Abstract results revealthat, the autofretage treatmentof thick_wall

Government, Military

ABSTRACTThe process of producing residualstresses in thick_walled cylinder beforeit is putin to usage is called Autofretage, which it means; a suitable largeenough pressureto cause yielding within the wall, is applied toinner surface ofa sylinder and then removed. So thatacompressive residual stresses are generated to acertain radial depth at a sylinder wall. The objectiveofpresent study, is to investigate the influenceof autofretage treatment ontheradial, circumferential andtotal stresses using von. _mises yieldcriteria. Num. simulationcarried outon ABAQUS software to investigate thestresses distribution andcalculate the autofretage radius. The results revealthat, the autofretage treatmentofthick_wall sylinder lead to decrease thehoob and max. von.

_mises stresses and relocate them from the inner surface ofthe sylinder to somewhere along it’sthickness. The reduction in max. stresses is strongly depending on autofretagepressure, it wasvarying from (3. 6% at Pautofretage = 105 M. Pa. to 19. 2% at Pautofretage = 130 M.

Pa.) Also, ithas been found, there is no influenceof autofretage stages number on each of max. von. _misesstressand autofretage radius. Key words: autofretage, radial, hoob andaxial stresses, von.

_mises yield criteria, autofretage radius, optimum autofretagepressure.

1. INTRODUCTIONThe wide applications ofpressurized sylinder in chemical, nuclear, armaments, fluid transmitting plants, power plants and military equipment, in addition to the increasing scarcity andhigh cost of materials lead the designers toconcentrate their

attentions to the elastic – plastic approach which offersmore efficient use of materials 1, 2.

The treatment of producing residualstresses in the wall of thick_walled sylinder before it is put in to usage is called autofretage, which it means; asuitable large enoughpressure to cause yielding within thewall, is applied to the inner surface ofthe sylinder and then removed. So that a compressive residual stresses are generated to a certain radial depthat the sylinder wall. Then, duringthesubsequent application of an operating pressure, the residual stresses willreduce the tensile stresses generated asa result of applying operating pressure1, 3. The influenceofresidual stresses onload-carry capacity of thick_walled sylinders have beeninvestigate by Ayob and Albasheer 4, using each analytical andNum. techniques.

The results of the study reveal three scenarios in the design of thick_walled sylinders. Ayob and Elbasheer 5, used von. _mises and Tresca yieldcriteria to develop aprocedure in whichthe autofretage pressure determined analytically resulting ina reduced stress concentration. Then they coM. Pa. red the analytical resultswith F.

E. A. results. They concluded that, the autofretage treatment increasethe max.

allowable internal pressure but it cannot increase the max. internalpressure to case whole thickness of the sylinder to yield. Noraziah et al. 6 presented ananalytical autofretage procedure topredict the required autofretage pressure ofdifferent levels of allowable pressure andthey validate their results with F.

E. A. results. They found three cases of autofretage in design of pressurized thick_walled sylinders. Zhu and Yang 7, usingeach yield criteria von. _mises and Tresca, presented an analytical equation foroptimum radius of elastic-plastic junction in autofretage sylinder , alsotheystudied the influence of autofretage on distribution of stress and load bearingcapacity. They concluded, to achieve optimum radius ofelastic – plasticjunction, an autofretage pressure a bit larger than operating pressure shouldbe applied before a pressure vessel is put in to use. Hu and Puttagunta 8investigate the residual stresses in thick_ walled sylinder induced by internal autofretage pressure, alsothey found the optimum autofretage pressure andthe max.

reduction percentage ofthe von. _mises stress under elastic-limit working pressure. Md. Amin et al. 9determined the optimum elasto_plasticradius and optimum autofretage pressure usingvon.

_mises yield criteria , then they have been coM. Pa. red with Zhu and Yang’smodel 8. Also they observed that the percentage of max. von. _mises stressreduction increases as value of radius ratio (K) and working pressureincreases. F.

Trieb et al. 10 discussed practical application of autofretageon components for waterjet cutting. They reported that the life time of highpressure components is improved by increasing autofretage depth due toreduction of tangential stress at inner diameter, on other hand too highpressure on outside diameter should be avoided to prevent cracks generate. Inaddition to determine the optimum autofretage pressure and the optimum radiusof elastic-plastic junction , Abu Rayhan Md.

et al. 11 evaluated the influenceofautofretage treatment in strain hardened thick_ walled pressure vessels usingequivalent von. _mises stress as yield criteria. They found, the number of autofretagestages has no influenceon max. von.

_mises stress and pressure capacity. Also, they concluded that, optimum autofretage pressure depends on the workingpressure and on the ratio of outer to inner radius. II. Limits of pressureand Distributionof stress in non – autofretaged sylinder 2. 1. Limits of pressureof non – autofretagesylinder According to Von. _Mises yield criteria, Each of the internal pressure requires to yield the inner surface of the sylinder (i. e.

partial autofretage), PYi, and that to yield the whole wall of the sylinder (i. e. completely autofretage), PYo, can be calculated from equations (1& 2)4, 7PYi= …………………….

(1)PYo=

……………………. (2) 2.

2. Distribution of stress of non – autofretage sylinder The radial stress ? r, circumferential (hoop) stress ?? and axial stress ? z, distributions in non _autofretage sylinder subjected to an operating pressure, Pi, are given by Lame’s formulations which is available in 3, 4, 5, 6, 7 . As shown in Fig. (1),

it is obvious that the tensile hoob, ??, compressive radial , ? r, and max.

Von.

_Mises stresses have their max. values at the inner surface of the sylinder . The hoop stress has always positive value which represents as tensile stress while the stress in the radial direction is always compressive. Also the hoop tensile stress’s value is greater than radial compressive stress’s value. Fig. 1: Distribution of stress on non-autofretage thick-walled sylinder subjected to operating pressure. Fig. 2: Geometry of inspectedmodel.

III. Finite Element Analysis and Materials of Num. Simulation Models

Fig. (2)illustrates the geometry of inspectedsylinder that is made up of carbon steel with young’smodulus of (203 GPa), Poisson’s ratio of (0.

33) and yield stress of (325 M. Pa.) 12 . It subjected to internal pressure (Pi). The material is assumedhomogeneous and isotropic. To compute the required results, Num. simulation iscarried out on ABAQUS ver. 6.

9 13. The inspected cases are consider as 2D –planar problem with quadratic element have been used (CPS8R–8– nodes) IV. Validation of Num. Simulation In thepresent study, the validation of software has been done by coM.

Pa. ring theanalytical calculation results which obtained by solutions of equations areavailable in literatures 3, 4, 5, 6 7, with results of Num. solution usingABAQUS ver. 6. 9. From Fig.(3) , it is obvious that, the theor.

and Num. calculations of circumferential, radial and max. Von. _Misesstresses for different internal pressure are very closed and overlap eachother. It means, a good agreement is found between the results, and the staticanalysis shows that, the percentage of errors between the result of analytical and Num. solution are les than0. 5%.

This low percentage of errors affirm, there are no significsntdifferences between the theor. results and those obtained by simulation. Consequently, FE modeling using ABAQUS software can be used to study the influenceofautofretage treatment on the distribution of stress and location of autofretageradius (Ra) of thick_walled sylinder subjected to operating pressure. a b Fig. 3 : Validation of Num. solution results with theor.

results at different operating pressure; a – operating pressure = 80 M. Pa., b – operating pressure = 100 M. Pa.

. V. Results and Discussions 5. 1. Min..

Autofretage Pressure By calaculating the min.. pressurethat needed to yield the inner surface of the tested sylinder (PYi) from equation (1) , it wasfound equal to (104. 243 M.

Pa.). That is mean, the influenceof autofretage pressurewill start at (104. 243 M. Pa.), then the plastic deformation spreads through thesylinder thickness.

Fig. (4) shows that, the simulation solution of influenceof autofretage pressure on max. Von. _Mises stressfor different operating pressure, it is obvious that , there is no influenceof autofretagepressure on max. Von. _Mises stress generating in the sylinder due to the operating pressure as long as it isless than (104 M.

Pa.) for each value of operating pressure. Then , when it isexceed (Pautofretage ? 104 M. Pa.) the maximunm Von. _Mises stress decreases depending on the autofretage pressure, the bigger value of autofretage pressure, the lower of max. Von.

_Mises stress. In addition to that , it has beenobserved from Table 1 that, the max. Von. _Mises stress decreases withincreasing the autofretage pressure even Pautofretage reache valueof about (130 M.

Pa.) then starts increasing, which it means, this value of autofretagepressure represents the optimum autofretage pressure 5, 6. This results agreewith result was found by 1, 9, 11. Fig. 4 : Simulation solution results of autofretage pressures' influenceon Max.

von. _mises stress at different operating pressure. Tab. 1 : F. E. A. results of influence of Autofretage Pressureon Max.

Von. _Mises Stress No. Operating Pressure, M. Pa. Autofretage Pressure, M. Pa.

Max. von. _mises Stress, M. Pa. 1. 90 120 247. 00 2. 90 125 241.

40 3. 90 130 238. 8 4. 90 131 240. 20 5. 90 132 241.

40 6. 100 120 273. 10 7.

100 125 265. 20 8. 100 130 260. 00 9. 100 131 260. 80 10.

100 132 261. 00 5. 2. Influenceof Autofretage treatmenton stress distribution Fig. s (5, 6 & 7) demonstrates the influenceofautofretage treatment on distribution of stress of thicked–walled sylinder subjected to operating pressure of (100 M.

Pa.). It is obvious, the autofretage treatment leads to decrease the value of max. Von. _Mises stress and relocated the compressive circumferential & max.

Von. _Misesstresses from the inner surface of the sylinder to somewhere through it's thickness. This newlocation of max. Von. _Mises stress called Autofretage radius, Ra. It does not depend on operating pressure while it is strongly affected by autofretagepressure as shown in Table 2, which shows the values of autofretage radius, Ra, with different valuesof autofretage pressure.

Also, it is found , the reduction in max. Von. _Mises stressesvarying from (3.

6 % at Pautofretage = 105 M. Pa.) to (19. 2% at Pautofretage= 130 M. Pa.).

It is vital to see that , there is no significant influenceofautofretage treatment on radial stress as that seen on the circumferentialstress. Fig. 5 : Influenceof Autofretage Pr. on hoob & Radial stresses at operating Pressure = 100 M.

Pa.. Fig. 6 : Influenceof Autofretage Pr. on max. Von. _Mises stress at operating Pressure = 100 M. Pa.

. Table 2 : F. E. A. results of influenceof Autofretage Pressureon Max. Von. _Mises Stress No. Operating Pressure, M.

Pa. Autofretage Pressure, M. Pa. Max. Von.

_Mises Stress, M. Pa. Autofretage Radius, mm Reduction in Max. Von. _Mises stress % 1. 90 without 290. 00 100 — 2.

90 105 278. 975 101. 99836 3.

8 % 3. 90 110 264. 108 103. 99686 8. 9 % 4. 90 120 246. 88 111.

9915 14. 8 % 5. 90 130 238. 792 125. 9761 17. 65 % 6. 100 without 321. 836 100 — 7.

100 105 310. 00 101. 99836 3. 6 % 8. 100 110 294.

020 103. 99686 8. 6 % 9. 100 120 273.

116 111. 9915 15. 2 % 10. 100 130 259.

992 125. 9761 19. 2 % a b c d Fig.

7 : F. E. A.

of influenceof autofretage Pressure on max. Von. _Mises stress and location of autofretage radius at operating Pressure = 100 M.

Pa. ; a- without autofrettage, b- Pautofretage = 110 M. Pa., c – Pautofretage = 120 M. Pa., d – Pautofretage = 130 M. Pa..

5. 3. Influenceof Autofretage stageson max. Von. _Mises stress To investigate the influenceof autofretagestages on max. Von. _Mises stress, the inspectedsylinder was subjected to (100 M.

Pa.) as operating pressure and autofretage pressures of (110, 120 and 130 M. Pa.

) are done bytwo steps, at first step, the autofretage pressure has been applied in one stage, while atsecond step it was done by three loading stages (see Table 3). As can be noticed clearly in Table 3and Fig. (7), the Num. results confirm there is no influenceof autofretage stageson the max. Von.

_Mises stress generated in the sylinder due to operating pressure. This results arevery close to the with results have beenfound by 3. Tabe 3 : F. E. A. results of influenceof Autofretage stageson Max. Von.

_Mises Stress No. of case Autofretage pressure, M. Pa. First stage Unloading step M.

Pa. Autofretage pressure, M. Pa. second stage Unloading step M. Pa. Loading of Operating Pressure, M. Pa. Max.

Von. _Mises Stress, M. Pa. Case I 110 0 – – 100 294. 020 Case II 120 0 – – 100 273. 116 Case III 130 0 – – 100 259. 992 Case IV 105 0 110 0 100 294. 033 Case V 105 0 120 0 100 273.

05 Case VI 105 0 130 0 100 260. 254 Fig. 7 : Num. solution results of influenceof autofretage stagse on Max. von_mises stresses and autofretage radius at operating Pressure = 100 M. Pa. VI.

Conclusion The results of presentinvestigation can be summarized as :- 1. The autofretage treatmenton thick_walled sylinder leads todecrease the circumferential and max. Von. _Mises stresses and relocate them from the inner surface of the sylinder to somewhere along it's thickness, whichcalled as, autofretage radius, Ra . 2. The autofretage radius, Ra , is strongly affected by autofretage pressurewhile it does not depend on the operating pressure..

3. There is no influenceof autoffrettagestages on max. Von. _Mises stress developed in the sylinder subjected to an operating pressure.

References 1 A. B.

Ayob, M. N. Tamin and KabashiElbasheer," Limits of pressureof Thick – walled sylinders , Poceedings of theinternational MultiConference of Engineers and Computer scientist , IMECS 2009, Hong Kong, March 8 -20. 2 WangZhiqun," Elastic – plastic fracture analysis of a thick – walled sylinder ", International Journal of pressure VesselsPiping ", volume 63, 1995, pp.

165- 168. 3 D. Dinesh Babu and T. Jega Balaji," Theor. and finite Element Analysis oof High Pressure Components ", IOSR Journalof Engineering, Vol. 3, Issue 2, Feb 2013, PP: 25 – 34. 4 Amran Ayob and M. Kabashi Elbasheer, " Optimum Autofretage Pressure in thick Sylinders ", Jurnal Mekanikal, December 2007, N0.

24, pp. 1 – 24. 5 Noraziah Wahi, Amran Ayob and M.

KabashiElbasheer, ” Influenceof Optimum Autofretage on Limits of pressureof thickwalled Sylinders “, International Journal of Environmental Science andDevelopment, Vol. 2, No. 4, August 2011, pp. 329 – 333. 6 Noraziah Wahi, Amran Ayob and Mohd KabashiElbasheer,” Influenceof Autofretage on Allowable Pressure of thick –walled Sylinders “, InternationalConference on Environmental andAgriculture Engineering “, 2011, Singapore, IPCBEE vol. 15, pp.

14 – 16, IACSIT Press. 7 RuilinZhu and Jinlai Yang, ” Autofretage of thick sylinders “, International Journal of Pressure Vessels and Piping, Vol. 75, 1998, pp. 443 –446.. 8 Zhong Huand Sudhir Puttagunta, ” Computer modeling of Internal Pressure Autofretage Treatmentof a Thick – Walled Sylinder with theBauschinger Influence”, American Transactions on Engineering and Applied Sciences, Volume 1, No.

2, ISSN2229-1652, eISSN 2229-1660. 9 Md. Tanjin Amin, Abu Rayhan Md. Ali, TousifAhmed and Faisal Ahmed, ” Optimum Design of Autofretaged thicked – walled sylinders”, Global Journal of Researches in Engineering, vol. 13, Issue 8, Version 1, 2013, Online ISSN : 2249-4596, Print ISSN : 0975 – 5861 10 F. Tried, J. Schedelmaier and M.

Poelzl, ” Autofretage– Basic Information and practical application on components for waterjetcutting “, American Waterjet Conference, 2005 WJTA, 2005, August 21 – 23, Houston, Texas. 11 Abu Rayhan Md. Ali, Nidul Ch. Ghosh andTanvir-E-Alam, ” Optimum Design of Pressure Vessel

Subjected to Autofretage Treatment”, International Journal of Mechanical, Aerospace, Industrial, Mechatronic andmanufacturing Engineering, vol.

4, No. 10, 2011, PP. 1040 – 1045. 12 W. JR.

Callister, ” Material Science andengineering; An Introduction”, 7th Edition, 2005, New delhi. 13 ABAQUS ver. 6. 9, 2009, Getting Started; standard User’s Manual.