Compound fault detection in gearbox based on time synchronous resample and adaptive variational mode decomposition

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1. Introduction

Gearboxes are vital elements that are extensively used in vehicles, aeroplanes and power plants. The gearboxes fault account for 80% in the breakdown of the transmission machinery [1]. Due to the long running time and poor working conditions, the faults of gearbox often occur in the form of compound fault simultaneously. Compound fault of gearbox may cause more serious consequences or unnecessary economic losses in maintenance activities. Therefore, it is essential to carry out gearbox compound fault diagnosis to prevent the gearbox from malfunction and reduce the economic loss.

2. Body of abstract

A novel compound fault detection method based on time synchronous resample (TSR) and adaptive variational mode decomposition (AVMD) is proposed in this paper. The TSR can enhance fault signals of synchronous shaft gears and their meshing gears by eliminating signal components independent of synchronous shaft. Variational mode decomposition (VMD) can overcome the mode aliasing problem of empirical mode decomposition (EMD), but the decomposition effect is affected by the parameter setting. Thus, the paper proposes an adaptive VMD algorithm based on whale optimization algorithm (WOA), which optimize VMD parameters of the VMD. The compound fault experiment of gearbox is carried out to verify the effectiveness of the proposed method. The experimental results shows that the proposed method is an effective method for compound fault detection.

3. The flow chart of proposed method for compound fault diagnosis

The flow chart of proposed method for compound fault diagnosis is shown as Fig. 1. The specific steps are described as follows.

(1) The raw vibration signal is collected from gearbox by acceleration sensors.

(2) The raw vibration signal is processed by TSR technology, which enhances the synchronous shaft signal of each fault and eliminates the interference of the non-synchronous shaft signal component.

(3) A series of mode components are obtained by decomposing the synchronous shaft signals of all faults by AVMD.

(4) Calculate the correlated kurtosis of the mode components obtained by AVMD decomposition for all the fault synchronous shaft signals. Then the mode components with the maximum correlated kurtosis are selected for the next step.

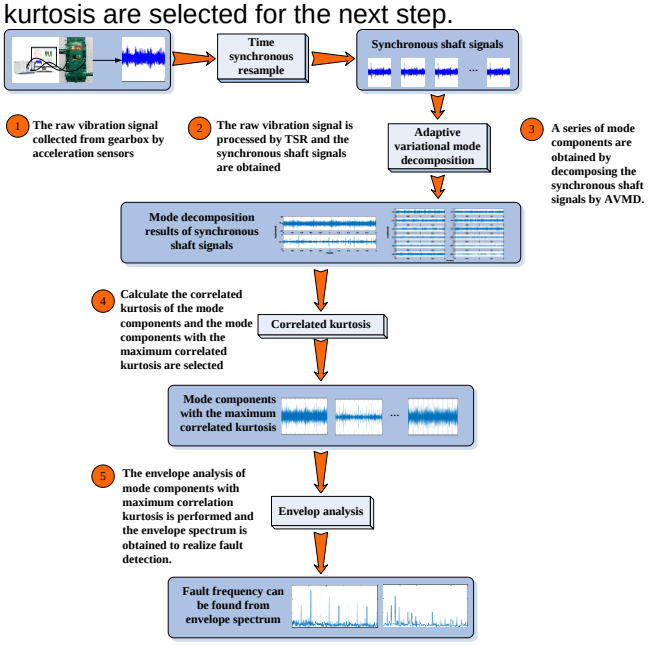

Fig.1 Flow chart of proposed method for compound fault diagnosis

4. Experimental result and conclusions

The performance of the proposed method is testified using experiment data of compound fault of gearbox. The result is shown as Fig. 2.

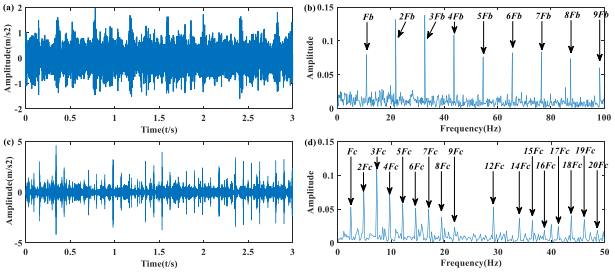

Fig 2. The diagnosis results obtained by proposed method (a) IMF of signal with broken tooth fault (c) IMF of signal with gear crack fault; (b) & (d) The envelop spectrum of (a) and (c)

The following conclusions can be obtained.

(1) TSR is an effective tool for extracting synchronous shaft fault signals and eliminating other interference signals. The experimental results show that TSR can eliminate the interference of non-synchronous shaft signal and enhance the fault signal of gearbox.

(2) AVMD can effectively overcome the shortcomings of mode aliasing in EMD. Through comparative analysis of experimental results, it can be proved that the performance of extracting fault features by AVMD is more competitive than traditional time frequency analysis methods such as EMD, EEMD and LMD.

(3) Through the experiment of compound faults in gearbox, the compound fault detection method based on TSR and AVMD proposed in this paper can detect compound faults of gearbox effectively.

References

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