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Characterization of Mechanical Seal Using Natural Materials

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Abstract: The aim of this research is to design and analysis of natural fibre mechanical seal using hybrid of Agave sisalana fibre and natural rubber as reiforcement and bio epoxy resin as matrix material. With the growth of the industrial sector, mechanical seal will become one of the most important things in the piping industrial. By converting natural rubber into mechanical seal, it gives advantages to both parties. Embedded with Agave sisalana is to increase the mechanical strength of the natural rubber material. The fabrication of the mechanical seal will involved internal mixing which is to mix up the waste tires with the Agave sisalana and hot pressing is to press or sinter the material into mechanical seal. The testing involved in this project is Tensile Test, Hardness Test, Absorption Test and last is Thickness Swelling Test. The result and data collected will be analysing by using graphs. Apart from that, ANSYS has been used to providing solid modelling and analysis on mechanical seal and mould. After analysing all the data, this project can be concluded that fibre is a very good reinforcement by increase the mechanical properties in polymer but at certain amount it can change the properties of the composites. From this research, the best composition is 85% natural rubber+5% Agave sisalana fibre+10% Bio Epoxy Resin.

Keywords: Mechanical seal, Bio-composites, Characterization, Analysis

I. INTRODUCTION

The waste problem considered as one of the most crucial problems facing the world as a source of the environmental pollution. It is contributing as a direct form in pollution that includes the negative effects on the health by increasing the diseases, diseases vector, percentage of mortality and lowering the standard of living. Malaysia still is a country that under the development and improvement in all parts of life such as social, industrial, economical and etc. Like all countries in the world, this will lead to generate new ways of living and increase the human requirements, and will also increase types and quantities of the waste in Malaysia, without any active processes to provide solution to this problem. Now a day, green technologies are widely used by all people around the world. All the people are trying to save the world for the next generations. Apart from that, natural rubber like tyres has become a major problem in the environment issues. With this waste tires laying around, it can cause the disease like dengue fever which can cause death to human being. In presenting the properties of tyres, it can be seen that tyre is a rubber article with a complex structure, in which rubber represents a Bio Epoxy Resin aproximately (85%) of the weight of car or truck tyres and the average tyre life is 50,000 km, after which it must be replaced. (DiChristina, 1994, and Anil, et al., 1994). As we all know, gaskets are widely used in piping systems in industrial. Gaskets are used to prevent leakage like oil and chemical from the piping systems. If the oil or chemical are leak to the environment, it can cause a major problems to human and environment. So, by producing gaskets from waste tires it will highly contributes towards the industrial cost saving and our cleanliness of our earth.

II. LITERATURE REVIEW

A gasket is a mechanical seal that placed in between two objects in order to prevent leakage of any kind of the pressurized or not pressurized media. The most important is the compression set of a gasket to adapt to flange irregularities and to any dimensional changes of the flange system caused by temperature changes during operation. The gasket requires resistance against media and temperature within the range of the given aBio Epoxy Resinlication. (Steadman and Associates, Inc, 2008). Requirements for a gasket are: Good compressibility and face adaptability, Good recovery and strength, Limited relaxation, Chemical and temperature resistance. Gaskets piping can be classified into two main categories which is Metallic or semi-metallic gaskets and non-metallic gaskets. Metallic or semi-metallic gaskets consist of metal or a combination of metal parts and non-metal parts. These gaskets are suitable for medium and high pressure aBio Epoxy Resinlications. Metallic gaskets require a much higher quality of the sealing surface than non-metallic gaskets. Non-metallic materials are used in low to medium pressure a Bio Epoxy Resin usually up to nominal pressures of 40 or 63 bars on the raised face and up to 200 bars in tongue grooved flanges (Annicelli, R.A., 2001). Gaskets are commonly produced by cutting from sheet gasket materials, such as gasket paper (beater addition), Non-asbestos, Rubber, EPDM, Nitrile, Buna, Neoprene, Flexible Graphite, Grafoil, Aflas, Kalrez, Viton, Silicone, Metal, Mica, Felt or a plastic polymer such as Teflon® (PTFE), Peek, Urethane, or Ethylene Propylene (EP). (Alan, N.G., 2001).

III. Natural Rubber

Rubbers are described as materials which show “elastic” properties. Such materials are generally long chain molecules known as “polymers” and the combination of elastic and polymers has led to the alternative name of “elastomers”. Rubbers and elastomers will be considered to be synonymous in this work. Products made from rubber have a flexible and stable 3-dimensional chemical structure and are able to withstand under force large deformations. For example the material can be stretched repeatedly to at least twice its original length and, upon immediate release of the stress, will return with force to a Bio Epoxy Resin approximately its original length. Under load the product should not show creep or relaxation. Besides these properties the modulus of rubber is from hundred to ten thousand times lower compared to other solid materials like steel, plastics and ceramics. This combination of unique properties gives rubber its specific a Bio Epoxy Resin like seals, shock absorbers and tyres. Modern rubber materials consist of a Bio Epoxy Resin aproximately 60 percent of synthetic polymers. The other part consists of vulcanisation agents, softeners, accelerators, anti-aging agents and other chemicals. These additions are necessary to achieve the desired properties of the final product. (Annicelli, R.A., 2001). Elastomers and rubber materials provide a variety of properties. Important specifications for elastomers and rubber materials include mechanical, thermal, electrical, optical, processing, and physical properties. Mechanical properties include tear strength (TS), ultimate tensile strength (UTS), tensile modulus or modulus of elasticity, elongation, and impact toughness as measured with an Izod test and a notched sample. (Annicelli, R. A., 2001)

IV. Agave Sisalana

Agave sisalana is under the fruit fibre classification. Coconut fibres were investigated by many researchers for different purposes. Earlier studies by Brahmakumar et al., (2005) proved that the fibres can be used as effective reinforcement and bonded in polyester matrix. These fibres were hybridized with the matrix to get a better mechanical performance. In the studies on mechanical performance and properties of short fibre reinforced polymer composites, Maries et al. (2006) have shown that both fibre length distribution and fibre orientation distribution play very important role in determining the mechanical properties. Sapuan et al., (2003) believed that mechanical properties of the natural fibre composites depend on several factors such as the stress-strain behaviours of fibre and matrix phases, the phase volume fractions and the distribution and orientation of the fibre or fillers relative to one another. This is obvious since the mechanical properties of the fibres are bigger than those of the polyester matrix. The mechanical properties of fibres reinforced composites are expected to depend on the content or volume fraction of the fibres in the composite (Murali & Mohana, 2007). Even a small change in the physical nature of fibres for a given volume content of fibres may result in distinguished changes in the overall mechanical properties of composites. Therefore the influence of fibres content on mechanical properties of fibres reinforced composites was investigated. Table 2.1 shows the mechanical properties of fibres reinforced composites with fibres volume changing from 5 to 15 %. (Bujang, I. Z. et al., 2007).

Table 1: Mechanical properties of composites with different fibres volume (Bujang, I. Z. et al., 2007)

Fibre content (vol%)	Tensile Strength (MPa)	Failure Strain (%)	Young Modulus (MPa)
5	24.8	3.9	633
10	21.9	4.8	461.4
15	19.8	601	318.8

From the Bujang, I. Z. et al., (2007) research the composite having a fibres volume of 5% showed the best result. The tensile strength and Modulus Young were found to be decreased with incorporation of fibres which again points to the ineffective stress transfer between fibres and polyester

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resin. However the increase of fibres will make the composite tend to have low stiffness and ductility. Fibre dimensions of the various individual cells are said to be dependent on the type of species, location and maturity of the plant. The flexibility and rupture of the fibre is affected by the length to diameter ratio of the fibre and this also determines the product that can be made from it. The shape and size of central hollow cavity, lumen, depends on the thickness of the cell wall and the source of the fibre. The hollow cavity serves as an acoustic and thermal insulator because its presence decreases the bulk density of the fibre. (Flower et al., 2006).

V. METHODOLOGY

After all the research related to the project has been done, preparing raw material which is natural rubber, fibre and Bio Epoxy Resinfor mixing process. After mixing process, the material will be transfer to the hot pressing process. Then, the hot press product will be the specimen for the mechanical testing and environment testing. There are two types of mechanical testing involve which is tensile test and hardness test. Value of the Young's Modulus, maximum force, ultimate tensile strength, elongation and strain at fracture or break phase can collect from tensile test. While, values hardness can get from Durometer hardness test. Apart from that, environment test like absorption test and thickness swelling test will also be conduct. After getting all the data from the testing, the data will be compare and analyze with the value of the existing product.

VI. RESULTS AND DISCUSSION

In this hardness testing, graph is plotted using the average data from 3 different compositions. Indentation hardness tests are used to determine the hardness of the material to deform. For each composition, the test is conducted for 10 times at different location of the samples. All the data were taken when the Shore durometer shows the highest value. The higher hardness value indicates the higher resistance of a material to localized deformation.

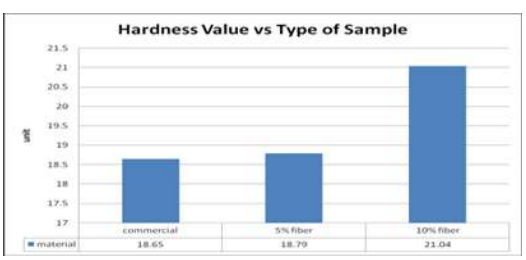

Fig 1Hardness value vs type of sample

Based on the graph at Figure 4.1, the sample with the composition of 80%NATURAL RUBBER embedded with 10% ASF and 10% BIO EPOXY RESIN give the highest hardness value. On the other hand, the composition 85%NATURAL RUBBER+5% ASF+10%BIO EPOXY RESIN is slightly higher than the commercial gasket. From this testing, by adding different amount of fibre, it can increase the hardness of the natural rubber. It is important to know the hardness of the materials because the gasket must have higher resistance to deformation in order to prevent leakage after being compressed by the pipe.

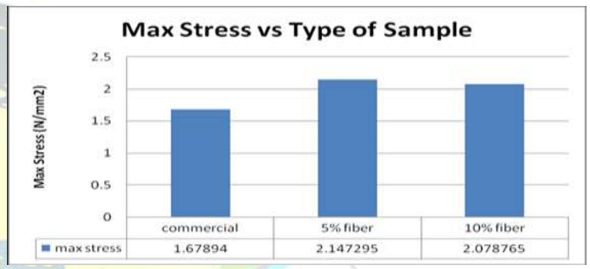

Fig 2 Max stress vs type of sample

In Figure 4.2, it shows the graph of Max stress over Type of sample. The composition with ASF 5% is also the highest in this graph if compare to others. As can be seen at Figure 6.2, max stress for composition of 10% ASF is lower than 5% ASF. Based on the research from Bujang, I. Z. et al., (2007), the tensile strength and Modulus Young were found to be decreased with incorporation of fibres which again points to the ineffective stress transfer between fibres and polyester resin. However the increase of fibres will make the composite tend to have lower stiffness and ductility. From the tensile test, the composite having a fibres volume of 5% showed the best result. Able to know the max stress of the gasket give a big advantage to the factory because it gives a safety factor in withstand the stress of disaster like earthquake.

For this testing method, 2 specimens from each composition will be soaked in 3 different types of liquid which is water, salt water and oil. This method is to check how much moisture it will absorb. This testing is important because absorption to some extend resulting gasket failure and swelling which lead to piping leakage.

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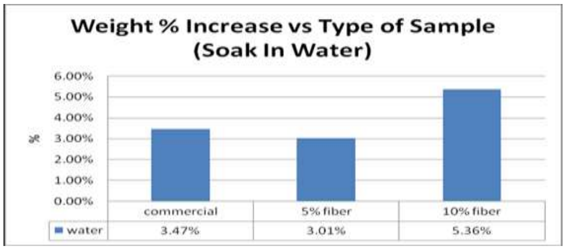

Fig 3 Weight % increase vs type of sample

Referring to Figure 4.3, 10% ASF composition have the highest percentage increase in weight, which means 10% ASF composition absorb the most water if comparing to other samples. 5% ASF composition is the lowest of all.

Fig 4 Weight % increase vs type of sample

For this Figure 4.4, the specimens were soaked in the salt water for 24hours. From the graph, it shows that 10% ASF composition still giving the highest percentage increase in weight. The lowest percentage is commercial gasket.

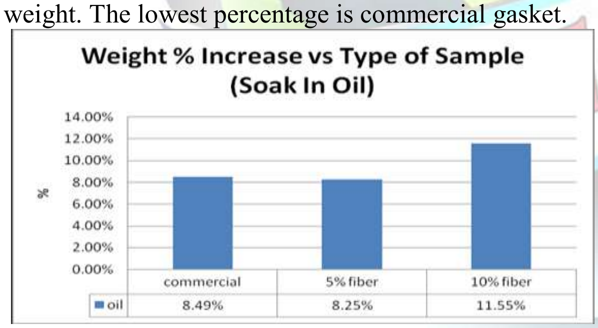

Fig 5 Weight % increase vs type of sample

The specimens were soaked in the oil and the result is shown in Figure 4.5. 10% ASF composition remain the highest percentage value and the lowest is 5% ASF composition. From this 3 absorption test, it is clear that by adding ASF to certain percentage it can change the properties of the whole material.

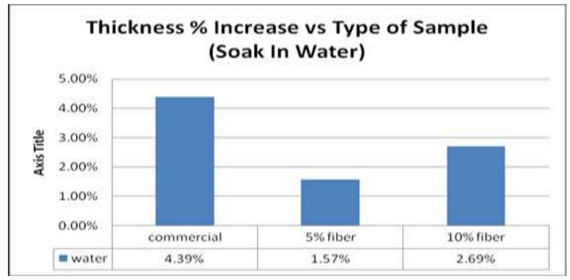

Fig 6 Thickness % increase vs type of sample

After finishing collecting data for weight percentage, the thickness measurement for the sample will be taken using vernier caliper. As can be seen at Figure 6.6, the bar chart is plotted using the percentage of average thickness increase. From this Figure 4.6, the commercial rubber has the highest percentage thickness increase and the lowest is 5% ASF composition after soaking in water.

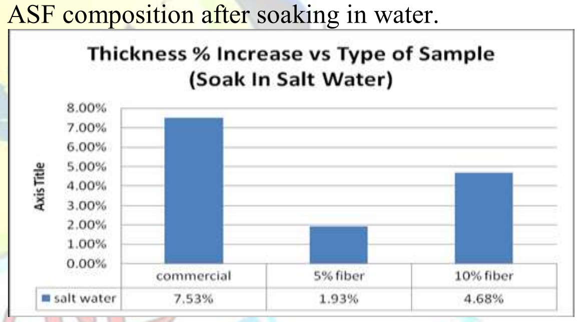

Fig 7 Thickness % increase vs type of sample

For this Figure 4.7, the samples were soaked in salt water. For the commercial rubber, the percentage thickness increase is 7.53%; 10% ASF composition percentage increase by 4.68% and the lowest is 5% ASF composition which is 1.93%.

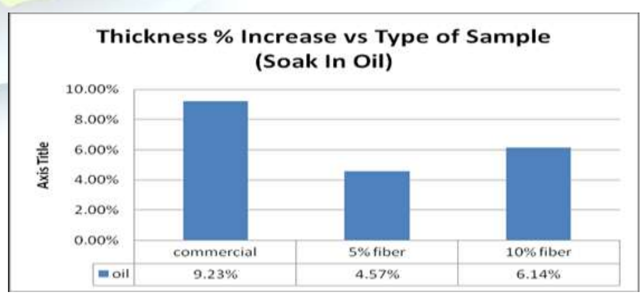

Fig 8 Thickness % increase vs type of sample

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As for this Figure 4.8, after soaking the samples in the oil, the commercial gasket remains the highest percentage thickness increase comparing to other 2 composition. The lowest is the 5% ASF composition with the value of 4.57%. Based on the results from this 2 environment test, it is clearly shows that even though the 80% NATURAL RUBBER+10% ASF+10% BIO EPOXY RESIN absorb the most liquid from all 3 medium which are water, salt water and oil the thickness swelling is not very high if comparing to the commercial gasket. The commercial gasket absorption is considerable but the thickness swelling is very high which can lead to dimensional inaccuracies and functional failure. As for the composition 85% NATURAL RUBBER+5% ASF+10% BIO EPOXY RESIN have the lowest values for both absorption and thickness swelling test. By comparing the 5% ASF composition and 10% ASF composition, the absorption values and the percentage thickness swelling increase as the content of ASF increase in the composites. The results from this analysis show the interaction between the ratios of natural rubber to fibre had significant influences on absorption and thickness swelling.

VII. CONCLUSION

After all the testing result have been analyse, it can be conclude that the new composition of natural rubber embedded with fibres shows a good performance in term of mechanical properties and environment properties. A part from that, comparison between the new composites material also can be made. Based on the result from hardness testing, the value of 5% ASF is greatly lower than the 10% ASF composition. But in tensile test, 5% composition composites can withstand higher force and stress comparing to the 10% ASF composites. Adding fibre can strengthen up the natural rubber properties, but when come to certain extents it can change the mechanical properties of the natural rubber from ductile to brittle. In addition, 10% ASF composition absorption and swelling is higher than the 5% ASF composition. Natural rubber known as a hydrophobic material but by adding fibre, it tends to change the matrix to hydrophilic material. Increasing fibres will certainly increasing the absorption rate and swelling percentage. A gasket cannot have high hydrophobic elements because a gasket is meant to prevent leakage and remain the same thickness and dimension even after soaking in liquid. Finally in concluding the whole project, the proper amount of fibre reinforcement plays important role in fabricating a good material with a better performance. Therefore, the composition that chosen to best fit the gasket requirement is the 85% NATURAL RUBBER+5% ASF+10%BIO EPOXY RESIN. With this conclusion, all the objectives have been achieved at the end of the project and it is a successful research.

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