Mechanism and Machine Theory 45 (2010) 1745–1765

Contents lists available at ScienceDirect

Mechanism and Machine Theory

journal homepage: www.elsevier.com/locate/mechmt

Kinetic uncertainty analysis of the reheat-stop-valve mechanism with multiple factors

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A R T I C L E I N F O

Article history:
Received 1 March 2009
Received in revised form 24 April 2010
Accepted 5 June 2010
Available online 31 July 2010

Keywords:
Reheat-stop-valve mechanism
Misalignment
Thermal deformation
Dynamic analysis
Failure
Uncertainty

A B S T R A C T

The reheat-stop-valve mechanism is a vital component which controls high temperature and high pressure steam in a steam turbine. But there is a great probability of catastrophic failures such as mechanical jamming or insufficiency in the mechanisms when closing the valve in working condition. This paper analyzes the leading influencing factors causing variant dynamic response, even failures in the mechanisms based on failure analysis. Then a method of performance analysis of the mechanism with clearance joints is represented involving all the leading factors. These factors are the dimensional errors, assembly deformation caused by interference coupling, misalignment and eccentricity in bearings and thermal deformation of high temperature steam. Our results demonstrate that the mechanism performance is exceedingly sensitive to the uncertain factors: dimensional errors, assembly deformation and misalignment in working condition. An infinitesimal variation range of 0.025 mm may lead to great uncertainty of dynamic performance or even failures when closing the valve. However, eccentricity at equivalent level contributes little effect. Recommendations based on this study have been adopted in engineering, which are proved to be effective.

1. Introduction

Steam turbines play a major role in the production of the main electrical power supply, and over 70% of the total power is generated by steam turbines [1]. The reheat-stop-valve mechanism is a vital component in the steam turbine, which controls the entry way of the high temperature and high pressure steam. As a result, it determines the running state of the steam turbine: operation or stop. Steady and unfailing dynamic performance of the mechanism is crucial for the safe and reliable operation of the whole steam turbine unit. However, the operation reliability of the reheat-stop-valve mechanisms is not satisfactory in work environment. There is a great failure probability: mechanical jamming, insufficiency or delayed close in the mechanisms when closing the valve.

In engineering practice, empirical estimation, logical-inference or examination by sectioning are active methods to explore the actual mechanism of failure [2–4]. Then applied force or coping matching parts are always used as temporary problem-solving measures. These means may solve problems, but they are unscientific or costly.

Several causes, for example special work environment (600 °C and 4.7 MPa steam) and small-lot production mode restrict mass actual tests. On the other hand, large quantity experiments are required because of manufacturing uncertainty. Thus, theoretical calculation is the optimal and feasible scheme. The reheat-stop-valve mechanism is an eccentric swing mechanism with clearance joints, whose schematic graphics is illustrated in Fig. 1. The input motion is transmitted through connecting link and connecting rod to the rotor-bearing system (valve shaft is the rotor and bearingI, bearingII, bearingIII and bearingIV are the bearings) in which four pairs of clearance joints are involved.

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doi:10.1016/j.mechmachtheory.2010.06.001

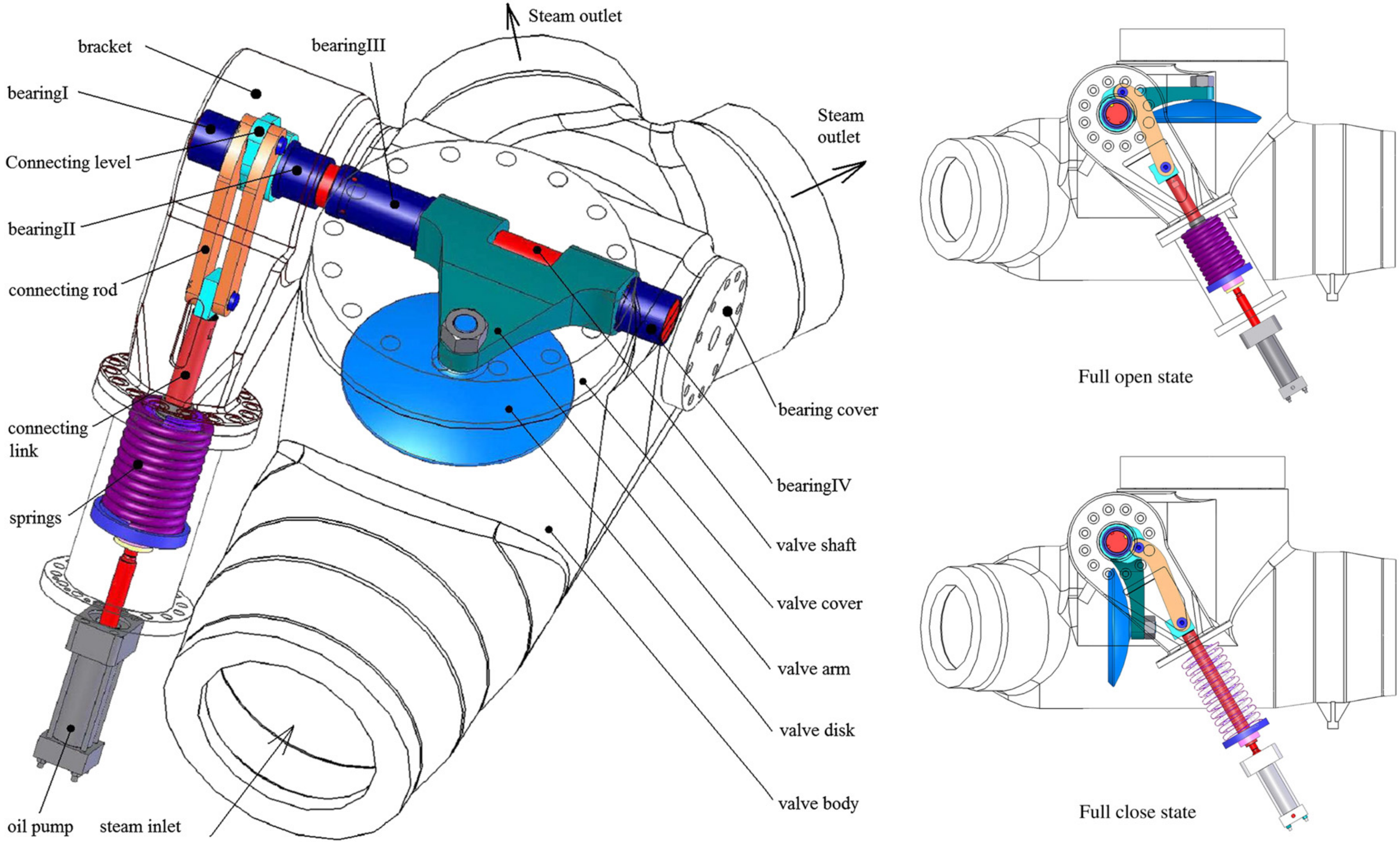

Fig. 1. Structure diagram of the steam turbine reheat-stop-valve mechanism.