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Gearbox fault diagnosis of high-speed railway train

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ABSTRACT

This paper is aimed at detecting crack faults of a lubricant level viewport and upper viewport of a high-speed railway train gear box operating for a repair cycle from 200,000 to 300,000 km. This paper reports a series of test results involving vibration and dynamic stress tests to identify the occurrence of partial resonance and stress concentration points of the gear box structure under external excitation tests. The results of the tests were confirmed using both finite element analysis and modal analysis. This paper also describes the causes of the crack fault on the gear box body and provides a comprehensive analysis of the causes of the gearbox crack. With this approach the faults on the high-speed train gearbox structure were identified and corrective solutions suggested.

1. Introduction

The gear box of high-speed railway trains consisting of gear box body, bearings and gears, is an essential component of the high-speed train. It is the main power transmission system which transmits power from the motor to the wheel set. Due to the complex structure of the gear box and the nonlinear coupling between the wheel and rail in practical operation, the gear box is exposed to many external excitations which can affect its performance and endanger the reliability and safety of the train [1]. Generally, crack faults occur at the lubricant level viewport and the upper viewport of the gear box body of high-speed railway trains in China after operating for 200,000 to 300,000 km. Such cracks if not detected in time can seriously affect the safety of the high-speed train's operation. Hence, finding the causes of the fault and finding solutions are essential for profitability and safe operation of high speed trains.

Vibration has been used in many gear box diagnosis investigation to understand the internal condition of the gear box. An abnormal vibration usually appeared if there is a fault in the gear box [2]. Hence, using vibration signals to diagnose the fault of the gear box is an effective tool [3–5].Techniques used in vibration analysis include Wavelet analysis [6,7], empirical mode decomposition (EMD), Hilbert transform [8], Time-Frequency analysis Wigner-Ville distribution [9] and others. However, most of these techniques are for gear fault detection, and their application for the gear box body crack detection is limited. The gear box body of a high-speed train is structured asymmetrically, affected by various constraints (installation on high-speed train bogies) and its dynamic vibration features are affected by wheel-rail coupling excitation [10]. The track irregularity can also affect the wheel-rail coupling and can result in force excitation [11]. Thus, this paper utilizes the inherent features of the gear box body, and makes use of rail vibration and dynamic stress testing, and combining finite elements and modal analysis [12,13], to analyze the cause of the crack and proposes solutions to remedy the crack fault of the gear box body for safe operation of high-speed railway trains.

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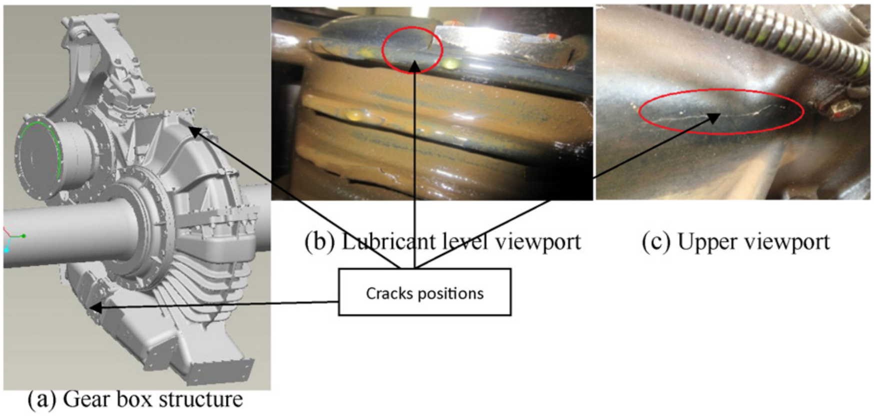

Fig. 1. Locations of cracks on gear box body.

2. Vibration test

In order to understand the causes of gearbox body cracks, vibration tests were conducted on the gearbox of operating trains in service and relevant vibration features of the gear box body were analyzed. The measurement of structural features in the vibration test was to obtain the condition of the gear box body by deploying acceleration sensors on the gear box body at the box axle end and the gear box end. The positions of gear box body cracks are shown in Fig. 1, where Fig. 1(a) indicates the positions of the cracks, Fig. 1(b) and (c) show the shape of the cracks, respectively. The propagation of gear box body cracks are clearly shown in the figures.

From the positions of the cracks, the locations of vibration measuring points on the gearbox body are shown in Fig. 2 to measure the vibration transmission and features of the gear box body structure (side view of the gearbox body structure is similar to letter "L"). Fig. 2(a) shows the overall location of vibration measurement points on the gear box body. Fig. 2(b), (c) and (d) illustrate the set-up of sensor locations at the respective measurement points. Measurement point 1 is at the end of the gear box which is the bulge of the body as well as the end of "L" view of the structure. The vibration at measurement point 1 is expected to be high and the mounting of acceleration sensor of point 1 is shown in Fig. 2(b). Measurement point 2 is located

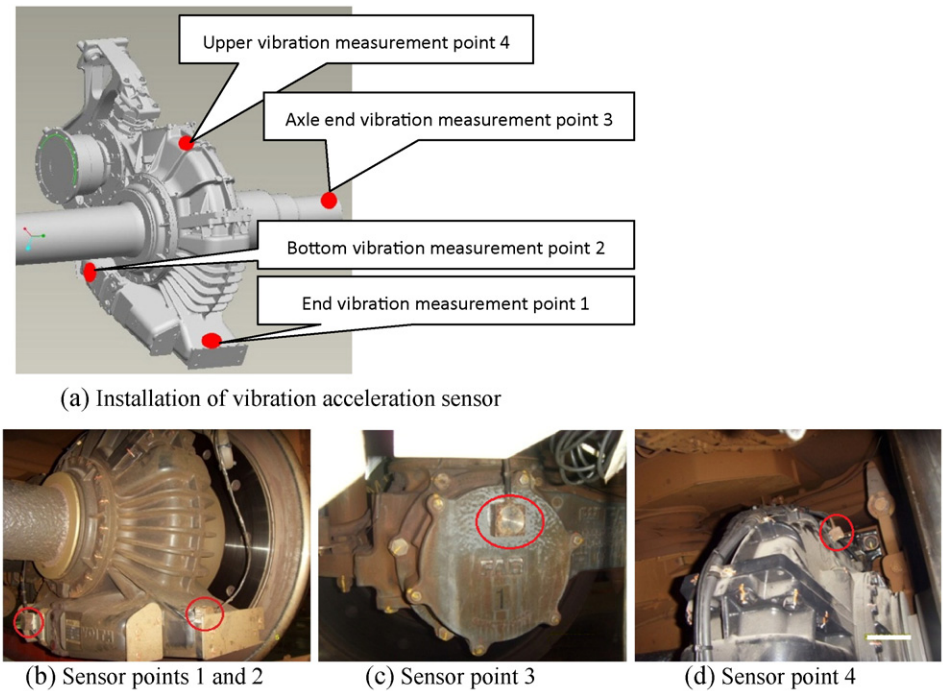

Fig. 2. Installation of vibration sensors on gear box body.