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Review

Dynamic modeling of gearbox faults: A review

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ABSTRACT

Gearbox is widely used in industrial and military applications. Due to high service load, harsh operating conditions or inevitable fatigue, faults may develop in gears. If the gear faults cannot be detected early, the health will continue to degrade, perhaps causing heavy economic loss or even catastrophe. Early fault detection and diagnosis allows properly scheduled shutdowns to prevent catastrophic failure and consequently result in a safer operation and higher cost reduction. Recently, many studies have been done to develop gearbox dynamic models with faults aiming to understand gear fault generation mechanism and then develop effective fault detection and diagnosis methods. This paper focuses on dynamics based gearbox fault modeling, detection and diagnosis. State-of-art and challenges are reviewed and discussed. This detailed literature review limits research results to the following fundamental yet key aspects: gear mesh stiffness evaluation, gearbox damage modeling and fault diagnosis techniques, gearbox transmission path modeling and method validation. In the end, a summary and some research prospects are presented.

Contents

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1. Introduction

In a gearbox, gears and gear trains are used to provide speed and torque conversions from a rotating power source to another device. It is widely used in industrial, civilian and military applications, for example in helicopters, wind turbines, bucket wheel excavators, tracked loaders, and milling machines as shown in Fig. 1. In industrial applications, gearboxes may work under constant operation condition or varying operation condition. This paper focuses on reported studies on the constant operating condition. Limited work in the area of dynamic modeling has been reported on the varying operating condition.

According to the arrangement of gear wheels, gear trains can be classified into four categories [2]: simple gear train, compound gear train, reverted gear train and planetary gear train (epicyclic gear train). One example is given in Fig. 2 for each type of gear train. The simple gear train has one gear mounted on each shaft. If there is more than one gear mounted on a shaft, the gear train is called the compound gear train. If the axes of the driving gear shaft and the driven gear shaft are co-axial, the gear train is known as reverted gear train. If one gear rotates on its own axis and also revolves around the axis of another gear, this gear train is termed as planetary gear train. A total of 34 different types of planetary gear sets are described in Ref. [3]. A basic planetary gear set contains one sun gear, one internal gear (ring gear), one carrier and several planet gears that mesh with the sun gear and the ring gear simultaneously. The first three gear trains are collectively called fixed-axis gear trains in this paper since all gears only rotate on their own axis and all their axes are fixed. Comparing with fixed-axis gearboxes, planetary gearboxes can afford higher torque load due to the load sharing among multiple gear pairs and

Fig. 1. Some applications of gearboxes [1].