직선 운동 유닛의 감시 및 진단 시스템 개발

Development of Monitoring and Diagnosis System for Linear Motion Unit

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Keywords: Linear motion, vibration, frequency resonance, monitoring, diagnosis.

1. Abstract

In the present work, investigations by high frequency resonance technique for diagnosis of defect frequencies of linear motion unit are reported. Raw vibration signature of the moving parts at different speeds of operation has been demodulated. Envelope detected spectrum is analyzed to evaluate various defect frequencies and their energy levels. Experimentally evaluated frequencies are compared with theoretically determined defect frequencies. These frequency values and their energy levels are used to monitor intrinsic condition of linear motion unit as well as to establish severity of existing/developed defects on the LM guide and inside the LM block. Relative comparisons of linear motion units of the same type are made at various operating speeds under identical conditions of operation on the basis of identified defect frequencies and severity of defects.

2. Introduction

Linear motion units (LMU), as a kind of common assembly units, are widely used in various transportation machineries. With the improvements of material and manufacturing technology and the higher and higher demands on production efficiency and environment protection, especially in household applications and many other areas, the vibration and noise characteristics of LMU turn into important quality parameters. The early scratch defects generated in manufacturing not only affect vibration level of LMU, but also are the main reasons leading to abnormal sounds.

In actual production process, it requires accuracy, high efficiency and intelligence to diagnose the scratch defects of not only the rolling element bearing but also the LMU parts. In order to analyze the characteristics of LMU vibration caused by early scratch defects and to seek the diagnostic method suitable for the production process, a simplified vibration model of early scratch defects of LMU is built. Based on the analysis of vibration characteristics of early scratch defects, a diagnostic technology is presented in this paper.

3. Characteristic Analysis On Vibration Caused By Scratch Defects

The vibration caused by the balls hitting on the LM guide. With the motion of the LM block, balls roll inside the block and hit the LM guide at the beginning of the time they touch the LM guide. When the block moves from one side to the other side, balls inside the block hit on the LM guide one by one. If there are scratch on the ball or LM guide, the vibration caused by hitting will appear abnormal one. Bigger amplitude vibration comes out from the block and is caught by the acceleration sensor. Through this kind of abnormal signal, we can find if there is scratch on the ball or LM guide.

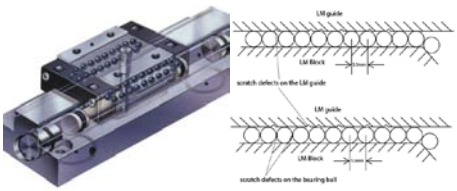

Fig. 1 Rolling Bearing inside the LM block

Structure of hardware mainly contains vibration detection system of industrial personal computer (IPC) and actions control system of PLC, which is illustrated in Fig. 5. During vibration detection, the vibration signal on one point of LMU's outer side is collected by the piezoelectric acceleration sensor and AE sensor, then amplified by the charge amplifier and converted to voltage signal. The voltage signal of the vibration is converted by an A/D converter and then is sent to IPC for its further processing after band-pass filter. In actions of measuring procedure, the positions and states of the tested LMU is detected respectively by corresponding sensors, and the actions of mechanical system are implemented by devices controlled by PMAC.

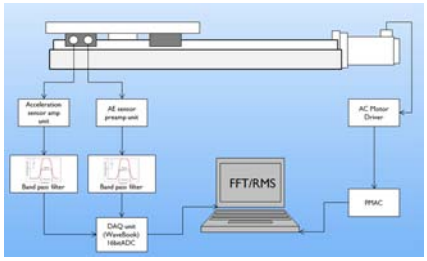

Fig. 2 Structure of the mechanical system

3.Results

From the vibration signals in time domain, it is obvious that the abnormal vibration generated by the early scratch defect of LMU has more series of periodic damped oscillation waveforms. And the scratch defects excite high frequency natural vibration. The frequency of occurrences of the damping waves is basically equal to the ball passing frequency corresponding to the defect. The phenomenon of amplitude modulation is not clear in vibration signal with defect on one ball because the defect on ball enters into and leaves the contact zone indefinitely as the bearing is rotating. But the defect level in motion element defect frequency is so clear in envelope spectrum of vibration signals that the tested unit could be judged with defect on one ball. The RMS processing result also shows higher level energy with the scratch defects on the LM guide and on the balls inside the LM block. The FFT figure shows that the scratches cause the amplitude higher than the normal situation. And according to the further figure that RMS result shows, the scratch defect of LMU's RMS results also spears a higher level comparing to the normal situation. That absolutely means the increase at RMS result and FFT figure show us how much defect on the LMU. And monitoring at both RMS and FFT results can help us to know the statue of the LMU.

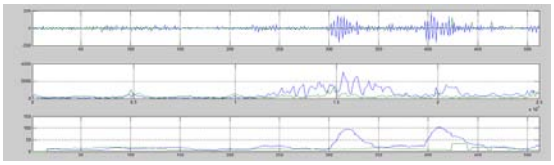

Fig. 3 RMS and FFT results

4. Conclusion

(1) For the vibration of a linear moving unit, the scratch defects on its linear motion elements can be considered as impulse source with the period of T related to the defects. The following conclusions can be drawn from the experimental results and analysis .
(2) Scratch defects excite high frequency natural vibration. And the abnormal vibration generated by the defects is a kind of periodic damped oscillation with larger-amplitude and decaying waveforms.
(3) FFT and RMS processing is suitable for LMU statue diagnostic.

References

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