FULLY AUTOMATED 3D-CRACK PROPAGATION ANALYSES BASED ON TETRAHEDRAL FINITE ELEMENTS

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ABSTRACT

This paper describes the development of software to perform three-dimensional crack propagation analyses. The software is based on the conventional finite element method with second order tetrahedral element and an automatic mesh generation software. Although hexahedral finite elements have historically been used in fracture analyses and methodologies to compute the crack parameters have been developed for the hexahedral elements, the authors successfully developed a VCCM (virtual crack closure-integral method) for the second order tetrahedral finite element in present research [1,2,3,4]. VCCM accurately computes the stress intensity factors based on an energetic approach. Use of the tetrahedral element allows us to adopt an automatic mesh generation program. Kawai et al [5] is developing a mesh generator for 3D crack analyses. The direction and rate of crack propagation are predicted based on the stress intensity factors and the shape of crack is updated. Hence, a software package containing the modules for mesh generation, for finite element analysis, for stress intensity factor evaluation, for predicting the rate and the direction of crack propagation and for updating crack configuration, is being developed. The outline of the software is illustrated in Fig. 1. At WCCM8, some example problems will be presented.

Furthermore, VCCM for tetrahedral finite element has been extended for four-node-generalized tetrahedral finite elements with rotational and strain like degrees of freedoms at the corner nodes [6]. Some numerical results will be presented.
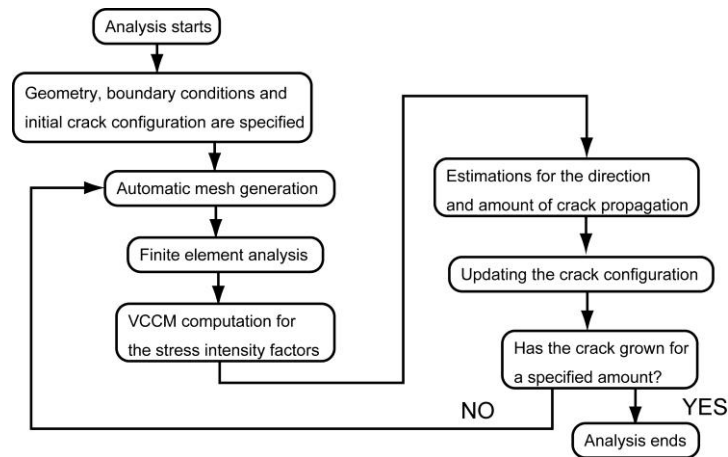
Fig. 1 The flow chart of crack propagation analysis

REFERENCES

[1] H. Okada and T. Kamibeppu, "A virtual crack closure-integral method (VCCM) for three-dimensional crack problems using linear tetrahedral finite elements", *CMES: Computer Modeling in Engineering & Sciences*, Vol. **10**, No. 3, pp. 229-238, (2005).

[2] H. Okada, G. Yagawa, H. Kawai, K. Shijyo, D. Fujita, Y. Kanda, T. Fujisawa, T. Iribe, "The State-of-the-Art Methodology to Compute the 3-D Stress Intensity Factors for Arbitrary Shaped Cracks in Complex Shaped Structures", Computational Mechods in Engineering & Science; proceedings of EPMESC X (Enhancement and Promotion of Computational Methods in Engineering and Science X), CD-ROM, (2006).

[3] H. Okada, K. Araki and H. Kawai, "Stress Intensity Factor Evaluation for Large Scale Finite Element Analyses（Virtual Crack Closure-Integral Method (VCCM) for Mixed Mode/Complex Shaped Crack using Tetrahedral Finite Element）", *Trans JSME Series A*, **73-733**, pp. 997-1004, (2007).

[4] H. Okada, H. Kawai and K. Araki, "A virtual crack closure-integral method (VCCM) to compute the energy release rates and stress intensity factors based on quadratic tetrahedral finite elements", submitted to Engineering Fracture Mechanics, (2007).

[5] H. Kawai, H. Okada and K. Araki, "A mesh generation technique for three dimensional crack propagation analysis using virtual crack closure-integral method (VCCM) and tetrahedral finite element", submitted to Trans JSME Series A, (2007).

[6] Y. Kanda, H. Okada , S. Iraha, J. Tomiyama , K. Murotani and G. Yagawa, "Fracture mechanics parameter computation using tetrahedron finite element with drilling degrees of freedoms（Virtual crack closure-integral method for generalized tetrahedron finite element）", submitted to Trans JSME Series A, (2007)