An adaptive approach for recovering overlapping echoes in oil film thickness measurement by ultrasound

Abstract

Purpose- For oil film thickness measurement using ultrasonic spring model, obtain the isolated reflection from the oil film layer is the most key point. While for oil film thickness measurement in thrust bearings with thin liner, the reflection from the substrate-Babbitt interface will overlap with the reflection from the oil film layer and this overlapping will incur the unavailable of the ultrasonic spring model. In order to obtain the isolated reflected signal from the oil film layer accurately, an adaptive method was developed to recover the overlapping echoes.

Design/methodology/approach- A Genetic Algorithm based Support Matching Pursuit (GA-based SMP) was developed to provide the optimal echo number and initial parameters guesses automatically and efficiently, after that, the traditional EM model was used to fine tune the accurate results.

Findings- The developed method was test by both simulated echoes and the overlapping echoes encountered in the ultrasonic oil film thickness measurement of thrust bearing. The results demonstrate that the developed method have a good performance on recovering overlapping echoes adaptively.

Originality/value- The work shows an adaptive method to recover the ultrasonic overlapping echoes. When used in ultrasonic oil film thickness measurement, it can help to extend the traditional ultrasonic spring model to be applicable in objects with four or multi layers.

Keywords: overlapping echoes; ultrasonic spring model; GA-based SMP method; EM method; adaptive.

I. Introduction

Ultrasonic spring model is an emerging and promising method for measuring oil film thickness below $10\,\mu m$ (Dwyer-Joyce et al., 2003, Zhang et al., 2005). It utilizes the reflection ratio of the incident ultrasound on the oil layer to calculate the oil film thickness. In the oil film thickness measurement using the ultrasonic spring model, attaining the isolated echo reflected from the oil layer is the key point. For most objects measured before, they can be modeled as three-layer (steel-oil-steel) structure(Hunter et al., 2012, Mills et al., 2013, Drinkwater et al., 2009, Reddyhoff et al., 2006, Dwyer-Joyce and Kasolang, 2006). The echo reflected from the oil layer is inherently isolated (shown in Fig.1), so it is easy to obtain the reflection coefficient and then calculate the corresponding oil film thickness. While for the oil film thickness measurement in some applications such as thrust bearing, as there is normally a Babbitt liner on the surface of the substrate, the structure becomes four-layer structure comprising the substrate-Babbitt-oil-steel composition. When the Babbitt liner is thin, the echo reflected from the substrate-Babbitt will overlap with the one reflected from the oil layer (shown in Fig.2)(Drinkwater et al., 2006, Zhang et al., 2015). This overlapped echo will incur the unavailability of the reflection coefficient and then invalidation of the ultrasonic spring model as the echo reflected from the substrate-Babbitt interface will pollute the original frequency spectrum of the echo reflected from the oil film layers

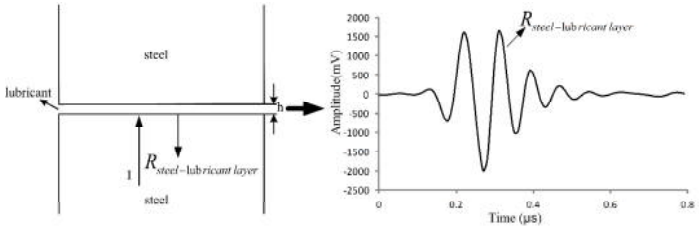

Fig.1. Schematic of three-layer structure and the isolated echo reflected from the steel-lubricant layer