Optimization of a Turbine-Rotor-Disk Structure for Inducing Compressive Residual Stress around the Center Hole by Means of Over Speed Rotation

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1. Introduction

To improve the fracture strength and fatigue life, compressive residual stress was induced around the center hole of the turbine rotor disk structure by means of over speed rotation and the phenomenon was studied. An optimum rotor disk structure - a reverse-tapered structure to induce equal compressive residual stress around the center hole - was developed. Over speed rotational tests were done on several rotor disk structures based on the optimum structure, and the residual stress and radial residual deformation of the center hole were measured. An elastic-plastic finite element analysis gave residual-stress and radial-residual-deformation values close to the experimental ones.

2. Structural Optimization

2.1 Numerical Results

The rotor disk structure was optimized to minimize the centrifugal stress at the center hole. A nonlinear programming method was used to reduce the equivalent centrifugal stress. The obtained optimum structure was the reverse-tapered structure. This rotor disk structure had an increased sectional area which improved the stiffness. Therefore the peak centrifugal stress at the center hole was reduced. Moreover the increased total centrifugal stress acted at the hole opening of the center hole. Therefore the centrifugal stress was equalized at the central hole. So we expect that sufficient compressive residual stress can be given uniformly at the center hole.

2.2 Experimental Results

Over speed rotational tests were conducted using optimum rotor disk structure made from aluminum alloy A5052. Measured residual stresses were consistent with calculated values. So we consider that sufficient residual stress as calculated by an elastic-plastic analysis can be given at the center hole regardless of rotational speed.

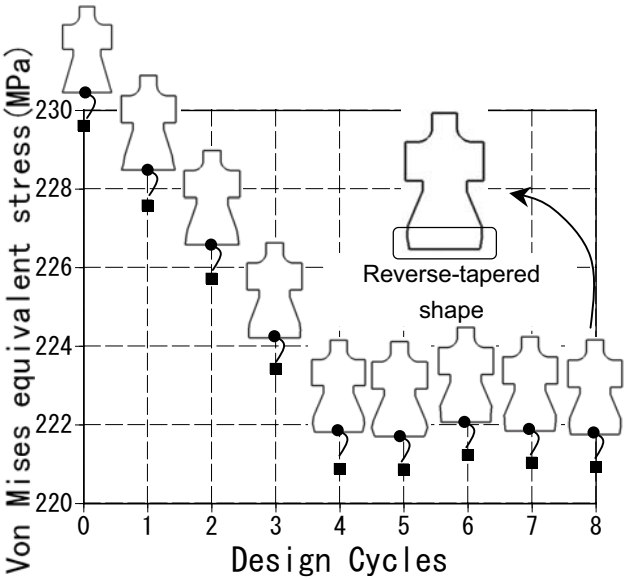

Fig. 1 Process of optimization.

3. Conclusions

We found the optimized reverse-tapered rotor disk structure could reduce the centrifugal stress at the center hole most effectively. At the center hole, residual deformation and residual stress calculated by elastic-plastic analysis were consistent with values measured by over speed rotational tests.

References

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