MECHANICS AND MATERIALS IN DESIGN

Edited by
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PREFACE

M²D'2006 is the fifth international gathering of scientists and engineers interested in the fields of engineering mechanics, design and materials engineering planned for July 24-26, 2006 in the beautiful city of Porto, Portugal. This is a well-established meeting with followers from some 35 nations.

The first conference of this series was held in Toronto in 1996 and attracted over 150 delegates. The second was organized by Professors J.B. Hull and R. Gentle in Nottingham in 1998. The third was organized by Professor S.A. Meguid in Orlando in 2000. The fourth was organized by Dr. T. Mori and Professor H. Fujii in Nagoya, Japan in June 2002. These meetings resulted from the belief that of those disciplines associated with advanced product design and manufacture, engineering mechanics and materials engineering have made the most significant advance in recent years. Important and dramatic improvements in component design can be made by the use of the latest advances in mechanics and materials. Indeed, as a result of the activities in these three important fields: Mechanics, Materials and Design, the International Journal of Mechanics and Materials in Design was established in 2004. With Professor J.F. Silva Gomes being an important member of the Editorial Board and Professor Shaker A. Meguid being its Editor-in-Chief.

It is with this in mind that this ***Fifth International Conference on Mechanics and Materials in Design*** is organized. The purpose is to bring together scientists and engineers from the mechanics and materials communities to present their latest results and discuss new advances over a broad range of topics dealing with analytical, numerical and experimental techniques in mechanics and advances in materials' technology as well as case studies. We have done our best to provide the delegates with an environment conducive to exchange of knowledge, networking and making new friends.

We take this to thank our colleagues who contributed considerably to the event by organizing topical symposia and by helping us to launch this important meeting. We are truly grateful for their efforts. We also wish our overseas friends to have a great time in Portugal. We wish you all a happy and successful stay in Porto.

Shaker A. Meguid
J.F. Silva Gomes

REF: A0605.0057

STRESS INTENSITY FACTORS FOR NOTCHED ROUND BARS USING FEM

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SYNOPSIS

This study proposes alternative methods to estimate the stress intensity factors (SIF) of notched round components with axial hole subjected to an axial force or bending moment. The method is based on analytical equations proposed by Harris and on alternative formulation using finite element method (FEM). This finite element is based on the theory of thin shells to obtain the stress field along a notched round component with only one-dimensional finite element. Several numerical examples are presented to illustrate the proposed method. The comparisons with the elastic finite element showed satisfactory results and good agreement with SIF analytical equations.

INTRODUCTION

In structural elements where geometric singularities exist, the high level of stresses there developed may determine the generation of cracks, which may propagate if the external loads are time dependent as a consequence of a fatigue phenomenon. The proposed finite element is a tool to reduce the amount of work invested in the assessment of the components integrity eventually containing notches. This type of structural situation may arise in a stress field with a remarkable variation when subjected to bending efforts. This finite element appears as an attractive tool for definition of the stress field along notched surface shell element decoupled from the one-dimensional element proposed. Once defined the stress field along the edges of the component part containing notches, an approached procedure can be carried out even without a subsequent finite element analysis, using published graphical results (Harris 1997). The displacement field of the finite shell element results from the superposition of the rigid beam displacement and a complete Fourier terms development. The deformation model considered is a semi-membrane strain field, (Fonseca et al 2006). The SIF determination in opening mode is function of the following equation (Harris 1997) from Neuber's stress concentration factors in straight components:

$$K_I = \frac{P}{\pi\left[(c+a)^2 - c^2\right]} \times \sqrt{\pi t} \times F(c,a,t) + \frac{4M(c+a)\cos(\theta)}{\pi\left[(c+a)^4 - c^4\right]} \times \sqrt{\pi t} \times G(c,a,t) \tag{1}$$

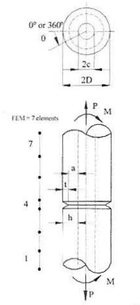
F and G are function of notched geometry according figure 1:

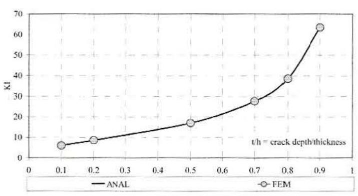
$$F(c,a,t) = \left[0.8 + \frac{t}{a+c}\left(4 + 1.08\frac{c}{a}\right)\right]^{-1/2} \text{ and } G(c,a,t) = \left[0.8 + \frac{t}{a+c}\left(7.12 + 1.08\frac{c}{a}\right)\right]^{-1/2} \tag{2}$$

Analytical solutions for the SIF are usually only possible for relatively simple geometric configurations. Using the alternative FEM, stresses field in the vicinity of the crack may be obtained and KI may be determine even if in arbitrary bodies.

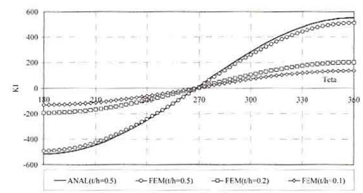
RESULTS

Next figures show the geometry, the mesh used and SIF variation for different straight round geometries. Increasing the relation between crack depth and thickness component KI increases too. When a bending moment is applied the KI value is different along the notched section orientation.





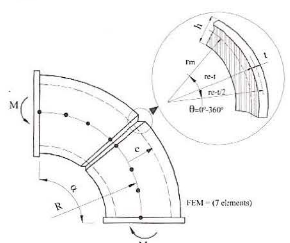
a) KI obtained for axial force P.

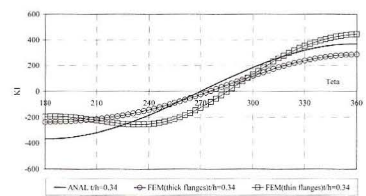


b) KI for axial force P and bending moment M.

Fig. 1 – Notched round straight component and mesh used. KI function of t/h.

Figure 2 represents a notched round elbow component, the mesh used and the KI results at mid length. The KI value depends of end constraints and varies along section orientation.





a) KI for bending moment M applied.

Fig. 2 – Notched round elbow component and mesh used. KI function of t/h for different elbow end constraints.

CONCLUSIONS

In this work some configurations in notched round components with axial hole are considered. The presented method using FEM has shown accurate values when compared with analytical equation proposed by Harris for straight components. The method proposed takes into account the elastic singularity of stress and is based on the conventional shell deformation model theory adapted for tubular structures. Using FEM any type of component configuration is studied.

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REFERENCES

Harris, D.O. Stress intensity factors for hollow circumferential notched round bars. Select Papers on Crack Tip Stress Fields, R.J. Sanford Ed., SEM Classic Papers Vol.CP2, 1997, p.185-201.

Fonseca E.M.M., Melo F.Q., Valente R.A.F. Determination of stress intensity factors along cracked surfaces in piping elbows structures. 10th Portuguese Conference on Fracture, 2006.