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Improving the Volumetric Efficiency of Six Cylinder Diesel Engine by Forced Air Supply and Studying Its Performance Characteristics

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Abstract: ***The main objective is to improve the volumetric efficiency using forced air induction and study the performance characteristics of a six cylinder diesel engine. To improve the volumetric efficiency of the six cylinder diesel engine, by forced air supply a blower is placed at the engine inlet. The performance characteristics are obtained by software provided by the "COMBUSTION ANALYSIS SOFTWARE", and the variation in volumetric efficiency of naturally aspirated engine to volumetric efficiency of forced air supply are compared.***

Keywords: Six Cylinder Diesel Engine, Volumetric Efficiency and Forced Air Supply

1. Introduction

Volumetric efficiency in the internal combustion engine design refers to the efficiency with which the engine can move the charge into and out of the cylinders. More specifically, volumetric efficiency is a ratio of the quantity of air that is trapped by the cylinder during induction over the swept volume of the cylinder under static conditions.

VE can be improved in a number of ways; most effectively this can be achieved by compressing the induction charge or by aggressive cam phasing in normally aspirated engines as seen in racing application. In either case VE can exceed 100%. Many high performance cars use carefully arranged air intakes and tuned exhaust systems that use pressure waves to push air into and out of the cylinders, making use of the resonance of the system. Two-stroke engines are very sensitive to this concept and can use expansion chambers that return the escaping air-fuel mixture back to the cylinder. A more modern technique for 4 stroke engines, variable valve timing, and attempts to address the change in volumetric efficiency with changes in speed of the engine: at higher speeds the engine needs the valves open for a greater percentage of the cycle time to move the charge in and out of the engine.

2. Intake Air Management For Diesel Engines

Managing the supply of air to the combustion chamber is an important process to ensure consistent and reliable performance of modern diesel engines. Air management encompasses all aspects that affect the quantity, composition, temperature, pressure, bulk motion and cleanliness of the combustion air at the start of the heat release period. Details of the intake system, cylinder head and valve train design, pressure boosting technology and charge dilution requirements are all important aspects of intake air management. Managing the supply of air to the combustion chamber is a critical aspect of modern diesel engines and can impact emissions, performance and fuel economy. Combustion air management is the process that is used to ensure that the air supplied to the combustion chamber at all operating conditions meet a number of requirements including

- Sufficient quantity of oxygen is available to ensure complete combustion.
- Sufficient amount of diluents are present to control the combustion temperature.
- The temperature and pressure of the charge air is controlled.
- Suitable bulk motion and kinetic energy is imparted to the charge air in the cylinder to support the mixing of air, fuel and intermediate combustion products.
- The size and concentration of impurities such as dust and dirt is acceptable.

3. Experimental Details

A six cylinder, four stroke Ashok Leyland, water cooled direct injection, overhead valve, naturally aspirated diesel engine with a bore of 104 mm and stroke of 118 mm and compression ratio 17.9:1, having the firing order 1-4-2-6-3-5 with a compression pressure of 36-39 kg/cm2 is used for the experiment. The engine load is applied with a help of an eddy current dynamometer. The capacity of the dynamometer at maximum torque is 70Kgm @ 600-700 rpm and the maximum power is 30 Load-cell. The air blower set up has a air flow rate of 70 CFM and pressure 4 inch- WG and speed 2800 rpm having a motor capacity of 1 HP with single phase. The six cylinder engine, the dynamometer and the air blower set up are shown in the following figures respectively.

Figure 1: Six Cylinder Diesel Engine

Figure 2: Eddy Current Dynamometer

Figure 3: Air Blower Setup with Engine

4. Results and Discussions

Initially the test was performed at a constant speed of 800 rpm. The performance parameters were noted down. Using the analysis software the graph of volumetric efficiency (%) v/s Load was obtained. On observation it is seen that there is an improvement in the volumetric efficiency. This experiment was continued for different speeds and the results are as follows.

The terms used are
BIAB: Before installing the air blower.
AIAB: After installing the air blower.
VE: Volumetric efficiency.

1. SPEED=800 RPM

Load (%)		20%	40%	60%	80%	100%
VE (%)	BIAB	77.8	76.1	75.8	73	71
	AIAB	82.8	81.7	81.3	80.1	79.7

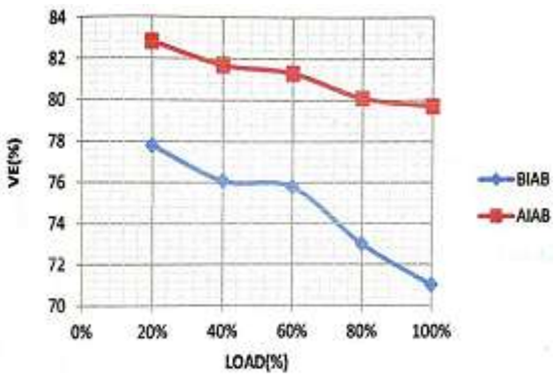

Figure 4: Comparison of VE to load

From the table and Fig.4 the variation of the VE with percentage load is shown. It can be seen from the fig.4 that as the load increases the VE decreases. This is mainly because as the load increases the cylinder gas temperature increases and leads to higher cylinder valve intake manifold temperature, thereby reducing the density of intake air. The VE of engine before supply of the forced air to the intake manifold of the engine is "77.8% at 20% load" and it is gradually reduces to "71% at 100% load".

After installation and supply of forced air to the intake manifold VE of engine is observed to be "82.8% at 20% load" and it gradually reduces to "79.7% at 100% load".

2. SPEED=1000 RPM

Load (%)		20%	40%	60%	80%	100%
VE (%)	BIAB	73.6	73.3	73	72.6	71.4
	AIAB	79	78.6	78	77.1	76.6

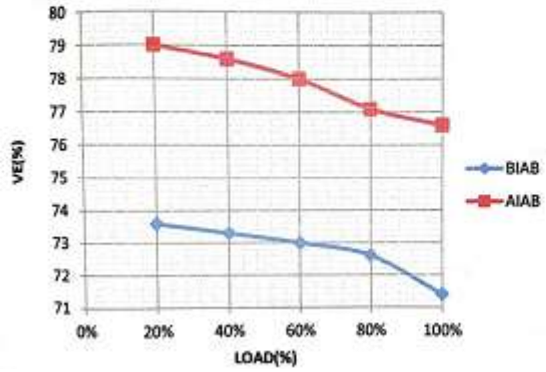

Figure 5

From the table and Fig.5 the variation of the VE with percentage load is shown. It can be seen from the fig.5 that as the load increases the VE decreases. This is mainly because as the load increases the cylinder gas temperature increases and leads to higher cylinder valve intake manifold temperature, thereby reducing the density of intake air. The VE of engine before supply of the forced air to the intake manifold of the engine is "73.6% at 20% load" and it is gradually reduces to "71.4% at 100% load". After installation and supply of forced air to the intake manifold VE of engine is observed to be "79% at 20% load" and it gradually reduces to "76.6% at 100% load".

3. SPEED=1200 RPM

Load (%)		20%	40%	60%	80%	100%
VE (%)	BIAB	62.5	62.3	61.7	60.8	60.1
	AIAB	67.6	67.3	66.8	66	65.5

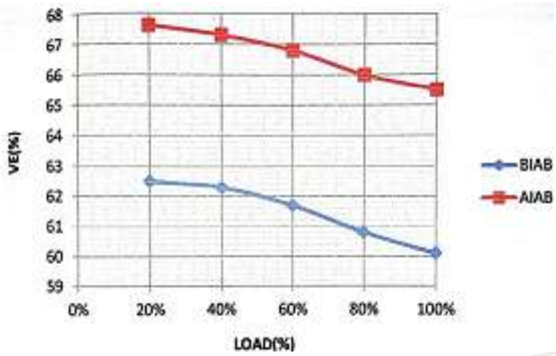

Figure 6

From the table and Fig.6 the variation of the VE with percentage load is shown. It can be seen from the fig.6 that as the load increases the VE decreases. This is mainly because as the load increases the cylinder gas temperature increases and leads to higher cylinder valve intake manifold temperature, thereby reducing the density of intake air. The VE of engine before supply of the forced air to the intake manifold of the engine is "62.5% at 20% load" and it is gradually reduces to "60.1% at 100% load".

After installation and supply of forced air to the intake manifold VE of engine is observed to be "67.6% at 20% load" and it gradually reduces to "65.5% at 100% load".

4. SPEED=1400 RPM

Load (%)		20%	40%	60%	80%	100%
VE (%)	BIAB	53.8	53.6	53	52.7	52.4
	AIAB	58	57.6	57.3	56.9	56.2

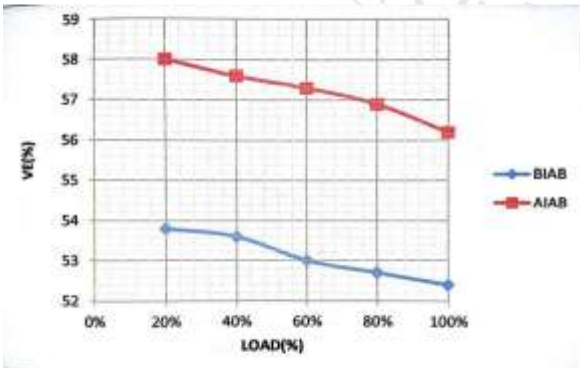

Figure 7

From the table and Fig.7 the variation of the VE with percentage load is shown. It can be seen from the fig.7 that as the load increases the VE decreases. This is mainly because as the load increases the cylinder gas temperature increases and leads to higher cylinder valve intake manifold temperature, thereby reducing the density of intake air. The VE of engine before supply of the forced air to the intake manifold of the engine is "53.8% at 20% load" and it is gradually reduces to "52.4% at 100% load".

After installation and supply of forced air to the intake manifold VE of engine is observed to be "58% at 20% load" and it gradually reduces to "56.2% at 100% load".

5. SPEED=1600 RPM

Load (%)		20%	40%	60%	80%	100%
VE (%)	BIAB	48.3	48.1	47.9	47.7	47.5
	AIAB	48.5	48.3	48.1	47.9	47.7

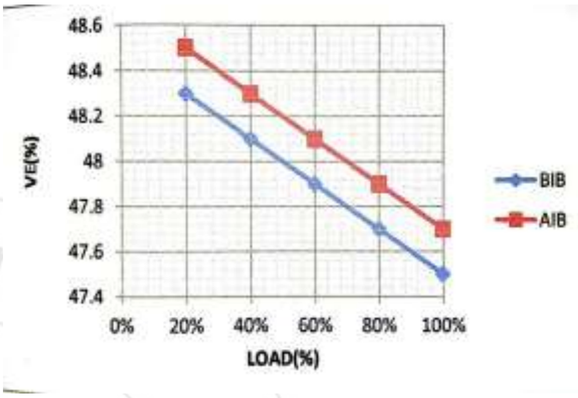

Figure 8

From the table and Fig.8 the variation of the VE with percentage load is shown. It can be seen from the fig.8 that as the load increases the VE decreases. This is mainly because as the load increases the cylinder gas temperature increases and leads to higher cylinder valve intake manifold temperature, thereby reducing the density of intake air. The VE of engine before supply of the forced air to the intake manifold of the engine is "48.3% at 20% load" and it is gradually reduces to "47.5% at 100% load".

After installation and supply of forced air to the intake manifold VE of engine is observed to be "48.5% at 20% load" and it gradually reduces to "47.7% at 100% load".

5. Conclusions

The following conclusions are drawn based on the experiments carried out on a six cylinder diesel engine under forced air supply conditions:

1) A centrifugal blower coupled to 1 HP induction motor is used to provide forced air circulation, the distance between blower outlet and filter inlet of the engine is set to an optimum valve which gives efficient values.
2) Resulting combustion parameters are directly availed by combustion analysis software, the different characteristics are tabulated, graphs are drawn and some direct graphs are provided by the software.
3) Comparing the combustion results of before and after installing the blower. We have noticed slight increment in the volumetric efficiency.
4) Here we have control over the only one i.e. air supply to the inlet component and several other components also affect volumetric efficiencies of the engine like throttle opening and engine speed as well as induction and

exhaust system layout, port size, valve timing and opening duration.

5) Gaining control over the remaining parameters enhances us to improve the volumetric efficiency vary nearer to the theoretical maximum value.
6) Since engine with higher volumetric efficiency are better able to handle higher speeds and produce overall power, there is concentrated interest in being able to alter or improve volumetric efficiency in a combustion engine.
7) Increasing volumetric efficiency via supercharging or forced air circulation plays an important role in increasing power output per unit volume of the engine to maintain power of aircraft engines at high altitudes were less oxygen is less available for combustion required by the engine and also in racing cars and other high power engines.

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