Strength Evaluation to Develop High Pressure Turbochargers
(2nd Report: Influence of Turbine Scroll on Blade Vibration)

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1. Introduction

In response to the requirement for a higher output of diesel engines in recent years, we have started to develop a turbocharger that has a higher pressure-ratio and volume-flow rate. One of the important technologies to design this kind of advanced turbocharger is an accurate evaluation of the strength for turbine blades at the resonance operating condition, in which serious accidents may occur through a failure of the blades on the market. In general the design life of a blade can be predicted by the centrifugal force and the resonance stress loaded to the blades. The centrifugal force can be calculated by the finite element method. For the resonance stress, however, the prediction is difficult, because the order of the stimulus value (ratio of exciting force to driving force) is not necessarily clear.

In the first report of this study, we applied a turbocharger under development as the test machine and measured the resonance stress at the resonance operating condition, and testified to calculate the stimulus value.

In this study, we applied for two kinds of turbine casings to measure the resonance stress at resonance condition, and calculated stimulus values.

2. Measurement and results

Fig.1 shows a cross-sectional view of the test turbocharger.

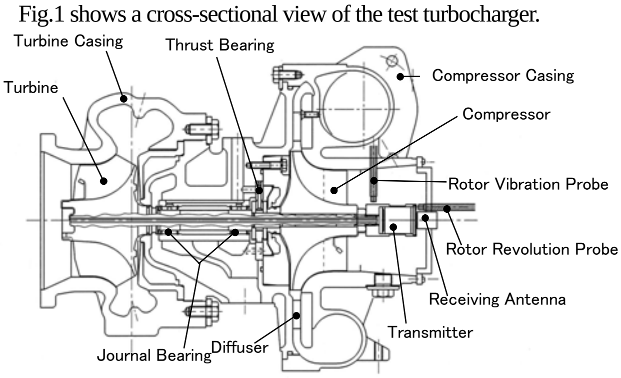

Fig.1 Cross section of Turbocharger

The axial force of the rotational assembly is supported with one thrust bearing, and the radial force with two floating bush bearings. The length of its rotor shaft is 294.5mm and the distance between the floating bush bearings is 65mm.The turbine wheel is formed by a precision casting of nickel alloy with 12 blades. The outer diameter of the wheel is 124.8mm at turbine inlet and nozzle blades are not equipped.

The resonance stress measurements for the turbine blade were performed with two kinds of turbine casings and the working parameters were rotating speed and turbine inlet temperature (TIT). Table 1 shows the main feature of turbine casings, in which A is the minimum area of turbine scroll and R is the distance between the center of turbine rotor and the minimum area of turbine scroll.

Table 1 Feature of Turbine Casing

Turbine Casing	A/R ratio	Mass Flow Ratio
Type-A	1.00	1.00
Type-B	1.12	1.04

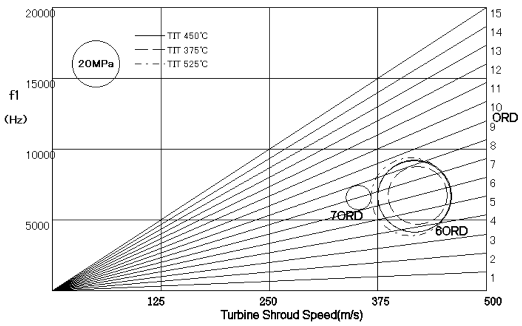

Fig.2 Campbell diagram of Type-B

Fig.2 shows a typical result of the blade stress measurements for Type-B casing at the resonance operating condition and the change of the evaluated stimulus values Sn is shown in Fig. 3.

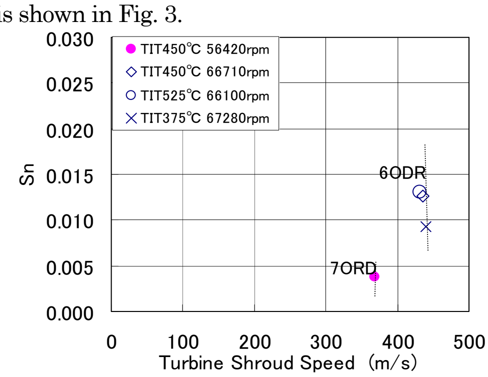

Fig.3 Stimulus of Type-B

3. Conclusions

The resonance stress of the blade for Type-A casing with a smaller A/R was higher than that of B. Also, the resonance stress was higher as TIT was high. Applying these results, we can attain to a more accurate prediction for the resonance stress with considering the operating condition, turbine casing size and stimulus value.

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