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Engine Sound Analyzer Using Fast Fourier Transform and Application for Motorcycle Engines

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Abstract

Various types of faults of the gasoline engine may result in similar symptoms. Sound analysis of engine has been conducted to diagnose the engine faults. This study presents a study of sound analysis of the normal engine and the engine with several different fault conditions. The motorcycle gasoline engine was our target of this study. The engine sound has been recorded by using a sound Cather Kowaseiki (Kek-7-1) at the engine with pre-determined directions base on Honda standart maintenance. The conditions of engine faults including idling condition and the engine that is not smooth while idling. In the signal processing of the sound, we use three signal features including fundamental frequency, Fast Fourier Transform and 3D analysis diagram. Thereafter, the important differences between normal engine and the fault engines are concluded. These proposed signal features can be used to discriminate all faulth conditions and the engine with normal condition effectively.

Keywords: Sound analysis, frequency, gasoline engine

INTRODUCTION

Motorcycle is a vehicle that is still the main choice as a means of transportation for most of the population in Indonesia. Based on data from the Indonesian Motorcycle Industry Association, motorcycle sales in Indonesia in 2017 reached 5,886,103 units of motorcycles, and in 2017 Honda managed 74.5% market share by selling 4,385,888 units of motorcycles. Astra Honda Motor (AHM) provides maintenance and motor support through the development of Astra Honda Authorized Service Station (AHASS). Maintenance was first popularized in Japan in 1950 using the PM (Preventive Maintenance) system. Predictive Maintenance is a technique to analyze the condition of the machine to predict the performance / condition of the machine, this technique pertained in nondestructive technique that aims to predict machine maintenance [1]. Predictive maintenance can be done in various ways one of them is by analyzing the noise. In essence the machine is a collection of several components that work together to produce a function.

In 2017 Astra Honda Motor has 3142 AHASS and 19,725 mechanics spread all over Indonesia. Consumers coming to AHASS in 2017 are 35,471,847 motorcycles. At AHASS there are several mechanics that are divided into several Technical Training Levels based on the work performed. Mechanical TTL-1 is mechanical maintenance, mechanical TTL-2 is mechanical and mechanical repair TTL-3 is a mechanical diagnosis, current mechanical composition TTL1-36%, TTL2-41% and TTL3-14%, and techniques of recognizing engine damage through new sounds are taught on TTL 3 mechanics.

When a machine is operating the machine will produce sound. Engine sound Signal processing is an important technique to separate various noise sources. FFT transformations have been used as an effective method of signal analysis [2]. These transformations have many transient parts, hence are unsuitable [3]. In recent years linear and bi linear time frequency distributions have been used as an alternatives [4]. Both of these methods have their own advantages and short comings. The former one has low resolutions while the latter one has low processing speed and is complex [5]. In this work time frequency analysis have been done on signals acquired from a gasoline engine test rig. Noise in an engine consists of several components like flow based noise, combustion noise, mechanical noise, etc [6]. Combustion noise is produced due to rapid change in pressure which causes vibrations and resonance of combustion chamber. As the piston moves from TDC to BDC, the gap between liner and piston causes impact of piston with walls of cylinder which is known as piston slap [6]. Motion of rotary parts adds low frequency components to overall noise levels. Gears, injectors and valve motion also contribute towards transient components of noise

MATERIALS AND METHODS

A. Experimental Design

The experimental design is presented in Fig. 1. It is a diagram for sound signals of the engine. It can be seen that the signals are collected into an engine database and a fault engine database as depicted in the top of the figure. The calculation of signal parameters is performed for both of the engine database and the fault engine database. The signal parameters from both databases are subsequently compared. After that the empirical differences between normal engine and the fault engines are investigated from the corresponding figures. All in all the data analysis is performed to show the differences between the normal engines the simulated fault engines. Three following important conditions of engine faults are selected from a number of conditions of engine faults which are normally found in the engine mechanic workshop. The gasoline engine from Honda Scooter with code engine k25 with 1 cylinders of 110-cc displacement is chosen as a test bed, and with this engine we test for two conditions:

- Engine smooth while idling
- Engine is not smooth while idling (ripple)

B. Parameter Calculation

Several were variations on the theme of using a heterodyne analyzer for performing the “frequency” analysis on a linear frequency scale with constant bandwidth, first to obtain the original power spectrum on a log amplitude scale, and then the second analysis of the log spectrum to the cepstrum on a linear scale. In between, the log spectrum was stored in a medium, which could either be a circulating digital memory (a Digital Event Recorder type 7502). There are many situations where editing could be carried out by modification of the amplitude only, which could be achieved using the real cepstrum. The modified amplitude spectrum can then be combined with the original phase spectrum of each record to generate an edited time record. A case in point is where discrete frequencies are to be removed. Whole families of uniformly spaced harmonics or sidebands can be removed by removing a small number of rahmonics in the cepstrum. Removing a discrete frequency really means setting the value at that frequency to the expected value of the noise, of which the best guide are the frequency components on either side of the discrete frequency, but usually at a much lower level.

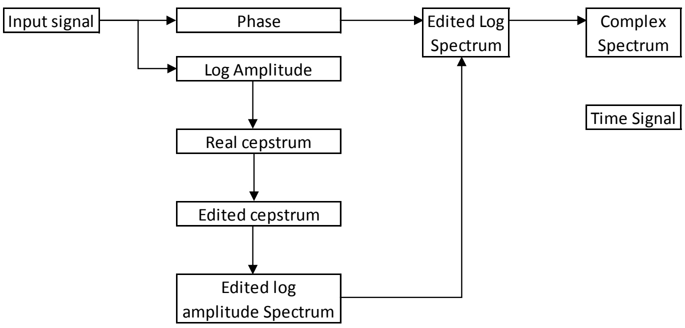

Figure 1. Cepstral analysis procedure of the signal database

The principle of the procedure is shown in Figure 1, where the original phase of each record is retained for combination with the modified amplitude obtained by liftering the real cepstrum.

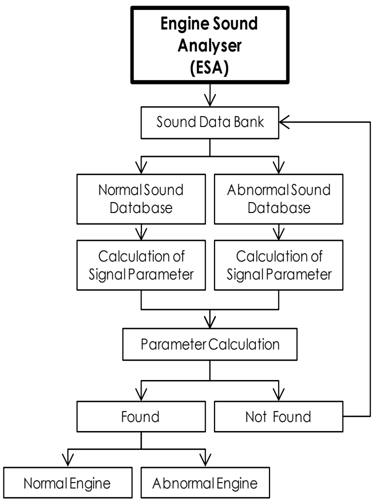

Figure 2. Block diagram of the experimental design for sound signals

The Principe of the procedure is shown in Figure 2, is the step of data verification process on Abnormal engine Sound Analyzer.

C. Parameter Comparison

The sound signal database is separated into two casesof normal engine and fault engine. In case of fault enginedatabases, there are three subsets for three importantconditions of engine faults including the engine that isnot smooth while idling (ripple), the engine that goes

RESULT

Signal from motorcycle gasoline engine capture using sound *sound cather kowaseiki kek-7-1* and process using sound wave 6.0. In this experiment I gave a deviation on the tappet looseness. Signal from engine computed into three ways. They are shown in the following figures comparatively.

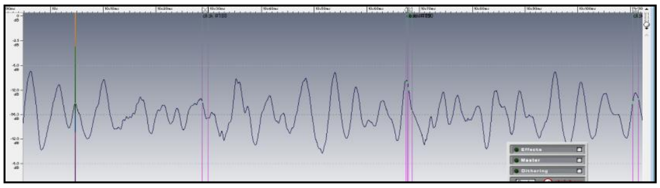

Figure 3. Sound signal Diagram for Normal Tappet

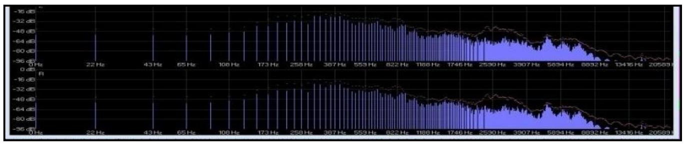

Figure 4. FFT analysis Diagram for Normal Tappet

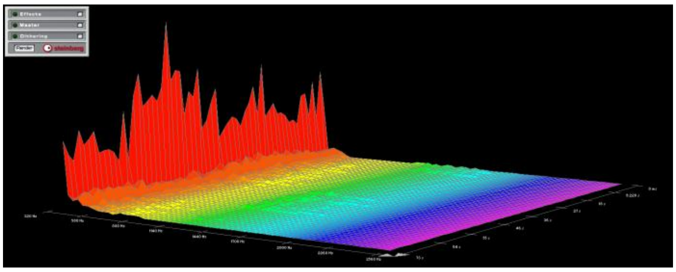

Figure 5. 3D Frequency Analysis for Normal Tappet

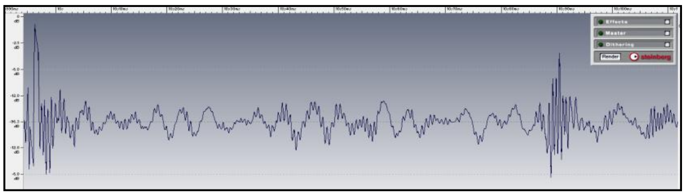

Figure 6. Sound signal Diagram for Abnormal Tappet

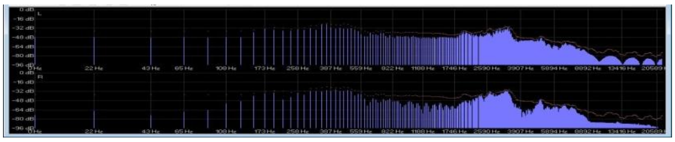

Figure 7. FFT analysis Diagram for Normal Tappet

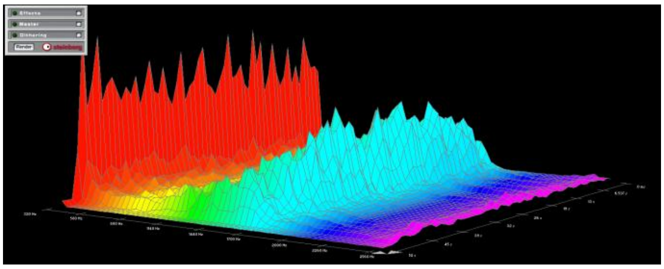

Figure 8. 3D Frequency Analysis for Abnormal Tappet

DISCUSSION

Considering the parameters of the sound of the engine in Fig. 3-8, it can be seen that the signal, Fast Fourier diagram, 3D Frequency Analysis are different for fault and normal case. In case of normal engine and the engine that is abnormal while idling the variance is have a many variables. For figure 5 and figure 8 graph built with frequency range 320 Hz to 2500 Hz if we compare the spectrum we can see how frequency spectrum is distributed in a mix.

CONCLUSION

The study of sound analysis of engine with two different conditions including the engine that is smooth while idling and not smooth while idling (ripple). Three parameters of signal features of sound signals from both normal engine and fault engine databases are calculated and subsequently compared. The significant differences between normal engine and the fault engines are presented from the corresponding figures. The signal parameters are explicitly able to discriminate fault engines and the normal engine.

CONCLUSION

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