INTERFERENCE STRESS INTENSITY IN TUBES AS AFFECTED BY THICKNESS TO DIAMETER RATIO AND LENGTH

H.H.Ziada* and A.K.Abd El Latif **

ABSTRACT

In the recent years the finite element method was used to determine the contact pressure distribution between any two elastic bodies, however the effect of friction at the mating surfaces are ignored and no manageable solution for the behaviour of an axi-symmetrical hollow components of finite length has been available.

In the present work, the authors consider the problem of fitted tubes with different thickness to diameter ratio and length. The finite element method is used to determine the stress intensity-double value of that determined by the maximum shear stress theory.

Computed results showed that the stress intensity across tube thickness and along its length is greatly affected by the tube thickness to diameter ratio, t/d_i, and tends to approach a constant value for $t/d_i \geqslant 0.05$. The length ratio between outer and inner tubes, L/L_1, have also a pronounced effect. The stress values on the inner tube increases with the increase in length ratio, while on the outer tube it decreases with the increase in length ratio and tends to have a constant value for $L/L_1 \geqslant 3$.

Comparing stress intensity results with that evaluated for the hoop stresses showed a slight difference on tube thickness and length, with a maximum difference of 10%.

INTRODUCTION

The use of pressure vessels, pipes and tubes in the advancing technologies of nuclear energy, chemical plant, petrochemistry that many others has been led to considerable research and development into improved methods of design, including work on both analytical and experimental stress analysis. Such work

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* Assistant Professor, ** Professor, Dept. of Mechanical Eng.
King Abdulaziz University, Saudi Arabia

tructed to resemble that used by other investigators [7], [8]. They consider that annuli of triangular and rectangular cross-section are suitable elements for constructing and hence, idealizing the shape and deformation behaviour of many axi-symmetrical components. These workers have also considered that even when assuming a simple strain distribution within these elements the accuracy of analysis achieved is remarkable providing that the elements are sufficiently small.

However, the use of higher order elements gives a considerable improvement of accuracy over the constant stain element. Therefore two-dimensional isoparametric element was used as a higher order version of the two-dimensional constant strain element. Two-dimensional isoparametric axi-symmetric ring elements for the tubes has been used for constructing of the model shown in fig.1.

The interface between the tubes was modeled by two-dimensional interface element, which represents two plane surfaces, it will maintain or break physical contact and may slide relative to each other. During solution, these interface elements will indicate if there is contact between surfaces-i.e. if a normal load exists within the elements, or if the two surfaces are separated or have a gap - i.e. if the normal load is zero.

The interface stresses were developed by introducing radial displacement (interference) at the contact surfaces. The nodes at the far end of the tubes are fixed in the y-direction. This was selected as reference fixed boundary conditions,which simulates a continuous tube.

The computations are iterative and the convergence was obtained when the conditions of the interface elements remain unchanged for the last two successive iterations.

The material properties of steel tubes used in this analysis are as follows:

Material yield strength = 240 MN/m^2

Modulus of Elasticity = 210×10^3 MN/m^2

Poissons ratio = 0.265

Density = 7800 kg/m^3

Coefficient of friction for the interface element = 0.35

RESULTS AND DISCUSSION

Fig.2, shows the stress intensity set up across the inner and outer tubes, for a transverse sections near to tube ends and at mid section, resulting from the interface fit. The stress is displayed in a dimensionless representation as functions of diameteral location. Stresses, are related to the interference pressure, p, as determined from Lame's equation and the diameter is related to the inner tube diameter.

of outer tube from both ends localize the stresses and reduce the difference between stresses at the ends of the inner tube.

Here it is again shown that the most highly stressed part of tube is at the inside diameter and yielding of the tube material will take place at this position. With any load application, the principal of supper position applied, i.e, the various stresses are then combined algebraically. Then yielding takes place deeper and deeper into the tube wall and eventually, the whole tube will yield. It is quite clear that this condition occurs when the stress intensity is equated to the yield strength. This is, more favourably occurs for the interference condition and sizes used at smaller t/d_i ratio.

Figs.6 to 8 represent the stress intensity along tube length and show the variation of stress distribution with the various outer tube lengths. The stress intensity on the inner tube increases along the tube length while it decreases on the outer tube as the outer tube length increases. Extension of outer tube length from both sides results in an increase in the stresses and give more uniform pattern. The discontinuities in contact between inner and outer tubes causes local stress concentration effects.

CONCLUSION

The stress intensity results emphasized the dependence of the stresses on the tube sizes. The hoop stresses across tube thickness and along its length is greatly affected by t/d_i ratio, and tends to have a constant value for $t/d_i \geqslant 0.05$.

The length ratio between outer and inner tubes, L/L_1, have also a pronounced effect on the stress intensity. The stress values on the inner tube increases with the increase in length ratio while, on the outer tube it decreases with the increase in length ratio and for both tubes it tends to have a constant value for $L/L_1 \geqslant 3$.

Comparing the stress intensity results with the hoop stresses obtained in earlier work showed a slight difference, with a maximum difference of about 10%, depending on the tube sizes.

REFERENCES

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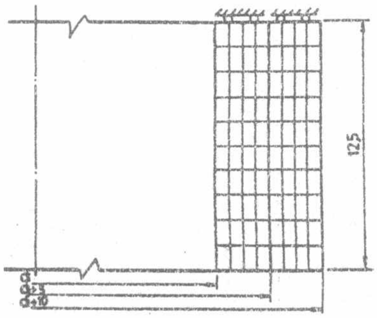
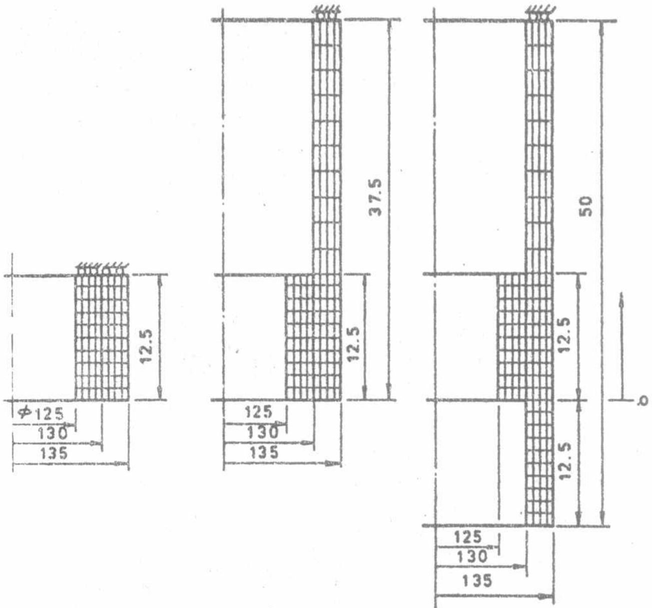


FIG.1a. FINITE ELEMENT MODEL FOR TUBES WITH DIFFERENT DIAMETERS. di=25,75,125 mm.

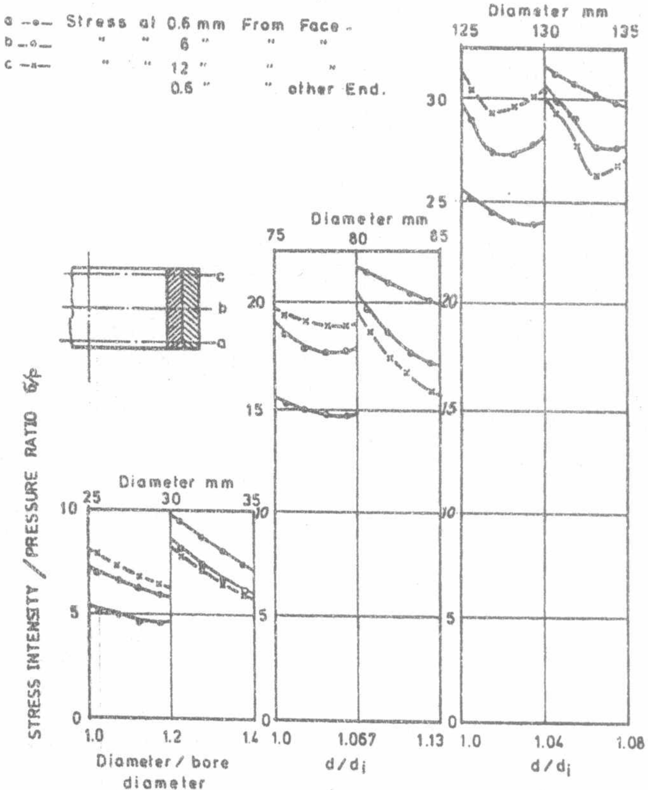


A. L/L1 = 1

B. L/L1 = 3 Extension From One End

C. L/L1 = 4 Extension From both Ends.

FIG.1b. FINITE ELEMENT MODEL FOR TUBES WITH DIFFERENT LENGTHS. L=12.5, 37.5, 50 mm

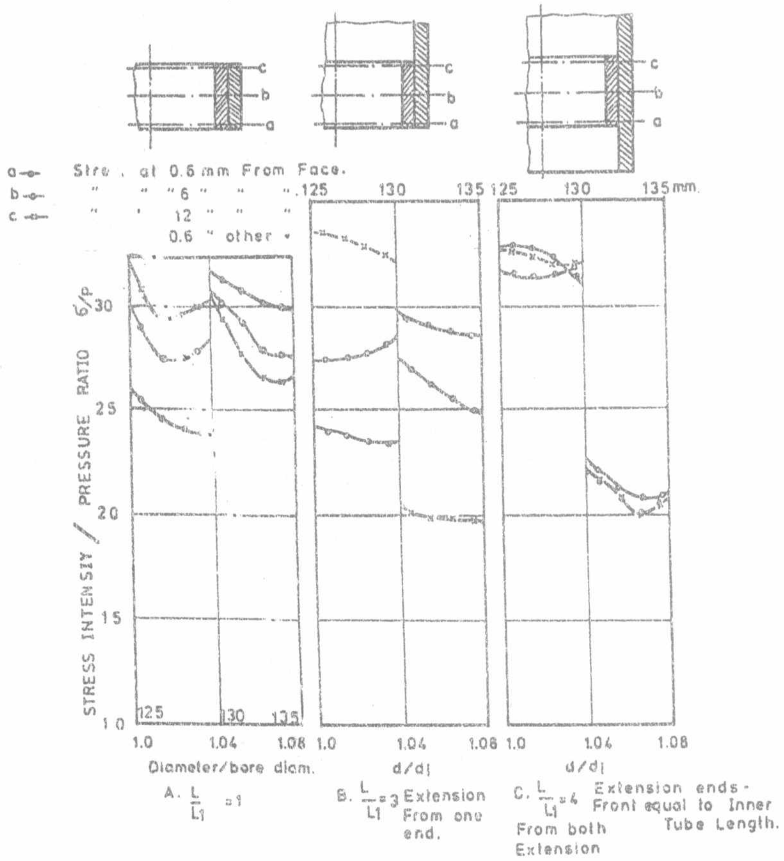


A. t/di = 0.1

B. t/di = 0.033

C. t/di = 0.02

FIG.2 STRESS INTENSITY ACROSS TUBE THICKNESS AS AFFECTED BY THICKNESS TO DIAMETER RATIO - t/di



A. $\frac{L}{L_1} = 1$

B. $\frac{L}{L_1} = 3$ Extension From one end.

C. $\frac{L}{L_1} = 4$ From both Extension. Extension ends - Front equal to Inner Tube Length.

FIG.5 STRESS INTENSITY ACROSS TUBE THICKNESS AS AFFECTED BY OUTER TUBE LENGTH.

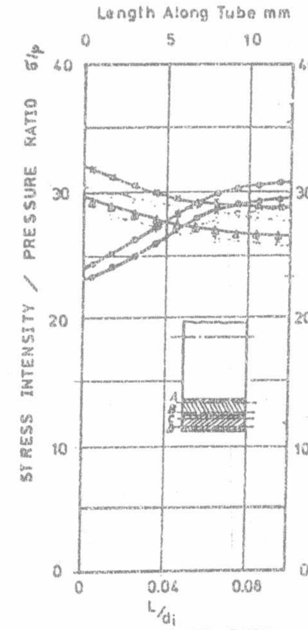


FIG.6 STRESS INTENSITY AS AFFECTED BY TUBE LENGTH $L/L_1 = 1$

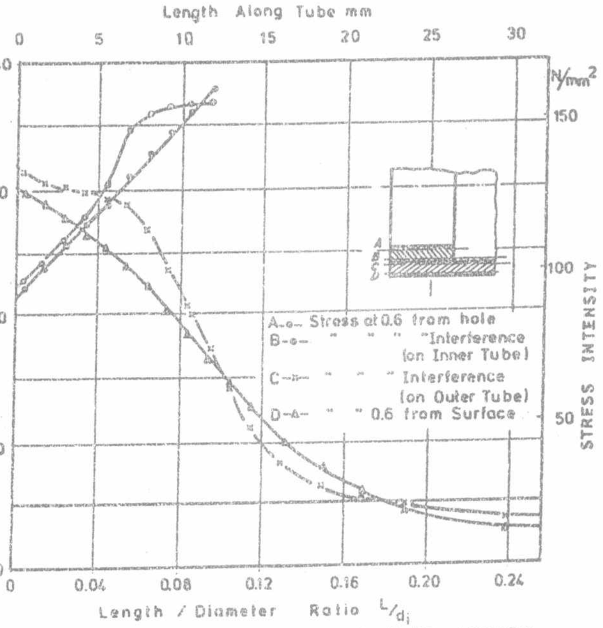


FIG.7 STRESS INTENSITY ALONG TUBE LENGTH AS AFFECTED BY OUTER TUBE LENGTH $L/L_1 = 3$