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Possible Causes of Induction Pressure Reduction in a Four Stroke Compression Ignition Engine: A Review

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ABSTRACT

Air induction pressure is important factor for enhancing Compression Ignition (C.I.) engine performance. Air induction pressure is a key factor for combustion in engine cylinder; it has direct influence on efficiency and engine out emissions. Fuel consumption rate is a basic dependent variable, varies because of any possible variable variations such as engine design, its operating conditions and fuel, air induction pressure and back pressure on engine. In this work, methods of controlling induction pressure are investigated with possible causes of induction pressure reduction in a four stroke Compression Ignition engine so that to improve engine performance. Supercharger and Turbo- chargers are used to increase the induction pressure and thereby amount of air supply so as to increase thermal efficiency of four stroke compression ignition engine.

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I. INTRODUCTION

Owing to Concern of environmental pollution and energy crisis all over the world, a 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 increased [1]. Diesel engines are more economically than any other device in this size range for bulk movement of goods, powering stationary/mobile equipment, and to generate electricity. The air induction system plays most important role in combustion of CI engine by providing necessary air charge [8, 9]. As we know that the pressure drop across the air intake manifold has a significant effect on the indicated power of the internal combustion engine. To improve the volumetric efficiency, the majority car manufacturers place the air grill at the front of a vehicle.The most important of these engine technologies are advanced air suction pressure improvements, fuel injection systems, combustion chamber modifications, and electronic engine control. Among them, air suction pressure improvements is introduced on both light- and heavy-duty diesel engines to improve efficiency and to control NOx emissions.air suction pressure in automobiles can be controlled in three different ways. One is using supercharger. The second is by using turbocharger, and the third one is to provide an modification of air induction system. Thus the air induction variation techniques seem to be more feasible as compared to other alternative techniques for improving engine performance and reducing exhaust emissions instead of going for engine and fuel modifications.Operating parameters of a Compression Ignition engine includes fuel consumption rate as a basic dependent variable, varies because of any possible variable variations such as speed of engine, Load on engine, engine design, engine operating conditions and fuel, air induction pressure and back pressure on engine. Air Supercharger and Turbo-chargers are used to increase the induction pressure and thereby amount of air supply so as to increase thermal efficiency of four stroke compression ignition engine [2, 3, 10].

The indicator diagram of a four-stroke diesel engine cycle consists of two enclosed areas as shown in the figure-1. The gross work done is represented by the large area. The smaller shaded area represents the loss of work due to exhausting of burnt gases and admission of new unburnt gas or charge, formed by the suction and exhaust operations is called pumping loop. To obtain the net work done, work obtained from the negative area is to be substracted from the gross work. For justification purpose, the pumping loop is magnified in figure. The volumetric efficiency of the engine is affected by the gas exchange processes. The performance of the engine depends on the volumetric efficiency. when the piston moves from bottom dead centre to top dead centre during the exhaust stroke, pressure rises and gases are pushed into exhaust pipe. Therefore the power required to drive the exhaust gases is called the exhaust stroke loss and increase in speed increases the exhaust stroke loss. The indicator diagram of a diesel four-stroke cycle engine shows the suction line ―ea‖ lies below the atmospheric pressure line [4-7].Owing to the restricted area, the entering air cannot flow into the cylinder in sufficient quantity to keep the pressure with the rapidly moving piston. The restricted area of the inlet passages results in the fall of pressure below the atmospheric pressure. Due to the restricted area of the exhaust passages that do not allow the gases to move out of the cylinder quickly as a result of which the exhaust pressure remains somewhat higher than the atmospheric pressure. Therefore the exhaust line ―de‖ does not coincide with the atmospheric pressure line but it rises slightly above it. With the use of supercharger the air pressure of the inlet on I.C. engine can be increased which results in decrease in the negative loop of the indicator diagram of a four-stroke diesel engine cycle. This can increase the net work done. [10,11, 12]

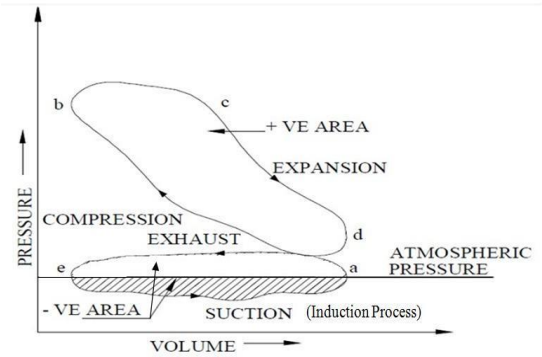

Figure 1: Theoretical Indicator diagram of a four-stroke diesel engine cycle

II. CAUSES OF AIR INDUCTION PRESSURE REDUCTION FOR C.I. ENGINE

In IC engines, induction of air is of greater importance than that of fuel even though air and fuel are vital substances in the combustion process. Causes of air induction pressure reduction for C.I. engine are discussed here.

1. Different Inclinations of the Intake Manifold:-

The main characteristic on designing an air induction system is its air flow through the system. The air flow efficiency of the air induction system has a direct impact on the power the engine can deliver. Decreasing the pressure drop inside the air induction system can smooth the air flow and increase the flow efficiency.The primary function of the suction manifold is to uniformly distribute the air in a direct injection engine) to every intake port in the cylinder head(s). Traditionally, the suction manifold has been manufactured from aluminium or cast iron however use of composite plastic materials is gaining popularity. The irregular or pulsating nature of the airflow through the suction manifold into each cylinder might develop resonances in the airflow at definite speeds. These may raise the engine performance characteristics at certain engine speeds, but may reduce at other speeds, depending on manifold dimension and shape. Engineers exposed that pulsating flow can be used to force additional air into the engine making it more competent. Air motion in CI engine influences the atomization and distribution of fuel injected in the combustion chamber and also supplies fresh air to the interior portion of the fuel drops and thereby ensures complete combustion. It increases the thermal efficiency of the engine by method of complete combustion and reduced excess air supply. That means it reduces specific fuel consumption of the engine [13]In-cylinder fluid motion controls the fuel-air mixing and premixed burning in diesel engines. With best possible turbulence, better mixing of fuel and air is achievable which leads to efficient combustion.

2. Different threads on the Intake Manifold:-

Swirl induced by the inlet manifold will be helpful to produce high turbulence prior to combustion within the cylinder. The effect of air swirl generated by directing the air flow in intake manifold on engine performance is studied. The turbulence is achieved in the inlet manifold with different types of internal threads of constant pitch. Inlet manifold with buttress threads is recognized as best possible configuration based on performance characteristics of engine. This is because inlet manifold with buttress threads achieved a higher swirl coefficient and swirl ratio compared with inlet manifold having acme and knuckle threads.The volumetric efficiency is maximum for engine with inlet manifold having buttress internal threads and minimum for engine with normal inlet manifold and in between these two engines with inlet manifolds having acme and knuckle internal threads at a given load [14].

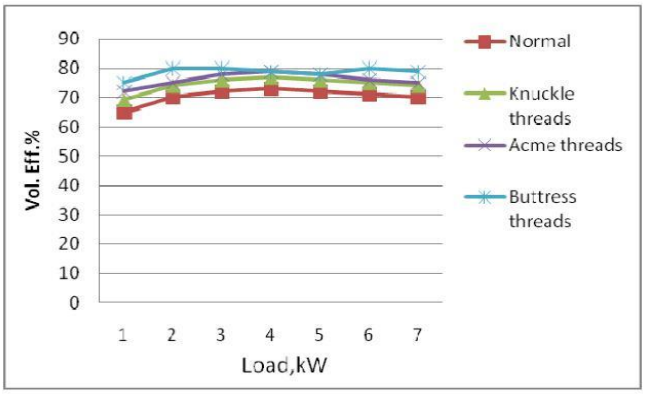

Figure no 1:-Volumetric efficiency Vs Load [14]

3. High Altitude road conditions:-

High altitude performance is a most important worry for automobiles. Owing to lack of air density and pressure at

high altitude the mass flow rate to engine drops considerably with altitude. The reason as altitude increases, air thins and as air is essential for combustion, power produced by the engine decreases. [19]

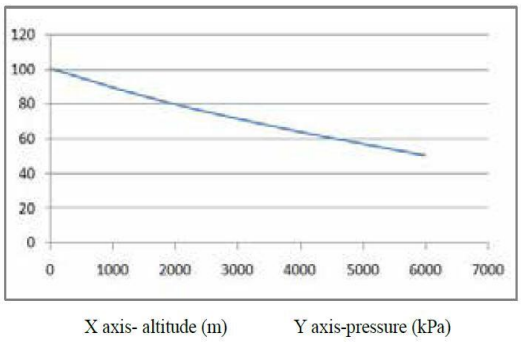

Fig. 2: Pressure variation with altitude [18]

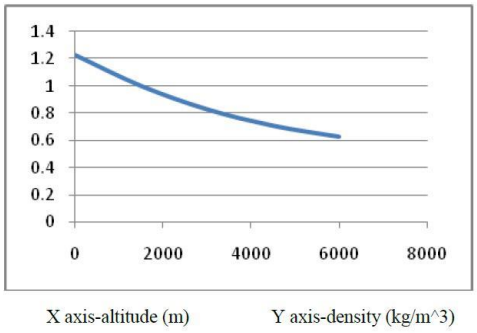

Fig. 3: Variation of air density with altitude [18]

From Figure 2 and 3, it is seen that as going to higher altitude there is a considerable decrease in atmospheric pressure and air density.

4. Charge Air Temperature:-

It is apparent that the engine's power decreases as the air intake mass flow rate diminishes. The properties of air which affect the mass flow rate, among others are the density which is associated with the air temperature. The volumetric efficiency is increased as the charge air temperature reduces. But, the increase of charge air temperature could also probably improve the fuel vaporisation in engine cylinders. The increase of inlet temperature promoted in the reduction of in-cylinder trap mass (thermal trottling effect). Therefore, the capacity of oxygen and heat capacity of the air charge significantly reduced when air temperature increases.[16]

5. Air Filters:-

Engineers are generally interested in two parameters namely temperature and pressure drop through the air filter in order to carry out an assessment of the design and performance of air filter. While discussing the relationship of filter efficiency and pressure drop with the porosity, fiber diameter and filter thickness and found that filter efficiency has exponential relationship with filter porosity, fiber diameter and thickness. The empirical equation for the prediction of the pressure drop across the dust cake of coal gasification (CG) fly ash formed on a ceramic filter considering temperature effect is developed. Poor air quality will significantly impact the performance of diesel engine. The air intake is an open loop system, and the air filter only has one opportunity to filter the contaminant out of the intake air.[15]

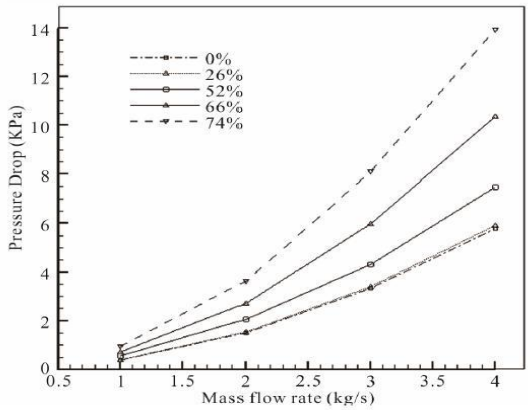

Fig. 4: Altering pressure drop with variety of mass flow in different masking holes at air filter. [15]

III. Conclusions

To minimize the pumping work, induction pressure must be atmospheric pressure or slightly above for obtaining the maximum output from the engine.Induction pressure is directly proportional to pressure drop across complete air induction system or design of all air induction system components and specifically pressure drop in air filter causes reduction in induction pressure. Regular cleaning of air filter for removal of accumulated dust or any other solid particles, improvement of filter and engine air inlet flow area design is likely to make this practically feasible. It is necessary not just to adequately implement air induction system in new technology, but also older technology engines which are still on the road. Basic causes of reduction in induction pressure and remedial actions are suggested in this work. Regular cleaning of air filter particularly in C.I. engine air induction system devices specifically requires attention because of dust or any other solid particles accumulates in flow path.Economical maximum air supply through air induction system to increase combustion efficiency and thereby reduction in engine out emissions without adversely affecting the engine performance with durability is the ideal requirement from any air induction System.

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