Abstract in the wall of thick-walled cylinder

ABSTRACTThe process of producing residualstresses in a thick-walled cylinder before it is put into usage is calledAutofrettage, which it means; a suitable large enough pressure to causeyielding within the wall, is applied to the inner surface of the cylinder andthen removed. So that a compressive residual stresses are generated to acertain radial depth at the cylinder wall. The objectiveof the present study, is to investigate the effect of Autofretage process onradial, circumferential and total stresses by using von.

_misesyield criteria. Numerical simulation carried out on ABAQUS software to investigate the stressesdistribution and calculate the Autofretage radius. The results reveal that, theAutofretage process of thick-wall cylinder lead to decrease the hoob andmaximum von. _misesstresses and relocate them from the inner surface of thecylinder to somewhere along it’s thickness. The reduction in maximum stressesis strongly depend on Autofretage pressure, it was varying from (3.

6% at PAutofretage = 105 M. Pa. to 19. 2% at PAutofretage = 130 M. Pa.

) Also, ithas been found, there is no effect of number of Autofretage stages on both ofmaximum von. _mises stress and Autofretage radius. Key words: autofrettage, radial, hooband axial stresses, von.

_mises yield criteria, autofrettage radius, optimum Autofretagepressure. 1. INTRODUCTIONThe wide applications of pressurized cylinderin chemical, nuclear, armaments, fluid transmitting plants, power plants and military equipment, in addition to the increasing scarcity andhigh cost of materials leadthedesigners to concentrate their attentions to the elastic – plastic approachwhich offers more efficient use of materials 1, 2. The process of producingresidual stresses in the wall of thick-walled cylinder before it is put intousage is called Autofretage, which it means; a suitable large enoughpressure to cause yielding within the wall, is applied to the inner surface ofthe cylinder and then removed. So that a compressive residualstresses are generated to a certain radial depth at the cylinder wall. Then, during the subsequent application of an operating pressure, the residualstresses will reduce the tensile stresses generated as a result of applyingoperating pressure 1, 3. The effect of residual stresses on load-carry capacityof thick-walled sylinders have been investigate by Amran Ayob and KabashiAlbasheer 4, using both analytical and numerical techniques. The results ofthe study reveal three scenarios in the design of thick-walled sylinders.

AmranAyob and M. Kabashi Elbasheer 5, used von. _misesand Tresca yield criteria todevelop a procedure in which the Autofretage pressure determined analyticallyresulting in a reduced stress concentration. Then they coM. Pa. red theanalytical results with FEM results. They concluded that, the Autofretageprocess increase the maximum allowable internal pressure but it cannot increasethe maximum internal pressure to case whole thickness of the cylinder to yield. Noraziah et al.

6 presented an analytical Autofretage procedure to predictthe required Autofretage pressure of different levels of allowable pressure andthey validate their results with FEM results. They found three cases of Autofretagein design of pressurized THICK _WALLED sylinders. Ruilin Zhu andJinlai Yang 7, by using both yield criteria von. _misesand Tresca, presentedan analytical equation for optimum radius of elastic-plastic junction

in Autofretagecylinder, also they studied the influence of Autofretage on stress distributionand load bearing capacity. They concluded, to achieve optimum radius of elastic- plastic junction, an Autofretage pressure a bit larger than operatingpressure should be applied before a pressure vessel is put into use. Zhong Huand Sudhir Puttagunta 8 investigate the residual stresses in the thick-walled cylinder induced by internal Autofretage pressure, also they found theoptimum Autofretage pressure and the maximum reduction percentage of the von.

_misesstress under elastic-limit working pressure. Md. Tanjin Amin et al. 9determined the optimum elasto – plastic radius and optimum Autofretage pressureby using von. _misesyield criterion , then they have been compared with Zhu andYang's model 8.

Also they observed that the percentage of maximum von. _misesstress reduction 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 effect ofAutofretage process in strain hardened THICK _WALLED pressure vessels by usingequivalent von. _mises stress as yield

criterion. They found, the number of Autofretagestages has no effect on maximum 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. 2. PRESSURE LIMITS AND STRESSDISTRIBUTION IN NON – AUTOFRETTAGED CYLINDER2. 1.

Pressure Limits of Non – AutofretageCylinderAccording to von. _misesyieldcriterion, Both of the internal pressure requires to yield the inner surface ofthe cylinder (i. e. partial Autofretage), PYi , and that to yield the wholewall of the cylinder (i. e.

completely Autofretage), PYo , can becalculated from equations (1and 2)4, 7 2. 2. Stress Distribution of Non- Autofretage CylinderTheradial stress or, circumferential (hoop) stress o0 and axial stress oz, distributions in non – Autofretage cylinder subjected to an operating pressure, Pi, are given by Lame's formulations which is available in 3, 4, 5, 6, 7 . Asshown in Fig.

(1), it is clear that the tensile hoob, o0, compressive radial, or, and maximum von. _misesstresses have their maximum values at the innersurface of the cylinder. The hoop stress has always positive value whichrepresents as tensile stress while the stress in the radial direction is alwayscompressive. Also the hoop tensile stress's value is greater than radialcompressive stress's value. 3. FINITE ELEMENT ANALYSIS ANDMATERIALS OF NUMERICAL SIMULATION MODELSFig. (2) illustrates the geometryof investigated cylinder that is made up of carbon steel with young's modulusof (203 G.

Pa.), Poisson’s ratio of (0. 33) and yield stress of (325 M. Pa.) 12 . It subjected to internal pressure (Pi). The material isassumed homogeneous and isotroPic.

To compute the required results, Numericalsimulation is carried out on ABAQUS ver. 6. 9 13. The investigated cases areconsider as 2D – planar problem and quadratic element have been used (CPS8R-8-nodes)4.   VALIDATION OF NUMERICALSIMULATIONIn the present study, thevalidation of software has been done by coM. Pa. ring the analytical calculationresults which obtained by solutions of equations are available in literatures 3, 4, 5, 6 7, with results of numerical solution using ABAQUS ver. 6.

9. From Fig. (3) , it is clear that, the theoretical and numerical calculationsof circumferential, radial and maximum von.

_misesstresses for differentinternal pressure are very closed and overlap each other. It means, a goodagreement is found between the results, and the static analysis shows that, thepercentage of errors between the result of analytical and numerical solutionare les than 0. 5%. This low percentage of errors affirms, there are nosignificsnt differences between the theoretical results and those obtained bysimulation. Consequently, FE modeling using ABAQUS software can be used tostudy the effect of Autofretage process on the stress distribution and locationof Autofretage radius (Ra) of thick-walled cylinder subjected tooperating pressure.   5.   RESULTS AND DISCUSSIONS5. 1.

Minimum Autofretage PressureBy calaculating the minimum pressurethat needed to yield the inner surface of the tested cylinder (PYi) from equation (1) , it was found equal to (104. 243 M. Pa.).

That is mean, the effect of Autofretage pressure will start at (104. 243 M. Pa.), then theplastic deformation spreads through the cylinder thickness. Fig.

(4) showsthat, the simulation solution of effect of Autofretage pressure on maximum von. _misesstress fordifferent operating pressure, it is clear that , there is no effect of Autofretagepressure on maximum von. _mises stress generating in the cylinder due to theoperating pressure as long as it is less than (104 M. Pa.) for both value ofoperating pressure. Then , when it is exceed (PAutofretage > 104M.

Pa.) the maximunm Von. _mises stress decreases depending on the Autofretagepressure, the bigger value of Autofretage pressure, the lower of maximum von. _misesstress. In addition to that , it has been observed from Table 1that, the maximum von. _mises stress decreases with increasing the Autofretagepressure even PAutofretage reache value of about (130 M. Pa.

) thenstarts increasing, which it means, this value of Autofretage pressure representsthe optimum Autofretage pressure 5, 6. This results agree with result wasfound by 1, 9, 11. 5. 2.

Effect of AutofretageProcess on Stress Distribution Fig. s (5, 6 and 7) demonstrates the effect of Autofretage process on stressdistribution of thicked-walled cylinder subjected to operating pressure of (100 M. Pa.).

It is obvious, the Autofretage process leads to decrease the valueof maximum von. _mises stress and relocated the compressive circumferential andmaximum von. _mises stresses from the inner surface of the sylinder to somewherethrough it’s thickness. This new location of maximum von. _mises stress called Autofretage radius, Ra .

Itdoes 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 values of Autofretage pressure. Also, it is found , thereduction in maximum von. _misesstresses varying 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 effect of Autofretage   A C D B 5. 3. Effect of AutofretageStages on Maximum Von. _misesStressToinvestigate the effect of Autofretage stages on maximum von. _misesstress, theinvestigated cylinder was subjected to (100 M. Pa.

) as operating pressure and Autofretagepressures of (110, 120 and 130 M. Pa.) are done by two steps, at first step, the Autofretage pressure has been applied in one stage, while at second step itwas done by three loading stages (see Table 3). As can be noticed clearly inTable 3 and Fig.

(7), the numerical results confirm there is no effect of Autofretagestages on the maximum Von. _mises stress generated in the cylinder due tooperating pressure. This results are very close to the with results have beenfound by 3. 6.

CONCLUSIONThe results ofpresent investigation can be summarized as· The Autofretage process onthick-walled cylinder leads to decrease the circumferential and maximum von. _misesstresses and relocate them from the inner surface of the cylinder to somewherealong it's thickness, which called as, Autofretage radius, Ra .· TheAutofretage , Ra , is strongly affected by Autofretagepressure while it does not depend on the operating pressure.· There is no effect ofautoffrettage stages on maximum Von. _mises stress developed in the cylindersubjected to an operating pressure.

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