

**TRIBOLOGICAL PERFORMANCE OF WASTE SLURRY POWDER
REINFORCED (POLYPROPYLENE) USING PIN ON DISK TRIBOMETER**

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in fulfilment of the requirements for the degree of
Bachelor of Mechanical Engineering (with Honours)**

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DECLARATION

I declare that this project report entitled “Tribological Performance of Waste Slurry Powder Reinforced Polypropylene Using Pin on Disk Tribometer” is the result of my own work except as cited in the references

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APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (with Honours)

Signature :

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Date :

DEDICATION

To my beloved father and mother.

ABSTRACT

Tribology is the branch of knowledge that gives important role in industry. Begins, with small appliances in our household such as washing machine, table fan until to huge machinery that relates towards friction and wear. The tribology give effects of overall efficiency of equipment as its relates on maintainability for specific machine. Hence, this shows vital findings to get suitable solution for lubrication in order to bring lower maintenance cost that cause from wear and tear parts. Nowadays, the industry is expected to use the material that's friendly to environment. Besides, in order to reduce the pollution, the benefit of reduction cost from recycle usage of waste materials that's may be considered as secondary source of material that's high energy content that bring energetic advantages to industry. The waste material such as quarry dust is expected to bring good potential strength in reduce friction and wear. As for this paper, uses of quarry dust as to be new reinforcement substitutes in fabrication of polymer composites, which are supposed to bring zero waste strategy to improve tribological properties which bring benefit in reduction cost. The target of this study is to investigate the tribological performance of waste slurry powder reinforced Polypropylene (PP) under dry sliding conditions, and determine the wear mechanism when applied several load. The mechanism of material testing is using the pin on disk tribometer. The pin was shaped by compaction process of cylindrical mold to form pin sized of 30mm height and 10mm diameter. The composition were prepared using Polypropylene powder by 5%, 10, and 20% that being reinforce from quarry dust (QD). Through this study, the collection of data towards the coefficient of friction (COF) and wear rate concludes that effect of 5% presence of quarry dust will result of perfect mixing of reinforcement that's bring lower COF on various applied load. The findings shows the significant wear rate that reduce compared to other composition weightage that simulates under dry sliding condition.

ABSTRAK

Tribologi adalah satu cabang pengetahuan yang memberikan peranan yang penting dalam industri. Ia dapat dilihat bermula dari penggunaan perkakas kecil di rumah seperti mesin basuh, kipas meja sehingga jentera besar yang sering berhubung kait dengan geseran dan kehausan. Kesan dari geseran dan kehausan memberi kesan terhadap efisien bagi sesuatu mesin. Oleh itu, langkah penyelesaian adalah dengan menambah kesan pelinciran atau campuran bahan yang mempunyai kadar geseran yang rendah yang dapat mengurangkan kos penyelenggaraan yang lebih rendah yang menyebabkan bahagian-bahagian haus dan lusuh. Pada masa kini, industri kini tertumpu kepada penggunaan sisa buangan yang dijangka dapat mengurangkan pencemaran serta lebih mesra alam. Selain itu, dalam usaha mengurangkan pencemaran, dengan mengambil kira seperti penggunaan daripada bahan buangan yang telah diguna semula sebagai sumber kedua yang membawa kelebihan kepada industri. Bahan buangan seperti debu kuari dijangka membawa kekuatan yang baik serta mengurangkan geseran dan kehausan. Seperti di dalam kajian ini, penggunaan habuk kuari sebagai pengganti pengukuhan baru dalam fabrikasi komposit polimer, yang dilihat membawa strategi sisa sifar dan juga memperbaiki sifat-sifat tribologi yang membawa manfaat dalam kos penyelenggaraan. Sasaran kajian ini adalah untuk mengkaji prestasi tribologi terhadap polipropilena (PP) diperkuat habuk kuari di bawah keadaan gelongsor kering, dan menentukan mekanisme haus apabila dikenakan beberapa beban tambahan. Mekanisme pengujian bahan adalah menggunakan ujian “pin-on-disc” yang membuat permukaan cakera bercalar dan haus. Pin telah dibentuk oleh proses mampatan dalam acuan silinder untuk membentuk pin bersaiz 30mm tinggi dan diameter 10mm. Komposisi itu telah disediakan menggunakan serbuk polipropilena diperkuat dari habuk kuari (QD) sebanyak 5%, 10, dan 20% yang dicampurkan bersama. Melalui kajian ini, pengumpulan data ke atas pekali geseran dan kadar haus yang mempengaruhi komposisi yang berbeza dan beban yang dikenakan di bawah keadaan gelongsor kering. Hasil kajian telah dicapai, dan ini dapat dirumuskan dengan hasil campuran habuk kuari diperkuat dengan bahan polimer dapat meningkat sifat tribologi dengan 5% campuran bahan tersebut dapat mengurangkan pekali geseran dengan kadar isi padu yang terbebas lebih rendah berbanding campuran komposisi yang lain.

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LIST OF ABBREVIATION AND SYMBOL

PP	-	Polypropylene
QD	-	Quarry Dust
CO ₂	-	Carbon Dioxide
NO _x	-	Nitrogen Oxides
COF	-	Coefficient of Friction
wt%	-	Weightage Percent
ρ	-	Density
T	-	Temperature
RPM	-	Revolutions Per Minute

CHAPTER 1

INTRODUCTION

1.0 Background

Waste slurry powder can be generated from cement plant. High production of cement will cause waste from all over the world. (Jamin & Mahmood, 2016). It is indicate that the production of cement will emit CO₂ due to calcination of raw material and combustion of fuel. This will give impact towards emission of by 7% of CO₂ worldwide. This scenario can be seen in Malaysia as high development country located on the Southeast Asia. It's have the separation of population between peninsular and east Malaysia. This shows the country have created significance different level of development. Usually the plants will be handle from big company played by local producer and multinationals. The cement as the generally produced from calcium carbonate, silica, alumina and iron ore by extracting limestone rock, chalk, schist or clay from quarry. This continuous development will increase the pollution due to mass production from cement plant. The end result based on unethical dispose of waste into the open landfill will cause of dust, emission of CO₂, nitrogen oxides (NO_x) and sulphur dioxide (Stajanča & Eštoková, 2012). Then, it will harm all the environment and also the live communities.

The slurry powder result from the factory that usually contains marble slurry dust as cement additive. The proves from previous study back in 2009 from United States Environmental Protection Agency (USEPA) focussed on future for reducing greenhouse gas emission in the construction sector Anita Brown (2015). Besides, most of their path towards in improving fuel efficiency and recycling material.

In this studies, the potential waste usage from slurry powder from cement plant can be reuse in material matching with polymer matrix composite as new material in automotive components. The tribological properties of the proposed material will be explored based on their mechanical, friction and wear properties. The study against polymer tribology can be extensive knowledge based on the analysis of abrasion, adhesion, and fatigue (Myshkin, Pesetskii, & Grigoriev, 2015). This will bring beneficial effects on study of tribology that highlighting about friction, wear and lubrication.

1.2 Problem Statement

In recent years, the waste slurry cement powder are known as main adverse effects to the environment which is now addressed as a challenge of global issue. Now, the global tendencies concerned about the causes of climate change because of CO₂ emissions. Besides, this issue can be rise in the way to reduce carbon footprint as an important step to save our environment.

Therefore, substantial studies to discover on the global demand towards the greener environment by focussing on usage of waste composite materials that lightweight, renewable, high performance, eco-friendly, wear and corrosion resistant materials to meet the global demand are required. This study was conducted in order to discover the usage of waste slurry powder reinforced polypropylene as to propose a new automotive material component. This is because the tribological performance of said material is yet not been discovered. Hence, more information is important, to clarify the mechanical, friction and wear properties of the proposed material.

Auxiliary source getting from waste material can be considered that have energetic advantage due to its high energy content. Besides, the other interest on minimization and elimination of resulting from friction and wear at all level of technology where rubbing of

surfaces is involve become the root of research in tribology. Hence, the result is lead to greater plant efficiency, better performance, and significant savings. Accordingly, presenting more efficient lubrication or self-lubricating materials may be the solution in overcoming these problems.

Several study of literature review in order to generate some idea for this project. Based on previous study, there are several research towards waste material such as (Sivaraos et al., 2013) in waste tyre in order to achieve low friction. Besides that, it also been assesses in (Rahman, Hassan, Yahya, & Lafia-Araga, 2013) on application of fiber reinforced polypropylene composite. Another analysis also been done in where usage some other natural sources to be reinforced with polymer.

1.3 Objective

This objective of this study was the inspiration from the previous studies. Previous studies reported that every materials have their own coefficient of friction. This study is dominant towards using slurry powder as potential waste to get low wear rates and low friction. The objective of this study as follows ;

- a) To investigate the coefficient of friction (COF) of waste slurry powder reinforced polypropylene composite pin under dry sliding conditions
- b) To investigates the substantial wear mechanism of waste slurry powder reinforced polypropylene composite pin under dry sliding conditions

1.4 Scope of Project

In this study, there are several limitation as to finish this project;

- a) This study only focusing on waste slurry powder reinforced polypropylene
- b) The measure specifications in dry sliding distance ranging 500 m to 2500 m and temperature range between 27 °C up to 150 °C.
- c) The sliding speed is limited ranging from 500 rpm to 1750 rpm.

CHAPTER 2

LITERATURE REVIEW

2.1 Tribological Study

Tribology is the study that relatable in mechanical engineering, material science, technology and chemistry. That which is focussing on friction, wear and lubrication science. The scenario behind this study can be seen when the two different surface contact each other and have resistance on moving surface due to its coefficient of friction cause from the load. The notion of tribology was introduce by Peter Jost in 1966, that change the view of industry to create new demand, more reliable products, and better the quality of life. The study of friction, lubrication and wear are not just in the industry only, but it's also have important in our life of humankind and vehicle.

In automotive sector, the friction and lubrication have their significant result in the internal combustion engine (ICE) for better fuel consumption. Based on (Holmberg, Andersson, & Erdemir, 2012), the study shows that internal combustion engine (ICE) are not fully utilize their fuel that supposed to move the vehicle. They are several loses that happen when vehicle is moving.

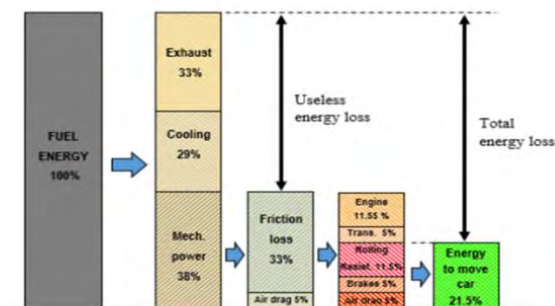


Figure 2.1 : Breakdown of passenger car energy consumption

[Source : Homberg et. Al (2012)]

To enlighten this matter, as shown in Figure 2.1 the present study tells that the effective percentage usage of fuel for combustion engine in order to move the vehicle. Eventually, not 100 % usage of fuel to combust, but only 21.5% of fuel consumption in order to give car in motion. The remain value of efficiency was release as the loss that have to bare due to friction in the vehicle itself and other circumstances. The minor loses starts when the engine start to combust. This will create initial friction of moving piston and crankshaft as the mechanical power take place that makes the slowing moving engine which take place as 11.5 % of loses. But the technology start to increase by the discovery in order to find suitable lubricant that have general viscosity for certain temperature. Unfortunately, this result also cannot be assume as fully solution in order to eliminate the friction. The result of combustion of engine will lead to emission from the exhaust produce that will generate losses of energy consumption by 33 %. As the result, we also can be assume that heat losses also be happen with directly proportional and make some loses in terms of cooling system cause to 29 % inefficient of fuel. Due to motion of vehicle, the air resistance start to consume cause from external air drag that create 5 % of loses. For the remain loss analysis was from the wheel where its counted as the friction from the rolling resistance, transmission and brake by 12.5 % for the total loses.

As for this study, the way in order to improve the efficiency of the engine by reduce the energy loss cause from mechanical interaction of the system. Which can be highlight in terms of friction, and wear of the moving component in the engine such as pistons, bearings and clutches. This result will be give benefit in terms of reduction of maintenance cost and also replacing certain part as be beneficial for financial savings.

There will be a challenge to the engineers to produce a vehicle which have better fuel efficiency as the improve in the ICE engine. Due to unstable price of global oil and also concerning on CO₂ emission that lead to global warming. Hence it will be other

solution to be better in maximizing the efficiency use of fuel and also towards the renewable energy like electric energy through the introduction of hybrid electric vehicle (HEV) and fuel cell technology by using hydrogen as replacement of conventional fuel like petroleum. The optimization in improving friction problem will save a lot of operational cost and manageable of percentage of fuel demand with find more efficient lubrication for the engine.

The broad field of study in tribology is not only focusing on machinery but it also in human nature. The previous study proves that the skin also has their own frictional properties like hand in order to grip or hold anything. The studies by (Ramalho, Szekeres, & Fernandes, 2013) to illustrates the coefficient of friction toward the sliding of human skin against the types of fabric. Hence, the result demonstrates that wool was the highest coefficient of friction for both gender. While the lowest value goes to polyamide-based fabric. From this study each volunteer will be measured on the ventral forearm for their friction effect from both gender.

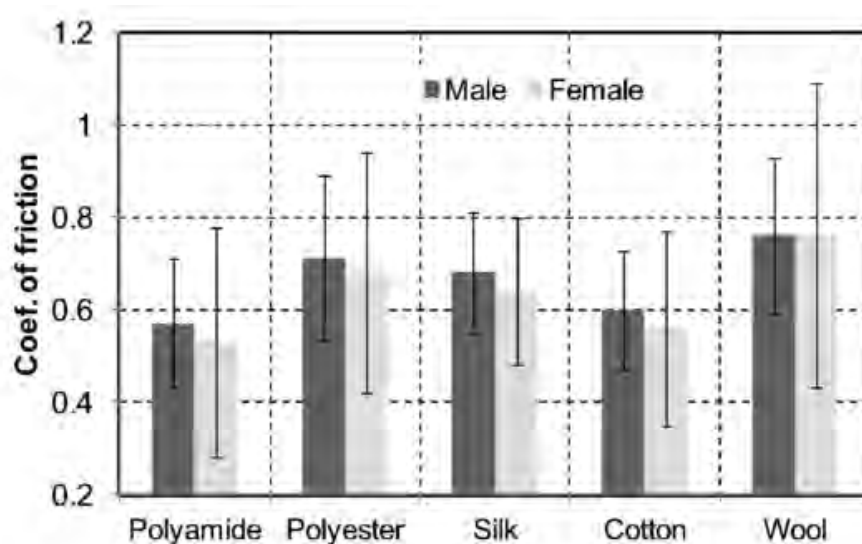


Figure 2.2 : Coefficient of friction (COF) for different fabrics against skin (ventral forearm)

[Source : (Ramalho et al., 2013)]

Then, after several of years the author comes with new discovery in friction of human skin against different fabrics for medical. The study from (Vilhena & Ramalho, 2016) e that the study toward of human skin in tribology is vital to improve and optimize materials and surfaces contact with the skin. Moreover, in the formation of skin injuries was be taken as critical factor on friction between the textiles and the human skin, if the shear forces and loads are high if longer period of time. The experiment was on material testing on four type of hospital fabrics in bed linen, like sheets and pillows. By determining the coefficient of forearm beneath in natural skin conditions.

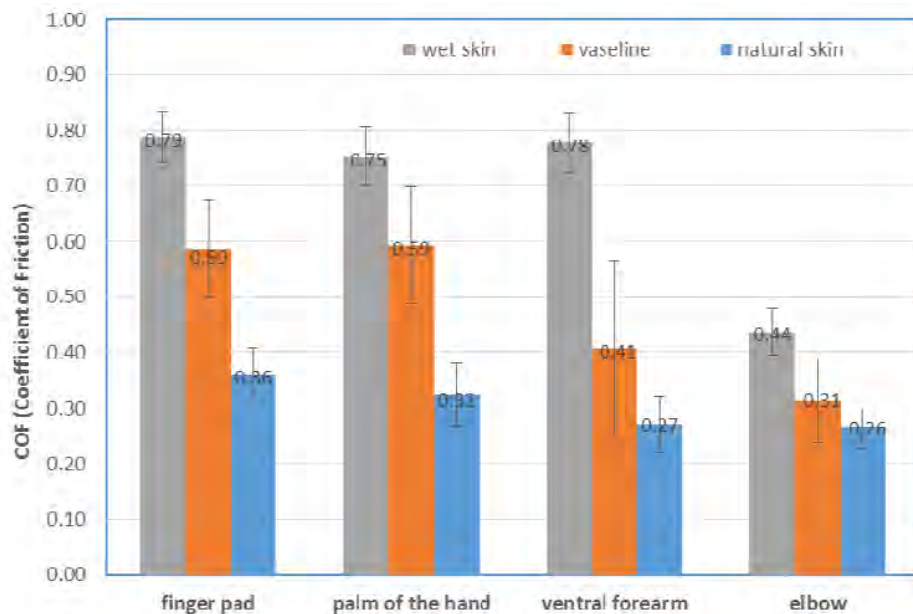


Figure 2.3 : Coefficient of friction (COF) for a reference hospital rubbing against different body region under different lubricating condition

[Source : (Vilhena & Ramalho, 2016)]

In vivo skin friction were conducted using a reference hospital fabric which across the four different skin regions (finger pad, ventral forearm, elbow, and palm of hand) with beneath different lubricating condition (wet skin, natural skin, and skin after spreading of

Vaseline). The figure 2.1(3) shows the average values of the coefficient of friction depends on different testing condition. The several analysis the been made by the presence of Vaseline that effect lubrication conditions. The coefficient of friction was consistently increase with the addition of Vaseline compared to the natural skin condition.

2.2 Ways to Reduce Friction

The application has been done as to apply the uses effect of friction in daily life. The friction can be known as the body of an object resist to motion during sliding or rolling when it moves tangentially over in contact. Sometimes, it is desirable to have low friction, in order to save energy. Also, the material that high friction is also beneficial in order to achieve the grip and stopping mechanism like in the case of brakes and shoes. They are several method in order to reduce the effect of friction ; lubrication, polishing surfaces, uses of ball bearing, and the correct combination of surfaces in contact. Its depend by adding lubricant, use different material or by surface coatings.

(Holmberg et al., 2012) explains that the history of mankind had faced a challenging cause by resistance of motion due to friction. The primal invention that's been struggle to overcome friction to lubricate moving contact by uses of water and later natural oils to transport heavy stone in construction of the pyramids in Egypt, 2400 BCE. The lubrication is the vital purpose to reduce wear. Besides, it's also act as a cooling agent as the thermal flow through the contact surface. When the lubricant flow to the stream channel it will react as protective film while allowing the two moving surface but stay separated. Therefore, the friction cause of moving motion will be lesser and the wear and tear are reduce.

According to Bharat Bushan (2013), he evaluates that clean solid surfaces when it slides generally can be define as high coefficient of friction and serious wear that expected

on its exact properties of the surfaces, such as low hardness, high surface energy, reactivity and mutual solubility. Foreign substances, such as organic compounds will make the clean solid surfaces to readily adsorb and build new layer surface. Also, the coefficient of friction and wear will be lower on the newly formed surface compared to clean surface. Unfortunately, the foreign material of the presence layer cannot be guaranteed the credibility during a sliding process. The lubrication can be in several states ; solid lubrication or fluid film lubrication (liquid or gaseous).

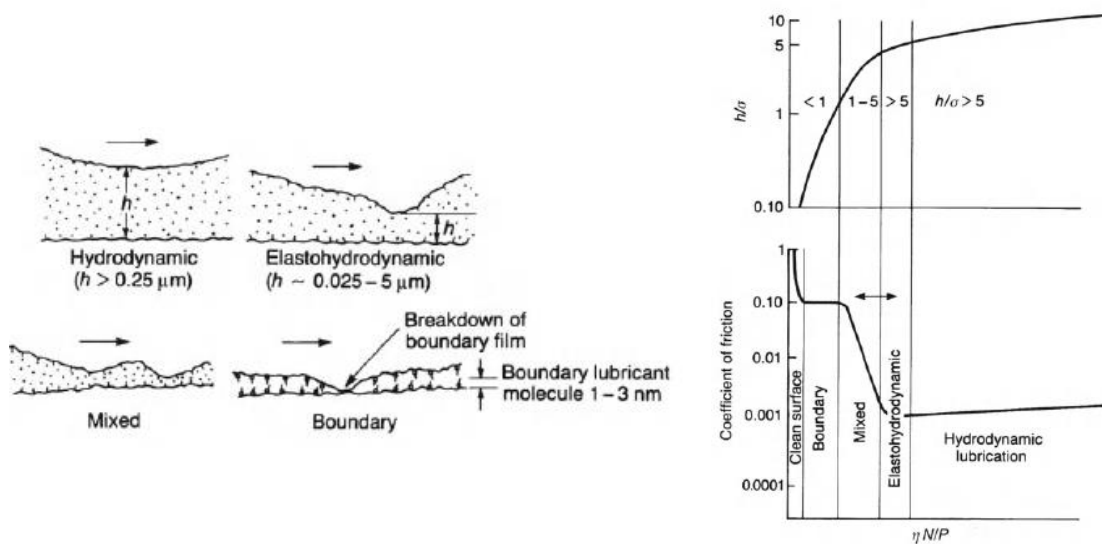


Figure 2.4 : Lubricant film parameter and coefficient of friction as a function of N/P (Stribeck curve) showing different lubrication regimes observed in fluid lubrication without an external pumping agency.

[Source : (Bhushan, 2013)]

This figure shows the parameter of lubricant film and lubrication regime. This, in turn, results in lesser number of parts to be repaired or replaced, along with longer life cycles of the parts and components. Lubrication is also used to reduce oxidation, and hence prevent rust.