Pg. 256-264.
Eiss, N.S., Wood, K.C., Herold, J.A., Smyth, K.A. 1979 _Model For The Transfer Of Polymer To Rough, Hard Surfaces, Transactions_ Asme, *Journal Of Lubrication Technology*, Vol. 101, , Pp. 212-219.
Dostupnénainternete:Http://Www.Stifner.Sk/Skola/Doc/Afm/Texty_Af m_2004.Doc (Cit. 2009-11-12)
Gong (Ed), RH (2011). Specialist Yarn and Fabric Structures: Developments and Applications. *Woodhead Publishing*. p. 349. ISBN 9781845697570.
G. W. Stachowiak, Wear: Materials, Mechanisms and Practice, John Wiley & Sons Ltd, West Sussex (2005).
Gant, Gee, Roebuck (2005), _Rotating Wheel Abrasion Of Wc/Co Hardmetals , Wear 72