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A Review on Effect of Air Induction Pressure Variation on Compression Ignition Engine Performance

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ABSTRACT: Owing to Concern of environmental pollution and energy crisis all over the world, research interest on reduction of diesel engine exhaust emissions and saving of energy is increasing. Because of Better fuel economy and higher power with lower maintenance cost, the popularity of diesel engine vehicles has been increased. Diesel engines are more economical than any other source in this range for bulk movement of goods, powering stationary/mobile equipment, and to generate electricity. The air induction system plays important role in combustion process by providing necessary air charge in case of Compression Ignition (C.I.) engine. Pressure drop across air intake manifold has significant effect on the indicated power of C.I. engine. To improve the volumetric efficiency, majority car manufacturers place air grill at the front of a vehicle. In this Paper, the causes and effect of air induction pressure variation on performance of compression Ignition engine is studied. It is observed that due to increased inlet air pressure results in better mechanical efficiency, volumetric efficiency, scavenging and reduced exhaust temperature at the engine exhaust thereby reduced oxides of Nitrogen.

Keywords: - Exhaust Emissions, Volumetric Efficiency, Air Induction Pressure, Air Intake Manifold

1. Introduction

Engine performance is responsive to induction depression particularly for Internal Combustion (IC) engines running without turbocharger or supercharger. The majority of engine intake systems has dirty duct, air box, air cleaner, clean duct, intake manifold plenum, and intake manifold runner. The classic length of the air intake system (AIS) can be up to 1 meter. The air path through this manifold presents a pressure drop challenge to the designer of air induction system. The pressure drop across the air intake system is known to have a significant influence on the indicated power of the IC engine. In the case of natural aspirated engine, the downward movement of piston generates the suction which creates pressure drop. The fall in pressure along the intake system is relia on engine speed and load, the flow resistance of different elements in the system, the cross sectional area through which the fresh charge moves, and the charge density. Standard steady flow test bed can be use to measure pressure drop along the air intake system. These measurements are carried out on complete air intake system together with cylinder head and ports. For direct injection engines where the port is shaped to generate the required degree of swirl within the cylinder, measurement of pressure drop is mainly important. Hence, to study of the effect of air intake pressure drop on a diesel engine is very essential. This paper intends to study the effect of air pressure on the combustion quality as well as emissions on diesel engine.

Rizalman Mamat et al. [1] studied effect of the pressure drop in the inlet manifold, on the engine performance and exhaust emission system of v6 diesel engine. The fuel used in this v6 diesel engine is Rapeseed Methy Ester (RME) and a comparison between (RME) fuel and ultra low sulphure diesel (ULSD) was conducted and a steady state test for both fuels were carried at BMEP 3.1 and 4.7 bar. The effect of air intake pressure drop on the engine performance and emissions of a V6 diesel engine has been investigated. Harshraj Dangar et al. [2] conducted experiment in a four stroke direct injection water cooled constant speed diesel engine typically used in agricultural farm machinery with pressurize inlet air attachment and EGR system. EGR was applied to the experimental engine separately and also with varying pressure of inlet air. Compressor was used to pressurize the inlet air. The combine

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effect of increasing inlet air pressure and EGR system on engine performance and emission like brake thermal efficiency, brake specific fuel consumption, NOx, CO, CO2 and HC was measured.

Meisam Ahmadi Ghadikolaei [3] investigated the effect of cylinder air pressure and fuel injection pressure on combustion characteristics of direct injection (DI) diesel engine. The combustion characteristics in this experimental study were measured in terms of ignition delay, combustion duration and injection duration at varying cylinder air pressure (10-15-20 and 25 bar) and fuel injection pressure (100-200 and 300 bar) based on diesel and gasoline. Shah et al. [4] reviewed on how the design and orientation of the intake manifold influence the Performance and Emissions characteristics of diesel engine. And concluded that varying the orientation of the Intake Manifold, cylinder flow field structure is greatly influenced which will directly affect the performance and emission of the engine. To enhance performance with least emissions certain orientation of the intake manifold can be optimized.

Hosseinzadeh et al. [5] studied pressure drop against 0%, 26%, 52%, 66% and 74% of air filter hole's masking for different mass flow rates using computational fluid dynamics. The effect of masking on altitude and performance at different revolutions per minute of the engine is investigated using GT-Power software which is one-dimensional computational fluid dynamics software. Also, an experimental and computational fluid dynamics study was carried out to predict altitude against different proportions of air filter hole's masking at 1000 rpm. Thiyagarajan et al. [6] predicted Dust distribution and pressure drop for a constant flow rate of air using commercial CFD code Fluent. They consider the deposition of dust on the filter and the resulting changes in the filter medium properties, which lead to increasing pressure loss across air filter.

Krishna et al. [7] investigated the in-cylinder flow pattern around the intake valve of a single-cylinder internal combustion engine using Particle Image Velocimetry (PIV) at different intake air flow rates. Yerrennagoudaru et al. [8] Optimized airflow performance during intake valve process. Analyses were done in CFD simulation and experimental using a test rig single cylinder 4 stroke direct injection diesel engine. GOUD et al. [9] studied the effects of air filters performance. The analysis is carried out with different simulation results in the form of numerical simulation of flow particles captured by air filters. George et al. [10] considered flow through the inlet manifold for a four cylinder turbocharger diesel engine at low and high rpm. At lower rpm at around 1500 the turbocharger boost pressure will negligible, thus the engine will be in natural aspiration. At this normal running condition the mass flow to engine drops considerably with altitude. Adem Guleryuz [11] focused on optimum required air need through turbocharger for local diesel engine. While researching actual need, new turbocharger filter were designed and manufactured for engine manufacturer. Dan Adamek [12] Discussed about Methods for Diesel Engine Air Intake and Filtration System Size Reductions.

2. 1 Effects of Air Induction Pressure on Engine Performance:-

2.1.1 Effects on Brake thermal efficiency:-

Trends of Brake thermal efficiency for different load condition are shown in fig. 1 and 2. Brake Thermal Efficiency is defined as break power of heat engine as a function of the thermal input from the fuel. It is used to evaluate an engine performance of converting fuel energy to mechanical energy.

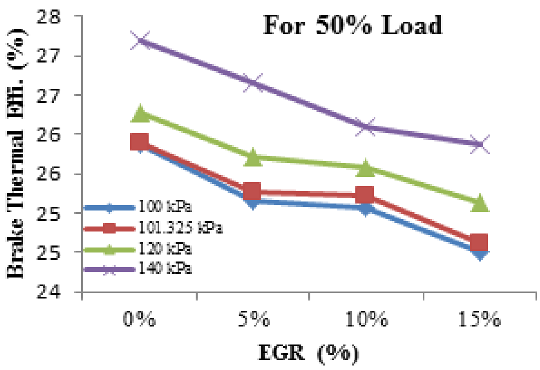

Figure No.1: Effects of Air Induction Pressure on Brake thermal efficiency for EGR rate at 50% load [2]

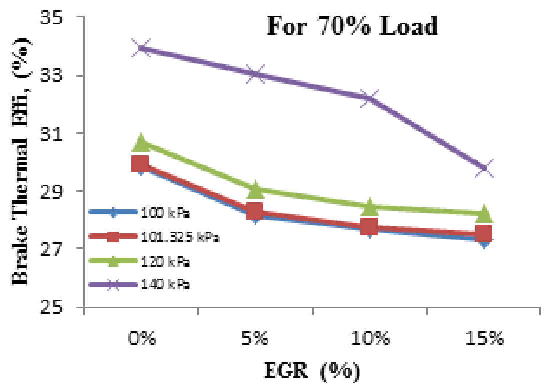

Figure No.2: Effects of Air Induction Pressure on Brake thermal efficiency for EGR rate at 70% load [2]

From figure 1 & 2, it is observed that brake thermal efficiency is increasing with increasing air induction pressure. With increasing inlet air pressure along with EGR it increases oxygen availability and significantly burning of fuel is occurred.

2.1.2 Effects on Brake specific fuel consumption:-

Fig. 3 and 4 represents comparison of BSFC for all datasets using EGR with inlet air pressure for 50% and 70% load condition. The BSFC is clearly a function of AFR as discussed in details by Heywood [13]. The discharge air increases when air induction pressure increases.

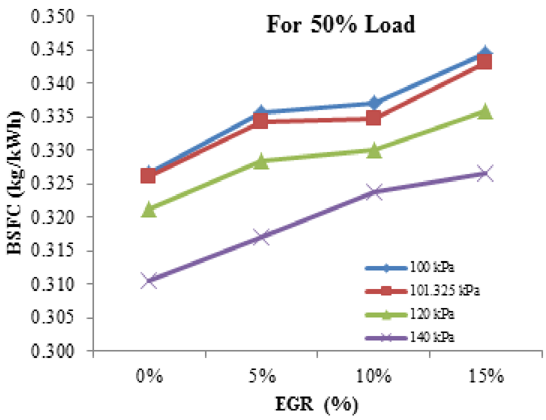

Figure No.3: Effects of Air Induction Pressure on Brake specific fuel consumption for EGR rate at 50% load [2]

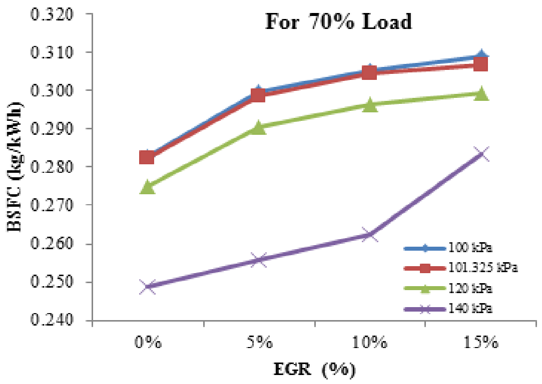

Figure No.4: Effects of Air Induction Pressure on Brake specific fuel consumption for EGR rate at 70% load [2]

From figure No. 3 & 4, it is observed that Brake specific fuel consumption is decreased with increasing inlet air pressure. It is due to by supplying pressurized inlet air, density of air increased and thus more oxygen available for combustion.

2.1.3 Effects on Exhaust gas temperature:-

Fig. 5 and 6 shows the exhaust gas temperature for increasing inlet air pressure and EGR rate at 50% and 70% load condition. The exhaust gas temperature decreases more by increasing inlet air pressure. Exhaust gas temperature also decreases with increase in inlet air pressure since advanced injection timing at higher inlet air pressure caused low-temperature reaction. In other words, as the inlet air pressure is increased further, cylinder gas temperatures are decreased, allowing more advanced injection timing. Thus by increasing inlet air pressure with EGR system lowered more exhaust gas temperature than individual EGR system.

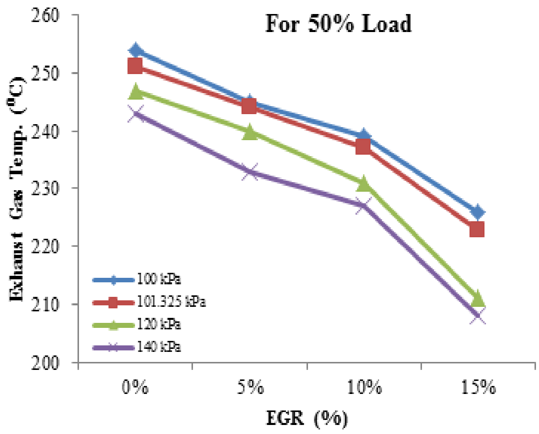

Figure No.5: Effects of Air Induction Pressure on Exhaust gas temperature for EGR rate at 50% load [2]

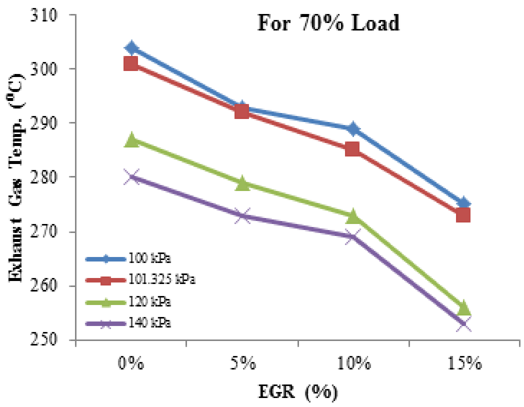

Figure No.6: Effects of Air Induction Pressure on Exhaust gas temperature for EGR rate at 70% load [2]

Conclusion

It is observed that, different methods of increasing air induction pressure are very effective to improve engine performance and emission control of Compression Ignition engine. It shows that increase in air induction pressure increases brake thermal efficiency, decreases exhaust gas temperature and decrease in Brake specific fuel consumption. Also increasing inlet air pressure reduces NO_x emission and increases HC, CO and CO_2 emission. Increase in CO, HC, and CO_2 emissions can be reduced by using exhaust after-treatment techniques, such as diesel oxidation catalysts (DOCs) and soot traps.

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