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Studying noise measurement and analysis

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Abstract

This paper presents some aspects regarding to sound characteristics, how the sound pressure level can be expressed, and how the sound analysis can be used for fault detection. Sound level meter is used for sound measurement, which provides measurements of sound pressure levels and displays it in units of dB. The sound level meter and different types of used transducers are briefly presented. In industrial environment noise measurements are made because useful sound cannot be separated from other noises. Motors' working is followed by vibrations and oscillations which are in audible frequency domain so any changes of the environmental noise can lead to useful information. If a fault occurs, the produced vibration sound overlaps with the base sound signal and modulation appears. In case of different faults frequency and amplitude modulations appear. The latter can be easily detected due to the sideband frequencies in the frequency spectrum. Using Matlab functions, the Power Spectral Density of a signal can be obtained. Knowing the specific frequencies due to the rotating element and analyzing the PSD of measured noise faults can be localized. If sideband frequency around the fundamental frequencies is shown, then it has the meaning of an abnormality presence.

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Keywords: noise; sound; measurement; frequency spectrum; fault detection.

1. Introduction

Sound is a common part of everyday life. The sounds can be also unpleasant or unwanted, so called noise. The level of annoyance depends on the quality of the sound and our attitude towards it. The sound can damage and

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destroy too. Sound measurements permit to determinate the level of the sound which may cause damage, or indicate a fault, and is a useful tool in noise reduction.

The sound is the result of oscillations, variations in atmospheric pressure. These pressure variations must occur at least 20 times per second to be heard. So the pressure variation per second is the frequency of the sound. The hearing domain of sound for a young person is between approximately 20 Hz up to 20 kHz, while the range from the lowest to highest note of a piano is 27.5 Hz to 4186 Hz.

The pressure variations travel through the medium. The speed of sound at room temperature is 344m/s. The sound is characterized through the wavelength also. The wavelength is the distance from one peak to the next in case of a sinusoidal sound pressure variation. The wavelength λ can be calculated from the speed v and frequency f of the sound: $\lambda = v/f$ This equation shows that large wavelength corresponds for low frequencies and for small wavelength corresponds to high frequencies (at 10 kHz the wavelength is 3.44cm).

A sound with one frequency is a pure tone. In practice there are no pure tones; sounds are made up of different frequencies. The industrial noises consist of a mixture of frequencies which is called broad band noise. In mathematics or measurements the white noise is often used, which is a sound with frequencies evenly distributed in the hearing domain. [2]

The sound can be characterized through the amplitude of the pressure variations. The human ear can detect an amplitude of 20 millionths of a Pascal. Express the sound amplitude in Pa results very large numbers. For this reason for sound measure it is used the decibel or dB scale. Using the logarithms scale comparing the sound pressure of one sound with another becomes easier.

The following definition gives the level of sound pressure p in decibels:

$$SPL = 10\log_{10}\left(\frac{p^2}{p_{ref}^2}\right) dB \tag{1}$$

Where SPL is the Sound Pressure Level in *dB; p* is the sound pressure fluctuation (above or below atmospheric pressure) and p_{ref} is 20 micropascals (2 x 10^{-5}Pa), which is approximately the threshold of hearing.

In this scale the normal conversation has 60-70dB, noise caused by traffic has 85-90dB, lawn mower 90-100dB, chain saw 110dB.

The threshold of human hearing varies with frequency; it is most sensitive to middle frequencies and less sensitive to lower and higher frequencies. To analyze noise, both frequency and amplitude need to be taken into account. The sound or noise level measurements are made using A-weighted filter, and the measurement unit is A-weighted decibels, dBA. The A-weighting filter has a frequency response corresponding to that of human hearing (in level range about 40 dBA). The sound level expressed in dBA expresses the loudness of the sound. A detectable change in level is circa 3-5dBA.

The ambient noise varies in level over time and to describe the noise variation with time there are used three statistical characteristics. If a noise level having XdBA exceeded 20% of the time during the measuring period, this result would be expressed with LA20 of XdBA. The LA90 characteristic is used to measure the average minimum or background A-weighted noise level. The third characteristic is the LAeq (A-weighted equivalent continuous noise level), and express the constant sound pressure level which is equivalent to the varying sound level over the measurement time. These have the same acoustic energy. [1],[2],[3]

2. The sound level meter

The sound level meter provides measurements of sound pressure level and displays it in units of dB. The bloc diagram of a sound level meter is shown on Fig. 1. [2],[4]

The input of the instrument is the microphone which converts the sound signal to an electrical signal. The sensitivity of the microphone determinates the measurement precision. There are four types of microphones which can be used in sound level meters: piezoelectric type, condenser type, electret and dynamic type. [6]