Noise Diagnostic and Reduction of a Scooter Engine Motorcycle

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Abstract: This paper presents an appropriate way to reduce the noise of a scooter engine motorcycle. The lead covering method is used to rank the noise sources of each engine component. With the noise spectra from measuring the pass-by noise and releasing the lead cover on each component sequentially, the correlations between specific frequencies and each component of the engine have been found. Furthermore, it is shown that the airborne noise comes from air cleaner or muffler. Additionally, the power transmission mechanism like cvt generates the structure-borne noise. Based on above results, some modifications of the scooter have been done. Finally, the pass-by noise level of the scooter is reduced by 2.5 dB(A).

MOTIVATION

Because the noise regulations for the motorcycle are more and more strict, the pass-by noise level of our scooter ought to be reduced. Besides, the arrangements of components are very compact and the noise characteristics are also different. It's inevitable that different kinds of measurements must be used in the diagnostic analysis.

DIAGNOSTICS OF THE NOISE SOURCE

In this research, three types of measurements have been done to diagnose the noise sources. Meanwhile cross-verifications have been made to ensure the correctness of these results.

1. Source ranking measurement
All of the components are covered by the lead sheets in the pass-by noise measurement. The test is followed by CNS 3110 standard (1), and the approaching speed is 40km/h. In the tests, the noise of each component is recorded before and after releasing the lead cover. Therefore, the noise contributions of all components are found to set the priority during the improvement (Table 1).

With the noise spectra before and after releasing, the source of particular frequency can be located as the peak increases abruptly. If that frequency is found from the spectrum of an original scooter, the noise source can be verified.

<table>
<thead>
<tr>
<th>Component</th>
<th>Contribution (%)</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left side of cvt</td>
<td>47.9</td>
<td>1</td>
</tr>
<tr>
<td>Front part of ext. pipe</td>
<td>17.4</td>
<td>2</td>
</tr>
<tr>
<td>Piston</td>
<td>10.5</td>
<td>4</td>
</tr>
<tr>
<td>Button, rear and top side of crankcase</td>
<td>6.8</td>
<td>5</td>
</tr>
<tr>
<td>Tail pipe</td>
<td>3.5</td>
<td>6</td>
</tr>
<tr>
<td>Others</td>
<td>13.9</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>-</td>
</tr>
</tbody>
</table>

2. Test rig measurements
The pass-by noise spectrum can be divided into airborne noise and structure-borne noise. The airborne noise usually comes from air cleaner or muffler, and the power transmission mechanism like cvt or crankcase generates the structure-borne noise. Transmission loss test and structure excitation test are used to diagnose these two kinds of noise sources.

(1) Transmission loss test
This test has been done in a semi-anechoic chamber. A shaker is used to excite the air at the noise generating side of the component to get the sound attenuation between two sides. It is shown that there exists 315Hz peak (local min.) for the muffler. The frequency peak approaches 400Hz (1/3 octave band) in the source ranking measurement. The air cleaner also generates 350Hz noise peak.

(2) Structure excitation test
Because there are radiation noise and transmission noise in the structure-borne noise, weighting of those must be understood to find and improve the noise sources. The whole engine is hung under a test frame and excited by a shaker near the piston to simulate the actual excitation (Figure 1). The vibration (X) and the near field noise (Lp)
are measured at the specific point on the cover of the component (2). The relationship between them are derived from 3 functions: $X/F \cdot LP/F \cdot LP/X$. It is shown that there are strong radiation noises at 2.26kHz and 1.8kHz for the cvt cover and crankcase cover respectively. These frequencies correspond to 2.5kHz and 2kHz(1/3 octave band) noise in the source ranking measurement (3).

![Figure 1](image)

**FIGURE 1.** The diagram of structure excitation test

(3) Crankshaft modal test
Since the noise of crankcase in the source ranking test seems complicated, the structure behavior of crankshaft must be inspected specially. The accelerometers are mounted on both bearings of crankshaft. It is shown that the noise frequencies at 1.2kHz(1" bending mode) and 1.9kHz(1" torsional mode) corresponds to 1.25kHz and 2kHz(1/3 octave band) noise in the source ranking measurement (3).

**NOISE REDUCTION**

1. Component modifications
From the cross verifications of the diagnostics above, there comes some conclusions; (1) 2.3kHz noise excited by the resonance of cvt cover, (2) 1.2kHz and 1.9kHz noise excited by the crankshaft, (3) 315Hz noise generated by the muffler, (4) 350Hz noise generated by the aircleaner. Some modifications have been done as following:
   (1) The cvt cover and the crankcase cover are covered by the high density materials.
   (2) The isolation materials are added between covers and the engine.
   (3) An additional layer is added on the exhaust pipe.
   (4) The outer side of the aircleaner is covered by the high density materials.

2. Verification tests
   (1) Structure excitation of the crankcase cover
   The test is similar to the structure excitation test in the diagnostics except that the crankcase cover is covered by the high density materials. The noise at 1.8kHz is reduced from 1.09Pa/N to 0.044Pa/N. The improvement is obvious (Figure 2).

![Figure 2](image)

**FIGURE 2.** Noise reduction at the near field of the crankcase cover

(2) Pass-by noise measurement
When all the modifications mentioned above have been done, it is found that the pass-by noise is reduced by 2.5dB(A). It means that 44% attenuation of the noise energy is obtained. The improvement is great because the both sides noise spectra are comparably reduced, especially above 2kHz range.

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**REFERENCES**


2556