DevelopingUltrasonic Sensor Technology for Measuring Roller Bearings

SATHEESAN MP

Lecturer In Mechanical Engineering,
Swami Nithyananda Polytechnic College, Kanhangad, Kasaragod Dt., Kerala

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Abstract

Damage to the bearing's working surface and the inability to determine the minimal film thickness limit the ability of most film thickness measurement methods to indicate lubrication state and warn of wear. Non-intrusive ultrasonic film thickness distribution measurements of bearings were proposed using two methods, the whole circumference measurement and the prediction based on limited measuring sites. Developing an ultrasonic thickness identification model was completed. Devices to measure film thickness and calibrate them were built.

Keyword

Sensor Technology, Ultrasonic, bearing , roller , lubricant

Introduction

Bearing failure is a common cause of costly breakdowns in rotating machinery, and rolling element bearings are critical components. It can be catastrophic to have a bearing fail in an application that is difficult to reach. Understanding load is important when it comes to bearing design and life expectancy predictions. ISO 281 is often used to estimate the life expectancy of rolling bearings at the design stage, and this works well for the majority of bearings in common applications. Many unexpected early failures have been observed in wind turbines, which have extremely variable and dynamic loads. [1] Up to one-third of wind turbine failures are attributed to gearbox bearing problems, which drastically diminish the wind turbines' availability.

For a long time, ultrasonic sensors have been a popular way to measure distance and detect objects. As the name suggests, ultrasonic sensors measure the time it takes for their produced ultrasonic pulse of sound to bounce off an object and return. Ultrasonic sensors are finding new applications due to their strengths and versatility in a range of designs as the market for autonomous robots, automobiles, and other comparable electronics continues to grow. [2]

A non-intrusive ultrasonic approach has been developed to avoid harming the interface between friction pairs. An increasing number of devices for ultrasonic film thickness detection have been created, each with a particular range of film thickness recognition. [3]

The basic advantages of ultrasonic instruments are:

- They are directed and can be found quickly and easily.
- In the event of impending mechanical failure, they give the user early warning.
- The ultrasonic range is the sole place where many problems can be detected.
- An increase in the ability to pinpoint is achieved by ignoring the aural noise. As a result, they are better able to spot issues.
- They can be used to find out if there are any leaks or if there is a risk of electric failure.
- Instruments can be employed in noisy situations.
- Depending on the maintenance programme, they might serve as a complement to or a replacement for other forms of predictive maintenance (PdM).
- They are able to make a diagnosis in a matter of moments.
- Even from within, it is feasible to isolate and repair faulty components.
- Ultrasound is more versatile because it can be utilised for a variety of purposes.
- Ultrasonic devices are non-destructive since they do not harm or interfere with the thing being tested.

- Ultrasonic testing can be carried out while the equipment is in use and still operate correctly.
- Current IRD users will have no problem utilising these tools.
- Equipment and various motor NDE bearings emit airborne sound waves that can be detected.

Elastic deformation of a medium's particles transmits sound waves, which are vibrations. The term "ultrasound" refers to vibrations above the human audible limit (Hz). For each sort of sound vibrational frequency, the range limit is depicted in Figure 1.

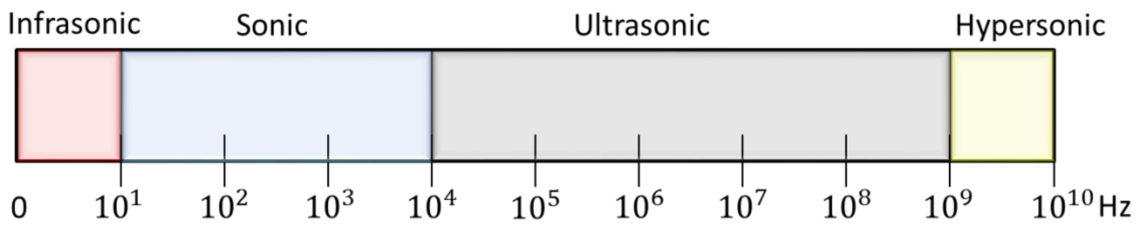

Figure 1.

For infrasonic, sonic, ultrasonical and hypersonical vibration, the frequency limits are shown in Fig 1.

Bats, for example, use ultrasonic vibrations to find their way around and locate prey. Nondestructive testing and evaluation of structures has been used in industry since the early twentieth century. Because of its versatility and wide range of applications, ultrasound is now employed in a variety of fields, including structural inspection without causing damage to structures and medical diagnosis. [5]

Review of Literature

An accurate model for determining film thicknesses more than 10μm was developed by Pialucha et al.[6] based on the resonance frequency. [7]Shown that the resonant model can also estimate film thicknesses exceeding 100μm, A reflected echo was used by Dwyer-Joyce et al.[8] to evaluate film thickness for the first time without the need of a reference signal.

For the first time, an ultrasonic approach was able to estimate distances down to 1μm in 2004, according to research by Dwyer-Joyce et al. [8]. 16 Later, they used a steel ball contact plane test equipment to conduct an experimental study on the mixed lubrication state.

One of these two vibrational viscometers was developed by Woodward (1953)[9], while the other by Rich and Roth (1953)[10]. A prototype for an on-site ultrasonic viscometer for lubricant characterisation was built for the first time. Using a Woodward viscometer, a vibrating plate controlled by a piezoelectric crystal immersed in a viscous fluid was connected with the damping it encountered.

For non-Newtonian fluids, Sheen et al. (1994)[11] attempted to use the reflectance approach to determine shear impendence by incorporating the Voigt, Maxwell, and power-law solution into the Newtonian model. It was Sheen who built the reflectance setup out of Perspex and wedges of plastic. Due to the high acoustic impedance of materials of technical importance, the sensitivity of reflection coefficient acquisition is greatly influenced (e.g.aluminium). The Newtonian model, which has been widely used, serves as the foundation for the construction of a new model for lubricant analysis.

Objectives

- Studying ultrasound technology and its benefits
- To learn about how ultrasonic sensors function.
- The multi-frequency sensor is being used to investigate an Ultrasonic system.
- To investigate the importance of viscosity in lubrication and tribology.

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Research Methodology

A research technique is a standardised approach to gathering data, analysing that data, and drawing conclusions from the findings of a study. A strategy for conducting a study is known as a research technique. Research can be described as the systematic collection and analysis of facts and information for the progress of knowledge in any subject. Using a methodical approach, the researchers hope to find solutions to theoretical and practical issues. Data for this research was gathered from a variety of published sources and is considered secondary in nature. A variety of relevant websites were used to gather the information needed to write this article.

Result and Discussion

To measure distances without touching them, these sorts of sensors have a transmitter and receiver or transceiver that can both send and decipher ultrasonic sound.[13].

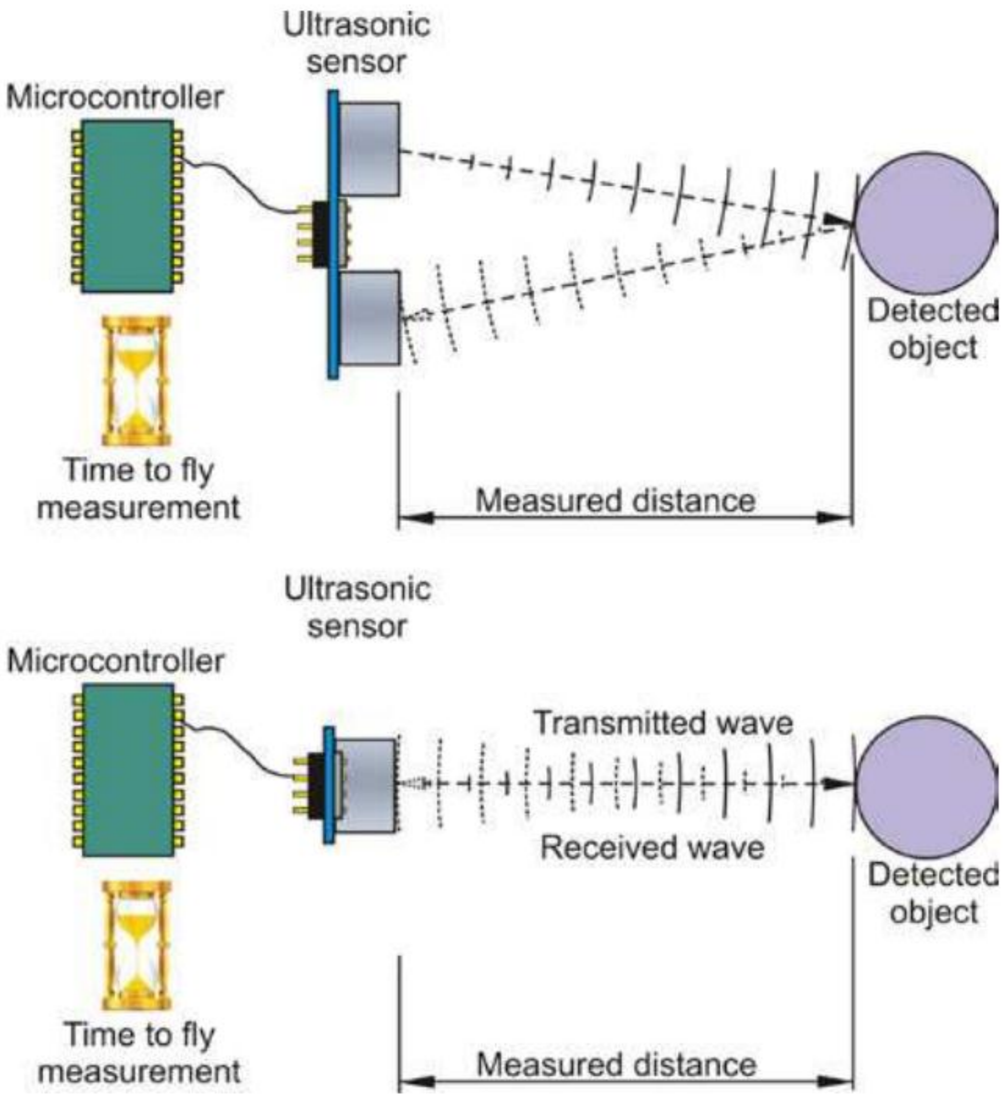

Fig. 2 Illustrates how an ultrasonic sensor works.

Collecting data was done with a system depicted in Figure 3 that measures many frequencies of sound, ultrasound, and temperature[14].

Fig.3 Multi-frequency ultrasonic sensor

In lubricated contacts, viscosity is the most critical metric to consider. There is a direct correlation between controlling this parameter and controlling both lubricant film thickness and friction in lubricated contact areas. Weak shear power, low oil viscosity, and a lower load level tolerated by the lubricated film are all linked to lower oil viscosity and higher friction values. [15]

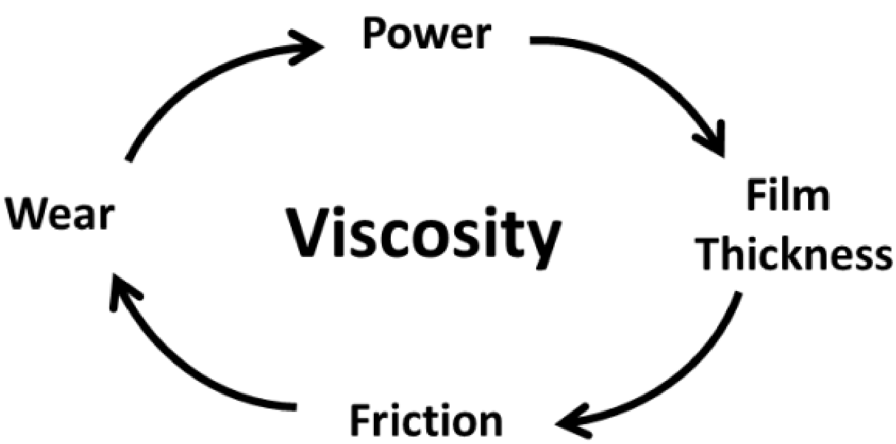

Figure 4: Lubrication and tribology depend heavily on viscosity.

Higher viscosity, on the other hand, can support higher loads and reduce contact surface wear, but it also raises the required shearing power. Viscosity has a significant impact on the lubricated contact characteristics, as shown schematically in Fig. 4.

Modeling lubricating film simulations and measuring devices are shown schematically (Fig. 5). To create and receive the necessary ultrasonic waves, an ultrasonic pulser-receiver (UPR) with an ultrasonic transducer is employed. [16] Using an electrical pulse, a transducer generates a high-frequency sound wave.

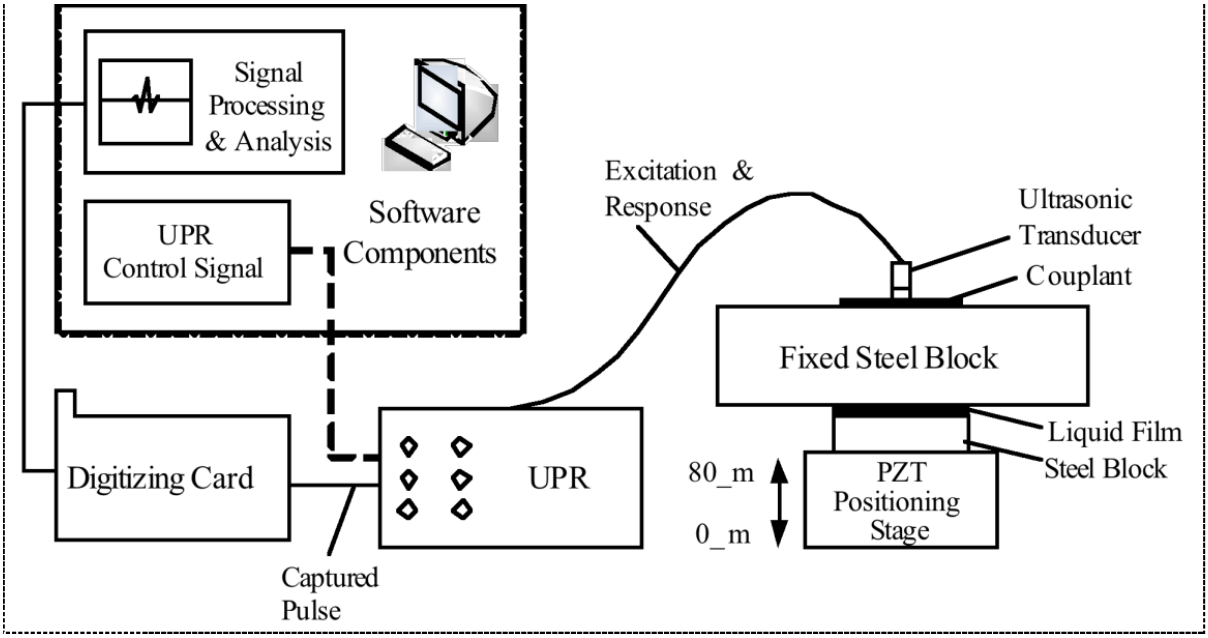

Fig. 5. The lubricating film simulation device is shown schematically

Ultrasound pulses were sent and received perpendicular to the lubricating film by placing an ultrasonic transducer with a 10 MHz centre frequency and an effective bandwidth of 7.5~13 MHZ (determined at –6 dB points). [17]

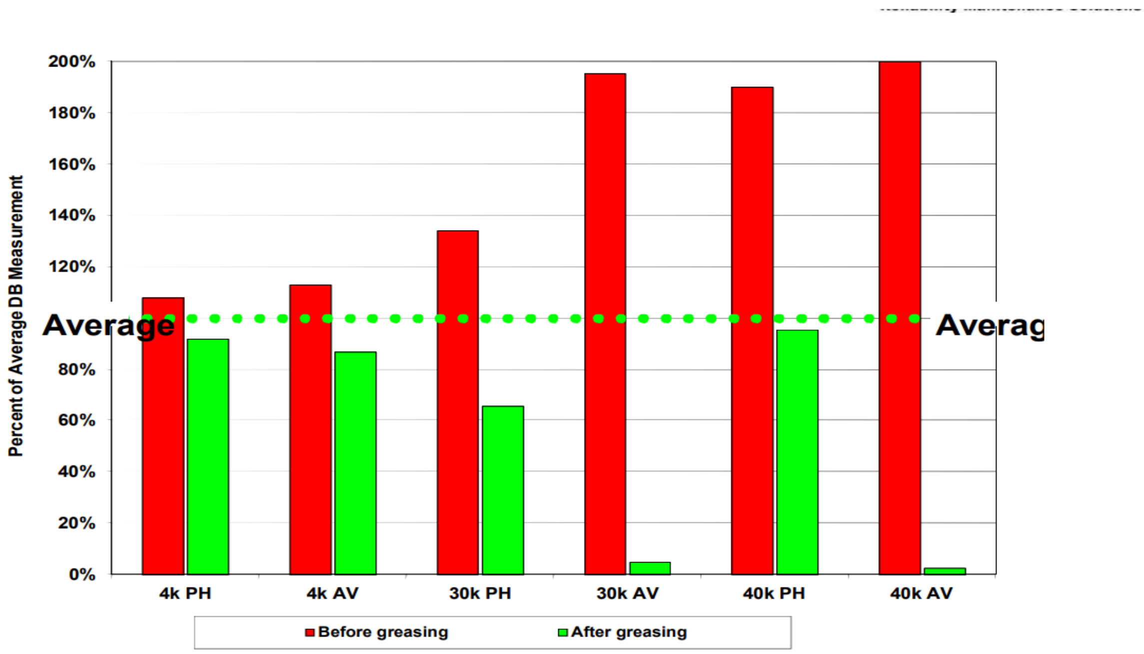

Figure 6: Grease added to a bearing has an effect

The "30k AV" and "40k AV" measurements for bearing alter dramatically, as seen in Fig 6. There are also "30k PH" and "40 PH." The "4k PH" and "4k AV" measurements reveal the tiniest shifts. [18]

Conclusion

Lubricants are necessary for the operation of machinery components. The viscosity of lubricants and lubrication is one of the most critical design characteristics. At the interface, this characteristic is connected to the thickness of the lubricant film, friction, and power of the elements. Temperature, contact pressure shear rate, and oil composition all affect viscosity. When employing a transducer with a centre frequency of 10MHz and water as lubricant, measurement accuracy isn't great in the range of film thicknesses between 40μm and 62μm. Due to the spring model approach's reduced sensitivity to film thickness variation in this region, resonance happens rarely when using resonance method. Using a transducer with a larger frequency range and altering the transducer's frequency can increase measurement accuracy in this region.

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