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Evaluation of Interference with Hole and Surface Crack Using the VNA-FEM Alternating Method.

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ABSTRACT

Generally, crack shape which exists in the three-dimensional structure can be approximated as an elliptical crack. It is necessary to carry out the evaluation in which the stress intensity factor is high for the prediction of growth and instable fracture of the crack in such structure. However, it is difficult that high-precise stress intensity factor is obtained, if element decomposition is not made fine in singularity vicinity such as crack leading edge, in general numerical methods for analysis such as finite element method and boundary element method. Also, using general numerical method for analysis, the calculation time becomes very high in order to analyze interference problem of the crack group, in order to require complicated element decomposition.

In this study, VNA solution -FEM alternating method which applied the VNA solution that can evaluate mechanical quantity of elliptical crack leading edge in infinite solid high-precise is used. By using this method, the interference between oil hole and crack on the surface of the crank shaft can be evaluated. Fractography of crankshaft is shown in Fig.1. From this figure, the crack leading edge trace can be confirmed with the crack propagation. The crack position was made to change along the trace, and the stress intensity factor in each condition was evaluated.

VNA solution -FEM alternating method is an analysis method based on the principle of the superposition. The procedure is shown in Fig.2. To begin with, the finite element model without the crack in the initial load condition is analyzed (process (a)). Next, the general solution of elliptical crack based on stress distribution on crack surface got by process (a) is calculated. Then, the stress in the analytical model exterior is required according to the general solution of elliptical crack (process (b)). In order to satisfy stress free face condition of the crack surface, the boundary condition which inverted the stress value is given in analytical model, and the again new finite element analysis is carried out (process (c)). The result got in process (c) is offered as a residual stress on the crack surface for obtaining general solution of elliptical crack again (process (d)). The alternating calculation is carried out during finite element analysis and analysis according to general solution of elliptical crack, until this residual stress sufficiently decreases in comparison with the initial stress on crack surface.

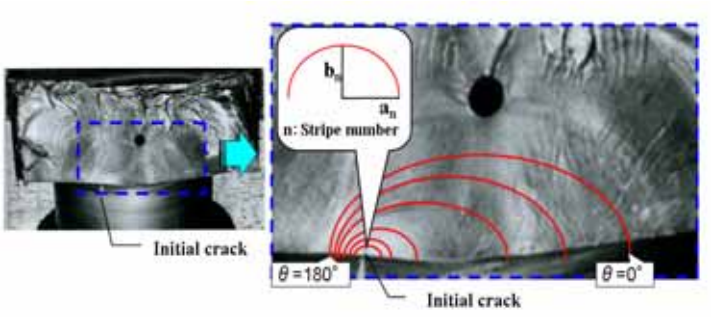

Fig.1 Fractography of crankshaft

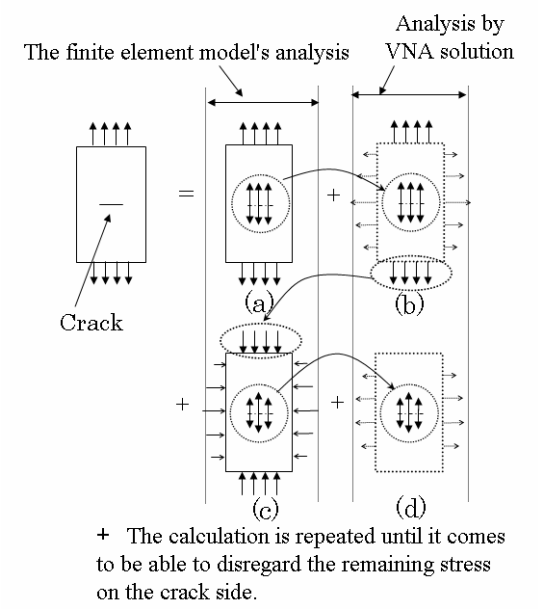

Fig.2 Concept chart of the alternating method

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