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Exhaust Energy Conversion Through Transducer

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Abstract

Energy exists everywhere in every form, but it's up to human ability to convert into work. Likewise, a vehicle loses its energy in many ways such as

- Engine loss - 62.4%
- Idling loss – 17.2%
- Accessories – 2.2%
- Drive line loss – 5.6%
- Aerodynamic drag – 2.6%
- Rolling resistance – 4.2%
- Braking loss – 5.8%

In this above losses accessorial energy loss can be compensated up by the sound energy generated by the engine. It may sound weird, but if know how exactly sounds are reproduced by the engine; it may resolve the losses due to accessories.First of all where does the sound come from? Sound is a pressure wave formed from pulses of alternating high and low air pressure which are created when an exhaust valve opens resulting in a burst of high-pressure gas suddenly entering the exhaust system. It is possible to add two or more sound waves together and get less sound. This principle of destructive interference is what actually happens in a vehicle exhaust system. The two waves that are out of phase with each other add up to zero and cancel each other. But, when these two waves are in phase with each other, they add up to a wave of same frequency producing twice the amplitude of the incident wave. This is known as constructive interference. Now, by the help of an acoustical transducer, the high amplitude resultant wave can be converted in to an electrical current of definite voltage. Hence, by the principle of constructive interference, the sound energy generated by an engine can be utilized to run the accessories like AC, power steering, windshield wipers, etc.

1. Introduction

In an Engine, pulses of alternating high and low pressure are created when an exhaust valve opens and a burst of high-pressure gas suddenly enters the exhaust system. The molecules in this gas collide with the lower-pressure molecules in the pipe, causing them to stack up on each other. In this way the sound wave makes its way down the pipe much faster than the actual gases do. A higher wave frequency simply means that the air pressure fluctuates faster. The faster an engine runs, the higher the pitch we hear. Likewise slower fluctuations produce low pitch sound. The wave's amplitude determines how loud the sound is. It is possible to add two or more sound waves together to get less sound. The key thing about sound wave is that the resultant sound you hear is the sum of all the sound waves that are hitting your ear drum at that time. Suppose you are listening to an orchestra, even though you may hear several distinct sources of musical notes, the number of pressure waves hitting your ear drum adds together, so your ear interprets only one pressure at any given moment. Now, it is possible to produce a sound wave that is exactly the opposite of another wave. This forms the basis of designing of headphones that are capable of canceling out noises. When the first and the second waves are in phase with each other, they add up to a wave of same frequency but twice the amplitude of incident waves. This is known as constructive interference. But, when these two waves are out phase with each other, they add up to zero. This is known as destructive interference. By the principle of destructive interference, when the first wave is at its maximum pressure and the second wave is at its minimum pressure, if both of these waves hit our ear drum at the same time, then we would hear nothing as the two waves add up to zero. This is what actually happens in the exhaust system of a vehicle.

2. Muffler

A muffler is a device which is fixed to the exhaust pipe to reduce the noise made by the engine. Located inside a muffler is a set of tubes, which are designed to create reflected waves that interfere with each other. The exhaust gas and the sound waves enter through the center tube of the muffler. They bounce to the back wall of the muffler and are reflected through a hole into the main body of the muffler. They leave the muffler by passing through a set of holes into another chamber, where they turn and go out to the last pipe.

3. Resonator

It is a chamber that is connected to the first chamber by a hole. It contains a specific volume of air and has a specific length that is calculated to produce a wave that cancels out a certain frequency of sound. When a wave hits the hole, part of it continues into the chamber and part of it reflected. The wave travels through the chamber, hits the back wall of the muffler and bounces back out of the hole. The length of this chamber is calculated so that this wave leaves the resonator chamber just after the next wave reflects off the outside of the chamber. The high-pressure part of the wave that came

from the chamber will line up with the low-pressure part of the wave that was reflected off the outside of the chamber wall. Hence, the two waves will cancel out each other.

4. Transducer

A transducer is a device which converts any form of energy into electrical energy. In an acoustical transducer, the sound energy from the source is converted into electrical energy of definite voltage. A microphone is an example of acoustical transducer, which interprets the sound energy and converts it into electrical energy. The different types of microphones are dynamic, ribbon, condenser, crystal and electret microphones. A microphone usually consists of a diaphragm, a coiled wire or voice coil, a magnet which produces uniform magnetic field and an audio output. In our experiment, we are going to use a dynamic transducer, which converts the incident sound energy into electric current.

5. Dynamic Transducer

A dynamic transducer is the one, which uses wire coil, permanent magnet and a thin curtain like diaphragm as its components.It consists of a thin diaphragm attached to the wire coil, so that the movement in diaphragm produces a longitudinal motion on the wire coil. The wire coil is wounded over a permanent magnet, which produces an uniform magnetic field. The output is drawn out from the ends of the wire coil.

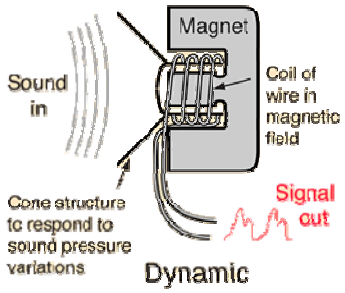

Fig. 1: A dynamic transducer which accepts sound, causing the motion of wire coil in the magnetic field.

6. Principle

When sound is made to incident on the diaphragm the coil wire moves over the uniform magnetic field,which produces a voltage across it. A moving coil inside a uniform magnetic field produces an electric current.

6.1 Working

When a sound of certain loudness is made to incident on the diaphragm of the transducer, it transfers the mechanical disturbance to the coil that is connected to it. This wire coil, which is wounded over a magnet, undergoes fluctuations,those results in the production of electric current. The motion of the coil affects the magnetic field

of the permanent magnet, so it generates voltage across the wire coil. The movement of the coil depends on the amount of fluctuations of the diaphragm, which in turn is decided by the frequency and loudness of the incident sound. In this situation, the sound source is the noise made by the engine, when it is in the working mode. Faster the engine running more will be the frequency and loudness of the sound coming from it.

$V = B*l*v$

Where,

"V" is the voltage generated,

"B" is the magnetic field,

"l" is the length of the conductor,

"v" is the velocity of the coil.

7. Implementation

Coming to the exhaust system of a vehicle, it consists of resonator and a muffler, which is used to reduce the sound made by the engine. By eliminating those sound reducing devices, a high efficient dynamic transducer can be placed at the exhaust pipe. This could convert the sound energy into electrical energy, but requires some measures for its efficient working. It is necessary that it must possess impedance which produces higher output voltage and the transducer must be unidirectional, which picks up sound from one direction only. The sound coming from the engine must undergo constructive interference and focused towardsthe diaphragm of the transducer, so that it is utilized to the maximum. Now, the sound energy hitting the diaphragm puts the wire coil under fluctuation which changes magnetic field enclosed by it, resulting in the generation of current of definite voltage. The sound of an engine without a silencer lies around 130db which can feed the 12 volt electrical system of a vehicle. Hence, by the principle of constructive interference and with the help of a transducer, the sound energy could be converted into electrical energy to feed the accessories of a vehicle which draws 2% of the total output of the vehicle.

8. Conclusion

Sound is a mechanical disturbance produced in the air, which can be converted into electrical energy by the means of an efficient transducer. The sound from the exhaust system of a vehicle is not to be reduced or cancelled out; rather it could be made to undergo constructive interference, before passing through a transducer for producing current. The 2% loss of vehicle's energy could be compensated by this technic by using an efficient transducer. The main disadvantage about this is, it may not work if we use an ordinary commercial transducer, due to its inefficiency. So, research as to be done in this part, to make this technic work 100%, commercially all over the globe.

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