ARTICLE
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Finite Element Analysis of a tube's waste Rubber to be used as a Diaphragm in Pressure Switch that is being built from available cheap Materials

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Abstract

A piece of rubber, from an old truck tube, is cut into three specimens to be tested in universal tensile tester. Unfortunately, the tensile tester does not have an ability to measure the change in thickness with the change in length i.e. The tester only reads the applied force with the deformation. Therefore, to get enough accurate data for the Workbench simulation, the first readings in the test was selected to be compared with their peers in the library of Workbench 2022. Two materials (Elastomer Yoeh and Elastomer Neoh-Hookean) in the library seem to follow the same behavior as the real rubber piece. Based on the properties of these two materials, the diameter of the diaphragm was selected to be about 25.55 mm and the geometry of this diaphragm is drawn using Catia R17 Software with the same thickness as an old tube, then the model was imported to Workbench 2022 where a three dimensional mathematical models were built using the properties of the two materials i.e. each material property has its own three dimensional mathematical model. Based on the obtained results from the two Workbench modeling, an experimental real model was built where diaphragm is cut from that old truck tube and the mechanical part of pressure switch is built using very cheap and available materials. Water pressure is applied to the new real model with the same amounts used in Workbench 2022. The deformation of the diaphragm is measured for each pressure value and be compared with the results previously obtained in Workbench. It is found that the most material approaching the real rubber is Elastomer Yoeh with some differences. The elastomer Yoeh material can be used in theoretical analysis with Workbench and the results can be followed in practical applications. The real deformation in practice is about 1.5 times from the Elastomer Yoeh deformation computed with Workbench.

Keywords: Stress, Strain, Deformation, Adaptive Remashing, Curve Fitting, pressure, Steps, Solution Convergence

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Introduction:

pressure switches can be used in industrial applications like well pumps, furnace, HVAC applications…etc[1]. Pressure switch works based on closing the electric circuit when the pressure reached to the preset point which is previously specified during the installation of the switch [2]. " Pressure switches are available in four types: diaphragm, bellows, bourdon-tube, and piston" [3]. For a diaphragm type, the liquid's pressure moves the diaphragm and this movement transferred to a contact system [4]. Rubber diaphragm has a flexible membrane which can work as a seal between two chambers and the pressure rise in one chamber will move the diaphragm forward to another chamber. Rubber diaphragms are simple durable and versatile [5]. The diaphragm is attached to a auxiliary devise by which the movement of the diaphragm is transferred to the sensing part where a transducer or on/off mechanical switch is used [6].

Preparations to form the diaphragm:

A 1.8 mm old truck tube thickness is used to form the diaphragm. Before cutting the diaphragm, three specimens, shown in Figure 1, were cut to be tested by universal tensile tester as shown in Figure. 2 below. Unfortunately, the tester does not have ability to measure the change in specimen's thickness with longitudinal deformation. That change in thickness besides other data are necessary to analysis the strength and the deformation of diaphragm using Constitutive models like Gaussian network model, partial or full network model, Rivlin model,neo-Hookean model, Mooney- Rivilin model, Yeoh model, Ogden model…etc[7]. Therefore, another way should be followed to obtain an exact approximate solution.

Fig. 1 Tube's Specimens

Fig. 2 Universal Tester

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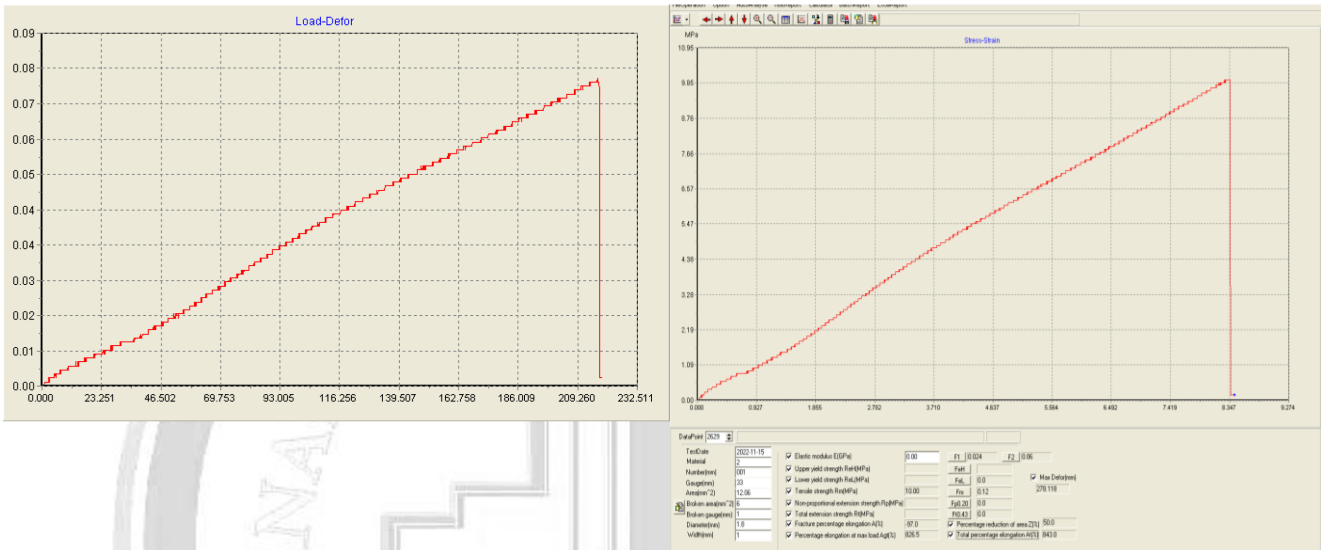
The data obtained from the universal tester are shown in Figure.3. It can be noted that the data imply applied force and its corresponding deformation regardless of the change in thickness. Also, when the tester reads stress and strain, it assumes there is no change in thickness.



A- Force- deformation relation B- stress- strain relation

Fig. 3 Tester's Results

In the Figure.3 above, the lower stress - strain readings are, the more accurate results are; because the change in thickness will be less at the beginning of the test where the applied forces are less. The first stress – strain reading in the figure above is 1.09 MPa stress by 0.927 strain. If a comparison is made between this reading with its corresponding amount available at the library of the Ansys workbench 2022, two materials (Elastomer Sample {Neo-Hookean} and Elastomer Sample {Yeoh}) mostly have the same stress-strain amounts [8]. Therefore, the two materials will be modeled with Workbench to study the deformation and associated stresses. The stress-strian relationships for the two materials are shown in Figure 4 and Figure 5

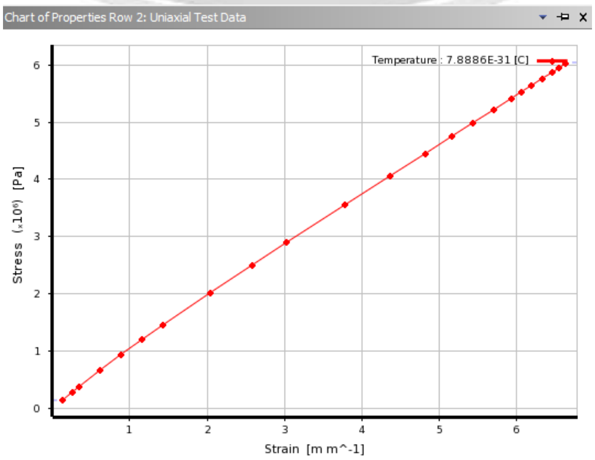


Fig. 4 Elastomer Sample (Neo-Hookean)

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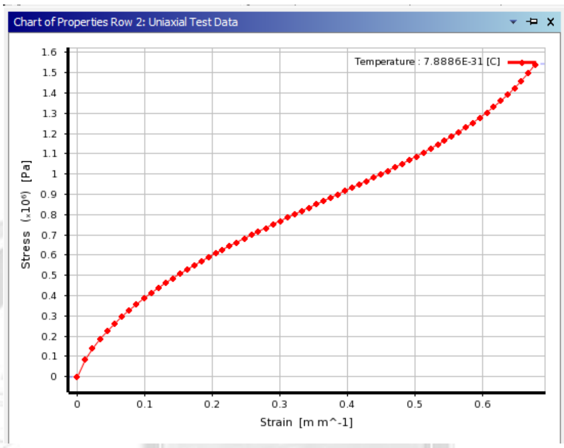
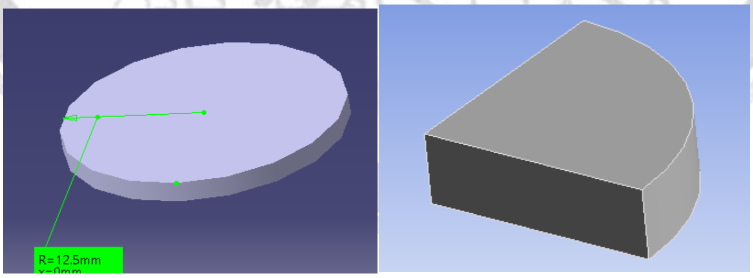


Fig. 5 Elastomer Sample (Yeoh)

Geometry and Workbench simulation:

Based on the properties of the two materials and what is available to hold the diaphragm in real practice, the diameter chosen for the diaphragm is 25 mm or 1 inch. The diaphragm is drawn by CATIA Engineering Graphic Software with a thickness of 1.8mm (the same thickness as in an old truck tube) as shown in Figure 4 below. But for time saving case, quarter the geometry is drawn and applied in the simulation with axisymmetrical boundary conditions to mimic the full one.

The expected applied pressure is selected based on a pressure gauge reading connected to outlet of domestic pump.



Full geometry **Quarter the Geometry**

Fig. 4 Geometry

Workbench Modeling:

Rubber has the main property of being highly deformed under small loads. Also, it has ability to retain to what it was after loads being removed [9]. However, Rubber does not follow linear stress-strain behavior within the deformation. Instead, it follows highly non-linear behavior [10].

As mentioned above in this paper, there are two materials approaching in their properties to the real practice. Therefore, two workbench models are made (one model for each material).

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Material Property

Here in this paper, there are two materials needed to be checked in simulation to obtain reseanable and more realistic approximation: -

1. The Elastomer Sample (Neo-Hookean): the mechanical property of this material is in Workbench library. The uniaxial test data and shearing test data are needed to be fitted based on certain modeling. The default Neo-Hookean model is recommended by the Workbench 2022 for this material. The other models were checked but most of them failed reaching the fitting required for the solution. The strain energy potential for (Neo-Hookean) model is [8]:

$$W = \frac{\mu}{2}(\bar{I}_1 - 3) + \frac{1}{d}(J - 1)^2$$

Where:
W- strain energy per unit reference volume
$\bar{I}_1$- first deviatoric strain invariant
μ – initial shear modulus of the material
d– material incompressibility parameter
J – determinant of the elastic deformation gradient

The Neo-Hookean model was solved with Workbench 2022 IR1 based on absolute error for curve fitting and all the parameters and constant were computed. The resulting fitting curves are shown in Figure 5 below:

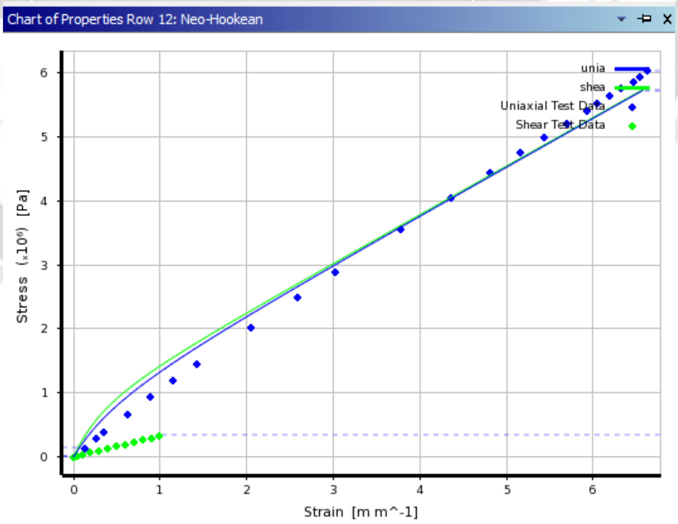

Fig. 5 Curve Fitting of Neo-Hookean based Material

2. The Elastomer Sample (Yeoh), the uniaxial test data, biaxial test data, and shearing test data need to be fitted in such a way that there is no crossing among uniaxial, biaxial, and shearing curves and each curve can pass or approach the points with minimum errors [9]. Therefore, Yeoh-3rd order is chosen for the modeling of this material based on absolute error for fitting. The strain energy function for the third order Yeoh hyperelastic model is [8]:

$$\psi = C_{10}(\bar{I}_1 - 3) + C_{20}(\bar{I}_1 - 3)^2 + C_{30}(\bar{I}_1 - 3)^3 + \frac{1}{d_1}(J-1)^2 + \frac{1}{d_2}(J-1)^4 + \frac{1}{d_3}(J-1)^6$$

Where: -
C_{10}, C_{20}, C_{30} are material constants
d_1, d_2, d_3 are incompressibility parameters
$\bar{I}_1$- is the deviatoric first principal invariant
J is the Jacobian

The model of material is solved with Workbench and the values of the material constants and incompressibility parameters were computed. The resulting fitting curve is shown in Figure 6 below

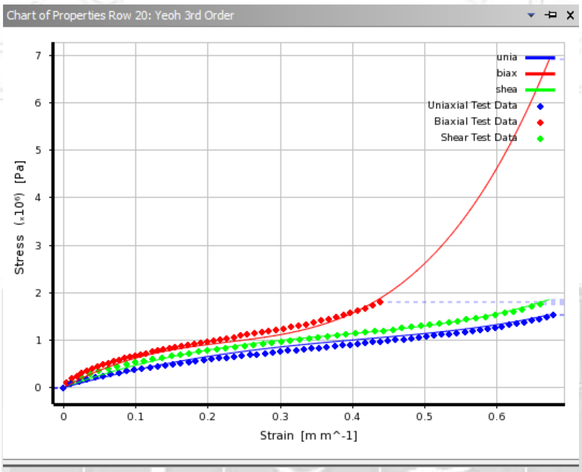

Fig. 6 Curve Fitting of Yeoh based Material

Meshing:

In this work, the elements of rubber subject to excessive deformation through loading. The shapes of elements are highly deformed or distorted within loading and it is impossible for the shapes to be similar to what they were before loading [10]. Also, in this work, there are two different materials to be used, therefore, two meshing procedures will be followed: -

For the Elastomer Sample (Neo-Hookean): this material was defined as mentioned above and its elements subjects to high distortion within solution. Therefore, changes are made in mesh's details window wizard, like in the mesh window wizard, the physical performance is changed from mechanical(default) to nonlinear mechanical and element order is changed to a linear. Also, an adaptive meshing option is activated to let software remesh the model within solution to avoid high distortion in elements. The skewness value is selected to be 0.6 to detect minimum distortion in elements in order to be remeshed later [11]. The element type is selected to be tetrahedron, as a requirement by adaptive meshing option, and the element's size is 1.8e-4 m. The elements size is relatively small to minimize element distortion and because of the small size, a high element number of about 36701 elements is generated and used during solution. The mesh of the model is shown in Figure 7 below

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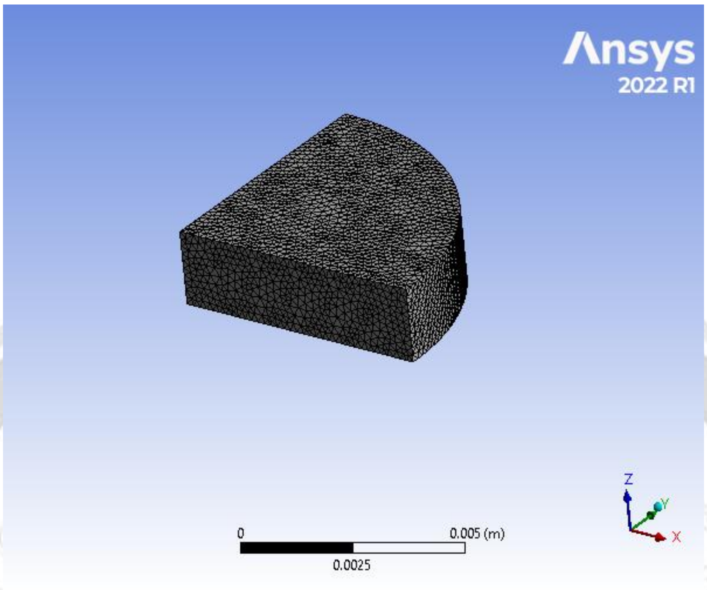

Fig. 7 Meshing of Neo-Hookean based Model

In contrast to the material above, The Elastomer Sample (Yeoh) material goes well with the simulation as will be explained later. There was no element distortion and the solution converged easily and accurately without requiring high element number or adaptive remehsing option or even tetrahedron element type. The element type used with this material is hexahedron with element size of 5e-4 m. The number of elements used in the simulation is 1243 elements. The mesh for the model of Elastomer Sample (Yeoh) material is shown in Figure. 8 below and despite the relatively big element size, but the results were relatively accurate.

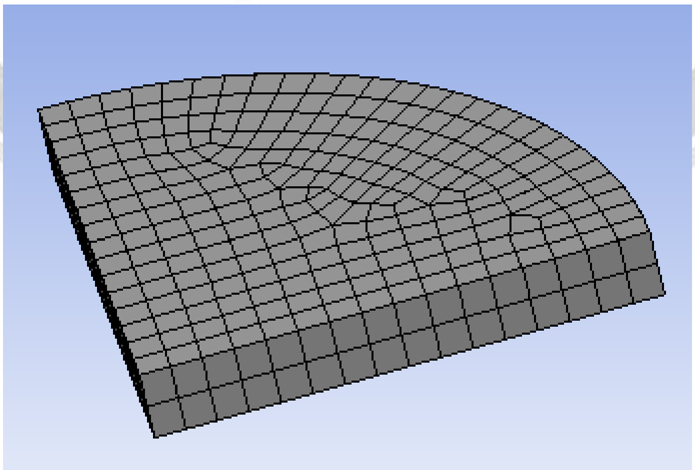

Fig. 8 Meshing of Yeoh based Model

Boundary condition:

Besides the axisymetrical boundary condition applied to the quarter geometry for both modelings, a fixed boundary condition is applied to the circumferential arch area as shown in Figure 9 below. Also, a pressure of 350 KPa is applied to top surface gradually within 10 seconds time, as shown in Figure 10 below, in which 10 substeps is applied for each second i.e. there are 100 total steps for pressure to be gradually applied to avoid the failure in

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solution due to non-convergence and element distortion. Also, a high deformation option is activated as a requirement for rubber modeling. Because of non-linearity, a substep option is selected with initional step option of 100, minimum step of 50 and maximum step is 500.

Note: The 350 KPa is the maximum gauge pressure value read by the gauge tool when 1/3 PH water pump is used and the pressure gauge tool alone is the connected directly to the pump without any other branch connections.

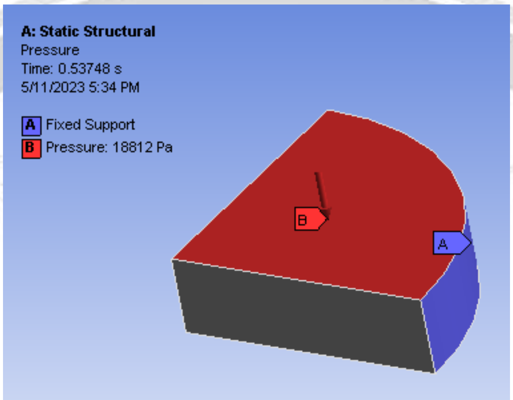

Fig. 9 Fixed Support (blue color) & Applied Pressure (red color)

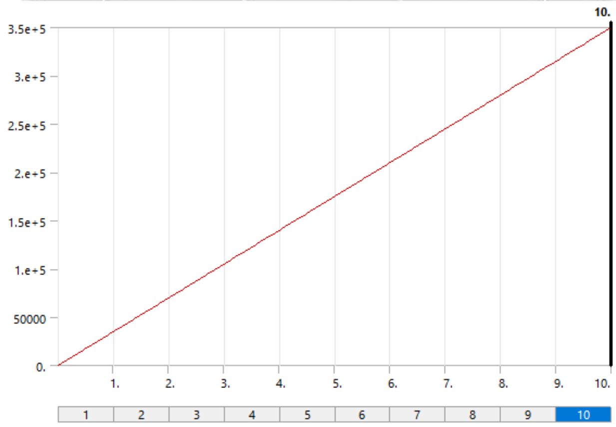

Fig. 10 Applied Pressure vs Time

Solution and Results:

The solution of such models is very time consuming, especially with Elastomer Sample (Neo-Hookean) material, due to non-linearity as well as high distortion in elements where adaptive meshing was used. An Intel core i7with 2.77 GHz computer is used for the simulation and in the analysis setting details for the Workbench 2022, an auto time stepping is change to on. The initial substeps is selected to be 20 and minimum substeps is 10 and maximum substeps is 500. The solution for each modeling is as explained below:

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First: Elastomer Sample(Neo-Hookean)

For the first material Elastomer Sample(Neo-Hookean), the solution is done and the force convergence of the solution is shown in Figure 11 below. As it is seen in that figure, the vertical brown line refers to remeshing circumstances.

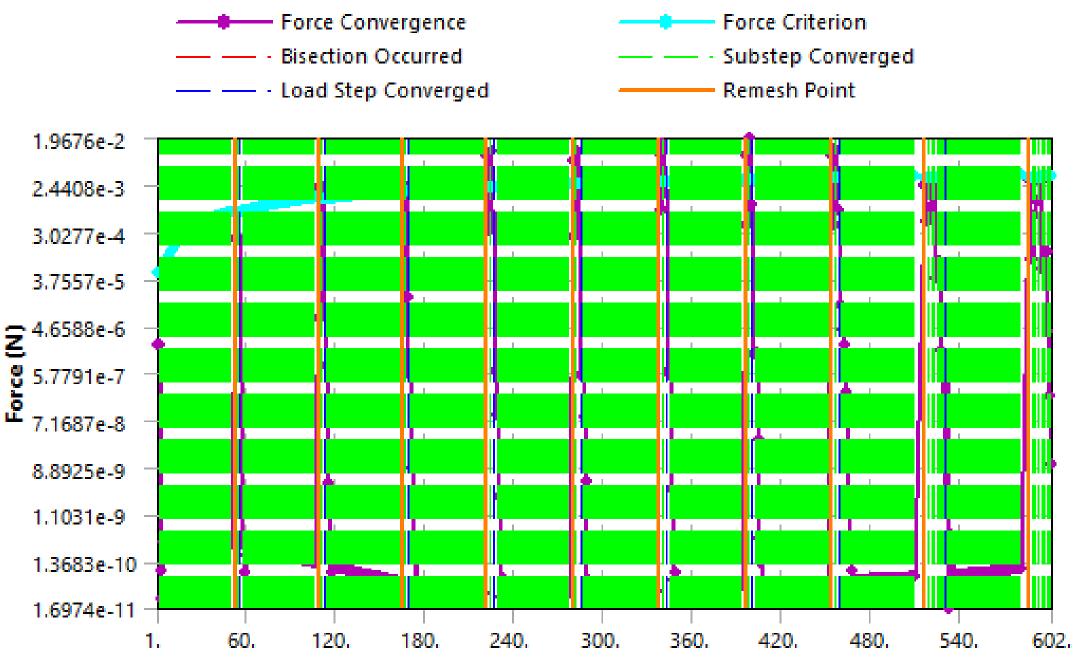

Fig. 11 Force Convergence with Neo-Hookean Modeling

The maximum deformation is about 4.7 mm downward, as shown in Figure 12 , and in Figure13 below. The maximum (Von Mises) stress is 6.7 MPa at the top edge of diaphragm near the fixed boundary conditions regions while the minimum stress is at the fixed boundary condition region itself as shown in Figure 14 below.

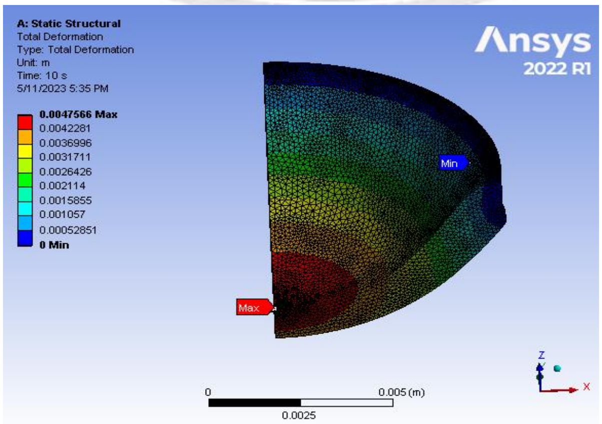

Fig. 12 Total Deformation for Neo-Hookean Model

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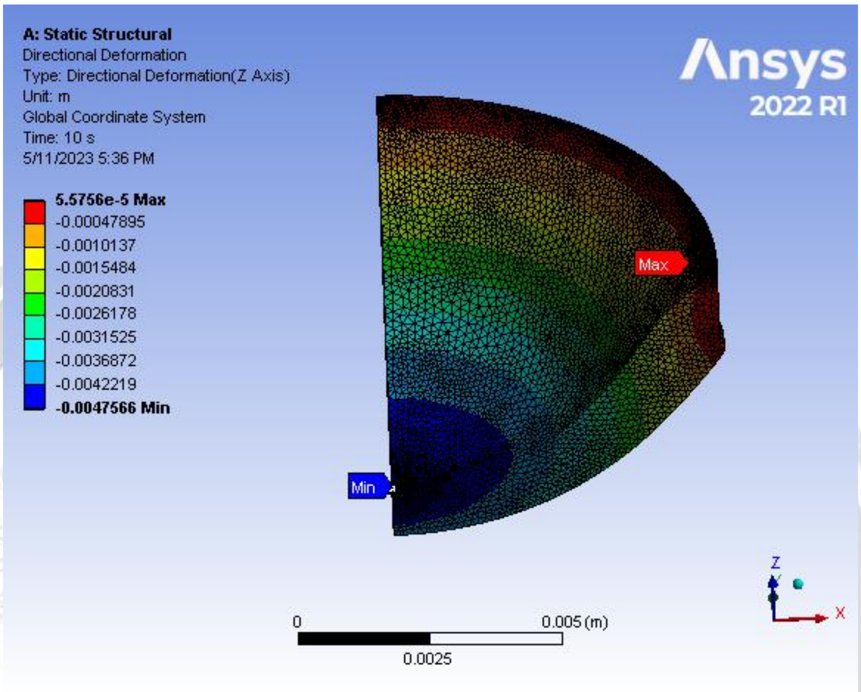

Fig. 13 Directional Deformation in vertical for Neo-Hookean Model

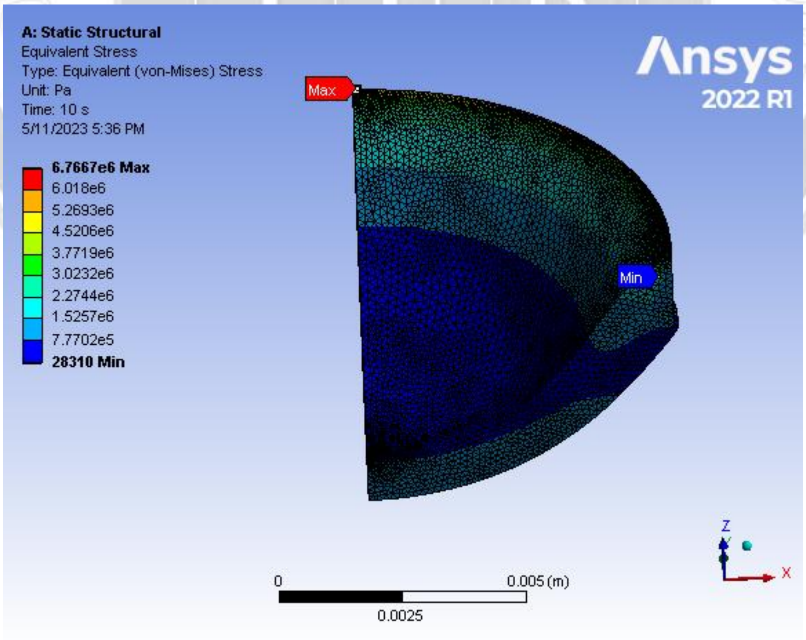

Fig. 14 Von Mises Stress for Neo-Hookean Model

Figure 15 below shows the change in pressure with the deformation or how deformation increases by pressure increment. The relation does not follow totally straight line because of non-linearity of the Elastomer Sample(Neo-Hookean) material.

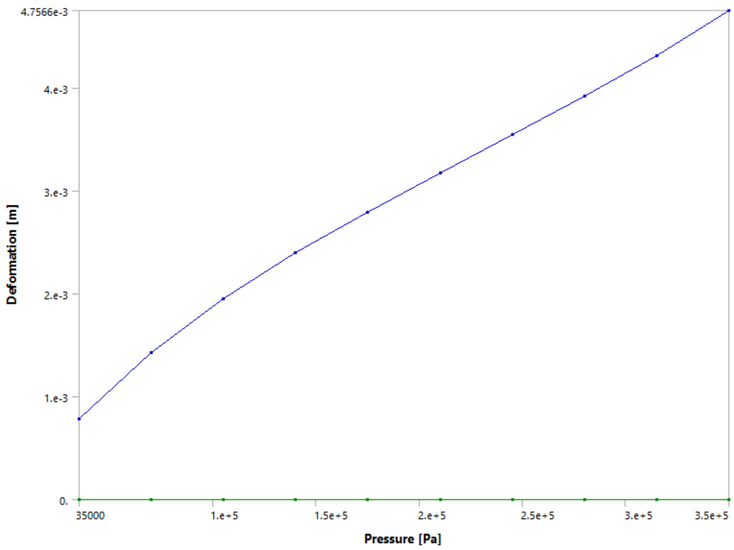

Fig. 15 deformation vs applied pressure for Neo-Hookean Model

Second: Elastomer Sample(Yeoh) solution

As explained earlier in Meshing section, there were no needs to do much changes in the meshing options. The solution is done with less consuming time, as a compare with consuming time of Elastomer Sample(Neo-Hookean), the force convergence diagram is shown in Figure 16 where it can be noted there is no remeshing process within solution.

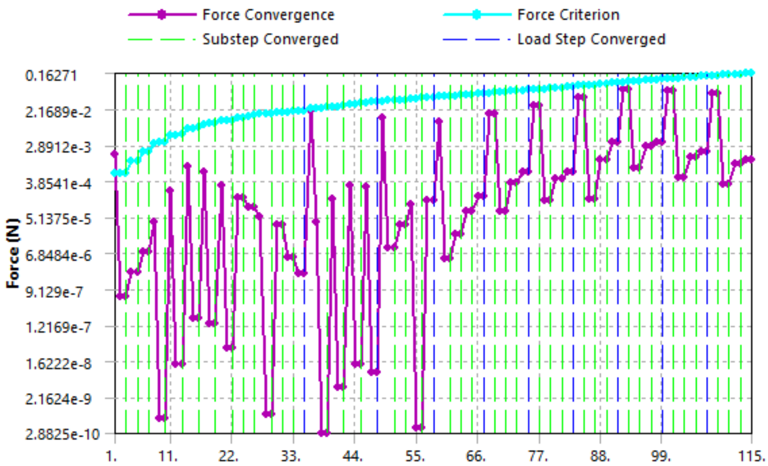

Fig. 16 Force Convergence for Yeoh Modeling

The maximum deformation is about 11.1 mm downward, as shown in Figure 17 below and Figure 18 below. The maximum (von misees) stress is 5.7 MPa at the top edge of diaphragm near the fixed boundary conditions regions while the minimum stress is at the fixed boundary condition region as shown in Figure 19 below. In order to recognize the

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results from those of Elastomer e(Neo-Hookean) modeling, the deformed shapes, in the figures below, are all in full circle i.e. no quarters the shapes are shown

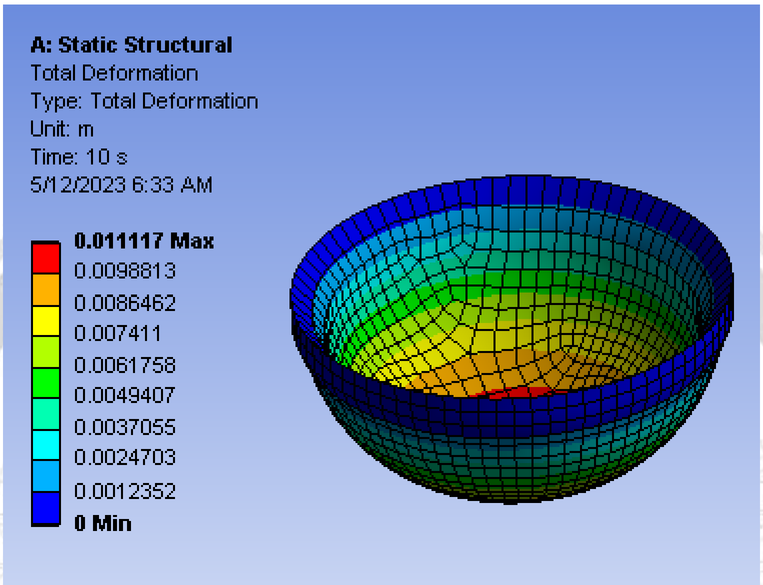

Fig. 17 Total deformation for Yeoh Modeling

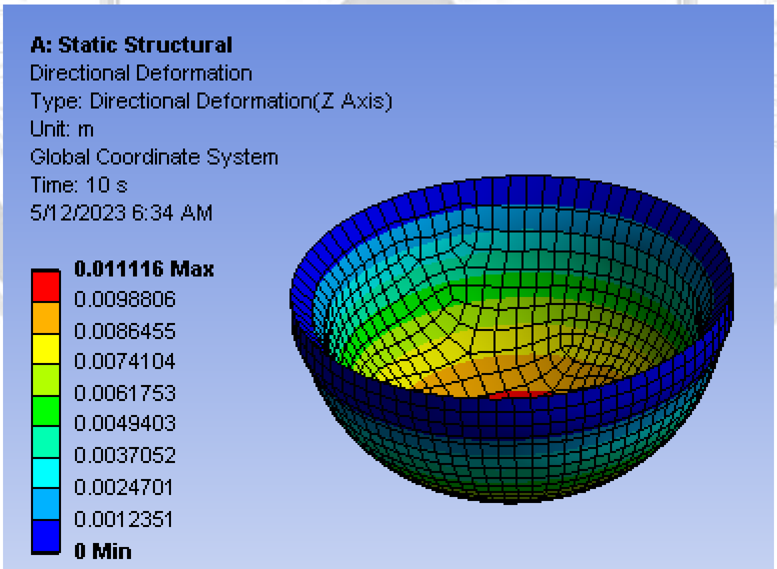

Fig. 18 directional deformation downward for Yeoh Modeling

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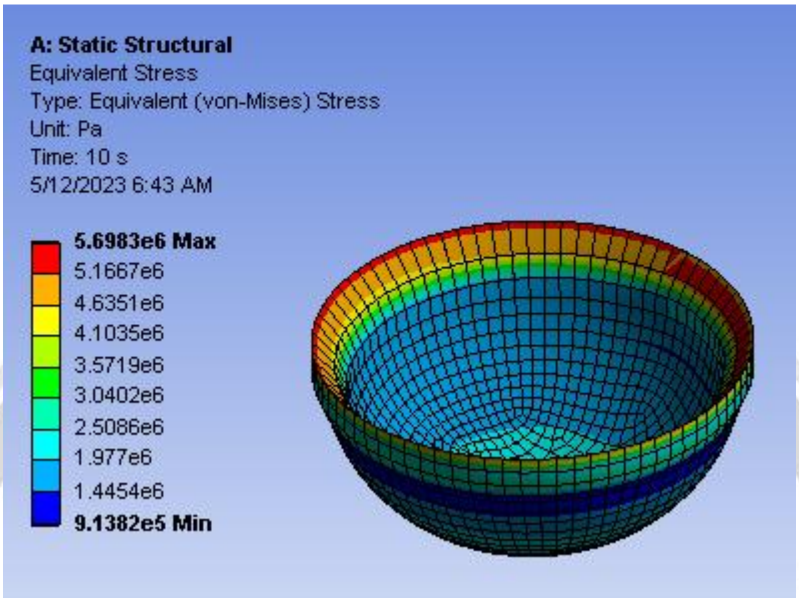

Fig. 19 Von Mises stress for Yeoh Modeling

Figure 20 below shows the change in pressure with the deformation or how deformation increases by pressure increment. The relation does not follow straight line because of non-linearity of the Elastomer Sample(Neo-Hookean) material.

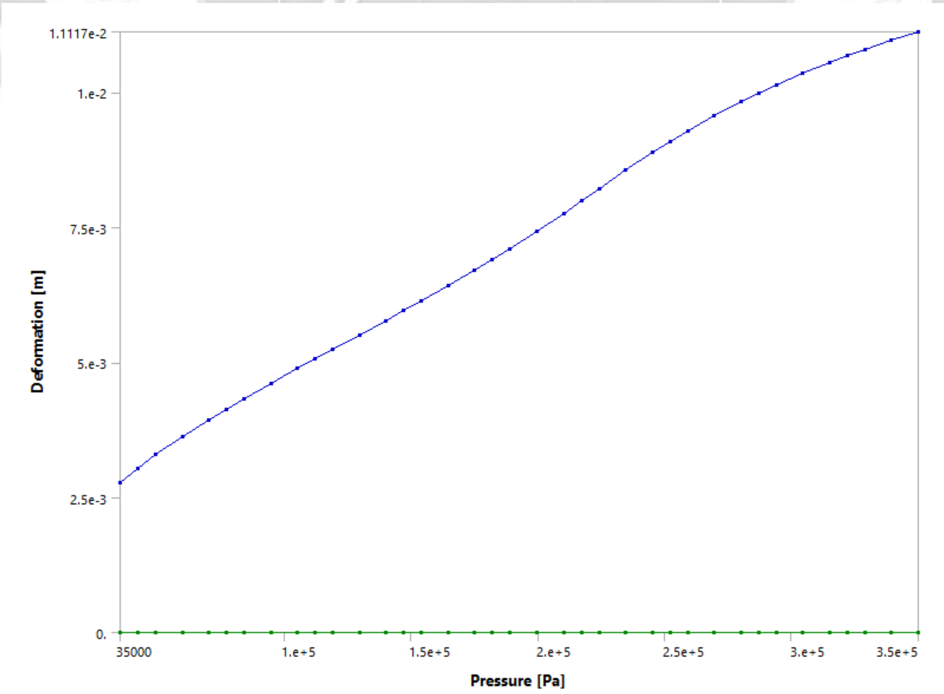

Fig. 20 Deformation vs applied pressure for Yoeh Modeling

Practical Work

Despite of the two different theoretical deformation results, the two theoretical deformation results give an indication on how the deformation and stress will be when the same boundary conditions and diaphragm's dimensions be applied in reality. The design of the pressure switch should consider the theoretical results besides adding extra tolerances because the corresponding practical results might be more or less than theoretical ones.

Designing of the Pressure Switch:

The pressure switch simply consists of two parts [12]: the mechanical where the diaphragm is and the electrical where normal electrical switch or sensor is, as shown simply in Figure 21 below. The fluid or water enters the mechanical part of pressure switch will directly deform the diaphragm. The amount of that deformation is proportional to the fluid's pressure. A lever is attached to the diaphragm from one side and the other side of the lever is attached to the electric switch. When the pressure of water becomes enough to deform the diaphragm to preset amount, the attached lever will move causing closing or opening the electric circuit depending on the task of the pressure switch. What is important in this work is the mechanical part and the amount of the diaphragm's deformation under the same amounts of pressure used with the theoretical calculations. So, there is a need to build a mechanical part according to diaphragm's theoretical properties.

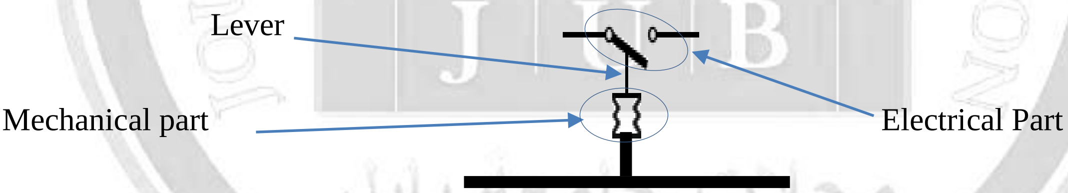

Fig. 21 A Simplified Pressure Switch Sketch

To build the mechanical part, an ironic union plumbing fitting of 25 mm diameter is selected to be as a holder and as a casing for the diaphragm as shown in Figure 22 below. This union fitting is cheap and available in everywhere besides it is considered as waste part because of its being replaced by PVC fittings.

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Fig.22 Ironic Union Fitting where diaphragm is inside

In Figure 23 below, the diaphragm is placed between the main two parts of the union fitting while the ring will tie and hold the assembly together including the diaphragm as shown in Figure 22 above. When water's pressure applies to one side of the diaphragm, the diaphragm will deform. The amount of that deformation can be measured directly using Vernier Caliper from the other side.

Fig. 23 Parts of Union Fitting with the Diaphragm

In order to measure the diaphragm's deformation with different values of water's pressure, a connection of big tap, guage and the mechanical part of pressure switch is used as shown in the diagram in Figure 24 below. The big tap works like pressure regulator and the purpose of using the big size tap is when it is fully open, the pressure will be very little or can be read as zero by the gauge. But when the tap is fully closed, a maximum pressure will be read by gauge; and at that moment, a maximum deformation of diaphragm can be measured with the Vernier Caliper as shown in figure 24 below. Therefore, the amount of the pressure, shown in gauge, can be change to any value (between the zero and maximum) by just adjusting the tap. Figure 25 below is a real picture for applying the sketch in Figure 24.

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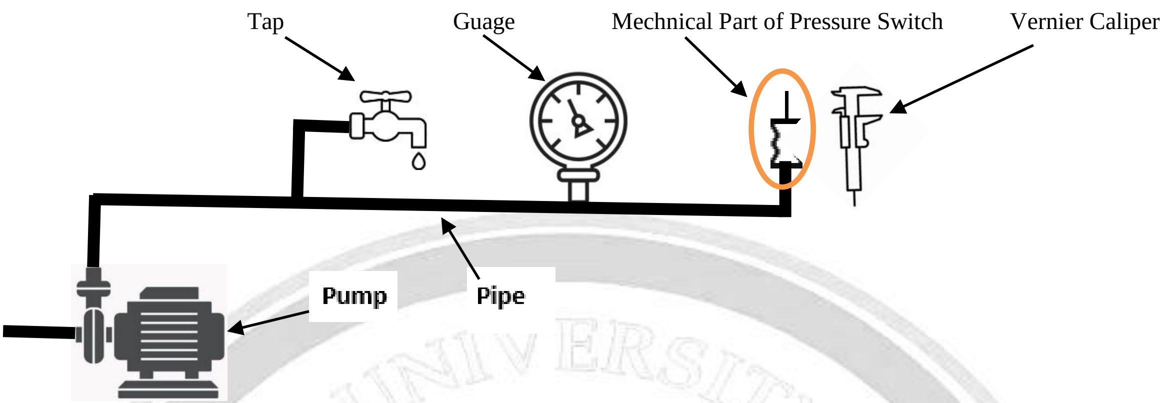

Fig. 24 Sketch of Pipes, Guage, Tap and Mechanical Part of Pressure Switch

Fig. 25 Real Picture of Practical Experiment

The values of the pressure used in practical test are the same pressure steps in theoretical calculations i.e. the pressure will increase gradually from 35 KPa to 350 KPa within 10 steps. Table 1 below shows the ten pressure values with their corresponding deformations, as measured directly by Vernier Caliper. The practical (experimental) deformation values in the Table 1 below represent the average of three repeated measurements of the deformations. Also, Figure 26 below shows the relation between the applied pressure and experimental or practical deformation.

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	Pressure KPa	Deformation (Practical) mm
1	35	3.1
2	70	6.8
3	105	7.77
4	140	8.6
5	175	10.37
6	210	12.8
7	245	14.2
8	280	15.35
9	315	16.2
10	350	16.6

Table 1 Applied Pressure and the Measured Deformation

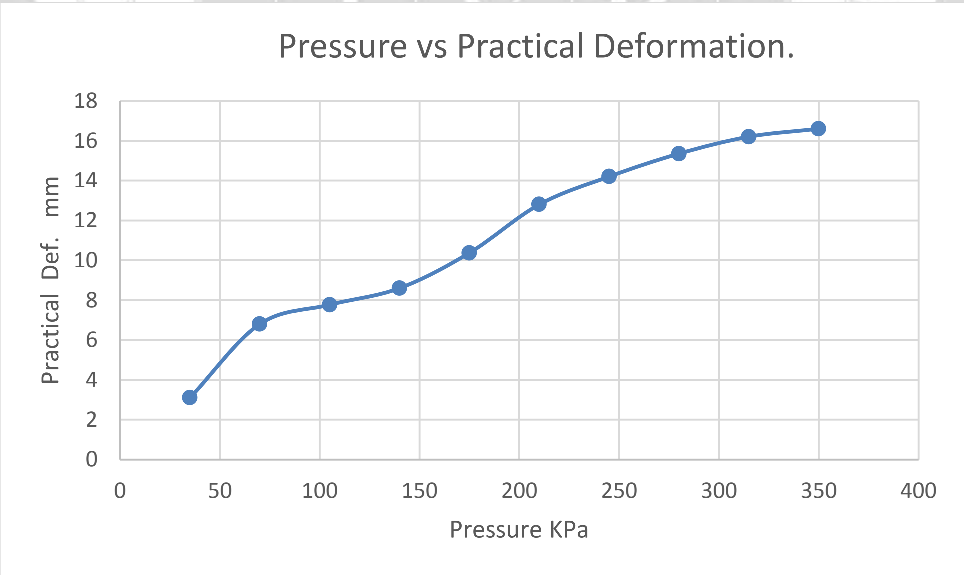

Fig. 26 Pressure vs Practical Deformation

Results and Discussion:

Table 2 below shows the experimental deformation, (Neo-Hookean) material deformation and (Yeoh) deformation with the applied pressure, knowing that the last two deformations were computed with Workbench 2022 as explained previously. Also, Figure 27

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below shows the experimental deformation, (Neo-Hookean) material deformation and (Yeoh) material deformation with the applied pressure.

Pressure KPa	Deformation (Practical) mm	Deformation Yeoh (Ansys) mm	Deformation Neo-Hookean (Ansys) mm
35	3.1	2.8	0.781
70	6.8	3.93	1.433
105	7.77	4.881	1.9543
140	8.6	5.773	2.3994
175	10.37	6.696	2.7973
210	12.8	7.7533	3.1757
245	14.2	8.8789	3.5473
280	15.35	9.8185	3.9238
315	16.2	10.552	4.3196
350	16.6	11.116	4.7566

Table 2

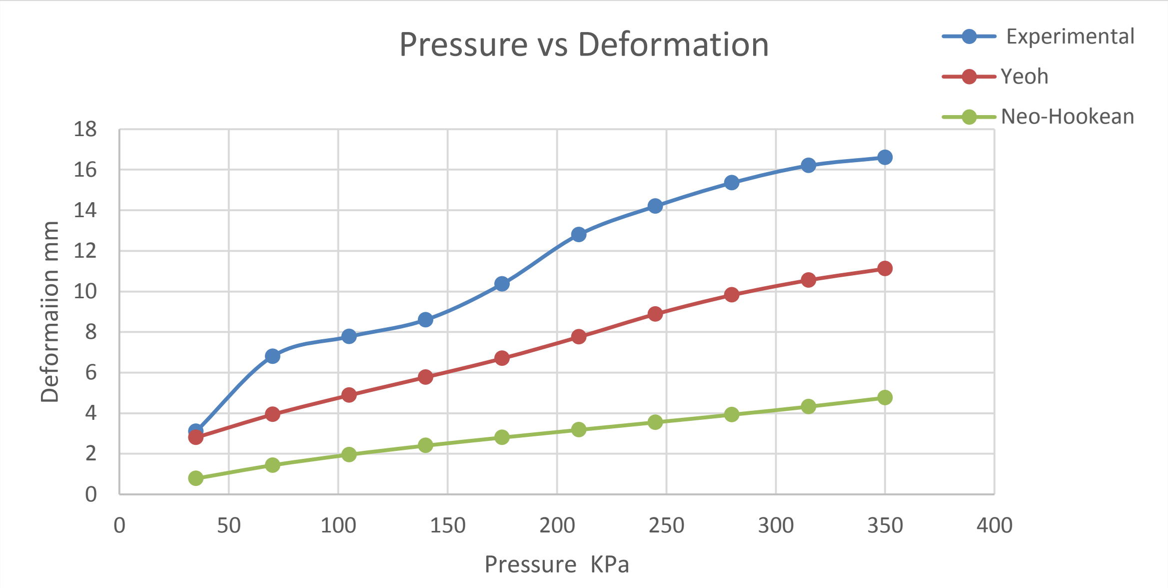

Fig. 27 Pressure vs Deformations

It can be noted that Elastomer (Neo-Hookean) results are so far from the experimental results that even, at the start point of (35 KPa), the corresponding deformations for both results are far from each other. That big difference is due to not selecting the right

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material in library of the Workbench 2022 because the real material (old tube rubber) does not have enough accurate data to be compared with i.e. the old tube rubber is like mystery material. Also, the elastomer based on Neo-Hookean seems to be far, at the beginning, from matching the real material deformation since it was very difficult to be simulated with Workbench 2022 and many modifications, like using adaptive remeshing option and using huge number of tetrahedron elements, have been made to the mathematical model to let it converge besides the solution takes huge time to reach convergence.

In Figure 27 above, the beginning deformation of Yeoh based Elastomer, at 35 KPa applied pressure, is nearly to be coincides with experimental deformation, but then the experimental deformation diverges from the Yeoh based Elastomer as pressure increases. At maximum applied pressure of 35 KPa, the maximum experimental deformation is about 16.6 mm while the maximum Yeoh based deformation is 11.12 mm. So, it can be noted that the maximum experimental deformation is about 1.5 times the maximum Yeoh based deformation. The Yeoh based Elastomer seems like it is the most material matching the experimental one as a compare with Neo-Hookean based Elastomer. The Yeoh Elastomer deformation has like a straight line form with very small curves as shown in Figure 27 above. The experimental deformation seems having much bigger curves, particularly at the beginnings, i.e. the experimental relation in Figure 27 gives an imagination that it is Yoeh deformation relation with bigger curves.

If it is supposed that the Yeoh based Elastomer is the most probably material used in truck's tube rubber. The difference between the experimental and the theoretical (Yeoh) results can be related to several reasons: -

1. The fixed boundary condition is applied to the Workbench model at the circumferential area of the quarter diaphragm as shown in Figure 28 below, while in the experiment or reality, the diameter of the diaphragm is bigger by about 4 mm i.e. the total diameter is 33.55 mm from which, 25.55 mm diameter forms the area or surface facing fluid (water) and the other 4mm (for each side) is used to hold the diaphragm with the two main parts of the union fitting as shown previously in Figure 23. These two main parts of the union fitting press the 4mm regional edge so its thickness will be less than the thickness of rest regions of diaphragm (1.8) mm as shown in Figure 29 below. The holding force of the diaphragm results in high friction between the diaphragm and the two main parts of the union fitting. It is hard involving friction into simulation because it will be extra non –linear solution of the model besides it will be too time consuming which is out of the computer capacity. Also, the less thickness in 4 mm region part of the diaphragm will decrease the stiffness in diaphragm due to small thickness [13].

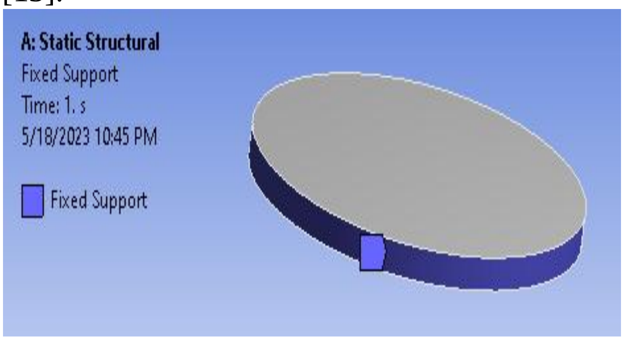

Fig. 28 Fixed boundary condition in Workbench

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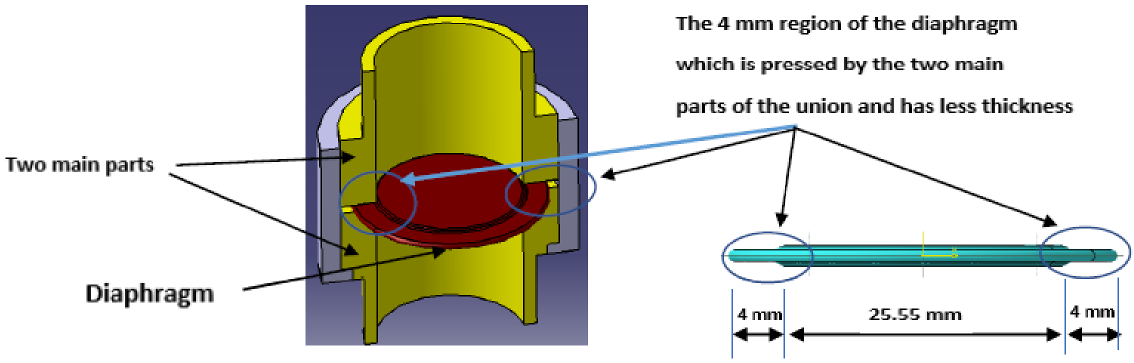

Simplified Cross-Section of Union with Diaphragm **Front View of diaphragm Shape inside Union**

Fig. 29 Simplified Real Diaphragm inside Union

2. Due to pressing force on the edges of the diaphragm, the diaphragm might have initial deformation prior to the deformation resulting in applied pressure by water.
3. The diaphragm thickness in experiment might be not uniform over the whole circular surfaces.
4. The diaphragm material in experiment might be not that homogenous as Yoeh Elastomer in Workbench.
5. The material of the tube might be different from what is previously assumed in this paper because, after all, the material of the tube is a mystery due to not enough experimental strength data.
6. The truck tube is old and waste material; its specifications or strength are degraded with time of age. Also, the old rubber has cracks on its surfaces, those cracks cannot sometimes be seen directly. The cracks lessen the strength of rubber to the load [14].

Conclusions

1. There is a gap between the experimental and Yoeh (Workbench) results and this gap is not constant but changes with tube's rubber age and applied pressure. Though, the gap can be easily contained by using an auxiliary device in mechanical part of the pressure switch. This auxiliary device is like, screw inside a spring with a nut, for adjusting and control the deformation of the diaphragm in order to work in synchronous with the electric part of the pressure switch. Also, the auxiliary device can contain or adjust the difference in deformation resulting in using different diaphragm's thickness or different tube's rubber's specifications. The design of the electrical parts as well as the auxiliary device will be in future work.

2. The old tube rubber can be a good source material to make a diaphragm for such type of homemade pressure switch. It is easy to be installed or replaced; its replacement is very similar to the washer replacement in normal tap.

3. This work of using an old tube rubber as diaphragm is very friendly to environment. It minimizes depending on petro-chemical manufacturing to produce a new diaphragm and resulting in avoiding all pollutants associated with such industries [15]. Also, it uses an old union plumping fitting which is considered as waste materials.

4. The cost of such diaphragm together with union plumping fitting is is very cheap. Also, a PVC union plumping fitting can be used instead of ironic one but it will cost a little bit higher.

Future Work

The future work will be to design the auxiliary device and the electric part of the pressure switch. The design should be as simple as possible besides it should be durable and reliable. Also, cheap available materials should be used in design and building these parts. Also, above all of that, safety must be taken care especially with the electrical parts and how to be far enough from water splash in case of diaphragm failure.

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ARTICLE

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التحليل الشرائحي الرقمي لمطاط الانبوب المطاطي المستخدم في إطارات المركبات (الجوب) لكي يتم استخدامه كحجاب حاجز في مفاتيح الكهربائية المعتمده على الضغط والمصنعه من مواد رخيصة ومتوفرة

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الخلاصة

هذا البحث هو لتحليل الاجهادات والانفعالات للمطاط المُراد استخدامه كحجاب او حاجز مطاطي في المفاتيح الكهربائيه المعتمده على ضغط المائع والمصنعه من مواد رخيصه ومتوفره. فتم اختيار وصله مطاطيه من أنبوب مطاطي قديم (جوب) المستخدم في الشاحنات فتم تقطيع عينات للفحص من تلك الوصله والذهاب بها الى جهاز الفحص بالشد لكن الجهاز ليس لديه إمكانية احتساب التغير بالسمك مع الطول بل يعطي فقط قراءات قوة الشد المسلطه مع الاستطالات الناتجه من تلك القوى. وللحصول على بيانات كافيه للمواصفات الميكانيكيه لتلك المادة لعمل محاكاة ببرنامج الانسس , تم اختيار بعض قراءات الأولى للشد والاستطاله ومقارنتها مع نظيرتها في المواد الموجوده ضمن مكتبة الانسس نظريا حيث تبين ان اقرب ماده في الانسس مطابقه للقراءات هي مادتي Elastomer Yeoh و Elastomer Neoh-Hookean. وبناءا على مواصفات الاخيره للمادتين تم اختيار قطر الحاجز المطاطي (٢٥.٥٥ mm) وتم رسمه ببرنامج Catia R17 بسمك الانبوب المطاطي القديم (جوب) للشاحنه, بعدها تم عمل محاكاة (لكل ماده على حدا) لذلك الحاجز المطاطي باستخدام برنامج Workbench 2022 تحت ضغوط عمل مختلفه لحساب التشوهات الناتجه خصوصا العمويه منها طبقا لمواصفات كلتا المادتين. وبناءا على تلك النتائج تم بناء نموذج عملي حقيقي حيث تم قطع وصله دائريه من ذلك الانبوب المطاطي القديم (الجوب) لتكون بمثابة الحاجز المطاطي Diaphragm وتم بناء الجزء الميكانيكي لمفتاح كهربائي يعتمد على ضغط الماء من مواد رخيصه جدا ومتوفره. تم تسليط نفس الضغوط المستخدمه في الانسس على النموذج الحقيقي وتم قياس التشوهات الناتجه ومقارنتها مع نظيرتها ببرنامج الانسس. حيث تبين ان المطاط المستخدم في الانوب المطاطي للشاحنات (الجوب) له مواصفات تقترب الى مواصفات مادة Elastomer Yoeh مع وجود بعض الاختلافات وتبين انه من الممكن الاعتماد على تلك المادة في عمل محاكاة نظريه والاستفاده من النتائج في التطبيقات العمليه. حيث تبين ان التشوه الحقيقي يعادل تقريبا ١.٥ مره من التشوه النظري لمادة Elastomer Yoeh المحسوب بواسطة برنامج الانسس

ألكلمات الداله:- اجهادات, انفعالات, تشوهات, إعادة تقطيع الشرائح , تقاريب المنحنيات, ضغوط , خطوات , تقارب الحل.