

DESIGN AND OPTIMIZATION OF EXHAUST SYSTEM FOR INTERNAL COMBUSTION ENGINES

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Abstract: In the automobile industry, exhaust emission control and optimizing and using of non-conventional materials is major challenge for the research and development department of every company. Practical weight reduction and making the system compact, and personalization of single exhaust system are the main goals of this review paper. Introduction of the active back pressure control valve is the main feature of this research study.

Key words: Emission control, Compact system, Custom exhaust, Back pressure control valve

INTRODUCTION

The exhaust system is used for the carrying away the unburnt gases from the combustion chamber to the surrounding. Also gases like NO_x and CO are harmful for the society. Simultaneously increasing engine performance for various driving conditions are also to be achieved. The exhaust system used are the designed for keeping single amount of back pressure on the exhaust valve. This study focuses on the study of designing exhaust system for back pressure adjuster valve which can be changed as per the driver's input. Also using of non-conventional material which could increase the overall efficiency of vehicle. Since, emission control of combustion vehicle is one of the major challenge to achieve it. In this study we also tried to get analysis of catalytic converter for breakdown of unburnt harmful gases. For this purpose study of various paper was essential for the design of further research work. Various research papers by many of the publication houses are studied are explained in this paper for the flow of the research work can be easily decided.

Literature Survey

Prof. B.S Patel et al^[1] states that the design of muffler is a trial and error process because of the nature of several different properties coming together in a way that they cannot be considered at once. The design of muffler is a multifarious function that affects noise characteristics, emission and fuel efficiency of the engine. Frequently mufflers were developed by techniques like BEM (boundary element method) or FEA (finite element method), but these processes are time consuming especially the model generation in FEA. Mufflers have been developed over the years with

electro-acoustic analogies and experimental trial and error. Electronic noise suppression mufflers use a sound pressure wave 180 degrees out of phase generated by an electronic device to cancel out similar sound waves generated by the engine. The 180 degree sound wave can also be created within the engine muffler by reflecting the outgoing wave, this reflected sound is used to attenuate the main noise. Muffler design methodology is specified along with various formulae. The approach mentioned serves the purpose of reducing the number of iterations. Jigar H. Chaudhari et al^[2], the objective of his paper is to decide the muffler design which reduces a large amount of noise level and back pressure of the engine. He has stated the basic requirements of a muffler classified into two categories namely general and specific. He discussed briefly the design procedure of a muffler and stated the parameters of design of a muffler namely number of chambers, number of inlet and outlet pipes, diameter of inlet and outlet pipes, holes on the pipes, size of the muffler. Praveen V. et al^[3] have worked towards designing an active muffler for the KTM390 single cylinder engine the active muffler which works as a normal reflective muffler till the 7500 RPM range, after which an electronic controlled throttle mechanism is used to reduce the backpressure by using tachometer signal from the engine to control the throttle. The electronic throttle will be controlled using an ARDUINO board and control the backpressure, with respect to the Engine RPM. This ensures that Noise level rules are met without compromising on the performance of the engine. R. Singh et al^[4] in his paper the pulsations due to the suction and discharge of the system pressure in the air and their causes were observed. This paper sheds light on the valve interaction, the motion imparted to the valve due to due to pressure differentials. As the valves are opening, both the flow equation and dynamic equation is applicable. He also states the condition for a multi cylinder case where a number of cylinders discharge a gas into a common pipe, the pulse of the equal order can be imposed directly. He also stated the approaches for evaluation of the pulsation in the system namely Lumped Parameter approach and Distributed Parameter approach. Prasad V. Shinde et al^[5] in his paper the study of different types of muffler is done and their characteristics also, he has also stated the noise limit standards applicable in India for specific areas and also for passenger vehicles and transport vehicles. Dhananjay D. Mahale et al^[6] the objective of his paper is to increase the brake power of the engine and reduce the backpressure as compared to a commercial muffler. The characteristic of a semi active muffler which operates in two conditions that are

Normal mode (high noise attenuation) and Free Flow mode (minimum back pressure). How a semi active muffler is different than a normal muffler has also been discussed here. He observed that when the throttle is wide open, a lot of back pressure reduction occurs and the noise level is increased at the time of the working of the semi active muffler exhaust system. P. Sriramam et al [7] have studied the methods to reduce the exhaust emissions in automotive engines by pretreatment of fuel by emulsifying it with water and EGR (exhaust gas recirculation). Conditioning the exhaust gas after combustion by addition of ammonia by using Urea. He has also plotted a graph stating the experimental correlation between NOx emissions and intake O2 concentration. Marios Sideris et al [8] studied the methods used for determining the storage of oxygen in catalytic converter. The methods for use of temperature sensors for determining the capacity of exothermic reactions of a catalytic converter.

Summary

From the study of above research papers a brief overview of the exhaust system noise attenuation techniques and the various processes for designing an exhaust system or muffler, the parameters for designing a muffler, effects of hardware configuration of the engine on the noise and flow characteristics, how to exercise control over the NOx emissions in a number of ways for an IC engine is obtained.

Trial & error process:

It is a time consuming process in which actual physical model is created and then tested for the desired output. In past few years this was the only process that was used to manufacture the exhaust systems.

Electro-acoustics

In this type an external agency is used to create destructive interference inside the muffler chamber to reduce the noise level of the engines. It helps the compact design but the also increases component addition. The result of this method used can be effective for the systems.

Electronic noise suppression:

Creating the 180 degree out of phase pressure waves for reduction in noise and generation of destructive interference is the key of this processes. Wave generating system is used in this technique to generate pressure waves.

ECT mechanism:

A throttle valve is inserted in the header pipe duct to increase the efficiency as well as to suppress the noise level coming from the engine. The throttle valve is operated by the tachometer in association with ARDUINO signal after exceeding certain value of engine rpm to reduce the back pressure generating on the engine.

Semi active mufflers

The exhaust system which is acting as a both free flow and the noise attenuating type can be done in the same system is also a significant change that can be implemented in the new designs.

Noise suppression materials

The exhaust muffler may be lined with a sound absorbing material such as glass wool, steel wool, perforated pipes that break the pressure wave can be employed.

Types of mufflers (silencers)

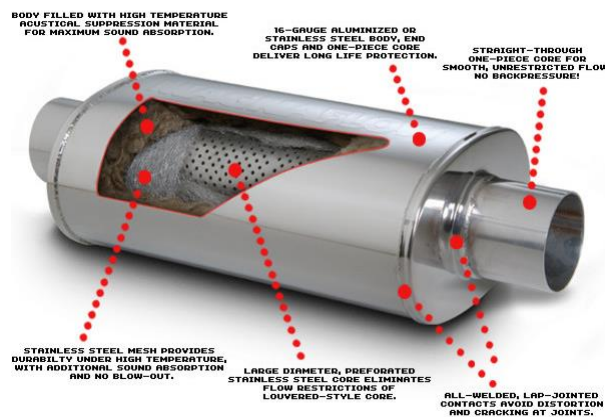
1. Absorption muffler



2. Reactive muffler



3. Combination muffler



We succeeded in getting the designing of an optimum exhaust system based on various factors like, optimum back pressure value, header diameter, Noise attenuation materials, coefficient of friction of inner walls of the pipes and muffler chambers, Concentration of catalyst used in the catalytic converter.

Conclusion

Exhaust system design is key factor for the recent years to increase the efficiency of an I.C. engines. Also it is very helpful for the noise damping for better ergonomics of the driver and improvement of ride quality. Controlling emissions and reducing environmental pollution for achieving higher euro norms in lesser investments. There are many gaps can be filled by using the

REFERENCES

- [1] A Review paper on Design of Muffler toward Reduce Sound in Exhaust System of IC Engine- 2015- Prof. B.S.PATEL, Sunil Khokhar -By changing the design iteration trial and error base
 - [2] Muffler Design for Automotive Exhaust Noise Attenuation - 2014 - Mr. Jigar H. Chaudhri, Prof. Bharat S. Patel, Prof. Satis A. Shah -Combination types are preferred to reduce the noise
 - [3] Active Muffler for Single Cylinder Engine, Using Electronic Throttle Control for FS cars-2017- Praveen, V. and Sethupathi, P. -Using Electronic Throttle Control
 - [4] A review of compressor line pulsation analysis and muffler Design research-1974 - R. Singh, W. Soedel -By theoretic and experimental regarding pulse flow area
 - [5] A Review on muffler design for exhaust noise attenuation-2017 -Prasad V. Shinde, P.M. Gavale -Mathematically modelling and CFD
 - [6] Design analysis semi active muffler-2017-Dhananjay Mahale, Shailesh L. Deshmukh
 - [7] Study of exhaust emission and its reduction technique in automotive engines-2015-P. Sriraman, R. Balasubramanyam -Wide opening of throttle reduces back pressure
 - [8] A review of Current techniques for measuring muffler transmission loss-2013-Z. Tao, F. Seybertrn - Mathematical analysed
 - [9] Methods for monitoring diagnosing the efficiency of catalytic converter-1998 -Marios Sideris -By using OBD sensors and air fuel ratio
 - [10] *Motorola Semiconductor Data Manual*, Motorola Semiconductor Products Inc., Phoenix, AZ, 1989.
- (Journal Online Sources style)**
- [11] R. J. Vidmar. (August 1992). On the use of atmospheric plasmas as electromagnetic reflectors. *IEEE Trans. Plasma Sci.* [Online]. 21(3). pp. 876-880. Available: <http://www.halcyon.com/pub/journals/21ps03-vidmar>