Effect of Variable Compression Ratio on The Performance of A Diesel Engine Fuelled With Diesel and Oxygenated Additives Blending

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Abstract— **This work investigates the effect of variable compression ratio on performance of a single cylinder four stroke diesel engines fuelled with diesel & oxygenated blending. Experiments were conducted with different compression ratios of 16,17and18 at various load conditions (0Kg to 9Kg) & at a constant speed of 1500 rpm. Diesel engine fueled with oxygenated additives blending of 2 Ethoxy Ethyl Acetate (EEA) & Dimethyl carbonate with diesel. First fuel blends which contain 5% (95% Diesel & 5% EEA), 10% (90% Diesel &10% EEA) and 15% (85% Diesel &15% EEA) of EEA additive & second fuel blend which contain 5% (95% Diesel & 5% DMC), 10% (90% Diesel & 10%DMC) and 15% (85% Diesel & 15% DMC) of DMC additive were prepared and the effect of these additives blends on performance of single cylinder variable compression engine. It was observed that increasing the Brake thermal efficiency at both additives blending in comparison with diesel. Brake thermal efficiency also increases with increasing compression ratio for diesel & all blends. Brake specific fuel consumption was found to be decreases at both additives blending in comparison with diesel. Brake specific fuel consumption also decreases with increasing compression ratio for diesel & all blends.**

Index Terms- **Variable Compression,2 Ethoxy Ethyl Acetate, Dimethyl carbonate, Diesel, Performance, Compression Ignition Engine.**

I. INTRODUCTION

Diesel engines are widely used for transportation and agriculture applications due to their reliability, durability and high thermal efficiency. However, there are two major challenges facing the use of Diesel engines. One is related with fossil fuel sustainability and other is related with environmental concern on engine emissions. So far, Diesel engines have adapted many technical break-throughs for reducing fuel consumption and pollutant emissions. Also increases break thermal efficiency by using diesel & 2EEA blends

R.Senthil, M.Kannan, .Nadanakumar, S. Santhanakrishnan, P. Lawrence investigates the performance and emission characteristics of a direct injection Diesel engine fueled with 2 Ethoxy Ethyl Acetate (EEA) blends. Different fuel blends which contain 5%, 10% and 15% of EEA were prepared.By using the blends of Diesel and 2 Ethoxy Ethyl Acetate, the emissions were reduced and simultane-ous improvement in the brake thermal efficiency was seen[1]

The investigation was carried out by Bhavin H. Mehta & Hiren V. Mandalia describes some properties of synthetic oxygenates and their influence on exhaust emissions from diesel engines. They were used Dimethyl carbonate as oxygenated additives with proportion 5%,10%, &15% with diesel. They were used single-cylinder, 4-Stroke, water-cooled diesel engine of 5 hp rated power for the purpose of experimentation. The engine is coupled to a rope brake dynamometer through a load cell. They observed that if these additives are added in diesel at appropriate proportion improves the engine performance and emission characteristics[2]

The investigation was carried out by T. Nibin, A. Sathiyagnanam and S. Shivprakasam, 2003 to improve the performance of a diesel engine by adding oxygenated fuel additive of known percentage. The effect of fuel additive was to control the emission from diesel engine and to improve its performance. The fuel additive dimethyl carbonate was mixed with diesel fuel in concentrations of 5%, 10% and 15% and used. The experimental study was carried out in a multi-cylinder diesel engine.

The result showed an appreciable reduction of emissions such as particulate matter, oxides of nitrogen, smoke density and marginal increase in the performance when compared with normal diesel engine as [3].

Prajapati Simit B., Dr. Rathod Pravin P, Prof. Patel Nikul K. invistigates the use of oxygenated additives into fuel oil is one of the possible approaches for reducing emission & improve performance of engine. They were use addition of DMC and EGM to diesel fuel which changes the physicochemical properties of blends. The energy density of blends decreases with the increase in DMC-EGM. Brake thermal efficiency increases with this blend. [4]

Rahul Sood, Ashwani Kumar, Gurpreet Singh Batth investigating study of diesel fuel was used as a reference fuel for 2-Ethoxy Ethyl Acetate –diesel blends. The blends containing 5, 10 and 15% of 2-Ethoxy Ethyl Acetate fuel by volume are tested on test rig developed for the experimentation. All the tests were conducted in steady state and were set at constant engine speed 1500 RPM. With the addition of oxygen in the fuel, it has been observed that the emission contents reduce remarkably & the addition of 2-Ethoxy Ethyl Acetate by 10% in diesel not only helps to reduce the exhaust emission but also increases the performance of the diesel engine.10% blend increases the BHP by 7.6% and BTE increases by 7.2% at full load conditions. [5]

Sayi Likhitha S S, B. Durga Prasad, Ch. R. Vikram Kumar invistigates the effect of blending of Diethyl ether (DEE) with diesel at various proportions (5%,7.5% and 10%) on the performance of diesel engine. The experimental results indicated that with the increase in the concentration of DEE to diesel increases the brake thermal efficiency, mechanical efficiency and decreases the specific fuel consumption. The performance of diesel engine at different compression ratios (18, 16 and 14) for diesel with 5% DEE blend was also evaluated in this work. Compression ratio 18 gives the best performance results than compression ratios 16 and 14 for blend of diesel with 5%DEE fuel [6]

R. Silambarasan, R. Senthil, G.Pranesh,P.Mebin Samuel, M.Manimaran investigates the optimum performance and emission characteristics of single cylinder Variable Compression Ratio (VCR) Engine with different blends of Annona Methyl Ester (AME) as fuel. The performance parameters such as specific fuel consumption (SFC), brake thermal efficiency (BTHE) were compared with the diesel fuel. It is found that, at compression ratio of 19.5:1 for A20 blended fuel (20%AME+80%Diesel) shows better performance and lower emission level which is very close to neat diesel fuel. It is also found that the increase of compression ratio increases the BTE and reduces BSFC and having lower emission without any engine in design modifications. [7]

Santosh Kumar Kurre, Shyam Pandey, Mukesh Saxena was performed in a 3.7kW, 4 –stroke single cylinder, water cooled, variable compression ratio, diesel engine fueled with the different blends of ethanol and diesel fuel run on three different compression ratios of 17, 17.5 and 18. The experiments were conducted for engine emission and performance with blendes of ethanol of 5% with diesel termed as fuel E5, 10% as fuel E10, 15% as fuel E15 and 20% as fuel E20. Brake specific fuel consumption decreases with the compression ratio increases. Brake thermal efficiency increase with the compression ratio for all fuel. [8]

II. EXPERIMENTAL SET UP

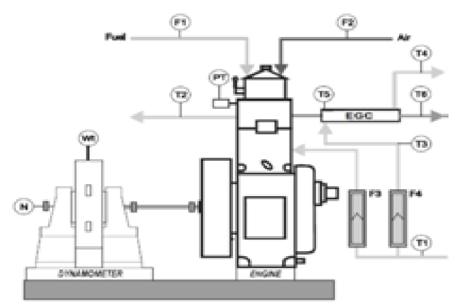

Fig.1 Block diagram of Experimental Set-up

F1-Fuel Flow line, F2-Air Flow line, F3-Water flow to engine WJ, F4- Water flow to EGC, N- rotary encoder, PT- Pressure Transducer (Piezo Sensor), Wt-Strain gauge (Load Sensor), T1(°C)-Water inlet temp to engine, T2 (°C)-Water outlet temp from engine, T3 ((°C)Water inlet temp to Calorimeter, T4 (°C)Water outlet temp from Calorimeter, T5 (°C)Exhaust gas inlet temp, T6 (°C)-Exhaust gas outlet temp.

In this work experiments are conducted on computerized Variable Compression Ratio (VCR) engine test rig as shown in Fig.1. The setup consists of single cylinder four stroke VCR (Variable Compression Ratio) Diesel engine connected to eddy current type dynamometer for loading. The compression ratio can be changed without stopping the engine and without altering the combustion chamber geometry by specially designed tilting cylinder block arrangement. The experimental set up consist two pressure sensors, one placed inside the combustion chamber to measure the combustion pressure and the other placed in the injection nozzle to find the injection pressure. The digital encoder is placed to place the crank angle movement. The gas calorimeter is fixed to the exhaust gases to measure the heat loss through the exact gases. The test rig also equipped with airflow, fuel flow, temperatures and load measurement sensors. The specification of the test rig is shown in Table No.1.

Table No.1 specification of the test rig

Engine type	**Single cylinder four stroke water cooled, Constant Speed, VCR Diesel Engine**
Engine Make	**Kirloskar Oil Engine Ltd.**
Stoke length	**110mm**
Bore diameter	**87mm**
Capacity	**661cc**
Engine Power	**3.5kw**
Engine Speed	**1500 rpm**
Compression Ratio	**12:1 to 18:1**
Orifice diameter	**20 mm**
Dynamometer	**Eddy Current Dynamometer**
Dynamometer arm length	**185 mm**

In this work different blends of diesel with DMC &EEA additive are prepared The diesel is thoroughly mixed with DMC & EEA and Due to lower density difference, blending is not difficult and also no separation observed. The properties determined by performing basic tests for different blends. All this combinations of diesel and additives was prepared in the laboratory itself by weight(%).First the experiments were conducted in single cylinder, Variable Compression Ratio diesel engine (Kirloskar make) at compression ratio 18 with pure diesel as well as different blends of diesel & DMC additive (5% ,10% and 15% DMC).Also blends of diesel & EEA additive (5% ,10% and 15% EEA) .A set of readings were obtained first by running the engine with diesel at CR of 18 and varying the load from 0 kg to 9 kg. After completion of the experiments with pure diesels then, the engine was run on different diesel and additives (DMC & EEA) combinations and the parameters were recorded as above. Similar sets of readings were recorded for the Diesel-DMC & Diesel-EEA fuel for the compression ratio of 16 and 17. For the changing the compression ration first the engine was started at compression ratio of 18 and then the compression ratio was changed by using the tilting head arrangement as shown in Fig.3 & actual set up diagram as shown in Fig.2

Fig. 2 Actual Experimental Set-up

Fig.3 Compression ratio adjustment

The fuels used for the experimental analysis were Diesel and three kinds of Diesel-EEA & Diesel-DMC blends. The blended fuels contain 5%, 10% and 15% of EEA &DMC in the Diesel by weight (%).The properties of Diesel, EEA and DMC given in Table No.2.

Table No.2.The Physical Properties of Additives

Component	**Diesel**	**DMC**	**EEA**
Chemical formula	$C_{12}H_{23}$	$C_3H_6O_3$	$C_8H_{12}O_3$
Density(kg/m³)	839	1069	975
Oxygen content (% volume)	0	53.5	23.57
Heating value(MJ/Kg)	43	13.5	16.7

III. RESULT AND DISCUSSION

In this work the comparative performance of different blends of Diesel and both additives (DMC & EEA) were analyzed by varying the loads in terms of brake thermal efficiency and specific fuel consumptions. The effect of compression ratios on the performance of DMC & EEA blend was evaluated in terms of brake thermal efficiency and specific fuel consumptions.

1. BRAKE THERMAL EFFICIENCY

The variation in Brake thermal efficiency at different load for Different blends are shown in fig. from 4 to fig. 9 with the increase in the load, the Brake thermal efficiency (BTE) increases at higher loads for all the blends. The addition of DMC &EEA increased the BTE. It is observed that the BTE gradually increase with increasing compression ratio. At maximum load with the compression ratio of 18, the BTE for 10EEA is 32.04% and it is maximum than the neat diesel fuel (29.9%). This is due to increase in compression ratio ensures better air-fuel mixing and faster evaporation and leads to complete combustion the presence of oxygen in the EEA helps in the complete combustion of the fuel raising the BTE.

2. BRAKE SPECIFIC FUEL CONSUMPTION (BSFC)

From fig. 10 to fig. 15 shows the variation of BSFC at different load for different blends of DMC & EEA and neat diesel fuel with different compression ratios. It is observed that the BSFC is gradually decreases with increasing compression ratio. At maximum load with the compression ratio of 18, the BSFC for 10EEA is 0.277kg/kW-hr which is minimum when compared with pure diesel (0.291kg/kW-hr). This is due to better combustion of diesel fuel, which results in higher heat release.

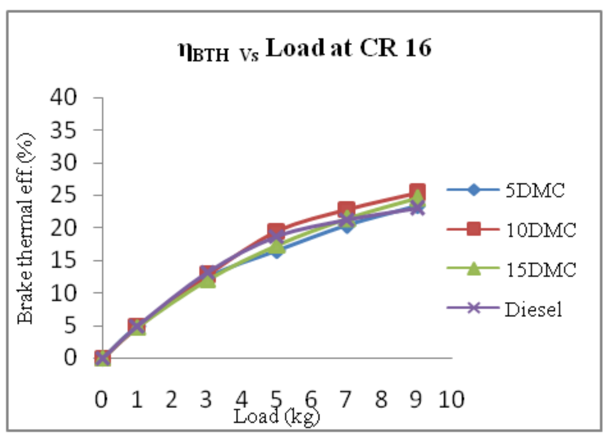

Fig 4.Variation of Brake Thermal Efficiency (η) with Changing Load at CR 16

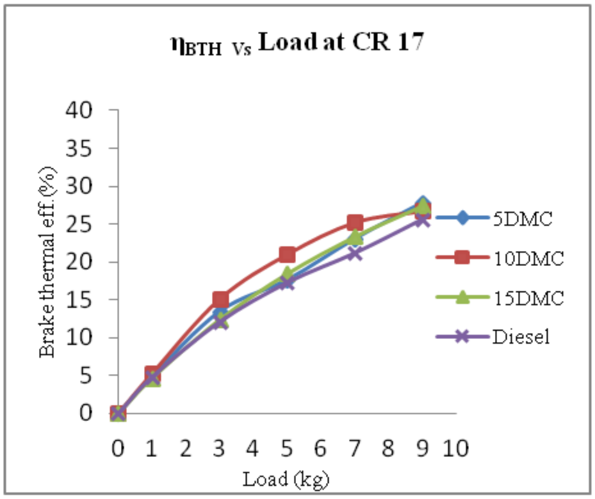

Fig 5.Variation of Brake Thermal Efficiency (η) with Changing Load at CR 17

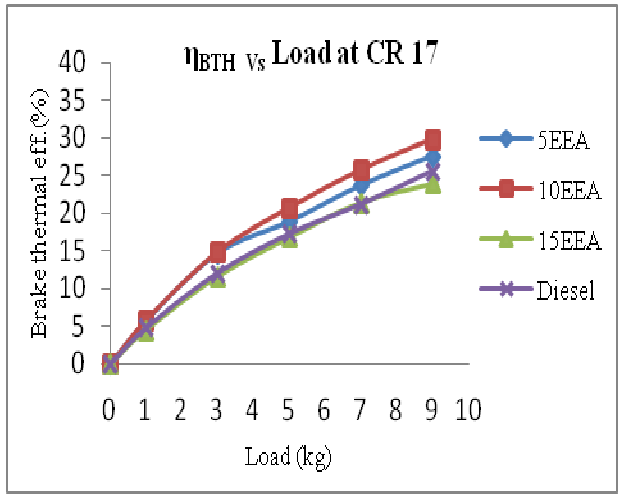

Fig 8.Variation of Brake Thermal Efficiency (η) with Changing Load at CR 17

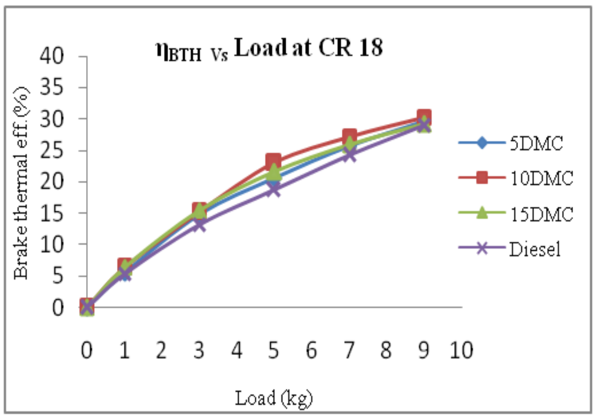

Fig 6.Variation of Brake Thermal Efficiency (η) with Changing Load at CR 18

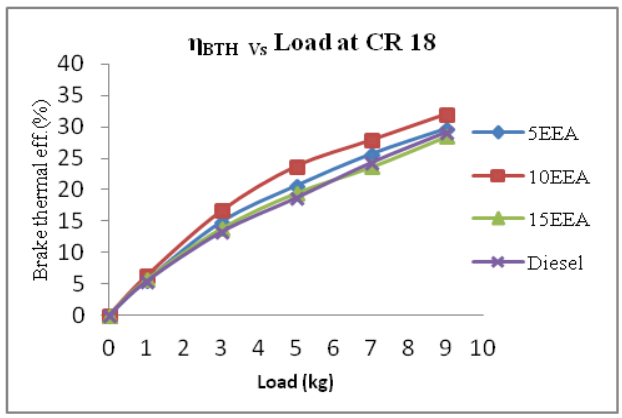

Fig 9.Variation of Brake Thermal Efficiency (η) with Changing Load at CR 18

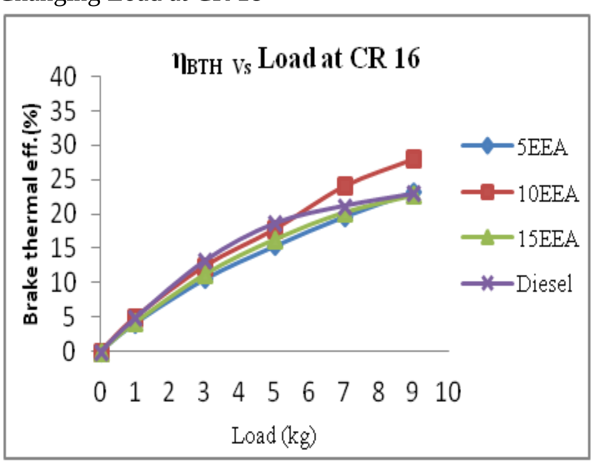

Fig 7.Variation of Brake Thermal Efficiency (η) with Changing Load at CR 16

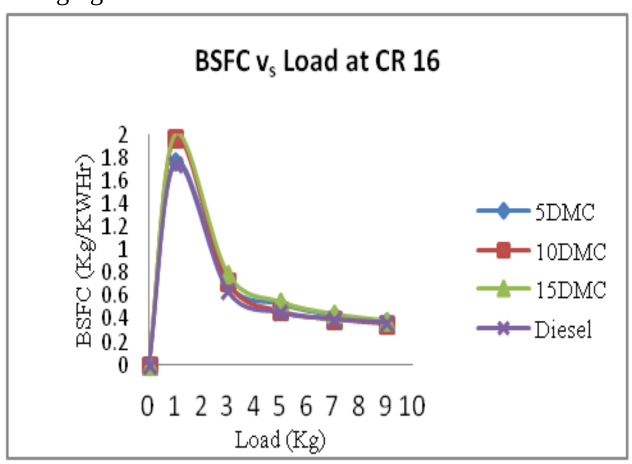

Fig 10.Variation of Brake Specific Fuel Consumption with Changing Load at CR 16

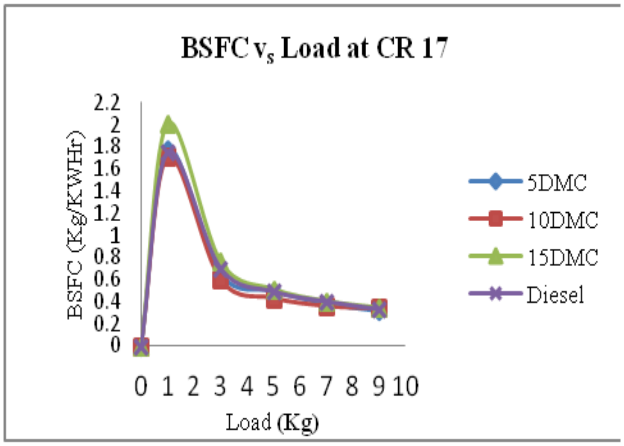

Fig 11.Variation of Brake Specific Fuel Consumption with Changing Load at CR17

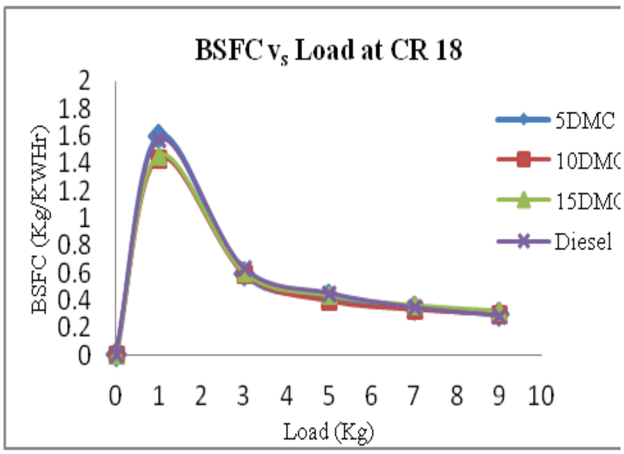

Fig 12.Variation of Brake Specific Fuel Consumption with Changing Load at CR18

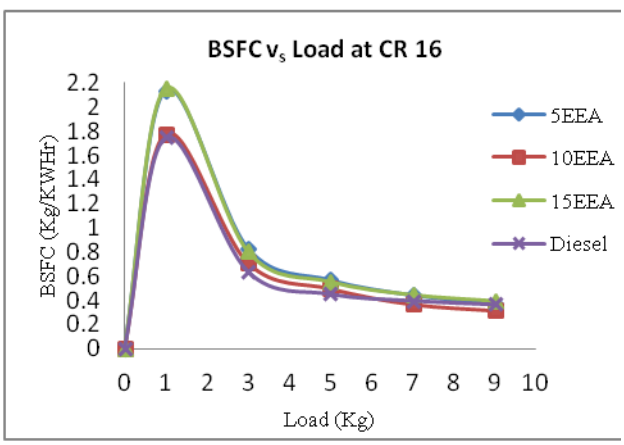

Fig 13.Variation of Brake Specific Fuel Consumption with Changing Load at CR16

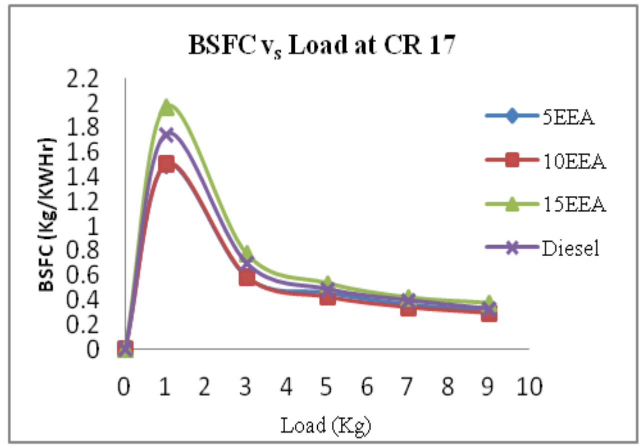

Fig 14.Variation of Brake Specific Fuel Consumption with Changing Load at CR17

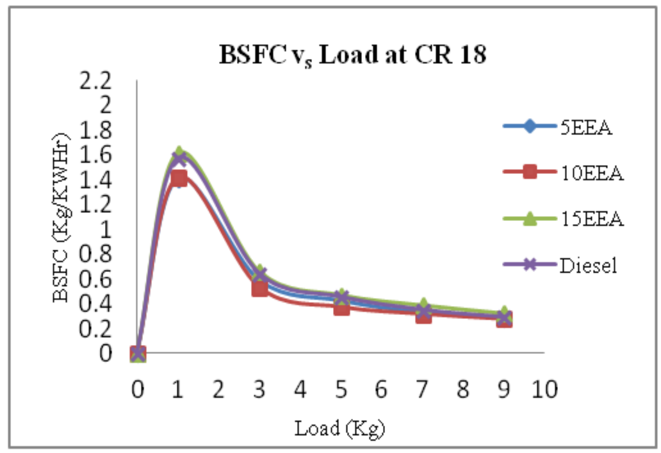

Fig 15.Variation of Brake Specific Fuel Consumption with Changing Load at CR17

IV. CONCLUSION

The performance characteristics of diesel and Oxygenated additives were investigated on four stroke single cylinder vertical water cooled VCR diesel engine. The conclusions based on experimental investigation at are as follows.

With the increase in the load, the Brake thermal efficiency (BTE) increases at higher loads for all the blends. It is observed that the BTE gradually increase with increasing compression ratio. At maximum load with the compression ratio of 18, the BTE for 10EEA is 32.04% and it is maximum than the pure diesel fuel (29.9%). This is due to improved atomization fuel vaporization, better spray characteristics and improved combustion through mixture.

It is observed that the BSFC is gradually decreases with increasing compression ratio. At maximum load with the compression ratio of 18, the BSFC for 10EEA is 0.277kg/kW-hr which is decrease when compared with pure diesel (0.291kg/kW-hr).This all is due to increase in compression ratio leads to reduction in dilution of charge by residual gases, Therefore improved combustion which results in better Brake thermal efficiency and lower BSFC.

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