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To cite this article: R E K Siregar et al 2018 J. Phys.: Conf. Ser. 1116 042036

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Static simulation to horse shoes alternative materials based basic polymeric foam reinforced fiberglass with ANSYS software

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Abstract: In this journal, we used Finite Element Method (FEM) calculations based on ANSYS software. The software will involves the value of the material properties. Then, will used to simulate the manufacture of horse shoe, when the horse stood silent, for fiberglass reinforced polymer materials and compared with the usual materials for horse shoe, the Mild Carbon Steel (A36) so that will be obtained which is the best between the two materials. In this simulation work, the horse shoe receives a load of 500 kg. From this simulation we will obtain Equivalent Stress, Normal Stress on each axis (X, Y, Z) from the loading direction experienced by horse shoes. Equivalent equivalence values of 0.21509 MPa polymeric foam while Mild Carbon Steel (A36) 0.1034 MPa and normal polymeric foam voltage values for X-axis 0.016426, Y 0.007111 and Z 0.0695, while Normal Stress from Mild Carbon Steel (A36) for X axes 0.02233, Y 0.0204 and Z 0.047. The simulation results provide an understanding of the normal force resistance of polymeric foam materials for Mild Carbon Steel (A36) materials, whereas for polymeric foam materials the equivalent stress is superior to Mild Carbon Steel (A36).

1. Introduction
The horses' shoes today are made of iron, aluminum and plastic. But horse shoes made from the above materials have their respective weaknesses [1]. Iron horse shoes have a weakness that is heavy and hard, causing the reaction force that arises when the horse's hoofs strike to the hard surface, will directly affect the horse's hooves, as well as the horse's joints and knees. Aluminum horse shoes are very soft, suitable only on soft surfaces as well as on soil and grass. Plastic shoes made of horses, very fragile, easy to wear and slippery [2]. Therefore, research is conducted to find alternative materials that can eliminate the weakness found in horseshoes with the material as above [3]. The loading experienced by the horse shoe at rest is the weight of the horse itself multiplied by gravity. Material selection greatly influenced the strength and lifespan of horse shoes, in previous studies replacing horse shoe material from steel to Composite (Polymeric foam reinforced fiberglass). However in the application, there are many factors that become problems in the field, such as heavy, corrosion and not rigid for rocky road [4]. Polymeric foam + fiber glass fiber is the latest innovation of the choice of horse shoe material type because it has advantages such as lightweight, anti-corrosion, flexible and
rigid for rocky road. In this journal a finite element method (FEM) based on material properties is used to analyze difficult loading in the experiment [5]. The load simulation is done using ANSYS software that handles non-linear problem. The purpose of this simulation analysis is to know the stress distribution from the maximum value of equivalent stress and normal stress for room temperature conditions [6].

2. Methods

2.1 Simulation Methods

The model proposed in this study was drawn with AutoCAD and used ANSYS software to simulate the loading process. For horseshoe use static structural. It is estimated that the value of loading at the time of the horse is not move, the mass of the horse is divided by 4, since the horse's feet which bear the total weight of the horse are 4 pieces, so that each horse's foot will bear the weight of the horse divided by 4.

2.2 Test method of polymeric foam material and mild carbon steel

The model used in the ANSYS simulation describes the load relationship with the cross-sectional area

\[ \sigma = \frac{F}{A} \]  

(1)

From the equation above it can be assumed that the loading and cross-sectional values of horseshoes with gravity constants 9.81 m / s^2 and for the weight of the horse, a thoroughbred horse type is taken which is a type of light horse weighing 500 kg [8]. Then, the force experienced by horseshoes is:

\[
\frac{500}{4} \times 9.81 = 1226.25 \text{ Newton}
\]

Total surface area of horse shoes on mold 130 mm -10 mm: \( A = 16.532,14 \text{ mm}^2 \). Then the normal stress (pressure) is: \( 1226.25 \div (16.532,14) = 0.0741 \text{MPa} \).

Previous polymeric foam material has been tested mechanically with variation of polyurethane chemical mixture with resin 157 BQTN-EX + catalyst and fiber glass reinforced and got best result with parameter presented in Table 1 [9].

| Parameter          | Value      |
|--------------------|------------|
| Weight             | 0.046 kg   |
| Volume             | 6.43E-5 m^3|
| Stress             | 17.3268 MPa|
| Strain             | 0.074      |
| Horizontal strain  | 0.037      |
| Vertical strain    | 0.1072     |

From the table above can be found density, modulus young and poisson ratio with the following equation [10].

Density

\[ \rho = \frac{m}{v} \]  

(2)
Modulus young
\[ E = \frac{\sigma}{\varepsilon} \]  
(3)

Poisson ratio
\[ \mu = \frac{\varepsilon_y}{\varepsilon_t} \]  
(4)

With the formula above we get the value of mechanical properties of polymeric foam and presented in the table. Table 2 presents the material properties values of the material model constants used for the loading behavior used in the simulations.

| Material Properties | Polymeric Foam | Low Carbon Mild Steel A 36 [11] |
|---------------------|----------------|----------------------------------|
| Density             | 716.5 kg/m³    | 7850 kg/m³                       |
| Modulus young       | 299.97 MPa     | 2E+5 MPa                         |
| Poisson Ratio       | 0.345          | 0.26                             |
| Bulk Modulus        | 3.2255E+08 Pa  | Bulk Modulus                     |
| Share Modulus       | 1.1151E+08 Pa  | 7.93+10 Pa                       |

3. Results and Discussions
This simulation is uses 2 materials, Polymeric Foam reinforced Fiberglass and Low Carbon Mild Steel A 36, which serve as a comparator with the same loading values (500 kg), in which the result of polymeric foam is close to the value of Low Carbon Mild Steel A 36. In the normal direction of axis, the polymeric foam material has a weakness.
Figure 1 Results of loading on Polymeric Foam at loading of 0.074 MPa
a) Equivalent stress, b) normal stress X, c) normal stress Y, d) normal stress Z
Figure 2 Loading results on Mild Carbon Steel at loading of 0.074 MPa
a) Equivalent stress, b) normal stress X, c) normal stress Y, d) normal stress Z

The results of the simulations of polymeric foam is presented on Figure 1 and for Low Carbon Mild Steel is presented on figure 2 and then tabled in Table 3

| Testing         | Horse Shoes Model |        |        | Unit |
|-----------------|-------------------|--------|--------|------|
|                 | Polymeric foam    | Mild Carbon Steel |        |      |
| Equivalent Stress | 0.21509           | 0.1034 |        | MPa  |
| Normal Stress X  | 0.016426          | 0.02233|        | MPa  |
| Normal Stress Y  | -0.007111         | 0.0204 |        | MPa  |
| Normal Stress Z  | 0.0695            | 0.047  |        | MPa  |

Based on the above table, we can create structurally static simulation graph on polymeric foam and low carbon mild steel, between stresses that occurs and pressure (stress vs pressure) and can be seen at Figure 3. For static structural simulation, the simulation is done according to ANSYS 14.5 software Stages.
Figure 3 Comparison graph of static structural testing on material polymeric foam and Low Carbon Mild Steel A36

From the graph above, it can be seen that for equivalent stress, polymeric foam has a higher value than low carbon mild steel A36. It can be seen that equivalent stress obtained from the simulation, there is a significant difference. Equivalent stress in polymeric foam, much greater than equivalent stress in Low Carbon Mild Steel A36. For normal stress on X and Y axis, polymeric foam has a value smaller than low carbon mild steel A36, and on the Z axis polymeric foam has a greater value.

4. Conclusion
An element model until based on ANSYS software is used to study the effect of stress experienced. From finite element method simulation when used material properties equation in engineering data and material model which design resembles original. In horse shoe loading for polymeric foam material has superior equivalent stress value of mild carbon steel material that is 0.21509 MPa and 0.103 MPa, for normal stress in certain direction polymeric have weakness that is on Y -0.007111MPa axis while mild carbon steel 0.0204 MPa. From the review of several criteria according to the above problem, polymeric foam material is superior to low mild carbon steel A36 in some aspects. Besides aspects that have been described with the above simulation, low carbon mild steel A36 has some disadvantages compare to polymeric foam, that is heavier, harder so that the horse is running then due to the hardness of low carbon mild steel stomping to the hard surface will happen reaction force that beat back up which can cause damage to horse's nails, joints, and hooves. Also low carbon mild steel is more slippery than polymeric foam and more corrosive than polymeric foam. Looking at these aspects, it can be concluded that polymeric foam can be recommended for horseshoe, as an alternate material of low carbon mild steel A36 with all the deficiencies of low carbon mild steel materials compared to polymeric foam.

Acknowledgement
On this occasion the author would like to express his deep gratitude to Prof. Mr. Dr. Ir Bustami Syam, MSME, as the responsible Laboratory of Research Center for Impact and Cracking (IFRC) Departement of Mechanical Engineering Universitas Sumatra Utara, Prof. Mr. Basuki Wiryosentono, MS, Ph.D, as the Thesis Supervisor of the researcher, and the Fellow colleagues both senior and junior in this study, which cannot be mention one by one.

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