

# DESIGN AND ANALYSIS A NEW MATERIALS OF GASKET PIPPING USING WASTE RUBBER TYRES AND COCONUT COIR FIBRE

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**ABSTRACT:** Waste tyres are a tremendous problem throughout the world. The tyre is designed to be tough and hardwearing, once they are no good as tyres they are difficult to cut up, hard to store or transport and of little value to anyone. With the growth of the industrial sector, gasket will become one of the most important things in the piping industrial. By converting waste tyre into gasket, it gives advantages to both parties. Embedded with coconut coir fibre is to increase the mechanical strength of the waste rubber material. The fabrication of the gasket will involved internal mixing which is to mix up the waste tires with the coconut coir fibre and hot pressing is to press or sinter the material into gasket. 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, software like CATIA and ANSYS will be used to in providing solid modelling and analysis on gasket and mould. After analysing all the data, this project can be concluded that coir 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 project, the best composition is 85% waste rubber+5% coir fibre+10% Polypropylene.

**KEYWORDS:** Gasket Pipping, Waste Rubber Tyres, Bio-composites Coir fibre, Hardness Testing; Tensile Testing; Absorption Testing; Thickness Swelling Testing; ANSYS, CATIA.

## 1.0 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.

## **1.2 Problem Statement**

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, waste 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 approximately (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.

## **1.3 Objectives and scope**

The objectives is study the existing materials and design of gasket piping. Propose a new alternative material using a waste tyre rubber embedded with coconut coir fibre. Test and analyse of the new material on strength, hardness, tensile strength and environment test. Design and development of a standard existing gasket mould. Research scopes is based on design gasket materials composition from waste tyre rubber and coconut coir fibre. The usage of the gasket is only focused on the round shape piping. Use single manufacturing process that involve low cost investment of tool and equipment but capable to produce high performance materials. Testing and analysis that involved on the mechanical properties.

## **2.0 LITERATURE REVIEW**

### **2.1 Gasket Pipping**

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 application. (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 applications. 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 applications 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).

### **2.2 Waste Rubber Tyres**

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 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 applications like seals, shock absorbers and tyres. Modern rubber materials consist of approximately 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).

Rubber recovery can be a difficult process. There are many reasons, however why rubber should be reclaimed or recovered:

- a. Recovered rubber can cost half that of natural or synthetic rubber.
- b. Recovered rubber has some properties that are better than those of virgin rubber.
- c. Producing rubber from reclaim requires less energy in the total production process than does virgin material.
- d. It is an excellent way to dispose of unwanted rubber products, which is often difficult.
- e. It conserves non-renewable petroleum products, which are used to produce synthetic rubbers.
- f. Recycling activities can generate work in developing countries.
- g. Many useful products are derived from reused tyres and other rubber products.
- h. If tyres are incinerated to reclaim embodied energy then they can yield substantial quantities of useful power. In Australia, some cement factories use waste tyres as a fuel source.

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)

### **2.3 Coconut Coir Fibre**

Coconut coir fibre 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 coir 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 coir 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 coir fibres reinforced composites was investigated. Table 2.1 shows the mechanical properties of coir fibres reinforced composites with fibres volume changing from 5 to 15 %. (Bujang, I. Z. *et.al.*, 2007).

Table 2.1: Mechanical properties of composites with different coir 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 coir fibres volume of 5% showed the best result. The tensile strength and Modulus Young were found to be decreased with incorporation of coir fibres which again points to the ineffective stress transfer between fibres and polyester resin. However the increase of coir fibres will make the composite tend to have low stiffness and ductility.

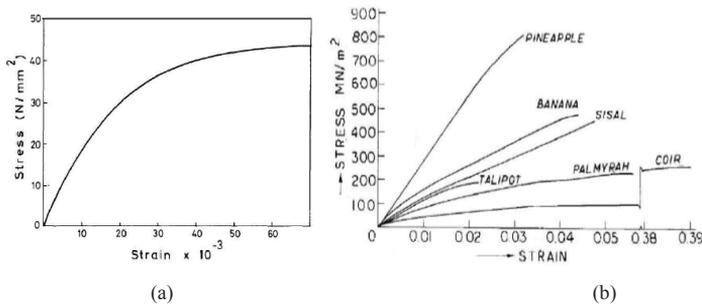


Figure 2.2: (a) Mean stress-strain curve for coconut fibre (Paramasivam, *et.al.*, 1984) (b) stress-strain curves of natural fibres (Satyanarayana, *et.al.*, 1990)

Figure 2.2a. shows stress-strain relationship for coconut fibres as reported by some researchers. Coconut fibre is the most ductile fibre amongst all natural fibres. Coconut fibres are capable of taking strain 4-6 times more than that of other fibres as shown in Figures 2.2b.

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)

### 3.0 METHODOLOGY

After all the research related to the project has been done, preparing raw material which is waste rubber, coir fibre and polypropylene for 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. The whole project

research and processes can be illustrated in flow chart as shown in Figure 3.1

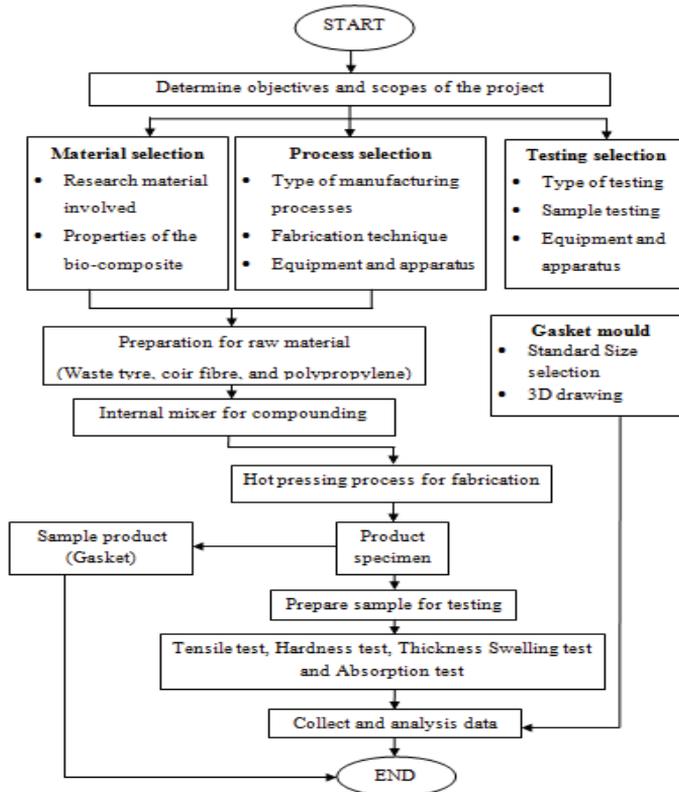


Figure 3.1: Methodology flow chart

## 4.0 RESULT ANALYSIS

### 4.1 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.

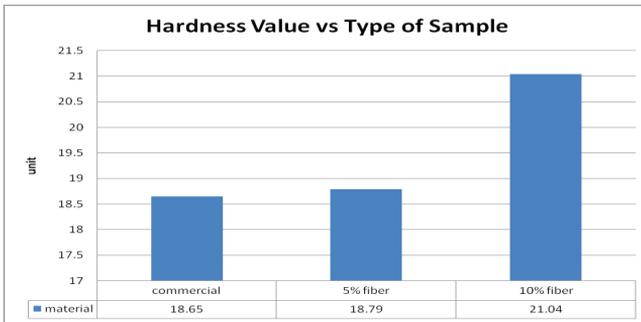


Figure 4.1: Hardness value vs type of sample

Based on the graph at Figure 4.1, the sample with the composition of 80%WR embedded with 10%CF and 10% PP give the highest hardness value. On the other hand, the composition 85%WR+5%CF+10%PP is slightly higher than the commercial gasket. From this testing, by adding different amount of coir fibre, it can increase the hardness of the waste 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.

#### 4.2 Tensile Test Analysis

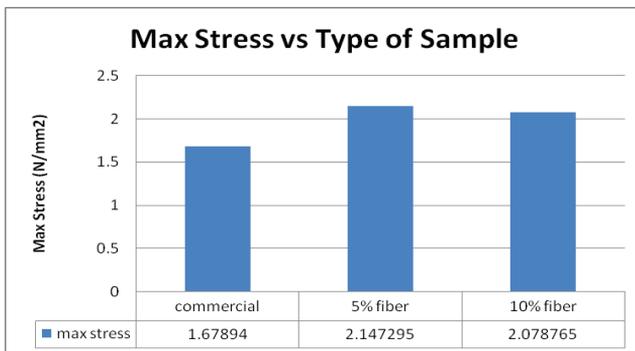


Figure 4.2: Max stress vs type of sample

In Figure 4.2, it shows the graph of Max stress over Type of sample. The composition with CF 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% CF is lower than 5%CF. 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 coir fibres which again points to the ineffective stress transfer between fibres and polyester resin. However the increase of coir fibres will make the composite tend to have lower

stiffness and ductility. From the tensile test, the composite having a coir 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.

### 4.3 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 will absorb. This testing is important because absorption to some extend resulting gasket failure and swelling which lead to piping leakage.

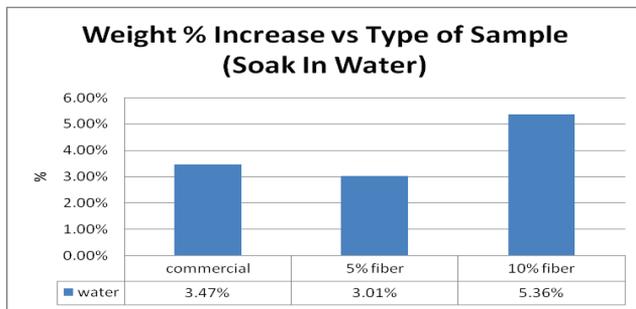


Figure 4.3: Weight % increase vs type of sample (soak in water)

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

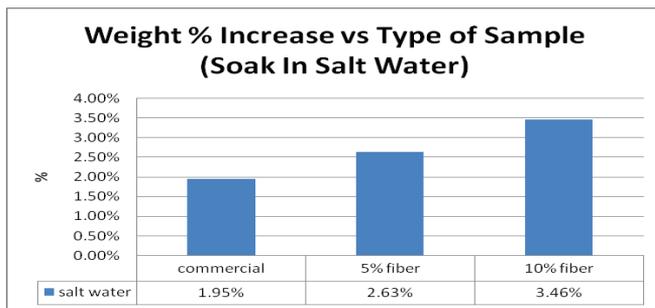


Figure 4.4: Weight % increase vs type of sample (soak in salt water)

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

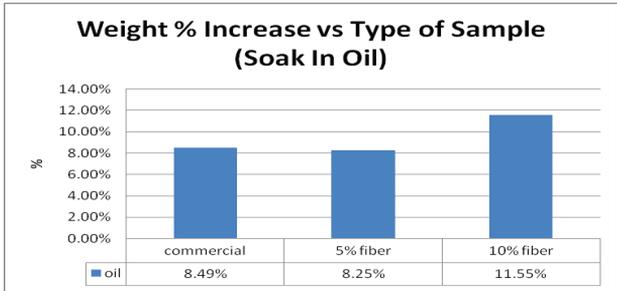


Figure 4.5: Weight % increase vs type of sample (soak in oil)

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

#### 4.4 Thickness Swelling Analysis

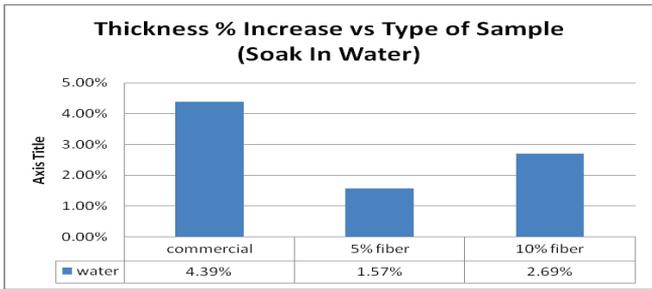


Figure 4.6: Thickness % increase vs type of sample (soak in water)

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%CF composition after soaking in water.

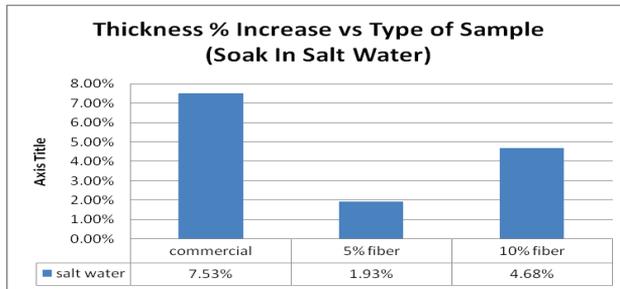


Figure 4.7: Thickness % increase vs type of sample (soak in salt water)

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

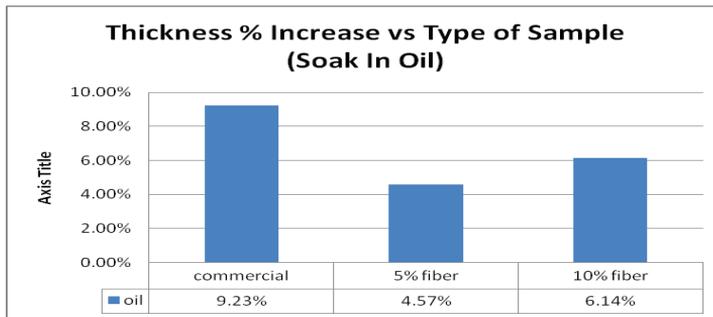


Figure 4.8: Thickness % increase vs type of sample (soak in oil)

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% CF 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% WR+10% CF+10% PP 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% WR+5% CF+10% PP have the lowest values for both absorption and thickness swelling test. By comparing the 5% CF composition and 10% CF composition, the absorption values and the percentage thickness swelling increase as the content of CF increase in the composites. The results from this analysis show the interaction

between the ratios of waste rubber to coir fibre had significant influences on absorption and thickness swelling.

#### 4.5 Gasket ANSYS Statistic Structural Analysis

To analyse 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.

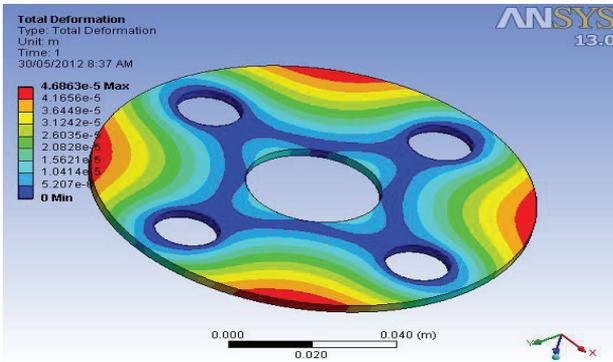


Figure 4.9: Total deformation

Figure 4.9 shows the total deformation of the gasket after applying 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 colour region has the values stated at the side of the gasket.

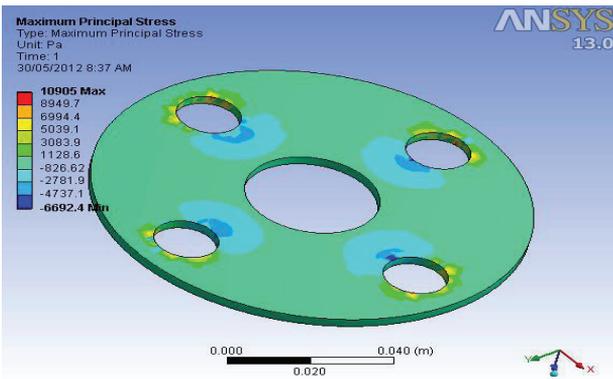


Figure 4.10: Maximum principal stress

In this maximum principal stress shown in Figure 4.10, most of the gasket surface has the same value which is -826.62Pa. While other stress value with small region can be seen around the bolt holes area.

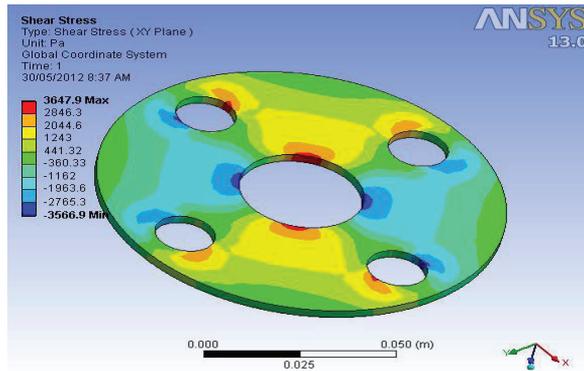


Figure 4.11: Shear stress

Figure 4.11 is about the shear stress. As can be seen, the shears happen between 2 axes which is axis-X and axis-Y. On the axis-X, both sides have higher stress value range from -360.33Pa to maximum value of 3647.9Pa. On the axis-Y, lower stress value range from minimum value of -3566.9Pa to -360.33Pa.

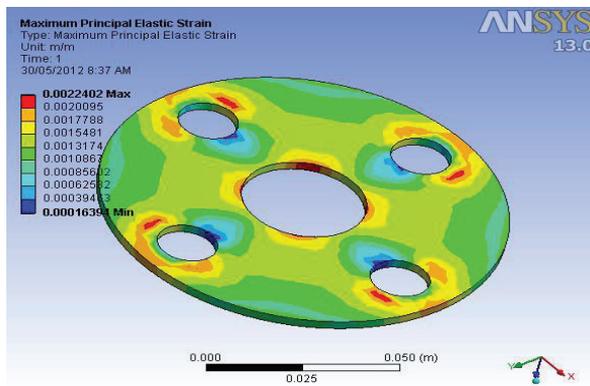


Figure 4.12: Maximum principal elastic strain

Figure 4.12 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.

## **5.0 CONCLUSION**

After all the testing result have been analyse, it can be conclude that the new composition of waste rubber embedded with coir 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% CF is greatly lower then the 10% CF composition. But in tensile test, 5% composition composites can withstand higher force and stress comparing to the 10% CF composites. Adding coir fibre can strengthen up the waste rubber properties, but when come to certain extents it can change the mechanical properties of the waste rubber from ductile to brittle.

In addition, 10% CF composition absorption and swelling is higher then the 5% CF composition. Waste rubber known as a hydrophobic material but by adding coir fibre, it tends to change the matrix to hydrophilic material. Increasing coir 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% WR+5% CF+10%PP. With this conclusion, all the objectives have been achieved at the end of the project and it is a successful research.

## **6.0 ACKNOWLEDGEMENT**

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