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APPLICATION OF VIBRATION SIGNAL ANALYSIS TECHNIQUES IN ROLLING BEARING FAULT DIAGNOSIS

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INTRODUCTION

Fault diagnosis is one of newest techniques developed in the recent ten years. It is used to judge the conditions in machinery through processing and analysis of measured external signals. This system monitoring,fault diagnosis and trend analysis (pridictive diagnosis) for machines can be done economically and accurately, and the maintenance of machines becomes more simple and purposeful.[1] [4].
Typical faults in bearing are: (1) Fatigue flaking. This is the most serious fault for bearings, in which case, elliptic chips or spallings would flake from the surface of the bearing. Continuous operation of the machine would make the flaking spread all over the surface. (2) Fatigue pitting. It is a kind of primary fatigue damage. There are many little points over the surface of the bearing that would be connected and lead to fatigue flaking through long time operation. (3) Wearing. Metals gradually wear away due to long operation. (4) Scuffing, skidding. By reason of careless manufacturing or mounting and breaking of the lubricant membrane in operation, bruises would result in the bearing. (5) Score. Impact load causes current of the metal in the race, forming true brinelling. Because of statical contact, the small amplitude of the bearing results in veneer corrosion which forms false brinelling. (6) Foreign material. Metal chips or dirt may be brought into the bearing, causing friction, extrusion and rough dark surface. Oil or wet may form early oxide rust. (7) Creeping. This refers to the relative motion between inner race and shaft. [2][3]

VIBRATION IN BEARING

The cause of vibration

Generally, there are four forms of vibration in a bearing: (1) Random vibration caused by design, mounting and lubrication. It exists in all bearings. (2) Vibration caused by the balls passing through the load region. (3) Vibration caused by the balls passing through the inner or outer race in which exist the above typical faults, and through the coarse or rough surface, by faulty balls (4) Vibration transferred by bearing from a foreign surce. They may be periodic, stationary, non-periodic, transient or random.

The fault frequency formulas for the radial rolling bearing

content / part	fault frequency formula (for presoure angle $\beta=0$)	$f_i = N/60$ (HZ)
inner race $f_{\beta i}$	$\frac{n}{2}(1+\frac{d}{D})f_i$ (HZ)	N - rpm of shaft n - number of balls d - ball diameter D - radial distance, two ball centers
outer race $f_{\beta o}$	$\frac{n}{2}(1-\frac{d}{D})f_i$ (HZ)	
ball f_β	$\frac{D}{d}(1-(\frac{d}{D})^2)f_i$ (HZ)	

SAMPLES AND DATA PROCESSING

We use 204 Type ball bearing as samples clamped on the SO-910 bearing vibration measuring instrument. Sample 1 is standard. Sample 3 and 4 are substandard. Fatigue 1 has natural fault. Geometry parameters: d=7.94, D=33.9, n=8. Calculated frequencies: f_i=26.35HZ, $f_{\beta i}$=130.064, $f_{\beta o}$=80.74, f_β=106.35, f_c=10.1 (cage rotating frequency). The record and analysis for testing data processing is shown in Fig.1. Some results of the processing are shwon in Fig. 2-4.

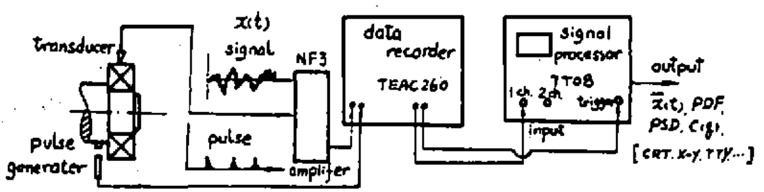

Fig.1. The record and analysis system for data processing.

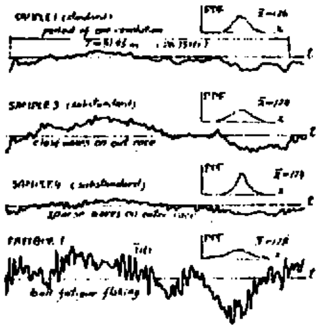

Fig.2. The averaging and the probability density (PDF).

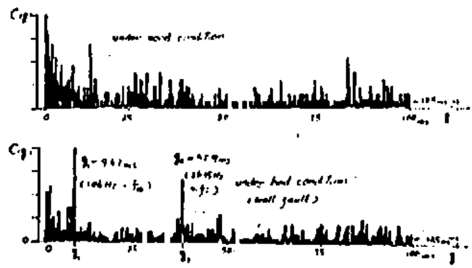

Fig. 3. Comparison of cepstum under two comditions.

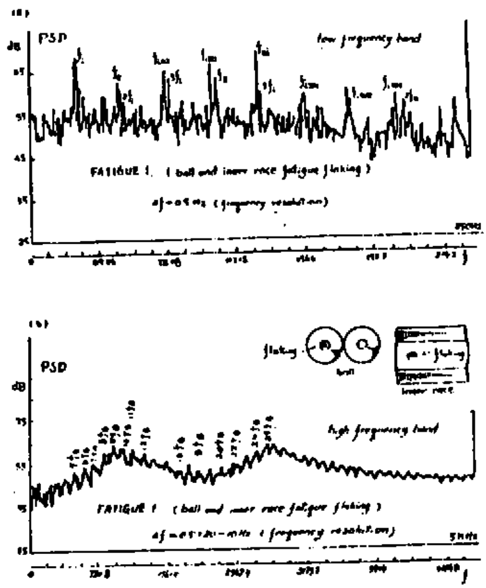

Fig.4. The signature in power spectral density (PSD) plot of Fatigue 1.(defect balls and inner race).

THE RECOGNITION TECHNIQUE FOR BEARING SIGNATURE

In the test, some effective recognition techniques of signature may be summa-rized as follow: (1) Basic frequncy judgment. The advantages of this method are the parts of fault can be easily distinguished. (2) Harmonic frequency judgement. It can be judged by the interval of harmonics. Careful measurement of their interval will indicate the part of the faults and givepredictive warning information in high order harmonic spectrum. (3) Side frequency judgement. Different side frequencies can help to judge the fault parts and to judge the severity of fault. Following table shows the feature of the bearing signature in various conditions.

feature / condition	shara peaks low freq.	shara peaks high freq.	PSD of peak low freq.	PSD of peak high freq.	side freq.	feature of freq. frame
good	very little	no	base line	base line	no	flat wide band noise
waveness is worse	little	hardly	↑10dB	↑10dB	not obvious	flat in high freq. range
mechanical damage	exist	many	↑10dB	↑30dB	obvious	regular peaks
fatigue damage	many	many	↑30dB	↑40dB	not obvious	irregular peaks

CONCLUDING REMARKS

The outhors found that averaging and PDF can only provide information concerning the existence of faults, and that the frequency domain function PSD and Cepstrum are good means for diagnosing the parts, propeties and severity of faults.

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