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Analysis on a Certain Engine FEAD Belt Vibration

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Abstract: The engine FEAD (Front End Accessory Drive) outputs the power and torque of the crankshaft to the front-end accessories such as water pump and generator through belt drive. With the development of economy and society, the customer pays more attention to comfort and subjective feelings, and has more strict requirements on the reliability and noise of the FEAD of the engine. The abnormal vibration and noise of the belt seriously affect the reliability of the engine and the subjective feeling of the audience. Therefore, a method to solve the vibration of the FEAD belt of the engine is analyzed. By appropriately reducing the connection stiffness between the crankshaft pulley and the crankshaft, the speed fluctuation, load fluctuation and crankshaft speed fluctuation of each accessory pulley of the FEAD are buffered and isolated through the elastic connection between the crankshaft pulley and the crankshaft. The test shows that this method can greatly reduce or eliminate belt vibration and abnormal noise, improve durability life, eliminate belt falling off caused by belt vibration, and improve engine reliability and audience's subjective feeling.

Keywords: Engine; Front end accessory drive; Belt vibration; Abnormal sound

1. Introduction

With the social-economic development, the audience pays more attention to the comfort and subjective feeling of the whole vehicle, and puts more stringent requirements for the reliability and NVH performance of the engine. The FEAD of the engine, as a transmission system, transfers the torque and power of the engine crankshaft to the front-end wheel system accessories, to drive the accessories to work, so as to ensure the normal operation of the engine [1]. The dynamic features of the front-end wheel system include rotational vibration of tensional arm and wheel, dynamic tension of band section, sliding between band-wheels, transverse vibration of band, etc. The vibration of front end wheel system mainly includes engine alternating torque, torque change of accessories, machining accuracy and installation error [2]. Abnormal phenomena such as belt vibration, abnormal sound, belt loss, pulley durability damage, tensioning wheel structure damage and other belts seriously affect the engine reliability and subjective perception of the audience. By solving the failure of the front-end wheel belt during the bench function verification of a certain supporting model, the front-end wheel belt vibration of the engine is analyzed and verified.

2. Belt Vibration Analysis

During the verification of platform function, a model is found that the belt shakes violently within the engine speed 650r/min~850r/min, the vibration shift amplitude peaks at 700r/min, and increases with the speed after 800r/min, the belt falls off for a certain time, and the fault state is shown in Fig. 1.

Figure 1. Failure state belt vibration amplitude

The front wheel line arrangement of the engine is shown in Fig. 2.

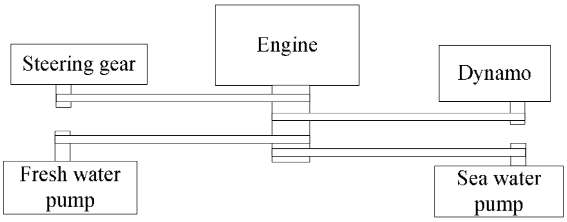


Figure 2. Schematic layout of the front wheel line of the engine

The parameters such as belt length, front wheel alignment, parallelism of rotating shaft of each pulley, perpendiculality of pulley groove and rotation shaft, belt tension and so on all meet the design requirements.

Ax axial torsional vibration is tested and the results are shown in Fig. 3.

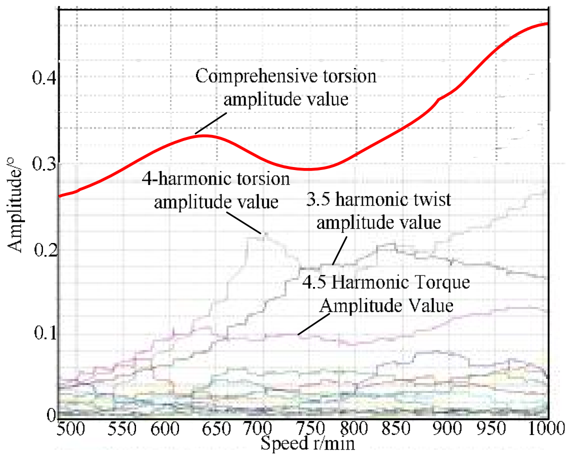


Figure 3. Measured values of torsional vibration of crankshaft system in fault state

According to Figure 3, in the speed range of 650r/min~750r/min, among the amplitude values of each harmonic order, the main harmonic order (fourth order) has the largest amplitude and resonance occurs at 700r/min. At 800r/min, the main harmonic order (fourth harmonic order) is at the peak and valley and monotonously increases in the speed range of 800r/min~1000r/min. The change trend of the comprehensive torsion amplitude value is basically the same as that of the main harmonic. The displacement amplitude of the belt vibration is consistent with the change trend of the amplitude of the main harmonic (fourth harmonic) torsional vibration and the comprehensive torsional vibration, and it is preliminarily judged to be the belt vibration caused by the shaft torsional vibration.

3. Belt Vibration Solution

Now consider reducing the stiffness of the connection between the crankshaft pulley and the crankshaft, and buffer and isolate the speed fluctuations and torque fluctuations between the crankshaft pulley and the crankshaft, so as to reduce the excitation of the torsional vibration of the shaft system to FEAD and reduce the displacement amplitude of the belt vibration value. The rigid connection between the crankshaft pulley and the crankshaft is changed to an elastic connection through an elastic coupling. The rigid connection state and the elastic connection state are shown in Figure 4. The coupling is a certain type of highly elastic coupling.

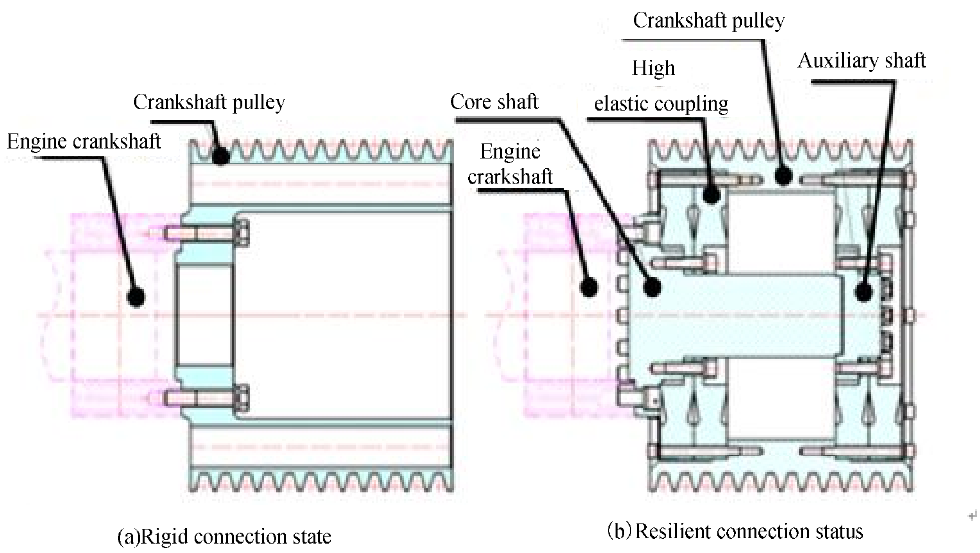


Figure 4. Rigid connection state and elastic connection state

4. Verification of the Solution to Belt Vibration

4.1. Comparison of torsional vibration of the two states

The calculation results of the torsional vibration of the shaft system are compared for the engine in the elastic connection state and the rigid connection state, as shown in Figure 5.

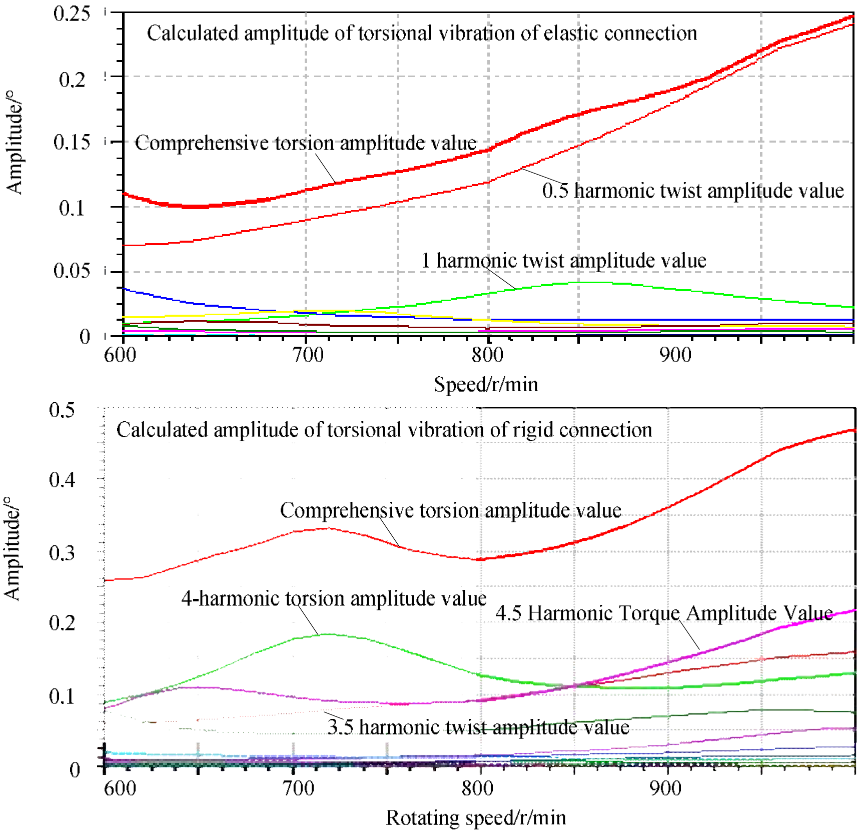


Figure 5. Calculated values of torsional vibration of crankshaft system in elastic connection

According to Figure 5, compared with the torsion amplitude value of the fault state, the comprehensive torsion amplitude value of the crankshaft system is reduced by 40%, and the maximum torsional vibration amplitude of each harmonic has been greatly improved, and there is no obvious shaft torsional vibration resonance in the full speed range.

4.2. Comparison of belt vibration longitudinal displacement in two states

The laser displacement sensor is used to test the belt vibration longitudinal displacement x of the engine in the elastic connection state and the rigid connection state. The test results are shown in Table 1.

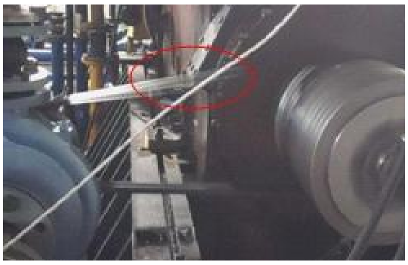
Table 1. Experimental results

Belt vibration displacement in elastic connection state/mm	Belt vibration displacement in rigid connection state/mm
5	16

Figure 6 shows the comparison results of the visual observation of belt vibration in the rigid connection state and the elastic connection state.

According to Table 1 and Figure 6, the belt vibration has been significantly improved.

(a)Rigid connection state



(b)Elastic connection state

Figure 6. Belt vibration degree

5. Conclusion

In order to solve the problem, the abnormal vibration of the engine belt causes the belt to fall off and the belt life is reduced. Start with the belt length, the alignment of the FEAD, the parallelism of the rotation axis of each pulley in the gear train, the perpendicularity between the center surface of the pulley groove and the rotating shaft, belt tension, torsional vibration, etc. Through the experiment, the influence of belt length, FEAD alignment, the parallelism of the rotation axis of each pulley of the train, the perpendicularity of the center surface of the pulley groove to the rotating shaft, and the belt tension are eliminated. Determined to be caused by the torsional vibration of the shaft system and the speed fluctuations and torque fluctuations of the accessories of the front-end. By appropriately reducing the rigidity of the connection between the crankshaft pulley and the crankshaft, the speed fluctuations, load fluctuations and crankshaft speed fluctuations of the accessory pulleys of the FEAD are buffered and isolated which greatly reduces small belt vibration and abnormal noise, improves the reliability of the engine and the subjective feelings of the audience.

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