IJARIIT INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact factor: 4.295
(Volume 4, Issue 5)
Available online at: www.ijariit.com

Study of noise reduction in single cylinder common rail direct injection diesel engine at idle speed

Rupinder Singh
rupinder1119@yahoo.com
Ramgarhia Institute of Engineering and Technology, Phagwara, Punjab

Gautam Kocher
hodme@riet.ac.in
Ramgarhia Institute of Engineering and Technology, Phagwara, Punjab

Jaswinder Singh
pkalota@ymail.com
Rayat Bahra Institute of Engineering and Nano Technology, Hoshiarpur, Punjab

ABSTRACT

The design and development of modern internal combustion engines are marked by a reduction in exhaust gas emissions and an increase in specific power and torque. The reduction of noise and vibration is one of the significant attractiveness towards making diesel engines for a long time now. Countries around the world continue to legislate against the release of specific levels of exhaust gas emissions such as nitrogen oxide, hydrocarbon, carbon monoxide, and smoke. The customer requirements for combustion noise need to be met, which can be completed by optimizing the combustion system. This can be met through the development of advanced combustion systems and the increased flexibility of fuel injection systems and ECUs. This research work presents the effects of Fuel Injection Pressure on the combustion pressure and optimizing the engine noise by using Taguchi method.

Keywords— *Diesel engine, Combustion noise, Fuel pressure, Signal to noise ratio*

1. INTRODUCTION

Driven by the expanding interest of clients for comfort, the subject of the engine and automotive acoustics is expanding in its significance in the vehicle development procedure. Higher assumptions about vehicle inside noise are joined by the prerequisite of a lowered noise of exterior, which can be taken into account as a pollutive factor. The combustion noise has a significant impact on vehicle acoustics. Particularly in the case of diesel engines which are injected directly, the excitation produced by the procedure of combustion influences the overall level of noise prominently. In perspective of the combustion noise, the SI engine could be viewed as a reference in light of its smooth pressure curve of the cylinder. The goal in the engineering of the diesel engine is the most ideal estimation of heat release rate and pressure curve to that of that of the SI engine while keeping up the common efficiency advantage characteristic to diesel engines. [1]

Diesel engines development calls for a decrease of NOx outflows in the meantime keeping up the economy of fuel. One of the techniques to lessen outflows is exhaust gas after treatment, anyway this technique is expensive. Another promising method is to acquire homogeneous blend in combustion mixture. There might be the disintegration of the mixture in this approach, subsequently, different elements must be considered while contemplating radiated noise from engine such as structural attenuation.

In present-day diesel motors methodology of dual injection has been utilized for accomplishing homogenous mixture development. Examination of in-cylinder pressure spectrum for a dual injection engine has indicated lobes with separation between lobes conversely relative to dwell time between two injections. With this strategy, the dominant part of emissions of noise has been observed to be in low and medium recurrence run. Anyway, the vast majority of the current investigation of a decrease in noise is engaged on ranges of high frequency, this call for an investigation of different elements like engines' structural attenuations. Structural attenuation is characterized as a function of transfer between in-cylinder pressure and combustion noise radiated from the engine. [2]

2. REVIEW OF LITERATURE

Vijayaraj V T et.al [3] presented about noise combustion in the passenger cars. Combustion noise in passenger cars controlled with DI (direct injection) diesel engines is frequently the principle motivation behind why end-clients are hesitant to drive this kind of vehicle. Along these lines, the great capability of diesel engines for the preservation of the environment because of their lower emissions of CO_2 could be missed. This circumstance declines with the present outline patterns (downsizing of the engine) and the developing new diesel combustion ideas which are noisy inherently. This negative component can be considerably more basic in transient activity because of the contribution of the fleeting changes of the path of both source and transmission on the noise of the engine. Subsequently, combustion noise must be considered as an extra basic factor in the development of engine along with performance. Along these lines, appropriate design processes are talked about in this paper. [3]

Tuan Anh Nguyen et.al [4] explores the attributes of generation of combustion noise in a diesel engine under running condition by utilizing wavelet transformation and transient combustion noise generation strategy. The outcomes demonstrate that combustion noise to a great extent added to the total noise of the engine in the beginning time of the expansion stroke. Most extreme impact energy due to combustion predominantly affected maximum combustion power and thusly on greatest engine noise power for every cycle. The power of combustion noise decayed with time exponentially. The period of combustion noise depends chiefly on the most extreme combustion noise power, which is controlled by the maximum impact energy due to combustion and radiation rate of transmission. [4]

Philipp Sellerbeck et.al [5] discussed improving the diesel sound quality the engine level as well as vehicle level. Diesel Impulsiveness also knew as Diesel knocking present in the diesel vehicles cabin is recognized as unpleasant due to its impulsive structure of time. JD Power data obviously show the customer's vehicles preference. The occurrence of such type of patterns of noise is affected by the process of combustion itself and also by all excited mechanical parts inside of the powertrain. It is necessary that all these factors have to be taken into account in combination. This paper gives an overview of appropriate technologies and methods, incorporating Binaural Transfer Path Analysis and Synthesis.

Ming Sheng et.al [6] proposed a strategy for describing the substrate noise over the UWB (ultra-wideband) frequency band in systems of UWB which is implemented by utilizing processes which are lightly doped by processes of CMOS. The structure of measurement in this method depends upon the modified GSG (ground-signal-ground) pads. Moreover, the impacts of distance-based substrate resistance and capacitive coupling between the substrate and the ground of setup of measurement are assessed by on-wafer estimation of test chip manufactured in 0.18 m CMOS process which is lightly doped. A proportionate circuit model of the presented structure of measurement is specified and demonstrates accurate fit. From the results of measurement, the method presented is shown for providing a band of measurement from 3 GHz to 10 GHz.

Insoo Jung et.al [7] proposed an advanced technique for developing combustion noise through the examination of diesel combustion. The wellspring of combustion noise of diesel engines was explored in this paper. In the improvement of combustion noise and exhaust emission, parameters of injection must be optimized at the cell where the engine’s noise could not be measured. For solving this problem, it is important to distinguish a strategy for developing combustion noise through measurements of the pressure of in-cylinder. It is realized that the diesel engine’s combustion noise is produced for the most part in the period of premixed combustion and relies upon the rate at which pressure increments. The noise of combustion was investigated by measuring the engine noise and pressure of in-cylinder. The results demonstrate that the combustion noise has a low relationship with the most extreme rate of increase in the pressure. Thus, another index known as the index of combustion noise was produced in the view of the level of pressure of the cylinder. This paper portrays a propelled strategy for producing combustion noise and delineates a few cases of the obtained results.

The extensive review of literature carried out for the present study reveals that a lot of work has been reported to study the combustion noise from Diesel Engines & its reduction thereafter. However, the following are the limitations:

1. The effect of injection pressure on noise at idle has not been studied extensively.
2. Most of the studies have focused on single cylinder fuel economy.

3. EXPERIMENTAL DESIGN

The engine utilized for this experiment is an automotive single cylinder air cooled four stroke diesel engines. Diesel fuel is directly injected into the combustion chamber with equipment of common-rail fuel injection. The idle speed is controlled by ECU based on the feedback from the crank sensor. From PC based software, the idle speed setpoint to the ECU can be changed online.

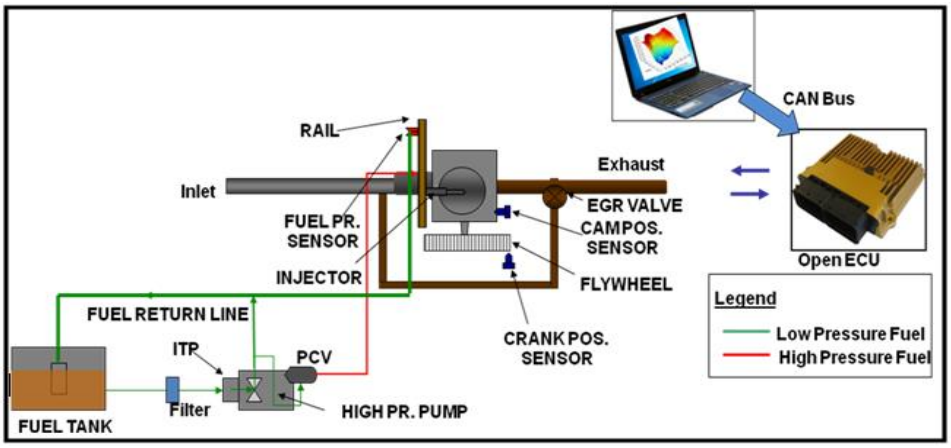

Fig. 1: Experimental Design

4. EXPERIMENTAL PROCEDURE

The main task of the experimental procedure is to study the engine combustion noise development at idle speed. Since the engine tested is of the automotive type, the main focus was on idle speed. For the experimental investigation, the engine was coupled to an Eddy Current dynamometer; though no load was supposed to be applied at idle. In our experiment, different idle speed set-points will be tried in order to measure their impact on engine noise.

4.1 Taguchi method

A Taguchi design is an experiment designed that gives you a chance to pick a process or product that performs functions more reliably in the working condition. Taguchi designs perceive that not all factors that bring about fluctuation could be controlled. These factors that are uncontrollable are known as noise factors. Taguchi designs attempt to distinguish control factors (controllable factors) that lessen the impact of the noise factors. During experimentation, you manage noise factors to force changeability to happen and after that decide optimal control factor settings that make the product or process resistant or robust. A to variation from the noise factors. A process outlined with this objective will create more reliable output product outlined with this objective will convey more predictable performance paying little attention to the environment in which it is utilized.

4.2 Noise factor

In Taguchi designs, factors that bring about fluctuations in the performance of a product or system, but could not be controlled during use of product or production. You can be that as it may simulate or control noise factors while performing experimentation. You ought to pick levels of noise factors that represent the scope of conditions under which the response ought to remain robust.

Common types of noise factors are:

- **External:** Environmental factors, customer usage etc.
- **Manufacturing variations:** Part-to-part variations.
- **Product deterioration:** Degradation that occurs through usage and environmental exposure.
- **Signal Factor:** A signal factor is a factor, with a range of settings that are managed by the product's user to make utilization of its intended function. Signal factors are utilized as a part of dynamic experiments, in which the measurement of response is done at every level of the signal. The main objective of the experiment is to enhance the relationship between the response and the signal factor.

4.3 Signals-to-noise ratios in Taguchi design

In Taguchi designs, a robustness which is measured is utilized for identifying control factors that diminish variability in a process or product by limiting the impacts of noise factors (uncontrollable factors). Control factors are those parameters of process and design that can be controlled. Noise factors could not be controlled while the use of a product or process, but can be controlled while performing experimentation. Higher estimations of the S/N (signal-to-noise) ratio identify settings for control factor that diminish the impacts of the noise factors.

Taguchi experiments frequently utilize a process of 2-step optimization. In step 1 utilize the signal-to-noise ratio for identifying those control factors that decrease variability. In step 2, identify control factors that move the mean to target and have a little or no effect on the signal-to-noise ratio.

4.4 Arrangement of Taguchi data

In the present study there are 2 noise factors taken which are as following:

1. Fuel Pressure
2. Engine speed

Control factors are:

1. The noise of Combustion (decibel)
2. Combustion Pressure (Pascal)

Table 1: Taguchi Orthogonal Array Design for Noise

S. no.	C1 A	C2 B	C3 Fuel Pressure (bar)	C4 Engine Speed (RPM)	C5 SNRA1	C6 MEAN1
1	1	1	240	1000	47.6042	240
2	1	2	240	850	47.6042	240
3	1	3	240	800	47.6042	240
4	1	4	240	750	47.6042	240
5	2	1	210	1000	46.4444	210
6	2	2	210	850	46.4444	210
7	2	3	210	800	46.4444	210
8	2	4	210	750	46.4444	210
9	3	1	205	1000	46.2351	205
10	3	2	205	850	46.2351	205
11	3	3	205	800	46.2351	205
12	3	4	205	750	46.2351	205
13	4	1	200	1000	46.0206	200
14	4	2	200	850	46.0206	200
15	4	3	200	800	46.0206	200
16	4	4	200	750	46.0206	200

Taguchi Orthogonal Array Design L8 (2^4) has been used. There were two factors and eight runs.

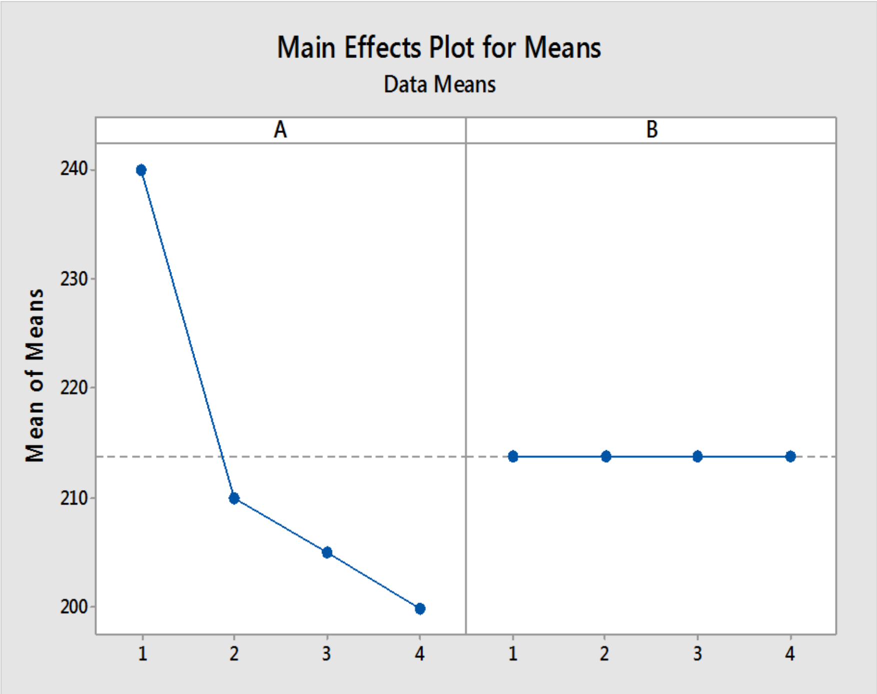

Fig. 2: Taguchi Orthogonal Array Design L16 (4^2) for noise values

Table 2: Response Table for Means

Level	A	B
1	240.0	213.8
2	210.0	213.8
3	205.0	213.8
4	200.0	213.8
Delta	40.0	0.0
Rank	1	2

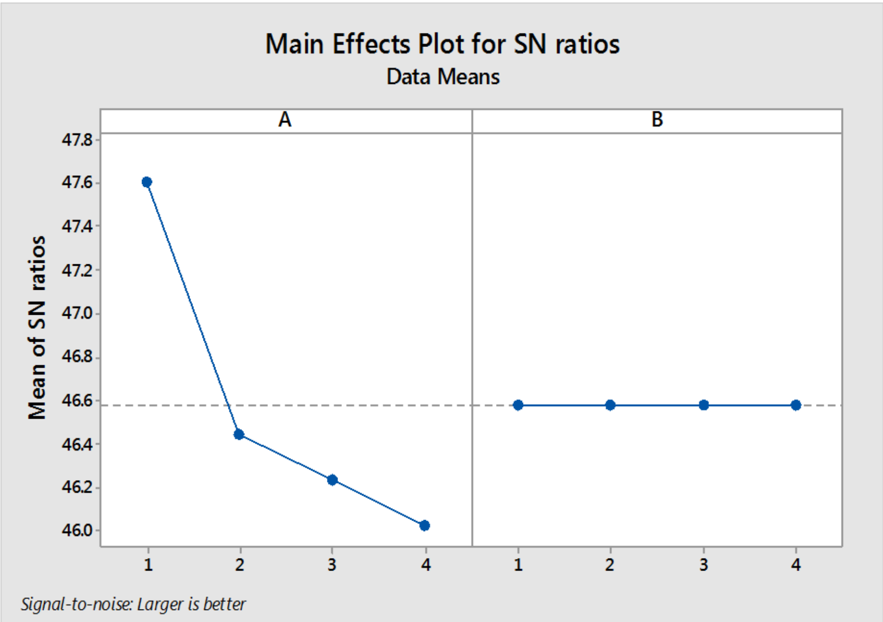

Fig. 3: Main effects plot for SN ratios

Table 3: Response Table for Signal to Noise Ratios

LEVEL	A	B
1	47.60	46.58
2	46.44	46.58
3	46.24	46.58
4	46.02	46.58
Delta	1.58	0.00
Rank	1	2

5. CONCLUSION

The main objective of this research was to reduce the noise by optimizing the fuel pressure. In this experiment at engine 750 rpm, we set the values of fuel pressure at 200 bar and find the minimum value of 46.03db noise. On further increasing the value of fuel pressure and here observed that the noise of the engine also increased. The amount of fuel pressure can cause an effect on engine noise. The future scope of this research is Air fuel pressure can also be varied by using automotive operating software which may affect the various input parameters. Noise reduction can also be done in single cylinder petrol engines. Combustion of the single cylinder injection system can also be varied by optimizing the input parameter.

6. REFERENCES

[1] Johannes Seifriedsberger, Peter Rumplmayr, “Evaluation of the combustion noise of passenger car diesel engines”, Automotive and Engine Technology, Springer, Vol. 1, Issue 4, pp 47-56, December 2016.
[2] S. Narayan, “Noise Optimization in Diesel Engines”, Journal of Engineering Science and Technology Review, pp. 37-40, 2014.
[3] Vijayaraj V T, Vijay S, Vignesh S, Nandha Kumar M, Naveen Kumar M, “A Study on Modern Diesel Engine Combustion Noise”, International Conference on Systems, Science, Control, Communication, Engineering and Technology, 2016.
[4] Tuan Anh Nguyen, Yuichiro Kai, Masato Mikami, “Study on Combustion Noise from a Running Diesel Engine Based on Transient Combustion Noise Generation Model”, International Journal of Automotive Engineering, pp. 131-140, August 2012.
[5] Philipp Sellerbeck, Christian Nettelbeck, Ralf Heinrichs, Thomas Abels, “Improving Diesel Sound Quality on Engine Level and Vehicle Level-a Holistic Approach”, SAE International, 2007.
[6] Ming Sheng, Tian Tong, Jan Hvolgaard Mikkelsen, Torben Larsen, “A Method for Measuring the Substrate Noise in the UWB Frequency Band on Lightly Doped Substrates”, IEEE, 2007.
[7] Insoo Jung, Jaemin Jin, Hyunkee So, Choong-Geun Nam, Kwangmin Won, “An Advanced Method for Developing Combustion Noise through the Analysis of Diesel Combustion”, SAE International, 2013.
[8] Mayur S. Sawade, Sandeep S. Kore, “Performance & Emission Optimization of Single Cylinder Diesel Engine to Meet BS-IV Norms”, International Journal of Research in Engineering and Technology, Vol. 4, Issue 3, March 2015.
[9] Florin Paun, Stephane Gasser, Laurent Leylekian, “Design of materials for noise reduction in aircraft engines”, Aerospace Science and Technology, Elsevier, pp. 63-72, 2003.
[10] Masahiko Kondo, Shuji Kimura, Izuho Hirano, Youichi Uraki, Ryoichi Maeda, “Development of Noise reduction technologies for a small direct-injection diesel engine”, SAE Review, pp. 327-333, (21), 2000.

