Characterization of Mechanical Seal using Hybrid of Natural Materials

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Abstract

Objectives: 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 reinforcement and bio epoxy resin as matrix material. Methods/Analysis: The fabrication of the mechanical seal will involve 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. Findings: Fibre exhibits a very good reinforcement by increasing the mechanical properties in polymer but at certain amount it can change the properties of the composites. The best composition is 85% natural rubber+5% Agave sisalana fibre+10% Bio Epoxy Resin. Application/Improvement: 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. Embedding with Agave sisalana increases the mechanical strength of the natural rubber material.

Keywords: Analysis, Bio-Composites, Characterization, Mechanical Seal

1. Introduction

The waste problem considered as one of the most crucial problems facing the world as a source of the environmental pollution¹. 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 living²-³. Now a day, green technologies are preferred all around the world to save it for the next generations⁴. Gaskets are widely used in piping systems in industries to prevent leakages such as oil and chemicals from the piping systems. Producing gaskets from waste tires will highly contribute towards the industrial cost saving besides preventing the pollution.

2. Materials and Methods

Preparation of raw material involves natural rubber, fibre and Bio Epoxy Resin for mixing process. After
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mixing process (85% natural rubber+5% Agave sisalana fibre+10% Bio Epoxy Resin ; 80% natural rubber+10% Agave sisalana fibre+10% Bio Epoxy Resin), the material was transferred 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: 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 be collected from tensile test. While, values of hardness can get from Durometer hardness test. Apart from that, environment test like absorption test and thickness swelling test was also conducted. After getting all the data from the testing, the data was compared and analyzed with the value of the existing product.

3. Results and Discussion

3.1 Hardness Testing Analysis

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. Based on the graph at Figure 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 fiber, 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.

3.2 Tensile Test Analysis

Figure 2 shows the graph of Max stress over Type of sample. The composition with ASF 5% is also the highest when compared to others. Max stress for composition of 10% ASF is lower than 5% ASF. Based on this research the tensile strength and Modulus Young were found decreased with incorporation of fibers which again points to the ineffective stress transfer between fibers and polyester resin. However, the increase of fibers will make the composite tend to have lower stiffness and ductility. From the tensile test, the composite having a fibers volume of 5% showed the best result. The max stress of the gasket gives a big advantage to the factory because it gives a safety factor to withstand the stress of disaster like earthquake.

3.3 Absorption Analysis

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 can absorb. This testing is important because absorption to some extend resulting gasket failure and swelling which lead to piping leakage. Referring to Figure 3, 10% ASF composition have the highest percentage increase in weight, which means 10% ASF composition absorbs the most water when compared to other samples. 5% ASF composition is the lowest of all. Figure 4 represents the specimens soaked in the salt water for 24 hours and shows that 10% ASF composition still gives the highest percentage increase in weight. The lowest percentage is commercial gas. The specimens were soaked in the oil and the result is shown in Figure 5. 10% ASF composition remains the highest percentage value and the lowest is 5% ASF composition. From theses 3 absorption tests, it is clear that by adding ASF to certain percentage can change the properties of the whole material.

3.4 Thickness Swelling Analysis

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,
the bar chart is plotted using the percentage of average thickness increase. From this Figure 6, the commercial rubber has the highest percentage thickness increase and the lowest is 5% ASF composition after soaking in water. For this Figure 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%. As for this Figure 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 and the thickness swelling is not very high when compared 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 increases in the composites. The interaction between the ratios of natural rubber to fibre had significant influences on absorption and thickness swelling. This result shows the influence of volume fraction of fibre in the matrix, as the mechanical properties increases with the volume fraction of fibre.

3.5 Statistic Structural Analysis

To analyze gasket stress and strain, ANSYS statistic structural will be used. After setting up all the required data in statistic structural analysis, the analysis result will focus on total deformation, equivalent stress, maximum principal stress, normal stress, equivalent elastic strain, maximum principal elastic strain and normal elastic strain. Figure 9 shows the total deformation of the gasket after a Bio Epoxy Resin lying compressive force at both surfaces. At the blue region, there is no deformation occurring and the red region at 4 places have the maximum value which have the highest tendency to deform. Other color region has the values stated at the side of the gasket. In this maximum principal stress shown in Figure 10, most of the gasket surface has the same value which is -826.62 Pa. While other stress value with small region can be seen around the bolt holes area. Figure 11 is about the shear stress. On the axis-X, both sides have higher stress value range from -360.33 Pa to maximum value of 3647.9 Pa. On the axis-Y, lower stress value range from minimum value of -3566.9 Pa to -360.33 Pa. Figure 12 shows the Elastic strain, values range from minimum to maximum can be seen around the bolt holes area. The gasket surface has elastic strain of 0.0013174 and 0.0010867.
4. Conclusion

The new composition of natural rubber embedded with fibers shows a good performance in terms 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 fiber 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 fiber, it tends to change the matrix to hydrophilic material. Increasing fibers will certainly increase 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.

5. References

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