MILITARY TECHNICAL COLLEGE

CAIRO - EGYPT

EXPERIMENTAL INVESTIGATION OF VIBRATION CHARACTERISTICS OF TAPERED ROLLER BEARINGS.

By

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ABSTRACT

This paper deals with the rib-roller end contact of taper roller bearings from the vibrational point of view in order to diagnose its failure when running under different operating conditions of axial loads, speeds, lubrication, and mounting fits.

The dynamic response of an axially loaded tapered roller bearing is obtained experimentally. A test rig is built to investigate the vibrational response of the tapered roller bearings when running under different operating conditions.

The results show that the vibrational response of the tapered roller bearings increases with the axial loading, unbalance, rotational speed, lack of lubrication, grade of fit, and wear of bearing elements.

INTRODUCTION

The rib-roller end contact is the essential part responsible for carrying the axial loading of tapered roller bearings. Most of wear failures occur at this contact are due to slip, side slip, high spin to rolling ratio, and insufficient area for the oil film pressure to be built-up.

In fact, the stresses, surface velocities, and lubricant films that exist in the bearing raceways, besides the essential rib-roller end contact have not been properly interpreted, until recently.

Zantopulos [1] proposed a comprehensive analytical and experimental study of the effect of misalignment on load distribution and fatigue life of tapered roller bearings. Andreason [2] presented a method to consider the importance of misalignment on the load distribution in a single tapered roller bearing.

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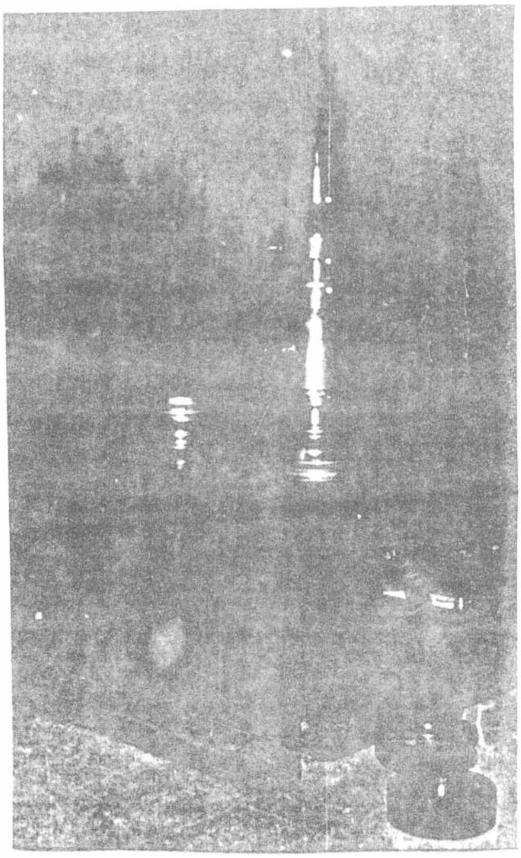

Fig. (1) : View of the test rig.

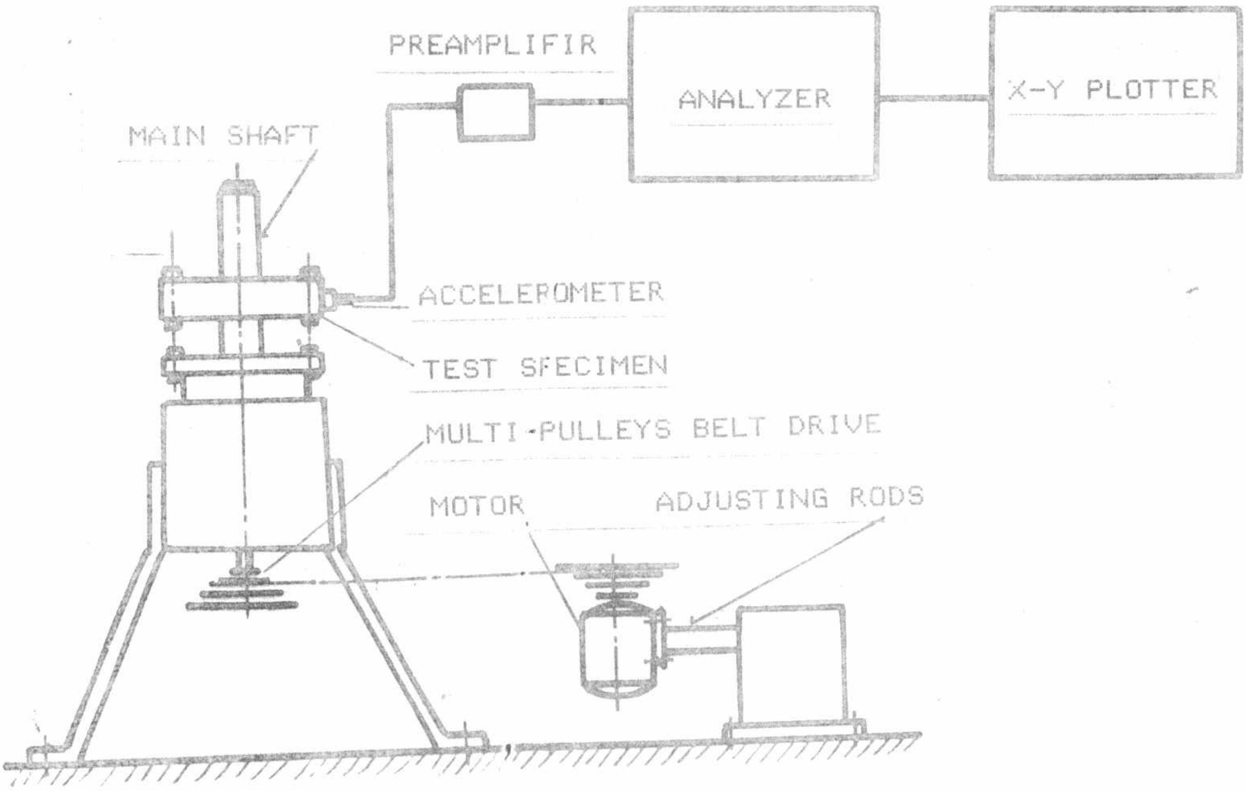

Fig. (2) : Scheme of the test rig.

Jamison [3] investigated the effect of certain design features, of tolerance control in manufacturing, and or wear under poor lubricating conditions on bearing performance for a specific point in tapered roller bearings.

The hydrodynamic and elastohydrodynamic lubrication conditions can be retained at the rib-roller end contact when a critical speed is reached [4]. Gadallah and Dalmaz [5] studied friction and film thickness both theoretically and experimentally under operating conditions representing those found in rib-roller end contact.

Liu [6] presented an analytical study of the load distribution in a tapered roller bearing operating at a high speed and under combined loading. The effect of wear and bearing damages of tapered roller bearings are investigated by Hoeprich and Widner [7].

The aim of the present work is to investigate the effect of different operating conditions : axial load, speed, lubrication and wear on the vibrational response of the tapered roller bearings. Moreover, the feasibility of using vibration measurement and analysis for diagnosis of faults and defects has also been investigated.

EXPERIMENTAL SET-UP

A test rig is built to operate at different working conditions of load, speed and lubrication. The axial load variation simulates the mounting fit as in real machineries. Both new and used bearings are tested. A scheme of the test rig is shown in Fig. (2), and a photograph of the rig is shown in Fig. (1). The rig consists of a shaft bedded in a housing through two angular contact ball bearings (SKF 7210). The housing is supported by a steel structure welded to a square steel plate bolted to a 2.5 ton cast iron base. The shaft is rotated by an A/C motor through a multipulleys belt drive. The tested tapered roller bearing (SKF 30208) is fitted to the top end of the shaft. The outer race is fitted to a fixed cup housing. The load is applied axially on the outer ring by weight calibrated discs. An accelerometer mounted on the fixed cup housing is used to measure the vibrational response. Externally two different unbalance loads of 0.2 Nm and 0.25 Nm are applied to the system by using a disc supported to the rotating shaft. Different grades of fit of the bearing are created by tightening or loosing the outer race of the test specimen. Two kinds of tapered roller bearings are used as test specimens. The first is a new one (SKF 30208), and the second is a used one of a truck axle after being in operation for a long period.

RESULTS AND DISCUSSIONS :

The experimental results show the variation in acceleration amplitude of the first harmonic frequency of the rotating shaft at different test conditions of axial load,rotational speed, lubrication, mounting fit, and wear of each bearing element.

EFFECT OF AXIAL LOADS

Experimental tests are carried out for different axial loads from 40 N to 250 N. Figure (3) shows the frequency spectrum of the measured acceleration signals at the bearing pedestal for the new lubricated bearing at speed of 2000 rpm for different axial loads. The acceleration amplitude increases with the axial load as shown in Fig. (4).The tests are repeated with externally applied unbalance of 0.2 Nm and 0.25 Nm, for different axial loads from 40 to 160 N at speeds of 750 and 1000 rpm. The acceleration amplitude increases by increasing the unbalance rating as shown in Fig. (5).

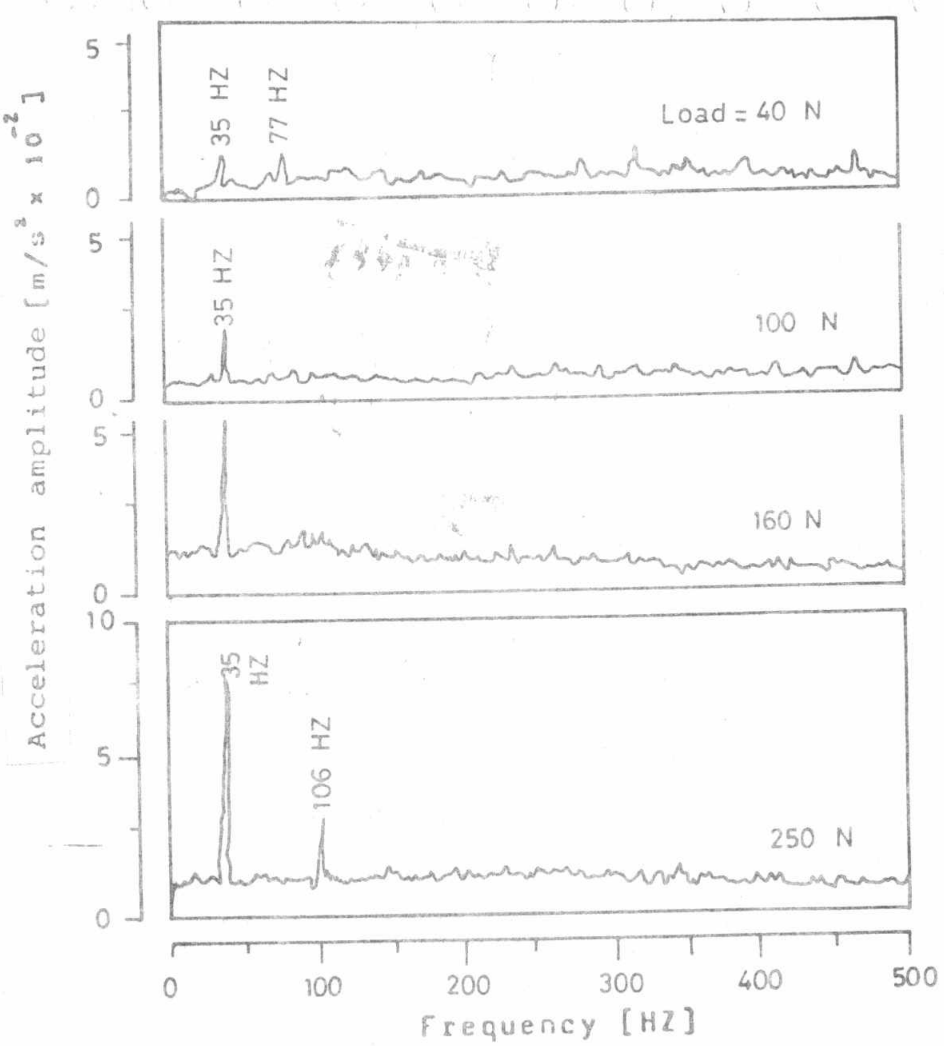

Fig. (3) : Frequency spectra of acceleration signals for a new lubricated beraing at n=2000 rpm, and at different axial loads.

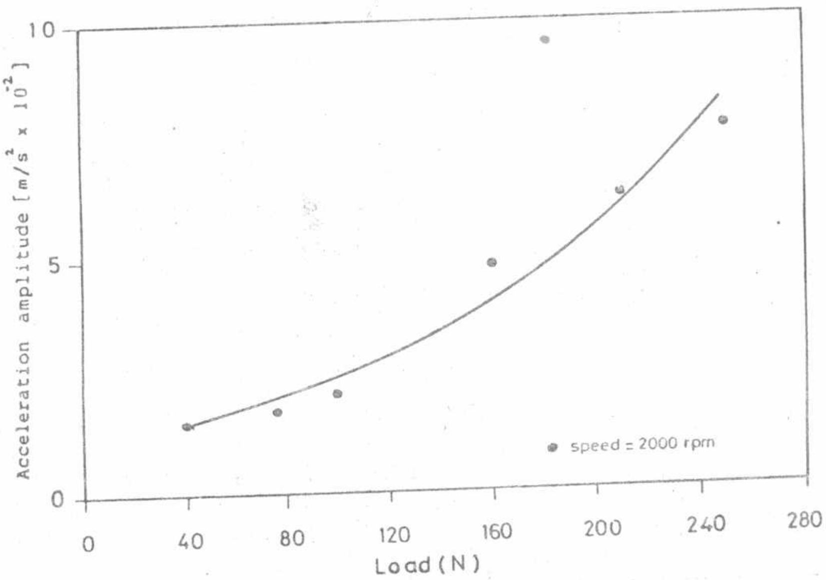

Fig. (4) : Variation of acceleration amplitude with axial load at speed n=2000 rpm .

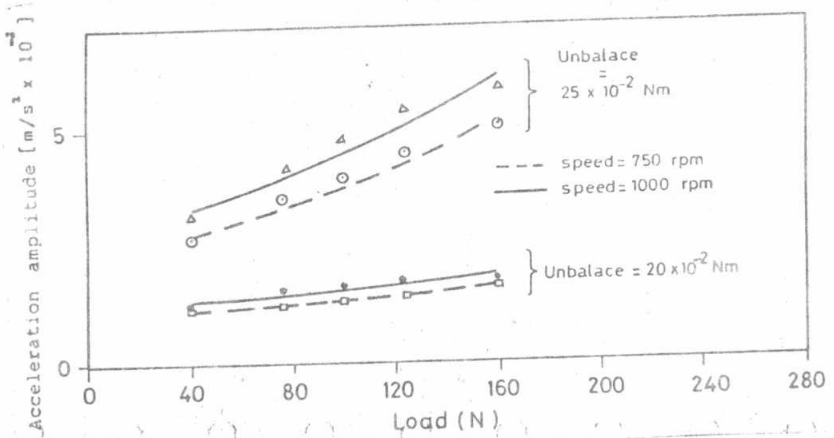

Fig. (5) : Variation of acceleration amplitude with load at different values of external unbalance loads and speeds.

EFFECT OF ROTATIONAL SPEED

Figure (6) shows the frequency spectra of the measured acceleration signal at the bearing pedestal for the new lubricated bearing at constant axial load of 250 N and at different values of rotational speeds. The amplitude of acceleration increases with the rotational speed as shown in Fig. (7).

EFFECT OF LUBRICATION

Figure (8) shows the spectra of the bearing vibration at rotating speed of 2000 rpm, when the bearing is dry (without grease). The variation of the acceleration amplitude with loads at speeds 1500 and 2000 rpm in case of dry rotation, and also for lubricated bearings are shown in Fig. (9). the results show that at dry contact, the amplitude increase with the rotational speed.

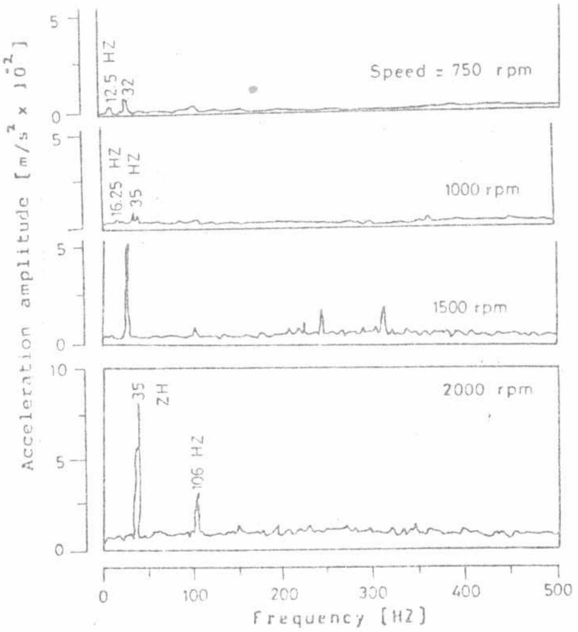

Fig. (6) : Frequency spectra of acceleration signals for a new lubricated bearing at constant axial load of 250 N and at different speeds of rotation.

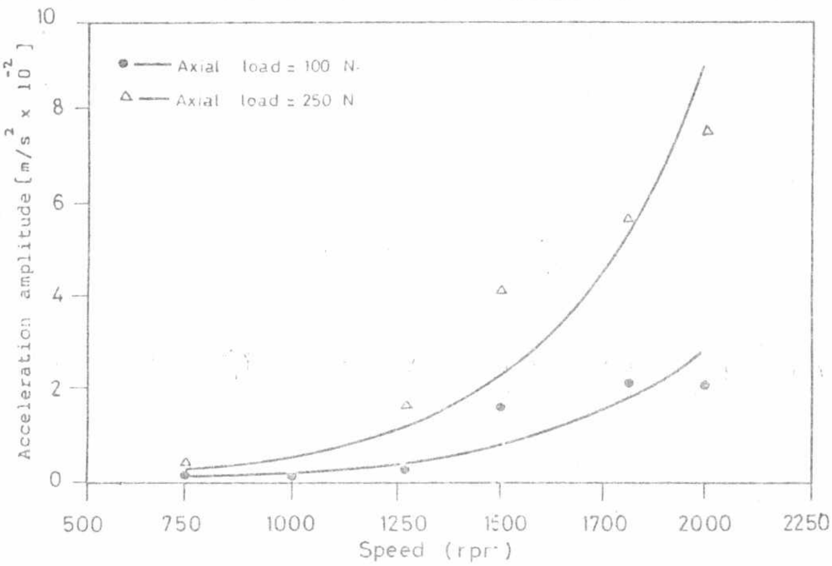

Fig. (7) : Variation of acceleration amplitude with speed of rotation at different axial loads.

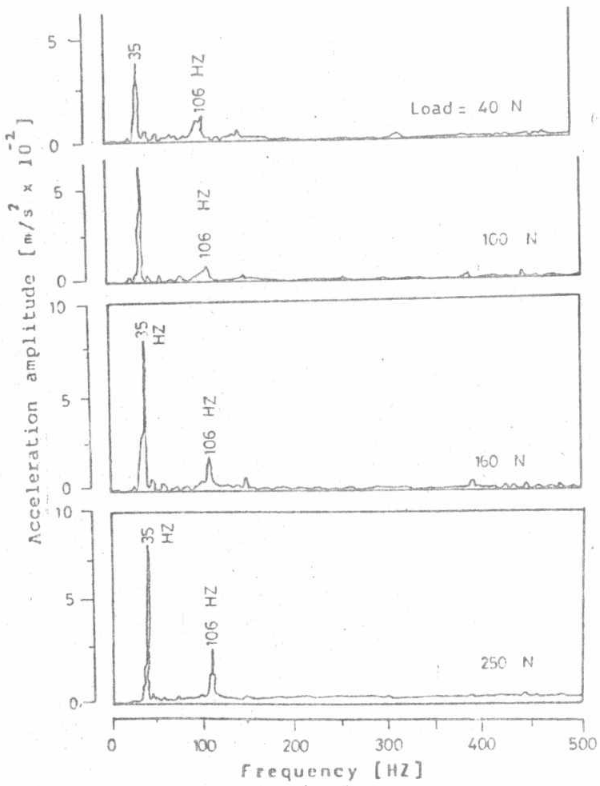

Fig. (8) : Frequency spectra of acceleration for a dry bearing at speed of 2000 rpm.

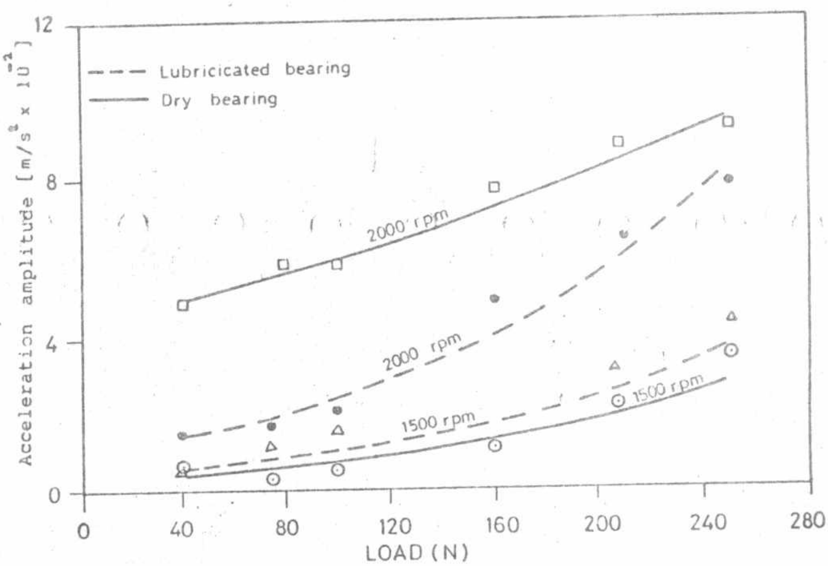

Fig. (9) : Variation of acceleration amplitude with loads for dry and lubricated bearings.

EFFECT OF BEARING MOUNTING FIT

The spectra of amplitude of acceleration at speed of 2000 rpm and different axial loads from 40 N to 250 N, is shown in Fig. (10) , for a clearance fit between the outer race and housing. It is shown that the amplitude of the first harmonic increases with the load. Figure (11) shows that the increase in amplitude with load is greater than that when the outer race is mounted with interference fit to the outer housing cup.

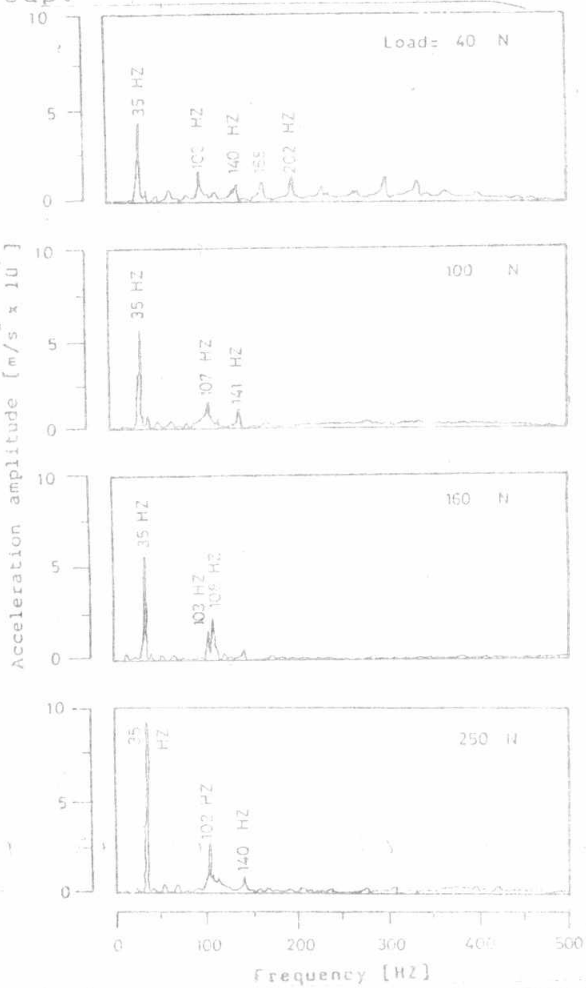

Fig. (10): Spectra of acceleration at different axial loads for clearance mounted bearing at speed of 2000 rpm.

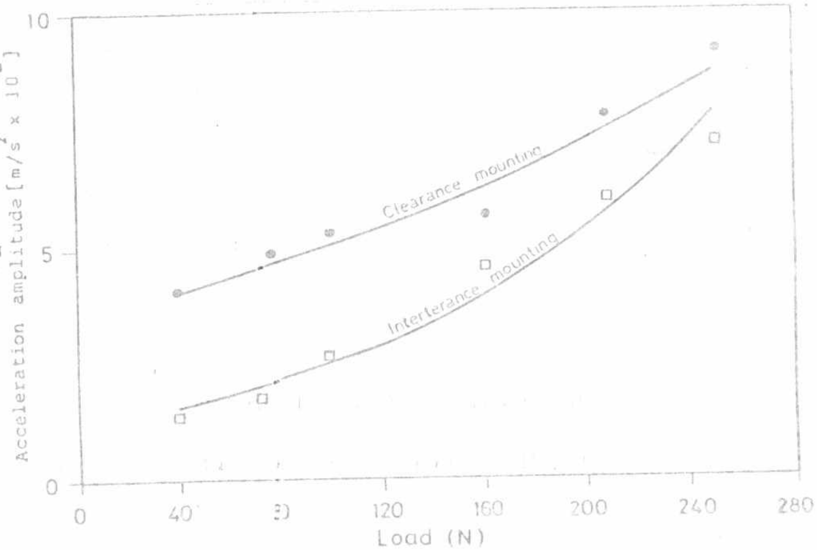

Fig. (11): Variation of acceleration amplitude with load for Interference and Clearance fits of mounting bearing running at n = 2000 rpm

EFFECT OF WEAR

The vibration spectra of the used bearing at speed of 2000 rpm and axial loads of 40 N to 250 N, is shown in Fig.(12). It is shown that the amplitude increases with the load , but is greater than that of the new bearing. Figure (13), shows the variation of the amplitude with different loads of the new bearing compared to the used one , both at the same speed. One can notice that defects of the roller element and outer race affect the frequency spectra in a clear manner.

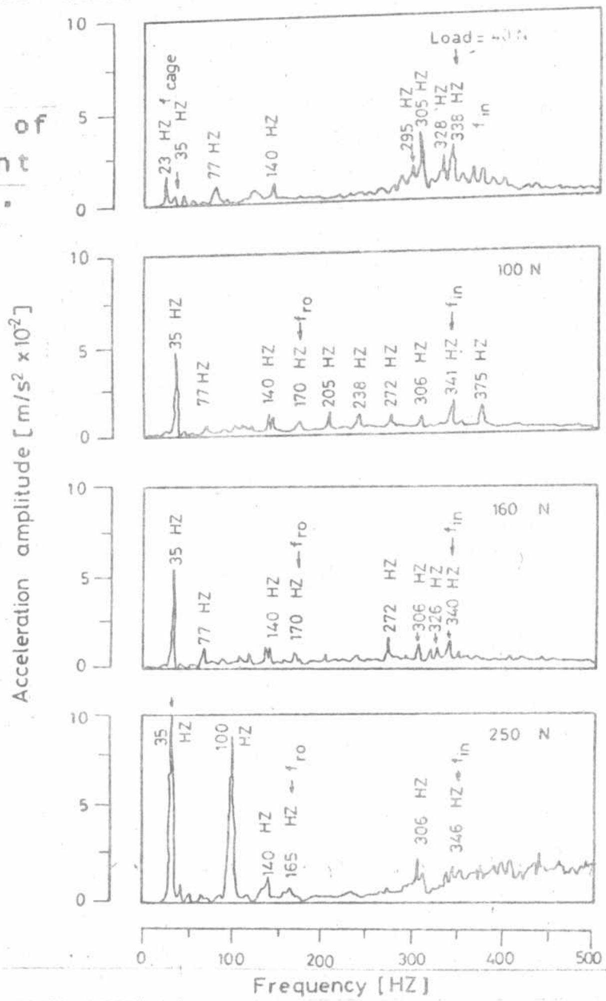

Fig. (12): Spectra of acceleration of used bearing at different loads and at n=2000 rpm.

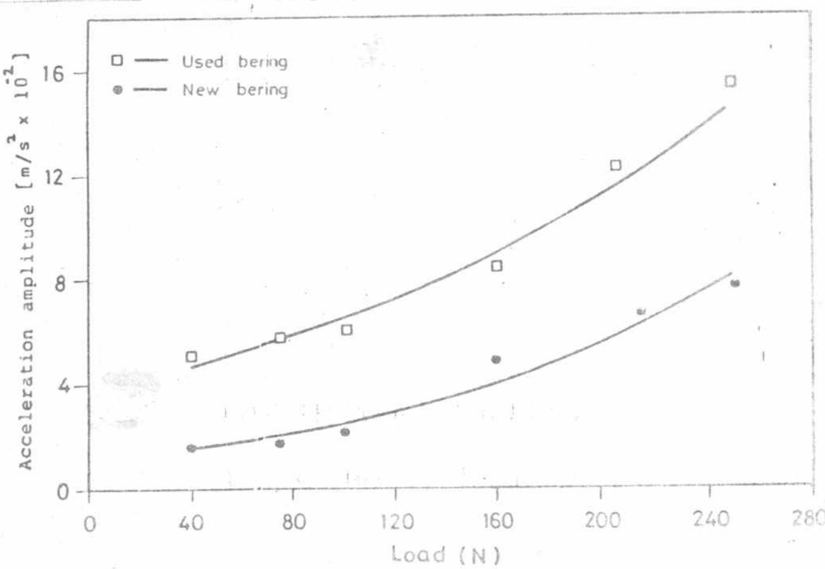

Fig. (13): Variation of acceleration amplitude with loads of new and used bearings at speed of 2000 rpm.

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CONCLUSION

The experimental results indicate that the vibrational response of the tapered roller bearing with rib roller end contact is strongly influenced by the operating conditions: axial load , speed , tolerance control, lubrication and wear .The measured vibrational amplitudes increase with increasing the load and rotor speed,bad or insufficient lubrication and with large values of mounting clearance. The rate of amplitude increase is higher at larger levels of axial loading .In case of used bearing , the amplitude increases with increasing the axial loads , but the rate of increase is higher than in case of a new bearing. Additional frequency components corresponding to the bearing defects appeared on the recorded spectra . This illustrates the possibility of using the vibration measuring techniques for diagnosis of tapered roller bearing defects.

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