A Precise Balancing Technology of the Rotor System Based on Multi Modal Analysis

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Abstract. The classical balancing technologies are easily limited by the condition of the rotational speeds. To solve the above problem, a novel balancing technology for identifying the unbalance parameters of the rotor system is proposed in this paper. Through basic coordinate transformation and multi modal analysis of the dynamical equations of rotor system in frequency domain, the precise calculation method for excitation forces is proposed. The excitation forces are calculated by the vibration responses and modal parameters at several special positions of the rotor model. Then the unbalance parameters are identified by the analysis of the amplitude and phase of the calculated excitation forces. The accuracy of the proposed method is demonstrated by numerical simulations of multi discs rotor systems. And the identified results prove the proposed method is suitable for balancing procedures with the conditions whatever variable rotational speeds or constant rotational speeds.

Introduction

Excessive vibration of the rotor system must be solved in the process of aero-engine development. The rotor operated with stable condition is an important guarantee to reduce the vibration, improve the safety, reliability and service life of aero-engine. Identifying unbalance of rotor system is a key factor for balancing rotating machinery. Modal balancing method (MBM) [1] and influence coefficient method (ICM) [2] are two classical ways in rotor balancing field while identifying unbalance parameters with steady-state responses under the circumstances of a series of selected rotating speeds. Meanwhile, transient balancing methods [3-4] during acceleration are also mentioned by some researches with the condition of several test-runs with trail weights. It can be concluded from above that the existing balancing methods are limited by rotational speeds, and there is no doubt that balancing without considering the condition of rotational speeds would make sense in field balancing. In this paper, we are devoted to identify the unbalance parameters with the conditions whatever variable rotational speeds or constant rotational speeds. And successfully proposing a novel balancing technology for identifying the unbalance parameters based on multi modal analysis. The balancing results of multi discs rotor systems demonstrate the accuracy and the effectiveness of the proposed method.

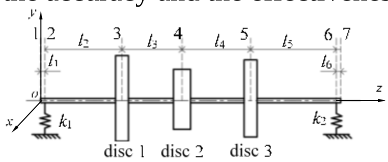

Figure 1: Academic model of the rotor system with triple discs.

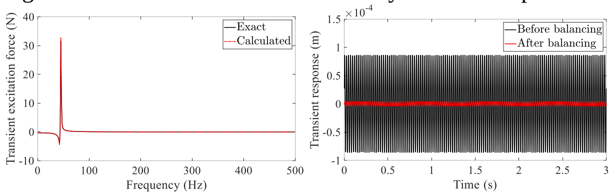

Figure 2: The calculated steady-state excitation force and response of disc 1 with constant rotational speed of 2700r/min.

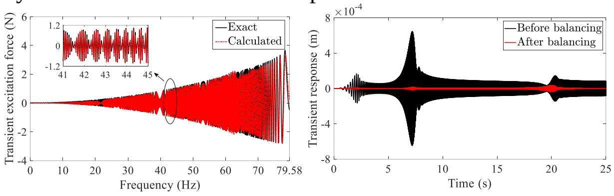

Figure 3: The calculated transient excitation force and response of disc 1 during acceleration.

Conclusion

This manuscript focuses on balancing the rotor system without the limitation of the condition of the rotational speeds, and successfully proposing a novel balancing technology for identifying the unbalance parameters based on multi modal analysis. The conclusions are summarized as follows: (1) The excitation forces are precisely calculated by the vibration responses and modal parameters at several special positions of the rotor model. (2) The residual vibration after balancing could be reduced to a very small range with the condition of constant rotational speed of 2700 r/min, proves the accuracy and the adaptability of the proposed method. (3) The residual vibration after balancing could also be reduced to a very small range during acceleration, attest to the accuracy and the adaptability of the proposed method.

References

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