Electrically Actuated Vehicle Exhaust Switch
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Abstract:
In countries like India, where the fuel prices are rising continuously, the need for higher fuel efficiency arises. This causes the automobile companies to design cars which provide higher fuel efficiencies but compromise on the power delivered by the engine. The engines are designed to provide significantly more power than what is told to the customer but due to fuel efficiency constraints, the true potential of the engine is not harnessed. There are various methods and ways to increase mileage on the cost of power like fuel injection tuning, using low air flow air filter, using reactive type muffler for the exhaust, installing speed control governors etc. Now these parameters can be varied in order to improve the performance of the engine, to provide more combustion and therefore more horsepower. But all this power increase doesn’t come free of cost; there will be a slight drop in the fuel efficiency as higher amount of fuel is required for more combustion in order to produce higher power. This project report suggests a method as to how we can incorporate both effective mileage and considerable increase in power of the vehicle.

Keywords: Fuel efficiency, automobile companies, power delivered, reactive type muffler, horsepower, effective mileage.

I. INTRODUCTION
The exhaust of an automobile is a very important part of the machine, in fact after the engine the exhaust system soaks up the most R&D resources. That’s because the pipe is critical for the vehicle’s performance, its sound and of course its compliance with various noise and emission regulations. The stock exhaust provides the automobile all the parameters required for the vehicle to run at a decent speed and standard power. But the engine of any car is way more powerful than we are told. It is only limited by the exhaust attached to it. The stock exhaust has a muffler which has bigger holes and the steel wool which covers the muffler and absorbs the sound waves and proves as an obstacle for airflow. On the contrary if we have a custom exhaust made with a muffler with smaller holes, we can increase the air flow out of the exhaust and reduce the steel wool and due to smaller holes, there will be lesser absorption of sound and will give out a much bolder and discreet sound which pleases the driver.

Classification of different types of mufflers:
- Reactive type
- Absorptive type
- Combination type

Reactive type muffler:
In this type of muffler Inlet and outlet tube are extended in chambers. Reactive mufflers generally consist of several pipe segments that inter connect with a number of larger chambers. The noise reduction mechanism of reactive silencer is that the area discontinuity provides an impedance mismatch for the sound wave travelling along the pipe. This impedance mismatch results in a reflection of part of the sound wave back toward the source or back and forth among the chambers. The reflective effect of the silencer chambers and piping essentially prevents some sound wave elements from being transmitted past the silencer. The reactive silencers are more effective at lower frequencies than at high frequencies, and are most widely used to attenuate the exhaust noise of internal combustion engines.

Absorptive type muffler:
This type of muffler design uses only absorption of the sound wave to reduce the noise level without messing with the exhaust gas pressure. This is known as glass pack muffler and it reduces backpressure but producing higher noise. The sound produced by this type of muffler is much higher compared to the other type of mufflers.

Combination type muffler:
Some silencers combine both reactive and absorptive elements to extend the noise...
attenuation performance over a broader noise spectrum. Combination silencers are also widely used to reduce engine exhaust noise.

III. OBJECTIVE

The main idea behind the project is to mount two different exhaust mufflers in the car, where in one is the stock muffler (reactive type) and the other is a custom-made absorptive type muffler. The custom muffler is designed in such a way that it allows free flow of the exhaust gases outside unlike the reactive type muffler where the exhaust gases have to pass through different chambers and pass out after bouncing several times inside. We all know that the more air outflow takes place, the more air is sucked inside the cylinder for combustion, hence more fuel is burnt and this results in more power. The advantage of the reactive muffler is higher fuel efficiency and that of absorptive type muffler is increased power. The main focus of the outcome of the project is to be able to switch between two exhausts. The reason for us to bring about this change is to harness the engine’s true potential which cannot be obtained using a stock exhaust. This also makes it an easier process rather than replacing the exhaust which is both time consuming and comparatively costlier.

We ought to bring about this change by using an ELECTRICALLY ACTUATED VALVE which is electrically controlled to switch between the two exhausts. Hence, we have come up with an idea of switching between TWO exhausts. One stock and one custom, so we could use either of those according to the situation. When commuting to office or going on a drive with family we could use the stock exhaust. And while cruising on a highway we can use the custom exhaust for more power while compromising on the fuel efficiency.

IV. LITREATURE REVIEW

Literature survey is carried out to get the background information on the issues to be considered in the present research work and to focus the relevance of present study. The propose is also to present a thorough understanding of various aspects of exhausts with special attention to their behaviour under various conditions. A great deal of work has already been done on the various factors affecting the exhaust and techniques used to overcome them.

Johan Wall., et al. [1]: conducted a study which revolves entirely around the introduction of bellows joint in an exhaust system. Bellows are used in exhaust systems to compensate for vibrations caused by engines and temperature differences resulting in thermal expansion. The study concludes that introduction of bellows causes reduced air flow hampering the power of the automobile, therefore the advantages of reduced bellows and improved flow conditions should be weighed against the disadvantages found in the study.

Jigar H. Chaudhri., et al. [2]: conducted a detailed study on the different types of mufflers, namely absorptive, reactive and combination type which is a combination of the latter two. There were five main parameters selected to design all three types of mufflers namely, quietness, maintenance, performance, design and weight of the muffler. The main specific requirements were reduced sound emissions, ability to be replaced, no increase in backpressure, easy mounting, easy on budget and easy manufacturing. Keeping all these factors in check the mufflers were designed and put to test. The test yielded the results in favour of combination type muffler which performed with at most efficiency with respect to the parameters and requirements considered.

Ashwani Kumar Naik [3]: carried out series of experiments to demonstrate a way to utilize the exhaust gases in an automobile to generate usable energy to increase the efficiency of the engine. Though this study failed to provide any such mechanism so to harvest exhaust gases, it provided a great deal of information about reducing the harmful emission to the atmosphere by proving vehicles with completely sealed fuel tanks which does not vent directly to the atmosphere.

AR. Palaniappan., et al. [4]: conducted a study on the exhaust gases obtained when the engine was supplied with air which is deprived of carbon-di-oxide. The end results obtained show that the deprivation of carbon-di-oxide in the supplied air to the engine resulted in much less carbon-mono-oxide and hydrocarbon emission.

Kunal Roy., et al. [5]: conducted and experiment which involves the use of platinum group metal in catalytic converter to reduce the exhaust to a more non-lethal form before releasing it into the atmosphere. It was found that utilization of exhaust systems is the most ideal approach to control auto fumes outflow. Three-way catalyst with stoichiometric motor control frameworks remains the condition of workmanship technique for all the while controlling hydrocarbon, CO and NOx outflows from vehicle. The practical reasons, constrained assets of platinum gathering metal and some working confinements of platinum assemble metal-based exhaust systems have roused the examination of option impetus materials.

V. EXPERIMENTAL DETAILS

V.1. HARDWARE REQUIREMENTS

- **Stepper motor:**
  The stepper motor used to actuate the valve is fixed to the screw thread which upon rotation moves the square plates forwards or backwards depending on the switching required.

Figure.4. NEMA 17 stepper motor
- **Arduino uno:**
  Arduino uno acts the main CPU of the stepper motor in which the program is stored and executed according the input given by the user. It is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button.

- **Motor driver:**
  A motor driver is a small Current Amplifier whose function is to take a low-current control signal and then turn it into a higher-current signal that can drive a motor.

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**V.2. FABRICATION:**

**1. FABRICATION OF MUFFLER**

The custom muffler fabricated is of absorptive type, which means it uses the design to absorb the sound wave and reduce noise and does not mess with the exhaust gas pressure. This implies that there is full free flow of exhaust gases without any obstacles, this enables more air to be drawn into the engine and more combustion which in turn results in higher power output.

**Materials used**

- Mild steel casing: Length 50cm, Diameter 11cm
- Mild steel pipe: Length 54cm, Diameter 5cm
- Circular plates: Diameter 5cm with 2cm cut out in the middle
- Glass wool: 500cm

**2. FABRICATION OF VALVE**

The valve is linearly actuated using a stepper motor interface with Arduino. It comprises of a 2inch square cross section with two square blocks mounted on a threaded rod. There are three holes, two on one side and one on the opposite side. The single hole is the inlet of exhaust. The other two holes decide which exhaust the gas passes through.

**Materials used**

- Square cross section mild steel casing: 5cm x 5cm x 30cm
- Square plates: 5cm x 5cm x 0.5cm
- Threaded rod: 30cm

**3. FABRICATION OF BEND PIPE**

A bend pipe is usually piping used to guide reaction exhaust gases away from a controlled combustion inside an engine or stove. The entire system conveys burnt gases from the engine and includes one or more bend pipes. An exhaust pipe must be carefully designed to carry toxic and/or noxious gases away from the users of the machine. Also, the gases from most types of machines are very hot; the pipe must be heat-resistant, and it must not pass through or near anything that can burn or can be damaged by heat.

**Material used**

- Mild steel
- Total length of the bend: 173cm

The bend pipes were procured based on the requirements for fabricating a bend pipe for the custom exhaust. The lengths...
were measured and markings were made based on the readings obtained from survey of car exhaust system keeping into account the constraints set due to space available, compactness and light weight.

VI. CONCEPTUAL CAD MODEL

![Figure 11. Design of muffler](image1)

![Figure 12. Design of valve casing](image2)

![Figure 13. Design of square plates mounted on threaded rod](image3)

![Figure 14. Design of bend pipe](image4)

![Figure 15. Final assembly (Front view)](image5)

![Figure 16. Final assembly (ISO view)](image6)

VII. RESULT

The test carried out to prove that the system functions as desired was the speed test using both the stock and custom exhaust. In this test there is a speed cap and the time taken to achieve this speed is recorded. It is done with both the exhausts separately. The speed cap is set at 60km/hr. The setup here is a straight road of 1km with no obstacles, speed breakers and potholes.

<table>
<thead>
<tr>
<th>EXHAUST</th>
<th>TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>STOCK</td>
<td>8 seconds</td>
</tr>
<tr>
<td>CUSTOM</td>
<td>6.5 seconds</td>
</tr>
</tbody>
</table>

This here proves that the custom exhaust fabricated allows for more airflow due to its design features, this in turn enables the engine to draw in more air thereby increasing the rate of combustion. Hence, we see an increase in power thereby decreasing the time by 1.5 seconds.

VIII. CONCLUSION

The main aim of the project was to mount two different exhausts on an automobile and design a mechanism to switch between the two. The switching mechanism was designed using a valve which switches with the help of a stepper motor interfaced with an Arduino. Main reason for switching was to harness the true potential of the engine with the help of a custom exhaust which basically works in the principle of air flow, more the air flow more the combustion, hence more the power output. The theory put forward was proved with the help of a speed test which comprised of taking the automobile from 0 to 60km/hr as fast as possible. With the custom exhaust the automobile was able to attain this speed 1.5 seconds faster than the stock exhaust.

IX. FUTURE WORK

Further developments in the design department can result in a more compact design of the valve which implies less weight, easy fabrication and much more efficient. Reducing the of the valve would open up a new set of possibilities meaning that there far much more lesser room required for mounting the mechanism which is quite an important factor considering the fact that it’s sort of extra equipment that needs to be attached to the automobile without removing anything existing. That being said the smoothness of the moving parts inside the valve can be improved thereby reducing the friction caused due to rubbing. With smooth motion achieved it would be possible to make the switching phase faster than it currently is since friction would be less. With further advancements the leakage can also be reduced which causes reduction in power out, at this stage it quite negligible but it can be improved nevertheless. All these factors would culminate to give a much efficient system with much higher power output for the same.
X. REFERENCES


