Al-Khwarizmi Engineering Journal, Vol. 14, No. 1, March, (2018)
P.P. 52-66

Al-Khwarizmi Engineering Journal

Study the Effect of Forming Media on the Hydroforming Process for Copper Tube

Rusul AbdulKareem Salman* **Hani Aziz Ameen****
Kadhim Mijbel Mashloosh***
Technical Engineering College – Baghdad/ Iraq
*Email: rusulalizee@gmail.com
**Email: haniazizameen@yahoo.com
***Email: Kadm52@yahoo.com

(Received 29 March 2017; accepted 11 October 2017)
https://doi.org/10.22153/kej.2018.10.003

Abstract

To observe the effect of media of the internal pressure on the equivalent stress distribution in the tube, an experimental study is done by constructing a testing rig to apply the hydraulic pressure and three dies are manufactured with different bulging configurations (square, cosine, and conical). In the other part, ANSYS APDL is generated to analyze the bulging process with hydraulic and rubber (natural and industrial) media. It was found that when the media is a rubber, the stress is decreased about 9.068% in case of cosine die and 5.4439% in case of conical die and 2.8544% in case of square die. So, it can be concluded that the internal pressure in the rubber media is much better than in hydraulic media. Also, the force needed for forming the shape using rubber is higher than that of hydraulic and the force needed to form using industrial rubber is higher than of natural rubber. The thickness distribution in the tube wall in case of rubber media is better than that for hydraulic media and for the industrial rubber is better than that for natural rubber for the same dies. In case of hydraulic, the lower forming pressure is needed to bulging process compared with the rubber media since height stress in the tube metal is existed, which causes the failure. For the case of rubber, the forming pressure that was needed to bulge process is higher when compared with the hydraulic media but with less stress in tube metal and the failure in the wall is not existed with rubber media for the same pressure of hydraulic.

Keywords: *ANSYS, bulging process, copper tube, hydroforming, industrial rubber, natural rubber,*

1. Introduction

Tube hydroforming is one of the cold forming operations on metal tubes, which takes it is a consideration all enough in the coming days. This process is carried out using a pressure (via hydraulic fluid or rubber media) in a closed tube from both sides. Girard A.C. A et al., 2006[1], studied the bulging tube experimentally using rubber type of urethane rod. Sadiq Jaffar Aziz, 2008[2], studied of tubes hydroforming process, by using of oil pressure developed inside the tube prepared to be formed also utilization axial force represented by axial displacement (axial end feed) that reduced the tube length, achieved an accept tube wall thickness distribution, and increased its thickness. Selvakumar A. S., et al., 2012[3], Studied the effect of deformation characteristics on tubular materials before and after heat treatment in hydroforming process. Sami Abbas Hammood, 2012[4], studied the best path to form a tube in the square cross-sectional die relying on the hydraulic bulge test and numerical simulation to reduce loss of the cost and time in the experimental work that used copper and aluminum metals. Emad Jabour Yousif, 2013[5], studied of the effect of each of the internal fluid pivotal in the load paths and powers, final tube wall loading paths have been identified on the pressure and axial regions forming and powers and failure scheme. Li H.Y., et al., 2015[6], studied the problem of the match of axial force and internal pressure, the results of experimental on the influence of loading path on hydroforming square hollow component was premised. Hani Aziz Ameen et al., 2016[7], studied the analytical model to analyze the stress state and wrinkling in the X-branch bulging tube during the hydroforming process using ANSYS LS-DYNA. Hani Aziz Ameen et al.,2016[8], studied the effect of die cavity configuration on the stress distribution in tube hydroforming process with and without rubber media. In this study the effect of the dies configuration (square, cosine, and conical) and pressure (hydraulic fluid and rubber (natural and industrial)) on the bulging process with the parameters (pressure, strain, thickness, and bulging height).

Dies Design

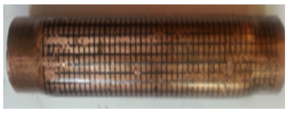
Three dies are manufactured with (square, cosine, and conical) configuration for bulging process that used hydraulic or rubber (natural and industrial) media. Also A die for preparation the rubber is manufactured as shown in Fig. 1.

(a) Rubber's die preparation (b) Square bulge die

(c) Cosine bulge die (d) Conical bulge die

Fig.1. Dies configurations.

In order to obtain the relationship between bulge height, thickness and pressure. A square grid was etched on each tube to measure the hoop and the longitudinal strain at the end of the process so to verify the deformations calculated by the FEM model via ANSYS. Fig. 2 presents the copper tubes at the end of the experimental process. The bulge area is plastically deformed. During the test the axial plungers are still and the tube is fully blocked. The experiments design starts from the observation of the tube bursting pressure and yield pressure. Within this range other different pressure levels have been investigated. For each of the tested tube, the bulge height, the radius of curvature in the longitudinal direction and the wall thickness were measured.



(a)Square tube (b) Cosine tibe

(c) Conical tube

Fig. 2. Bulging product's tube.

Cases Studied

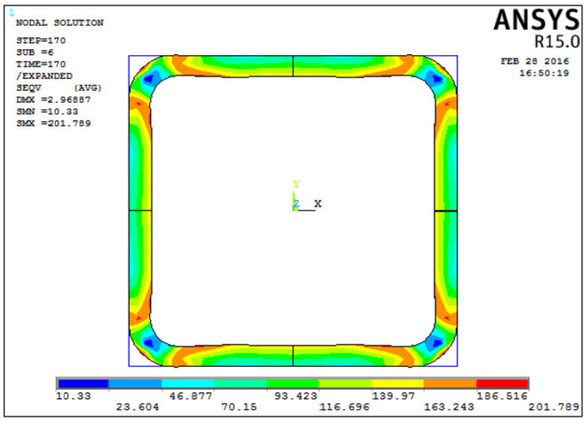
Firstly the internal pressure is investigated for different configurations (square, cosine, and conical) die's shape. Table (1) illustrated the comparison between theoretical (Ref.[9]) and experimental results of internal pressure. Good agreement is evident between the results.

Table1,
The values of internal pressure.

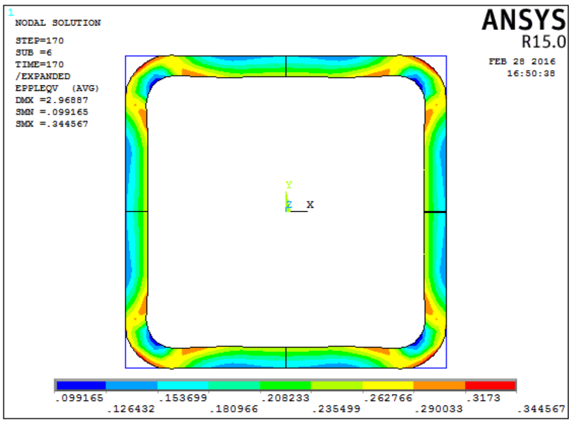
Case		Internal pressure Theoretical (MPa). Ref.[9]	Internal pressure Experimental (MPa)	error%
Square	Hydraulic	31.0656	37	16.0389
Cosine	media	24.41418	26	6.0969
Conical		25.8974	30	13.6753

2. Bulging Die with Square Configuration

In the square die the maximum equivalent stress without rubber was 201.789MPa and maximum strain 0.34456 as shown in Fig. 3 and 4 when using rubber the maximum equivalent stress was 196.029MPa and maximum strain 0.315487 as shown in Fig. 5 and 6, from that it can be shown that the equivalent stress of tube's wall in case of rubber media is about 2.8544% smaller than when using hydraulic fluid.



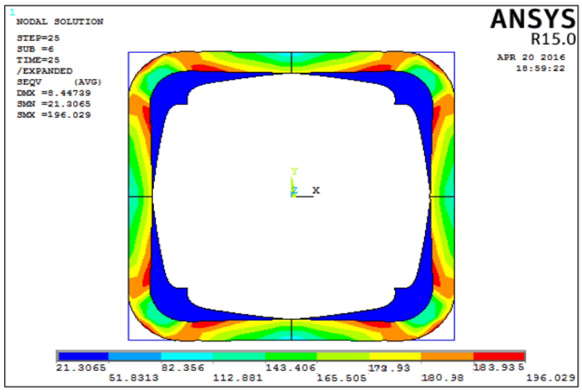
(a) equivalent stress



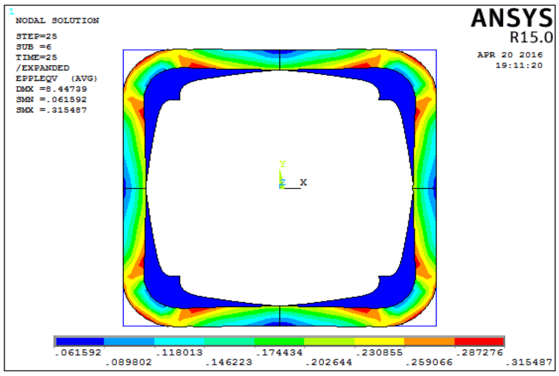
(b) equivalent strain

Fig. 3. Square die without rubber.

Fig. 4. Tube using hydraulic media.



(a) equivalent stress



(b) equivalent strain

Fig. 5. Square die with rubber.

Fig. 6. Tube using rubber media.

2.1. Bulging Height of Square Die

Fig.7 showed the experimental and numerical results for bulging height against pressure when the hydraulic is a pressure media at experimental and numerical test. Good agreement is evident between these results. It can be seen that increasing of hydraulic the pressure 9MPa with no bulge height and the tube wall deform after 9MPa with ramp behavior. Fig.8 shown the experimental and numerical results for bulging height against pressure when the natural rubber is a pressure media at experimental and numerical test. Good agreement is evident between these results. It can be seen that increasing the pressing of natural rubber, the pressure increased to 10MPa with no bulge height and the tube wall deform after 10MPa with ramp behavior. Fig. 9 shown the numerical results for bulging height against pressure when the industrial rubber is a pressure media. It can be seen that for increasing the pressing of industrial rubber the pressure increased to 14MPa with no bulge height and the tube wall deform after 14MPa with ramp behavior. Figs. 7,8,9 illustrated that there are different in the behavior of pressure with bulge height vs the pressure media. Hence it seen that it's higher with rubber and lower with hydraulic, and in case of industrial rubber higher than the natural rubber, and also the applying load are altered in case of hydraulic and rubber as shown since in the case of rubber the friction forces with the tube's wall are generated.

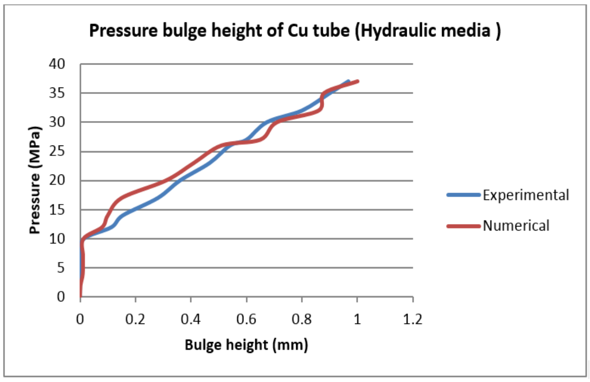


Fig. 7. Pressure with bulge height - hydraulic media.

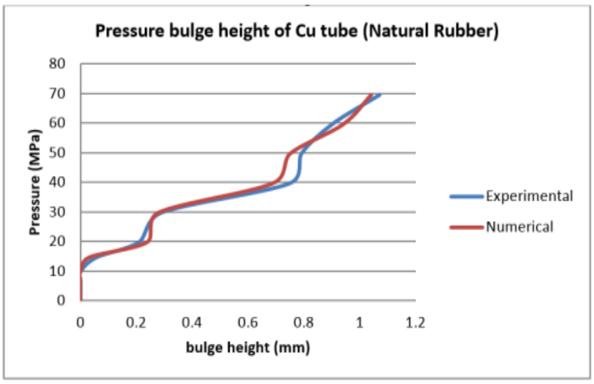


Fig. 8. Pressure with bulge height -rubber media.

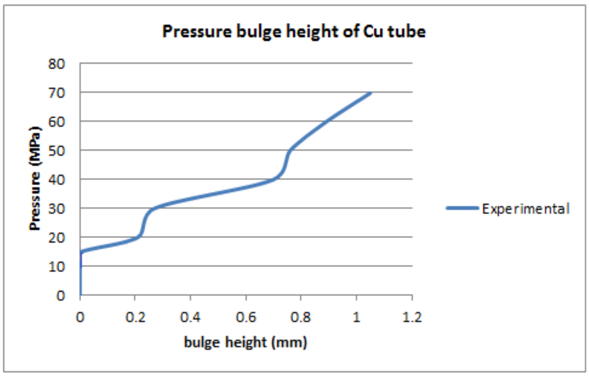


Fig. 9. Pressure with bulge height industrial rubber.

2.2. Strain Distribution

Fig. 10 to15 illustrated circumferential and axial strains evaluated experimentally using grid (2 or 4) mm, and numerically by ANSYS software, it's seen that values of strains are constant within (2-8)mm, increasing within (10-14) and decreasing in the range (16-22)mm and then constant with the period (24-88)mm after that it's increasing within (90-96)mm and decreasing within (100-103)mm, constant within (104-110)mm, and it's shown symmetry about the middle. Good agreement is evident between these results with average discrepancy 0.6623% for ε_1 and 2.4861% for ε_2 as shown in Figs.10 and 11 for hydraulic media. Also similar influences take place for natural rubber media as shown in Fig. 12 and 13, with average discrepancy 1.1848% for ε_1 and 1.0426% for ε_2, while in case of industrial rubber the results observed have the same behavior as shown in Figs. 14 and 15. Due to bulging, the metal is flow and causing alteration in strains with continuous applying the load. Fig. 10 to 15 it can be seen that the strains are began to increase in the region of bulging zone.

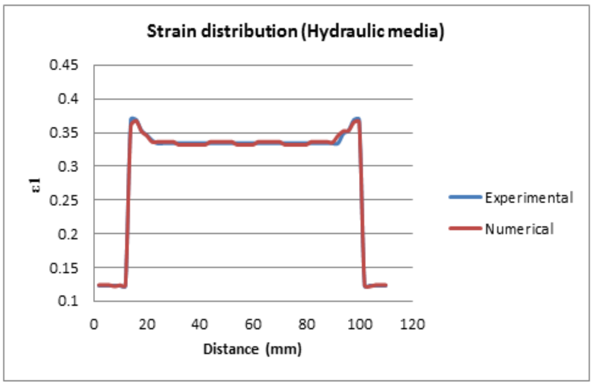


Fig. 10. ε_1 with length - hydraulic media.

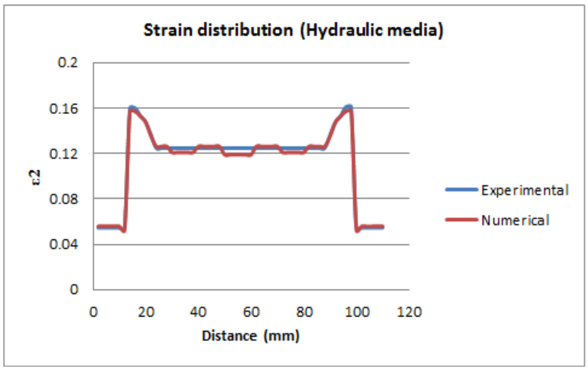


Fig. 11. ε_2 with length -hydraulic media.

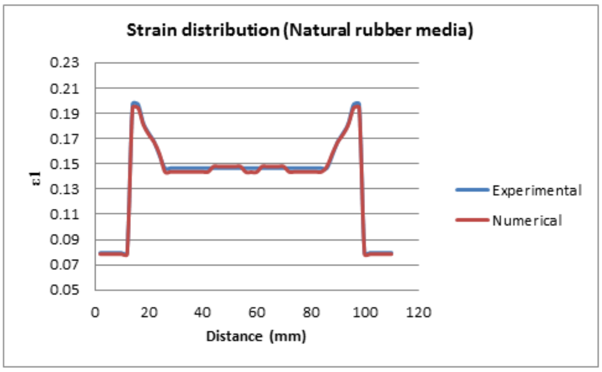


Fig. 12. ε1 with length - natural rubber media

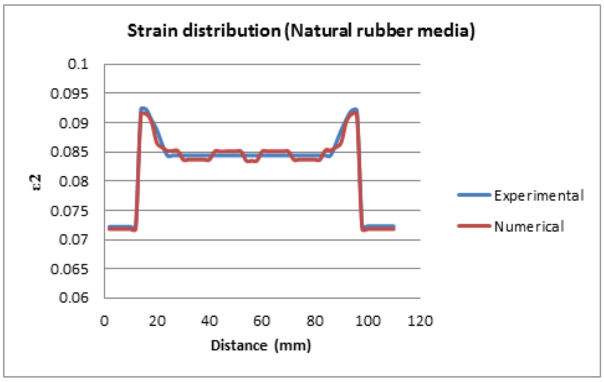


Fig. 13. ε2 with length with natural rubber media.

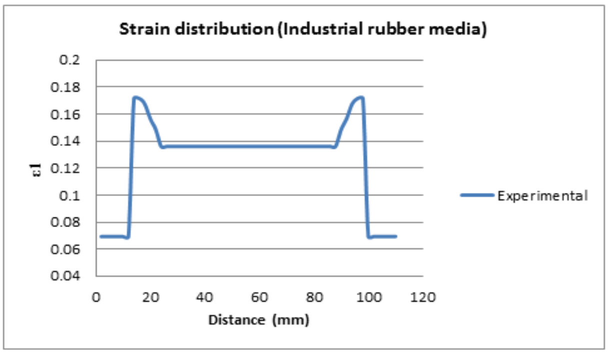


Fig. 14. ε1 with length -industrial rubber media.

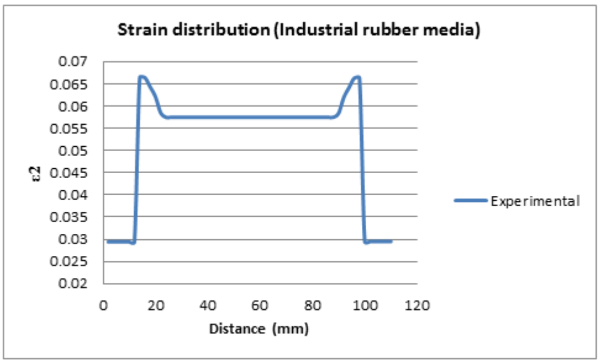


Fig. 15. ε2 with length - industrial rubber media.

2.3. Wall Thickness Distribution

Figs. 16 to 18 shown thickness distributions and location of thinning in the bulge test of copper tube. The tendency is reproduced but errors can be observed. The wall thickness is measured in the experiments by projector profile device, the tube is cutting in longitudinal direction. It can be seen that the behavior of the thickness against distance is not smooth, i.e. It's seen that values of thickness constant within (2-8)mm, decreasing within (10-14)mm and increasing in the range (16-22)mm and then constant with the period (24-88)mm after that decreasing within (90-96)mm and increasing within (100-103)mm , constant within (104-110)mm, and that shown it's symmetry about middle. Good agreement is evident between the experimental and numerical results. From the above discussion, it can be observed that the average discrepancy of the thickness was 0.7377% when using hydraulic and 0.4682% with natural rubber. Due to bulging, the metal is flow and causing alteration in wall thickness with continuous applying the load. Fig.16 to 18 shown the thickness is began to less than 1mm in the region of bulging zone. Figs. 16,17,18 illustrated the distribution of wall thickness along the tube for three media; it can be observed that the thickness in case of hydraulic is less than in case of natural and industrial rubber and thickness in case of natural rubber is less than industrial rubber media.

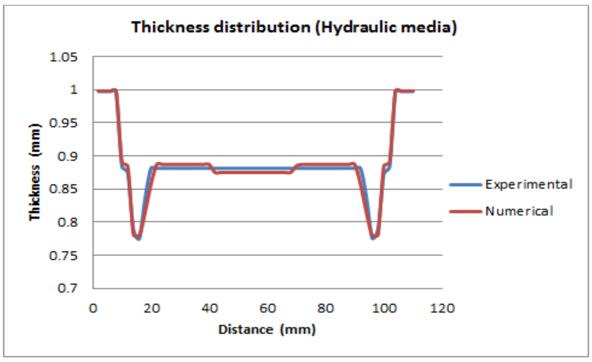


Fig. 16. Wall thickness -hydraulic media

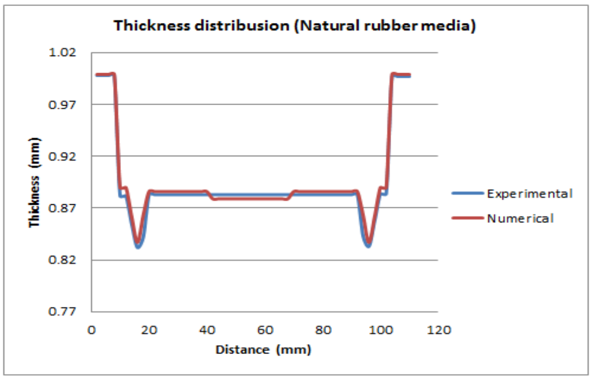


Fig. 17. Wall thickness -natural rubber media

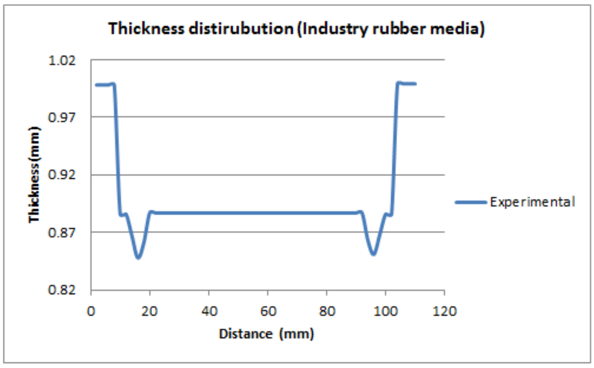
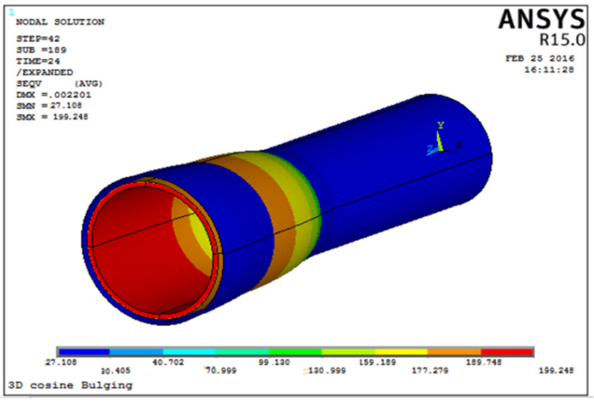


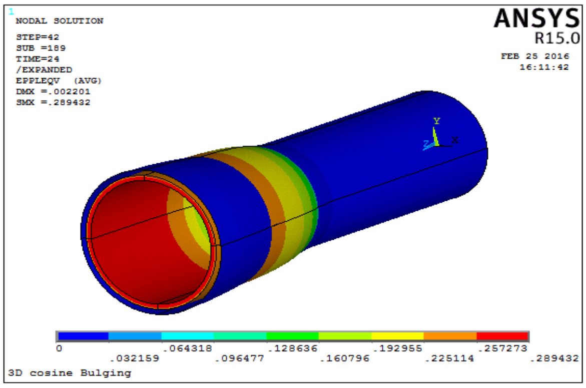
Fig. 18. Wall thickness - industrial rubber media

3. Bulging Die with Cosine Configuration

It's found that in the cosine die the maximum equivalent stress without rubber 199.248MPa and maximum equivalent strain 0.289432 as shown in Fig. 19 and when rubber is used the maximum equivalent stress 181.18MPa and maximum equivalent strain 0.23395 as shown in Fig. 21 from that it can be shown that the equivalent stress in tube's wall with rubber media is about 9.068% smaller than when hydraulic fluid is used. Fig. 20 illustrated the bulge tube when the hydraulic media is used and Fig. 22 illustrated the bulging tube when rubber media is used.



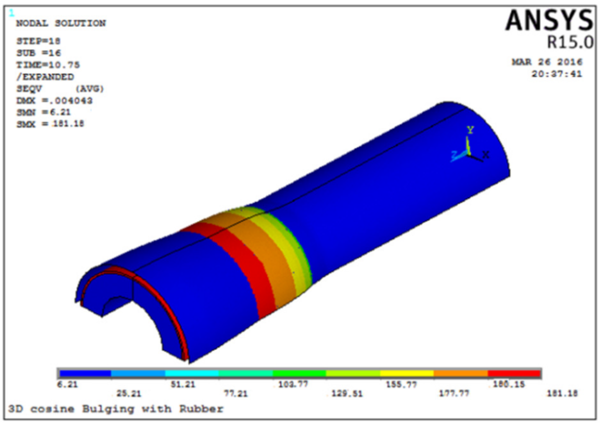
(a) equivalent stress



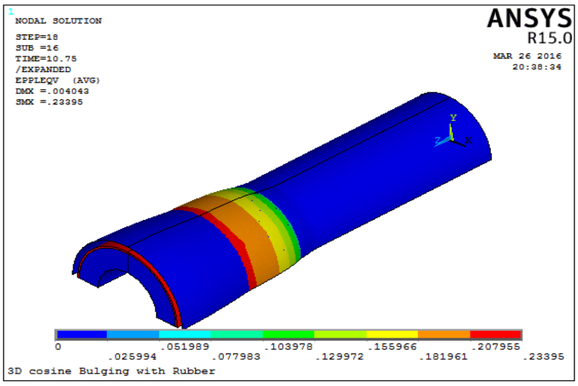
(b) equivalent strain

Fig. 19 Cosine die with hydraulic media.

Fig. 20. cosine cross-section using hydraulic media.



(a) equivalent stress



(b) equivalent strain

Fig. 21. Cosine die with rubber media.

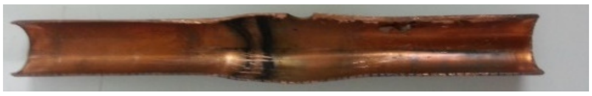


Fig. 22. cosine cross-section using rubber media.

3.1. Bulging Height of Cosine Die

Fig. 23 shown the experimental and numerical results for bulging height against pressure when the hydraulic is a pressure media. Good agreement is evident between these results. From this figure, it can be observed that increasing of hydraulic pressure to 2MPa with no bulge height and the tube wall deform after 2MPa with ramp behavior. Fig. 24 shown the experiment and numerical results for bulging height against pressure when the natural rubber is a pressure media. Also good agreement is evident between these results. From this figure, it can be seen that increasing the pressure due to natural rubber media to 10MPa with no bulging height and the tube wall deform after 10MPa with ramp behavior and when the industrial rubber is used, the pressure increased to 30MPa with no bulging height and the tube wall deform after 30MPa with ramp behavior as shown in Fig. 25. Good agreement is evident with ANSYS results. Figs. 23,24,25 illustrated that there are different in the behavior of pressure with bulge height with the pressure media. Hence it seen that it's higher with rubber and lower with hydraulic, higher with industrial rubber than natural rubber, and also the applying load are altered in case of hydraulic and rubber as shown that because of, in the case of rubber the friction forces against the tube wall is generated .

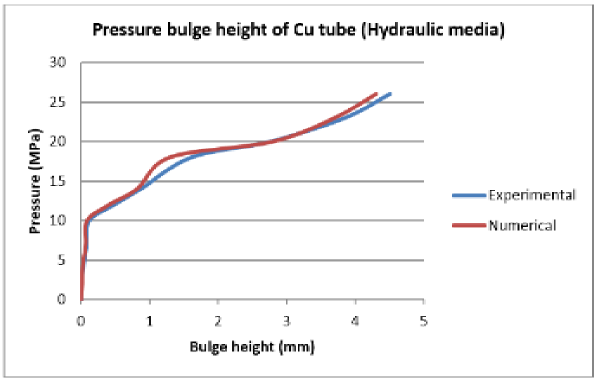


Fig. 23. pressure with bulge- height hydraulic media.

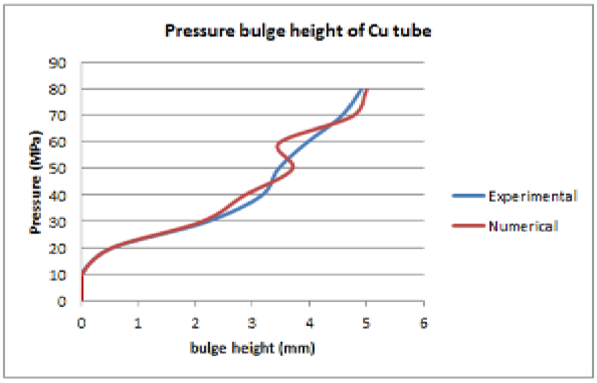


Fig. 24. pressure with bulge height-natural rubber.

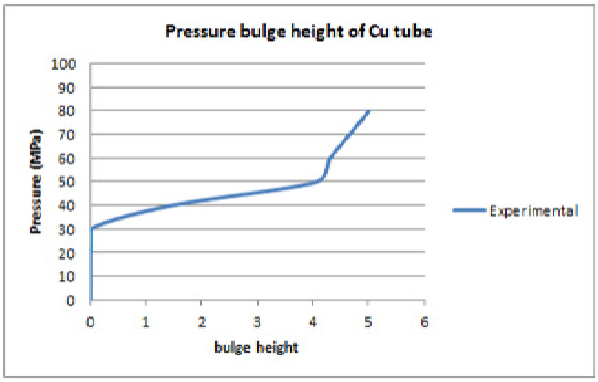


Fig.25. pressure with bulge height industrial rubber

3.2. Strain Distribution

Figs. 26 to 31 illustrated circumference and axial strains evaluated experimentally using grid (2 or 4) mm, and numerically by ANSYS software, it's seen that the values of strain remain constant within range (2-24) mm and increasing in the range (26-60)mm and then decreasing within period (62-96)mm after that the strain is seen constant within (98-120)mm, and it's shown symmetry about the middle, when hydraulic media is used. The average discrepancy 0.3327% for ε_1 and 0.7735% for ε_2 as shown in Figs. 26 and 27. Also similar influences take place for natural rubber media as shown in Figs. 28 and 29, with average discrepancy 1.2706% for ε_1 and 1.0022% for ε_2, while in case of industrial rubber the results observed the same behavior as shown in Figs. 30 and 31. Due to bulging, the metal is flow and that causes alteration in strain with continuous applying the load. From Fig. 26 to 31 it can be seen that the strains are began to increase in the region of bulging zone.

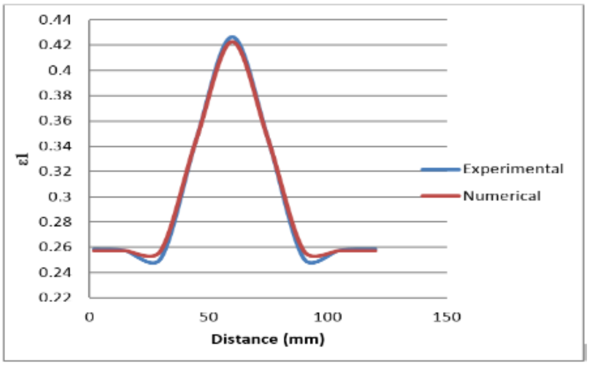


Fig. 26. ε_1 with length distance- hydraulic media.

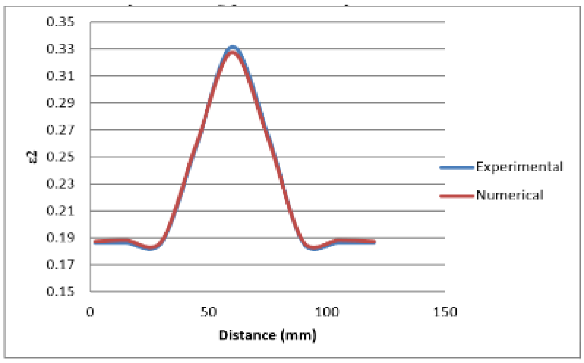


Fig. 27. ε_2 with length distance - hydraulic media.

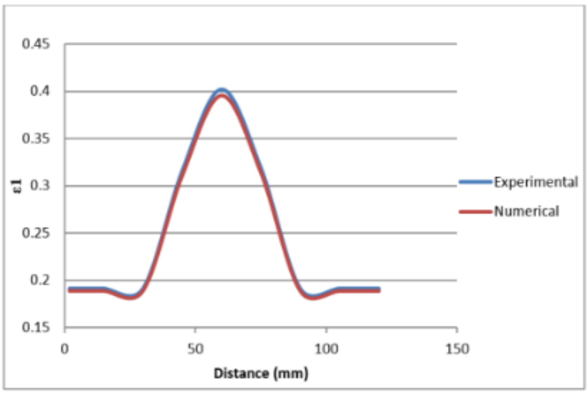


Fig. 28. ε_1 with length -natural rubber media.

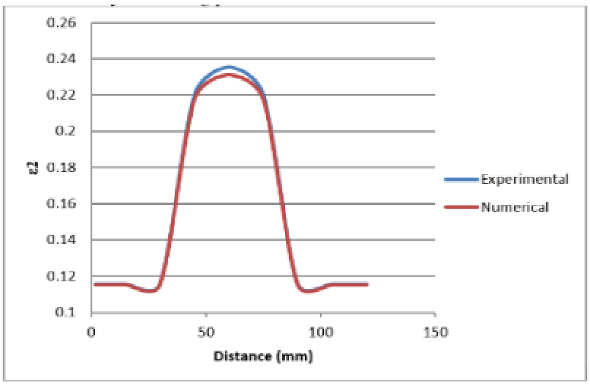


Fig. 29. ε_2 with length -natural rubber media.

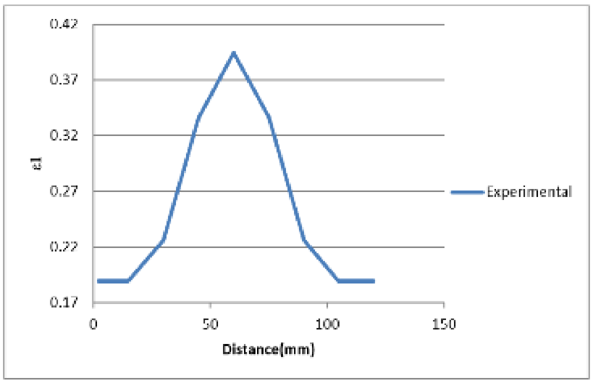


Fig. 30. ε_1 with length industrial rubber media.

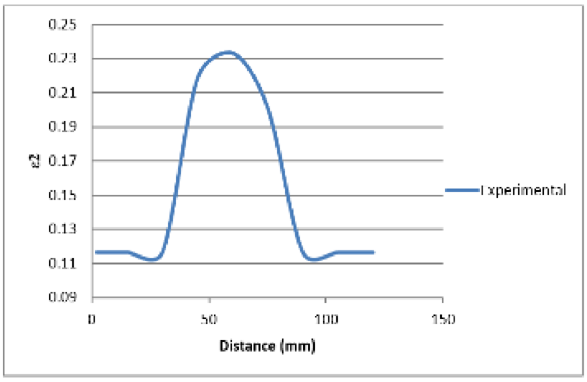


Fig. 31. ε_2 with - industrial rubber media.

3.3. Wall Thickness Distribution

Figs. 32 to 34 shown thickness distributions and location of thinning in the bulge test for copper tube. The tendency is reproduced but errors can be observed. The thickness of wall tube is measured experimentally by projector profile device, that cutting the tube it in longitudinal. It can be seen that the behavior of the thickness against distance is not smooth, i.e. it's seen that the values of thickness remain constant within (2-24) mm and decreasing in the range (26-60)mm and then increasing within period (62-96)mm after that the thickness is observed constant and it's symmetry about the middle. Good agreement is evident between the experimental and numerical results. From the above discussion, it can be deduced that the average discrepancy of the thickness was 0.5788% when hydraulic is used and 0.531% when natural rubber is used. Due to bulging, the metal is flow and that causes alteration in wall thickness with continuous applying the load. Figs. 32 to 34 shown that the thickness is began to less than 1mm in the region of bulging zone. Figs. 32,33,34 illustrated the distribution of wall thickness along the tube for three media; it can be seemed that thickness in case of hydraulic media is less than in case of natural rubber media and when the industrial rubber is used the wall thickness increased against natural rubber media. From Fig. 32 to 34 and Fig. 20 it can be deduced that the relationship between the cosine shape with variation of bulging height and wall tube thickness will be:

$$R = \left[\frac{1}{2}(R_1 - t) + (R_2 - t))\right] + \frac{1}{2}(R_1 - t) - (R_2 - t))cos\left(\frac{\pi.Z}{L}\right) \quad \ldots (1)$$

ε_1 Circumferential strain
ε_2 Axial strain
R1 Maximum radius of die
R2 Minimum radius of die
t Alternation thickness with bulging radius.
Z Length of section on die length
L Bulging die length

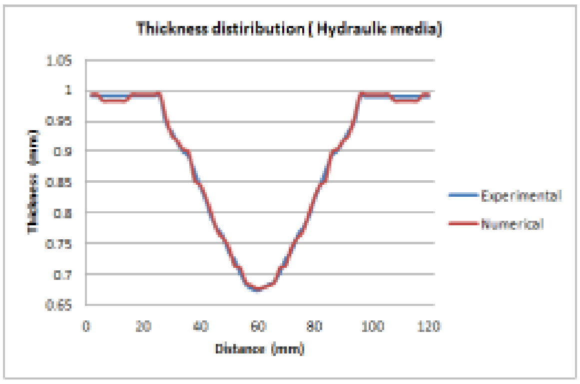


Fig. 32. Wall thickness - hydraulic media

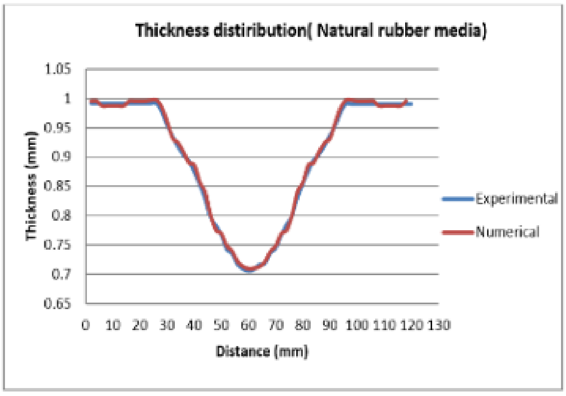


Fig. 33. Wall thickness -natural rubber media

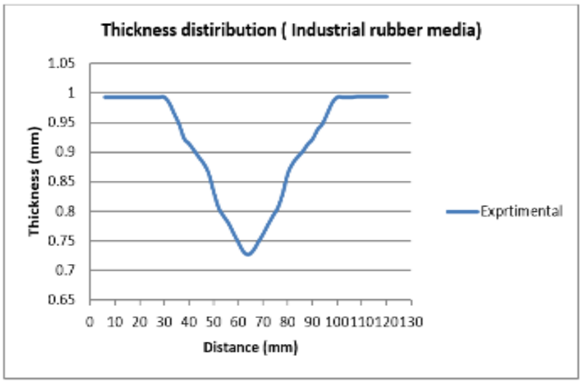
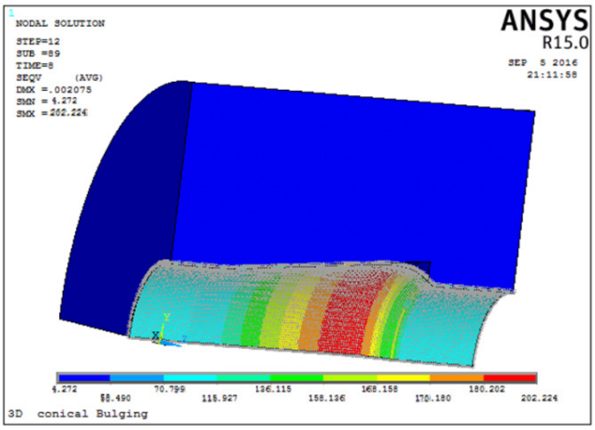


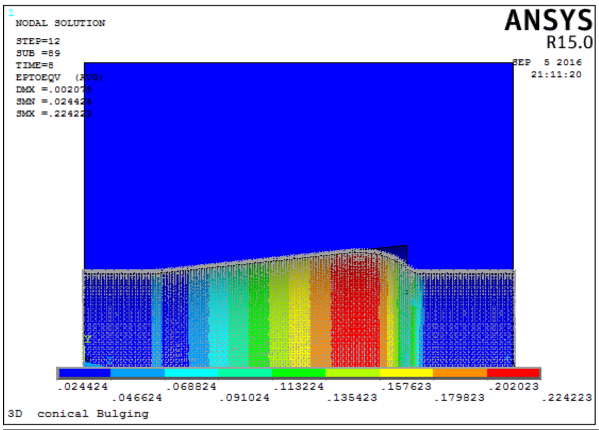
Fig. 34. Wall thickness industrial rubber media

4. Bulging Die with Conical Configuration

In the conical die the maximum equivalent stress with hydraulic media is 202.224MPa and maximum equivalent strain is 0.224223 as shown in Fig.35 and when using rubber as a media the maximum equivalent stress is 191.215 MPa and maximum equivalent strain is 0.690767 as shown in Fig. 37. From that it can be shown that the wall tube equivalent stress when the rubber media is used is about 5.4439% smaller than when hydraulic fluid is used. Fig. 36 illustrated the bulging tube when the hydraulic media is used and Fig. 38 illustrated the bulging tube when used rubber media.



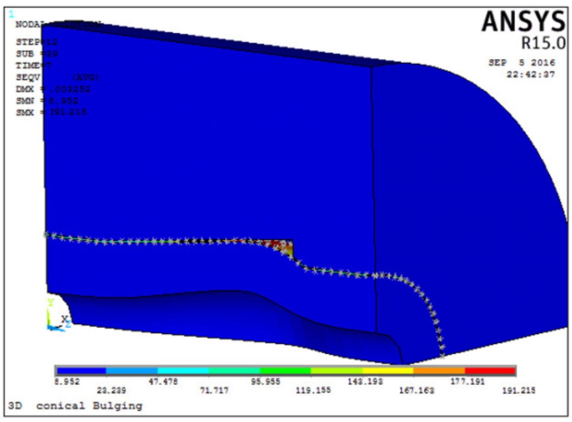
(a) equivalent stress



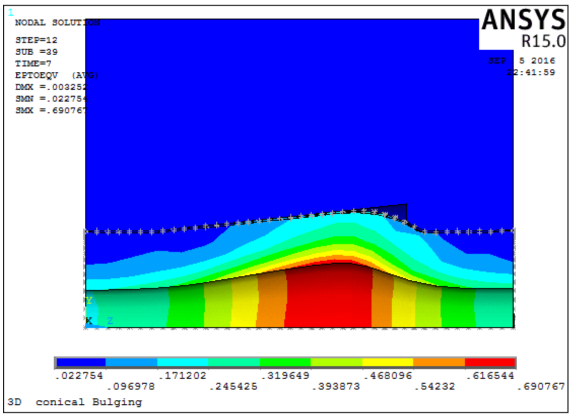
(b) equivalent strain

Fig. 35. Conical die with hydraulic media.

Fig. 36. Tube with conical section using hydraulic.



(a) equivalent stress



(b) equivalent strain

Fig. 37. Conical die with rubber media.

Fig. 38. conical section using hydraulic media.

4.1. Bulging Height of Conical Die

Fig. 39 shown the experimental and numerical results for bulging height against pressure when the hydraulic is a pressure media. Good agreement is evident between the results and it can be seen that increasing of hydraulic the pressure increased to 2MPa with no bulging height and the tube wall deformed after 2MPa with ramp behavior. Fig. 40 shown the experimental and numerical results for bulging height against pressure when the natural rubber is a pressure media. Figs.40 and 41, observed the behavior of natural and industrial rubber is the same that the pressure increased to 20MPa with no bulging height and the tube wall deformed after 20MPa with ramp behavior. Good agreement is evident with ANSYS results. Figs. 39, 40, 41 illustrated that there are different in the behavior of pressure with bulging height with the pressure media. Hence it seen that it's higher with rubber and lower with hydraulic medias, industrial rubber higher than natural rubber media, and also the applying loads are altered in case of hydraulic and rubber medias as shown that because in case of rubber media the friction forces with the tube wall is generated .

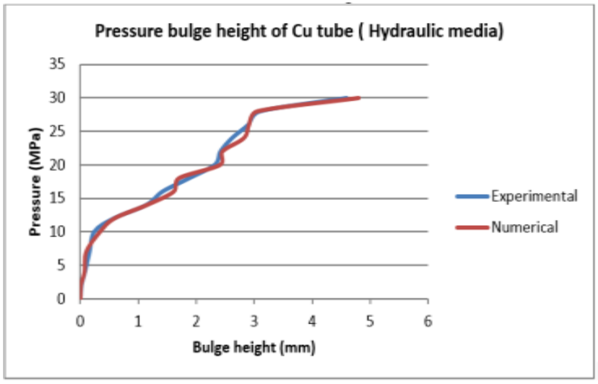


Fig. 39. pressure with bulge height hydraulic media

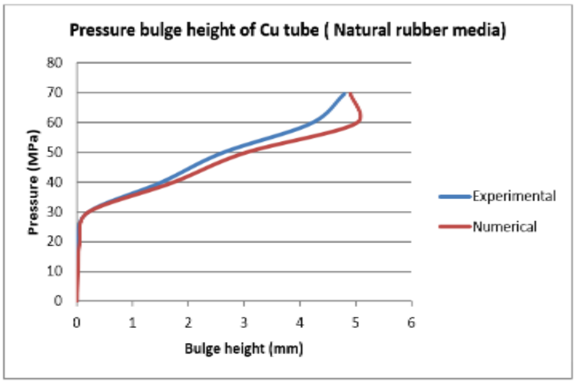


Fig. 40. pressure with bulge height natural rubber

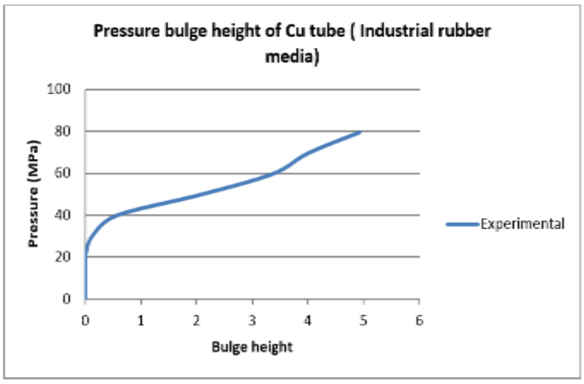


Fig.41. pressure with bulge height industrial rubber

4.2 Strain Distribution

Figs.42 to 47 illustrated circumference and axial strains evaluated experimentally using grid (2 or 4) mm, and numerically by ANSYS software, it's seem that the values of strain remain constant within (2-42)mm and increasing in the range (44-74) mm and then decreasing with period (76-95)mm after that the strain is seen to be constant within (95-114)mm, and it's shown not symmetry about the middle when it's using hydraulic media. Good agreement is evaluated between these results with average discrepancy 1.3879 % for ε_1 and 1.2918% for ε_2 as shown in Figs. 42 and 43. Also similar influences take place for natural rubber media as shown in Figs. 44 and 45, with average discrepancy 1.0623% for ε_1 and 0.7205% for ε_2, while in case of industrial rubber media the results had the same behavior of the Figs. 46 and 47.

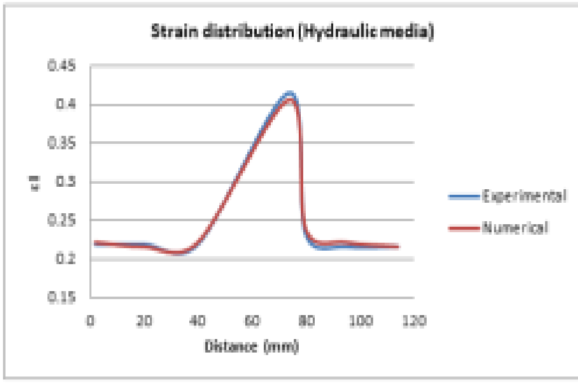


Fig. 42. ε_1 with length - hydraulic media.

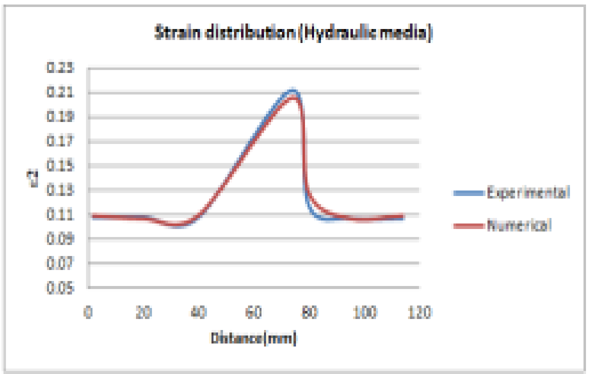


Fig. 43. ε_2 with length - hydraulic media.

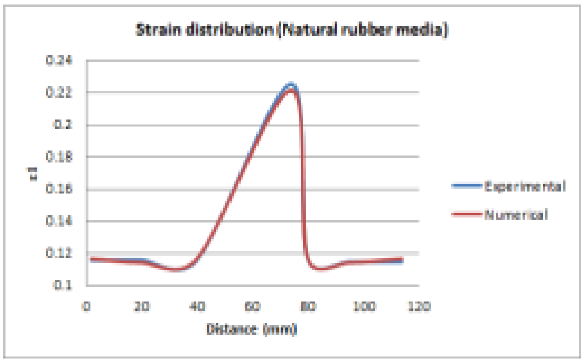


Fig. 44. ε_1 with length -natural rubber media.

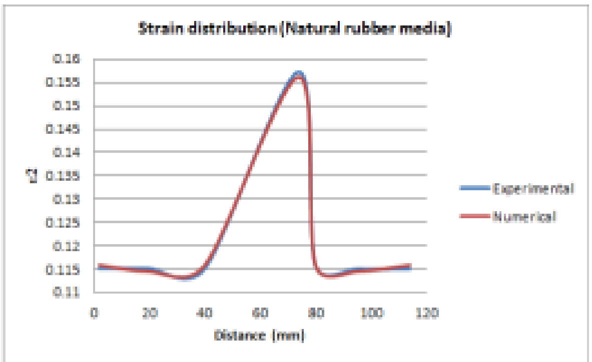


Fig. 45. ε2 with length -natural rubber media.

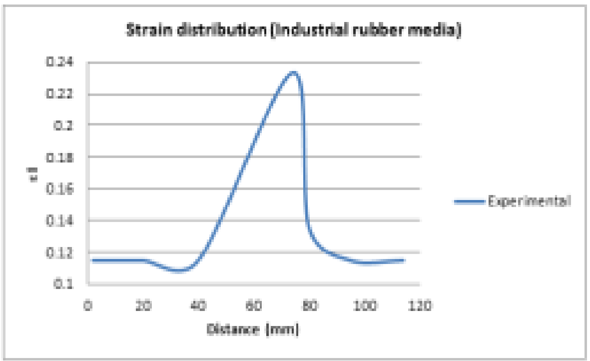


Fig. 46. ε1 with length industrial rubber media.

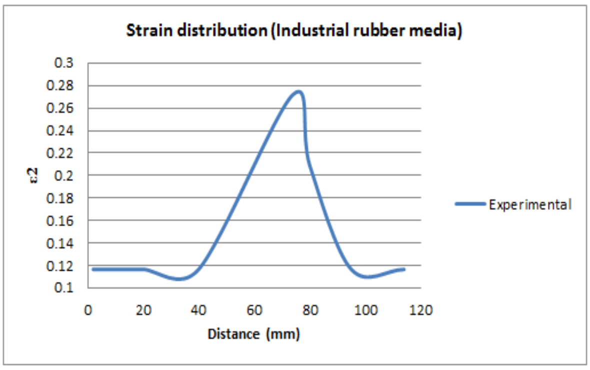


Fig. 47. ε2 with length -industrial rubber media.

4.3. Wall Thickness Distribution

Figs. 48 to 50 shown thickness distributions and the location of thinning in the wall of copper tube. The tendency is reproduced but errors can be observed. The wall thickness is measured in the experiments by projector profile device, the tube is cutting in the longitudinal direction. It can be seen that the behavior of the thickness against distance is not smooth, i.e. it's seem that the values of thickness remain constant within (2-42)mm and decreasing in the range (44-74) mm and then increasing with period (76-84)mm after that the thickness is seen to be constant and that shown it's not symmetry about the middle. Good agreement is evident between the experimental and numerical results. From the above discussion, it can be observed that the average discrepancy of the thickness was 0.611% when using hydraulic media and 0.4812% with natural rubber media. Due to bulging, the metal is flow and that causes alteration in wall thickness with continuous applying the load. Figs. 48 to 50 it can be observed that the thickness is began to less than 1mm in the region of bulging zone. Figs. 48,49,50 illustrated the distribution of wall thickness along the tube for three media; it can be seemed that the thickness in case of hydraulic media is less than in case of the natural rubber media and industrial rubber media and thickness in case natural rubber media is less than industrial rubber media.

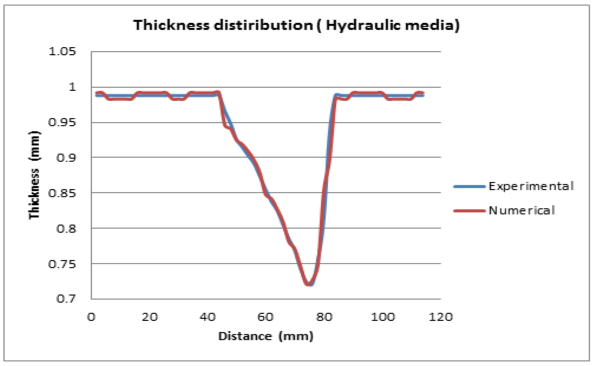


Fig. 48. Wall thickness -hydraulic media

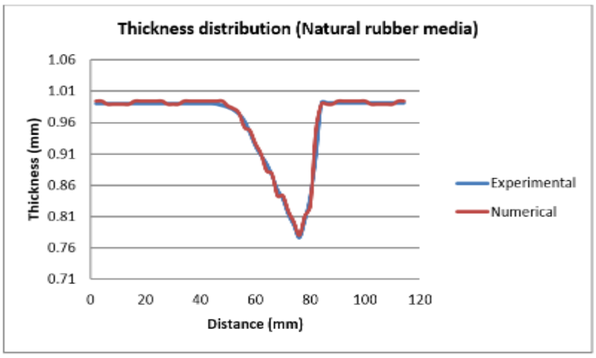


Fig. 49. Wall thickness -natural rubber media

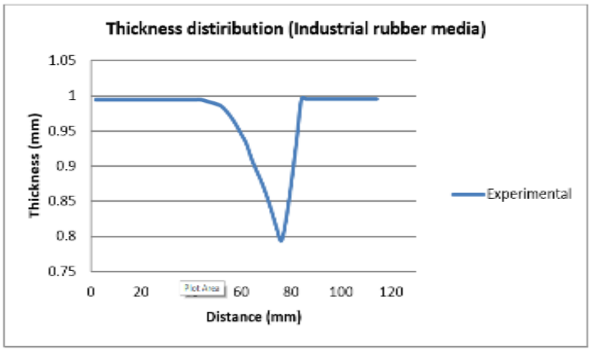


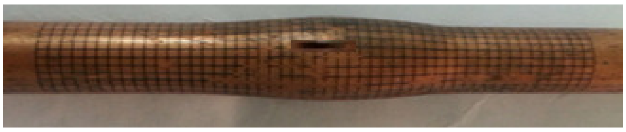
Fig. 50. Wall thickness - industrial rubber media

As the results, the comparison of the maximum equivalent stresses value for the numerical simulation is made for the three dies with and without rubber table (2) illustrated that. It is found that the stress decreased about 9.068% when the natural rubber is the media of the internal pressure in case of cosine die and 5.4439% in case of conical die and 2.8544% in case of square die. So it can be concluded that the rubber media used in bulging tube is much better than the hydraulic fluid, and from the experimental results , it can be concluded that the force for forming the shape using rubber media is higher than the hydraulic media and the force that needed to form by industry rubber media is higher than that foe natural rubber media.

Table 2,
The differences in equivalent stresses with hydraulic media and with natural rubber media

Bulge configuration	Equv. Stress with hydraulic [MPa]	Equv. Stress with natural rubber [MPa]	Error %
Cosine	199.248	181.18	9.068
Conical	202.224	191.215	5.4439
square	201.789	196.029	2.8544

In case of hydraulic media, the forming pressure needed to bulging process is less when with the rubber media but with height stress in the tube metal, and that let to cause the failure, while in case of rubber media, the forming pressure that needed to bulging process is higher using the hydraulic media but with less stress in tube metal, and the failure is not existed with rubber media for the same pressure of hydraulic. Fig. 51 illustrated that. It can be indicated that the crack happened in the tube is type I (open crack) in cosine die.



(a)With hydraulic media

(b) with natural rubber media

Fig. 51. Bulging tube with and without rubber.

5. Conclusions

1. It's found that the stress is decreased about 9.068% in the rubber media in case of cosine die and 5.4439% in the rubber media in case of conical die and 2.8544% in the rubber in case of square die. So it can Be concluded that internal pressure in the rubber media is much better than in hydraulic media.
2. In case of hydraulic, the lower forming pressure is needed to bulging process compared with the rubber media since height stress in the tube metal is existed. Which causing the failure, while in case of rubber, the forming pressure that needed to bulge process is higher when compared with the hydraulic media but with less stress in tube metal and the failure is not existed with rubber media for the same pressure of hydraulic.
3. The average discrepancy of the thickness is 0.7377% in the hydraulic media and 0.4682% in the rubber media in case of square die, and the average of discrepancy of the thickness is 0.5788% in the hydraulic media and 0.531% in the rubber media in case of cosine die, and it found the average discrepancy of the thickness is 0.611% in the hydraulic media and 0.4812% in the rubber media in case of conical die.
4. It’s found the maximum thinning of the thickness is 28.64%,when the hydraulic media ,16.8% when the natural rubber media and 15.2% when the industrial rubber media in case of square die, and it’s found the maximum thinning of the thickness is 32.5%,when the hydraulic media ,29.4% when the natural rubber media and 27.4% when the industrial rubber media in case of cosine die, and it’s found the maximum thinning of the thickness is 27.9%,when the hydraulic media

,22.4% when the natural rubber media and 20.6% when the industrial rubber media in case of conical die.

5. The distribution of tube wall thickness in case of rubber media is better than that for hydraulic media also it can be concluded that for industrial rubber is better than that for natural rubber.
6. The internal pressure when used the hydraulic media it's found the discrepancy between theoretical and experimental 16.0389% when used square die, the discrepancy 6.0969% when used cosine die , and the discrepancy 13.6753% when used conical die.

Acknowledgements

We would like to express my deepest gratitude to the staff of the Middle Technical University/ Engineering Technical College/Baghdad – Dies and Tools Technical Engineering Department for their support to complete this work.

6. References

[1] Girard A.C., Grenier Y.J., Mac Donald B.J.," Numerical simulation of axisymmetric tube bulging using a urethane rod" ,Journal of Materials Processing Technology, 172, pp346–355,2006.

[2] Sadiq Jaffar Aziz, "Experimental and Numerical Study of Tubes Hydroforming Process", Ph.D. thesis, Department of Production Engineering and Metallurgy, University of Technology 2008.

[3] Selvakumar A. S., Kalaichelvan K., and Venkataswamy S., "Effect of Heat Treatment Process on Hydroforming of Tubular Materials", European Journal of Scientific Research, Vol.68, No.3, pp. 377-388, 2012.

[4] Sami Abbas Hammood, " Numerical and Experimental Analysis of Tube Hydroforming in a Square Cross-Sectional Die", M.Sc. thesis, University of Technology, Production Engineering and Metallurgy Department,137 pages, 2012.

[5] Emad Jabour Yousif, "Experimental Study for Tube Hydroforming" ,M.Sc. Thesis, University of Tikrit, 2013.

[6] Li H.Y., Yu Z.J., Li J.H. and Liu M., "Experimental Research of Hydroforming Square Hollow Component", International Conference on Mechatronics, Electronic, Industrial and Control Engineering ,MEIC 2015.

[7] Hani Aziz Ameen, Kadhim Mijbel Mashloosh, Rusul Abdel Kareem Salman, " effect of loading path on the stress distribution and wrinkling in X-branch type tube hydroforming", International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181 Vol. 5 Issue 07, July-2016.

[8] Hani Aziz Ameen, Kadhim Mijbel Mashloosh, Rusul Abdel Kareem Salman, " effect of die cavity configuration on the stress distribution in tube hydroforming process with and without rubber media ", International Journal of Scientific & Engineering Research, ISSN 2229-5518,Volume 7, Issue 9, September-2016.

[9] Asnafi, N. , "Analytical Modeling of Tube Hydroforming", Thin-Walled Struct., 34, pp: 295–330, 1999.

دراسة وسط التشكيل في عملية التشكيل الهيدروليكي لأنبوب النحاس

رسل عبدالكريم سلمان*   هاني عزيز أمين   كاظم جبل شلوش*****

الكلية التقنية الهندسية- بغداد

*البريد الالكتروني:rusulalizee@gmail.com
**البريد الالكتروني:haniazizameen@yahoo.com
***البريد الالكتروني:Kadm52@yahoo.com

الخلاصة

تم دراسة تأثير أوساط الضغط الداخلي على توزيع الأجهاد المكافئ في الأنبوب , وتم أجراء الدراسة العملية من خلال بناء نظام لتطبيق الضغط الهيدروليكي وتصنيع ثلاثة قوالب مع تكوين انتفاخات تشكيل مختلفة (مربع وتقوس بشكل جيب تمام و مخروطي الشكل) . وتم أستخدام برنامج ANSYS من خلال برمجة الحالات أعلاه بأستخدام APDL لتحليل عملية النفخ مع الأوساط الهيدروليكية والمطاط (الطبيعي والصناعي). تبين أن الأجهادات تقل الى حوالي 9.068%عند أستخدام المطاط كوسط للضغط الداخلي في حالة أستخدام قالب ذو تجويف الجيب تمام و 5.4439% في حالة القالب ذو تجويف مخروطي و 2.8544% في حالة القالب ذو الشكل المربع. لذلك يمكن أن نستنتج الى أن أوساط المطاط المستخدمة في أنتفاخ الأنبوب هو أفضل بكثير من الأوساط الهيدروليكية, وتم أستنتاج عمليا أن قوة التشكيل التي نحتاجها للتشكيل بوجود المطاط أعلى من الهيدروليكية والقوة التي نحتاجها للتشكيل بواسطة المطاط الصناعي أعلى من قوة التشكيل بالمطاط الطبيعي. وتم استنتاج ان توزيع السمك لجدار الأنبوب في حالة أستخدام وسط المطاط أفضل من أستخدام وسط الهيدروليك وأستخدام وسط المطاط الصناعي أفضل من المطاط الطبيعي في نفس القالب. وبينت الدراسة انه في حالة الهيدروليك , فأن قيمة ضغط التشكيل المحتاج لعملية الأنتفاخ أقل مقارنة مع أوساط المطاط بينما وجد أن الأجهادات كانت عالية بمعدن الانبوب والتي تسمح لحدوث الفشل , بينما في حالة المطاط , وجد أن ضغط التشكيل المحتاج لعملية الأنتفاخ أعلى مقارنة من الأوساط الهيدروليكية ولكن مع أجهاد أقل في معدن الانبوب. و هذا بالتأكيد يوضح عدم حدوث الفشل في جدار الانبوب باستخدام أوساط المطاط لنفس الضغط بوجود الوسط الهيدروليكي.