Analysis on the Noise Reduction of Engine with Air Intake Resonator in Engine Intake System

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***Abstract*—Recently, this car is already an essential transport for all families. However, the car will cause a certain degree of environmental pollution, air pollution and noise pollution. Noise inside the car includes intake noise and exhaust noise. This article will investigate how to reduce engine noise in the intake system. For the driver to create a comfortable driving environment and reduce the noise generated by the gas flow in the intake system. We will design the resonance of the engine's intake pipe to find the best design and settings for the best intake pipe resonator. Since the car's intake noise is a major source of vehicle noise and therefore includes airflow noise, we will design the resonator design to study the effects of airflow. Traditionally, the use of integrated resonators has been one of the ways to eliminate rumbling noise caused by the acoustic resonance of air ducts. So in the dissertation, the resonator is placed beside the branch pipe to compare the design and position of the resonator and find out the best design and position of the engine noise reduction.**

Keyword - Intake noise reduce, Intake system, Air flow, Resonator, Engine

I. INTRODUCTION

Recently, this car is already an essential transport for all families. In the automotive market, parts are being developed to produce cars that meet the growing needs of consumers. Due to people-oriented vehicles and development, technologies to reduce vehicle noise and vibration are rapidly increasing. In particular, automotive engine manufacturers are focusing on the noise generated by the air intake system. In the vehicle noise, the noise reduction of the air intake system plays a very important role. The entire system that the car takes in outside air to the engine cylinder is called the air intake system. The intake system consists of a breathing tube, duct, resonator, air cleaner, throttle and manifold. The noise below 600 Hz generated here is called intake noise. This noise is known to be mainly due to the pressure pulsations and resonance phenomena of the air flow inside the intake system. From NVH's point of view, the intake noise is very important, accounting for about 30% of the total vehicle noise. Although the Helmholtz resonator is currently used to suppress the highest frequency of intake noise, it always requires a neck and a cavity due to its characteristics and is greatly limited in the nacelle in a limited space. In the normal development and design of vehicles, taking into account the audible frequency audible frequency (16Hz ~ 20kHz), is trying to reduce the intake noise of 60 ~ 200Hz. In particular, an intake system is recently being installed with pipes made of PET (polyethylene terephthalate) materials and resonators and the like in order to reduce exhaust noise and intake noise of the engine.

Therefore, in this paper, a pipe integrated resonator that can reduce the space occupation in the engine room will be introduced, a direct comparison with the Helmholtz resonator through the change of the neck, and considering how much performance improvement can be achieved. So in the dissertation, the resonator is placed beside the branch pipe to compare the design and position of the resonator and find out the best design and position of the engine noise reduction.

II. HELMHOLTZ RESONATOR MODEL

The Helmholtz resonator or the Helmholtz oscillator is a container with a gas (usually air) with a naked eye (or neck or port). Due to the "resilience" of the interior air, the volume of air in and near the aperture vibrates.

Although Figure 1 shows a simplified typical resonator, a Helmholtz resonator for an intake and exhaust system of a car generally has a different form from Figure 1, is easy to produce due to space limitations, Noise and other adjacent components. Like equation (1) as shown.

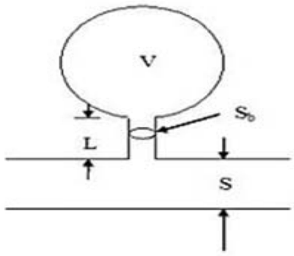


Figure 1: The simplified typical resonator

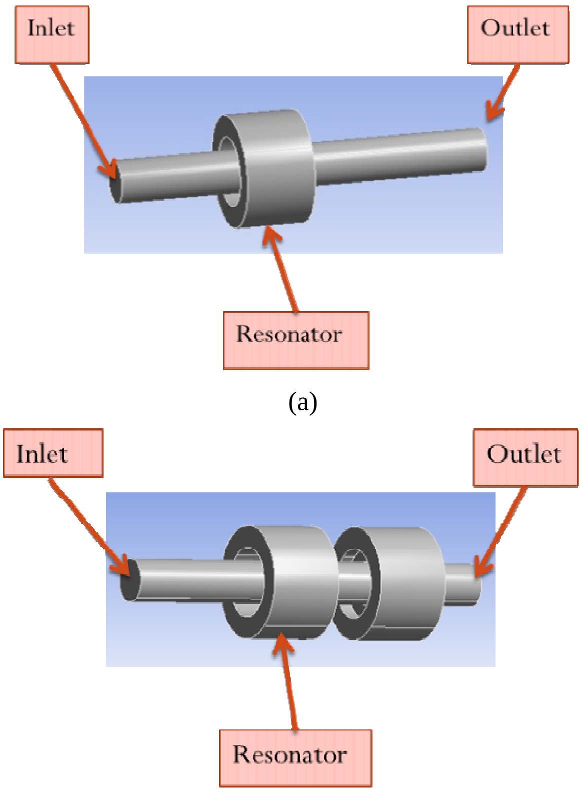
Analytical methods that predict the noise reduction performance of a Helmholtz resonator vary with its shape and frequency of interest. The simplest lumped model allows the resonant frequency to be predicted by the following equation when the wavelength satisfies a considerable condition compared to the size of the resonator.

$$f = \frac{c}{2\pi}\sqrt{\frac{S_b}{LV}} \qquad (1)$$

Where S_b is neck cross section area, L is neck length, V is cavity volume and c is speed of sound.

III. THE DESIGN OF THE RESONATOR

As described in this article, in the engine's intake system, we can set the new design of the resonator based on Figure 1, set up one or two cavities around the pipeline, in this system, as shown in Figure 2, Install on the existing intake system piping. In the new design, one or two cavities can be installed around the pipe to compare the data to find the best design. We keep the neck and cavity at a constant value.



(b)

Figure 2: The design of the new resonator.

Design specification (mm)

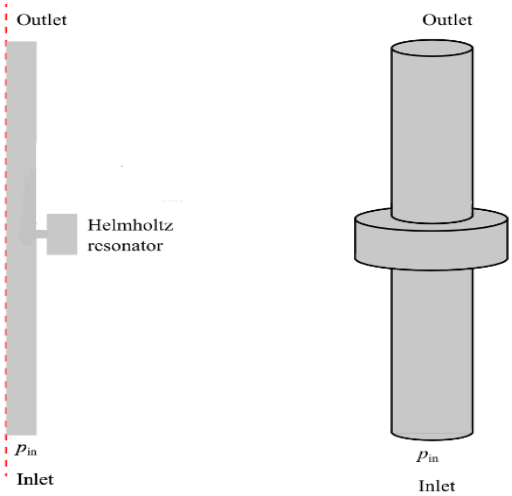


Figure 3: The design specification of the resonator

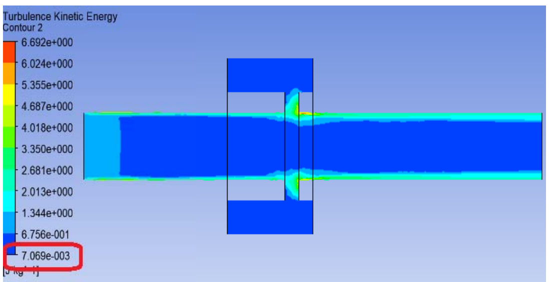
As shown in the figure above, we set the resonator design and fabricated the same size case 2 resonator to design the resonator around the pipe. In order to compare the effects of resonators (pressure and turbulent kinetic energy) on the air flow, a better one is found to reduce the air flow noise.

In the picture above, we compared different designs, just like different neck sizes, by analyzing the new design and comparing the results with the different designs by examining the direct effects and performance of pipe-integrated cavity necks. The cavity length and neck size are set to be consistent and analyzed.

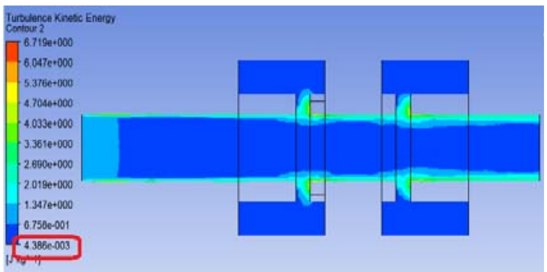
IV. The Result of the Analysis

With the different of the duct resonator designs, the results through ANSYS program were checked, through the analysis by this program find the variation occurred in the pipe, and find the optimum design of the duct resonator for the intake system analysis.

In the analysis results, the turbulent kinetic energy is shown in Figure 4. That is, the acoustic energy level is the same as the turbulent kinetic energy, so in Figure 4, we can find the minimum turbulent kinetic energy. In this simulation, different numbers of lumens result in different values. The first one shows that the minimum value is 7.069e-003 and the second one is 4.836e-003. So in this result we can see that the second resonator can affect the noise level and reduce the noise. Therefore, an analysis was conducted to examine the flow variation due to the newly installed pipe integrated resonator. As an analysis condition, the two transmission losses are compared as shown in Table 1, and the second transmission loss is superior to the first one. In this simulation, each TL is conspicuous at a frequency of 22.5891 Hz. Under this frequency condition, the change of TL is better than other frequency conditions.



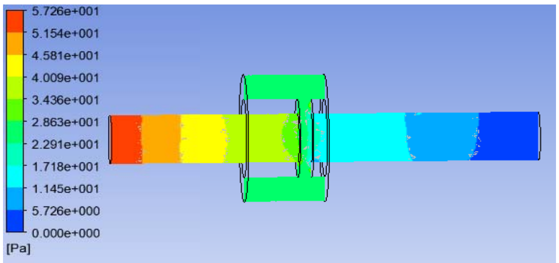
(a)



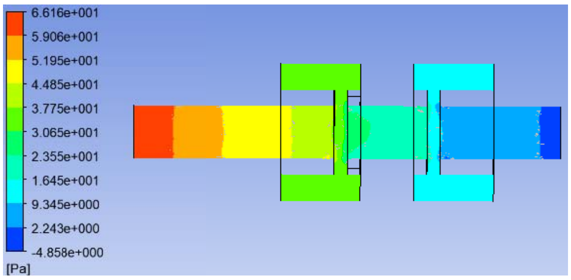
(b)

Figure 4: The Turbulence Kinetic Energy of the different cavity number.

In this experiment analysis, we can compare the pressure regions, through the pressure conditions can find the pressure drop scope, thereby we can find the air flow speed, because the low pressure produces the high air flow speed, and in another words, at the high pressure can make the air flow speed slow. So through add the resonator number make the air speed smooth flow, and make the noise reduction. Like as Figure 5 shown blew.



(a)



(b)

Figure 5: The pressure distribution of the different resonator conditions

Above Figure 5 figures show us the distribution of pressure, in order to compare pressure distribution in the different numebr of resonator condicitons, so according to pressure variation can find the resonator number 2 can make the air flow velocity profluent. In the picture 5(a) we can see the pressure's drop very sudden, like this suddenly to drop can cause the air flow speed up, make high noise, in the picture 5(b) the pressure drop gentle, like steady pressure can cause the velocity steady. Because the gentle drop in pressure leads to a steady flow of velocity.

TABLE 1. The different TLs with same frequency

	1	2
Frequency (Hz)	Transmission Loss (dB)	Transmission Loss (dB)
16	6.6532	17.4795
22.5891	0.27333	3.72856
45.0254	0.963343	1.17401
63.5678	0.457561	0.968241
89.7463	2.61026	2.9425
126.7056	10.3994	11.8224
178.8854	24.8313	26.7984
252.554	67.2434	64.2841

V. CONCLUSION

In this article, with the resonator design, we set the consistent neck and cavity, add the resonator number, compare the turbulence kinetic energy and TL(transmission loss) level find the effect of the resonator for noise reduction.

1. The number of the resonator has effect for the noise reduction.
2. At 22.5891Hz frequency, TL's various features are obvious. Under this frequency condition, the change of TL is better than other frequency conditions.
3. The Turbulence Kinetic Energy has obvious difference effect with the different number resonator. The two resonators are better than the one resonator set around the duct.

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