

Performance Parameters of B20 Neem Blend in CI Engine by Varying Injection Timing and Nozzle Hole Diameter

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ABSTRACT: In the present study an experimental work had been carried out to analyse the performance parameters of B20 neem blend by varying injection timing and nozzle hole diameter. The engine tests are conducted on Kirloskar 4-stroke single cylinder 1500 rpm water cooled direct injection diesel engine with eddy current dynamometer with standard injection pressure 230 bar was maintained constant throughout the experiment. 3 different injection timings such as 20°bTDC, 23°bTDC, 26°bTDC and 2 different nozzles such as (3×0.28mm), (5×0.20mm) varied to analyse the performance parameters. From the test results, it could be observed that among 3 different injection timings 26°bTDC injection timing gives lower BSFC and higher BTE for all 3 nozzles. Among 3 different nozzles (3×0.28mm) nozzle gives higher BTE as compared to 5 hole nozzle.

KEYWORDS: Neem biodiesel, nozzle, injection timing, performance, blend, CI engine.

I. INTRODUCTION

The world energy demand has been increased drastically in few decades. Firstly, the price of conventional fossil fuel is rising rapidly and has added burden on the pocket of common man and economy of the nations who imports it. Secondly, combustion of fossil fuels is the main reason behind the increasing the carbon dioxide (CO₂) level, which results in increase of global warming. The depletion of conventional sources are also becomes the main concern for research world-wide into alternative energy sources for internal combustion engines. Bio-fuels have the potential to become alternative “greener” energy substitute for fossil fuels. It is available in plenty in the world and also the renewable source of energy. Neem oil cannot be used directly in diesel engine because of their high viscosity. The viscosity may cause blockage of fuel lines, filters and results in poor atomization of fuel into the combustion chamber. To reduce the high viscosity of neem oil transesterification reaction has to be done. Biodiesel from neem oil had been a promising alternative for diesel for the future.

II. METHODOLOGY

A. TRANSESTERIFICATION PROCESS

It is most commonly used and important method to reduce the viscosity of vegetable oils. In this process triglyceride reacts with three molecules of alcohol in the presence of a catalyst producing a mixture of fatty acids, alkyl ester and

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glycerol. The process of removal of all the glycerol and the fatty acids from the vegetable oil in the presence of a catalyst is called esterification.

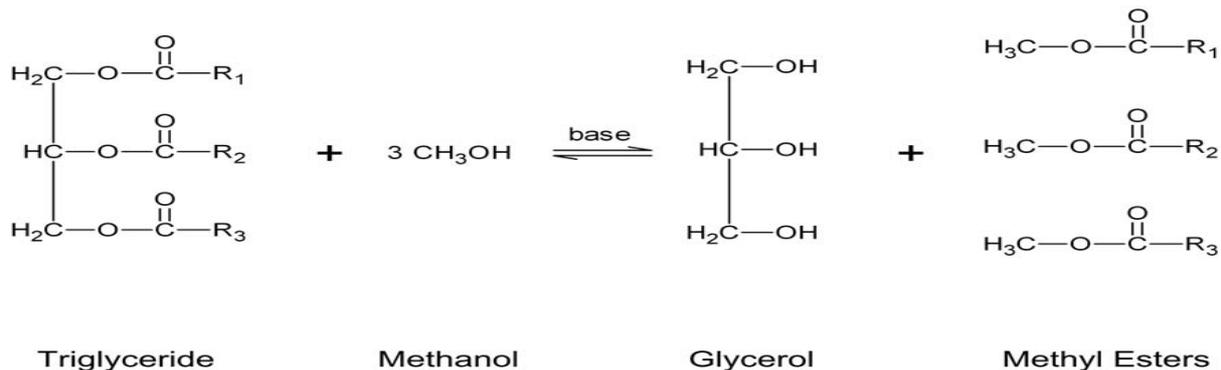


Fig-1: Transesterification reaction

B. PROPERTIES OF FUELS

Properties	Diesel	Neem biodiesel (NOME)	B20
Density (kg/m ³)	827	890	835
Kinematic viscosity at 40°C (cSt)	3.517	5.648	4.403
Flash point (°C)	47	174	69
Fire point (°C)	54	186	83
Calorific value (MJ/kg)	42	39.66	40.87

Table-1: Properties of fuels

C. EXPERIMENTAL SETUP



Fig-2: Computerized engine setup

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D. ENGINE SPECIFICATIONS

Engine Parameter	Specifications
Engine type	Kirloskar, Four stroke, Single cylinder, Water cooled, Direct injection
Bore	87.5 mm
Stroke	110 mm
Compression Ratio	17.5:1
Rated speed	1500 rpm
Rated power	5.2 kW
Injection pressure	230 bar
Injection timing	23° bTDC

Table-2: Engine specifications

The experiment was carried out to investigate the effect of change in injection timing and nozzle hole diameter on performance characteristics of B20 neem blend in a stationary single cylinder diesel engine and to compare it with diesel fuel. Technical specifications of the engine are given in above table-2. The engine was operated on diesel first and then on B20 blend of neem methyl ester. The performance parameters were analysed from the graphs regarding Brake specific fuel consumption (BSFC), Brake thermal efficiency (BTE) for the blends of B0 and B20. For determining the effect of injector nozzle diameter on diesel engine performance, the number of nozzle holes are increased such as 3 hole and 5 hole. All 3 holes have diameter of 0.28 mm. All 5 holes have diameter of 0.20 mm. Injection timing is varied by adding or removing the shims between the fuel injector pump and the engine body. It is found that by adding or removing each shim of 0.2 mm thickness, the static injection timing is varied by 3 degree. Addition of shims retarded the injection timing, while removing the shims advanced the injection timing.



Fig-3: Shims arrangement in engine



Fig-4: Photographic view of Shims

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E. NOZZLE SPRAY PATTERN



Fig-5: 3 hole nozzle spray pattern



Fig-6: 5 hole nozzle spray pattern

III. RESULTS AND DISCUSSION

A. BRAKE THERMAL EFFICIENCY (BTE)

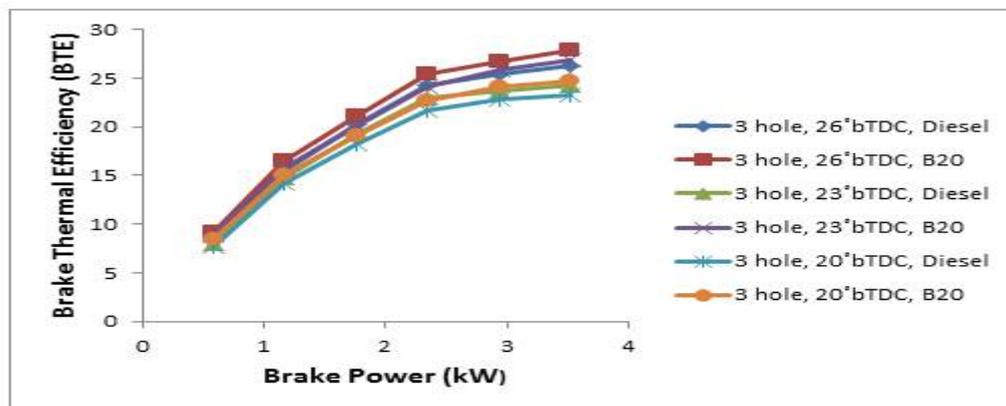


Fig-7: Variation of brake thermal efficiency with brake power for 3 hole nozzle at different injection timings

Fig-7 shows variation of brake thermal efficiency with brake power for 3 hole nozzle at 230 bar injection pressure and at different injection timings. BTE increases as the BP increases. It was observed that BTE of B20 fuel is better than diesel fuel due to more oxygen content in the B20 blend. For 3 hole nozzle 26°bTDC injection timing gives higher BTE as compared to other injection timings such as 23°bTDC and 20°bTDC injection timing. The increase in BTE at advanced injection timing may be attributed to improved combustion due to sufficient time availability for evaporation and better mixing of fuel and air, which resulted in higher premixed combustion. Retarded injection timing resulted in lower BTE due to less time for evaporation and better mixing of fuel and air resulting late combustion in operating cycle. For diesel fuel at 3.52 kW of BP, the maximum BTE was found to be 26.35%, 24.32%, 23.31% at 26°bTDC, 23°bTDC, 20°bTDC injection timings respectively. For B20 fuel at 3.52 kW of BP, the maximum BTE was found to be 27.85%, 26.82%, 24.75% at 26°bTDC, 23°bTDC, 20°bTDC injection timings respectively.

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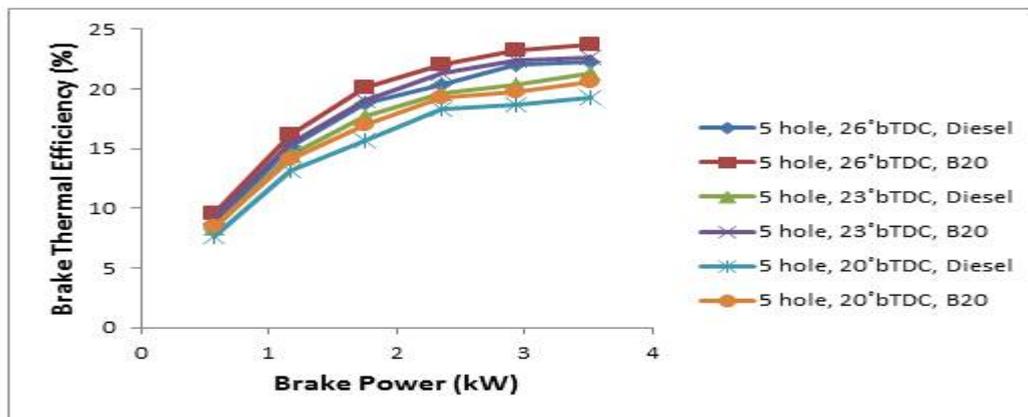


Fig-8: Variation of brake thermal efficiency with brake power for 5 hole nozzle at different injection timings

Fig-8 shows variation of brake thermal efficiency with brake power for 5 hole nozzle at 230 bar injection pressure and at different injection timings. BTE increases as the BP increases. It was observed that BTE of B20 fuel is better than diesel fuel due to more oxygen content in the B20 blend. For 5 hole nozzle 26°bTDC injection timing gives higher BTE as compared to other injection timings such as 23°bTDC and 20°bTDC injection timing. The increase in BTE at advanced injection timing may be attributed to improved combustion due to sufficient time availability for evaporation and better mixing of fuel and air, which resulted in higher premixed combustion. Retarded injection timing resulted in lower BTE due to less time for evaporation and better mixing of fuel and air resulting late combustion in operating cycle. For diesel fuel at 3.52 kW of BP, the maximum BTE was found to be 22.29%, 21.28%, 19.25% at 26°bTDC, 23°bTDC, 20°bTDC injection timings respectively. For B20 fuel at 3.52 kW of BP, the maximum BTE was found to be 23.72%, 22.69%, 20.62% at 26°bTDC, 23°bTDC, 20°bTDC injection timings respectively.

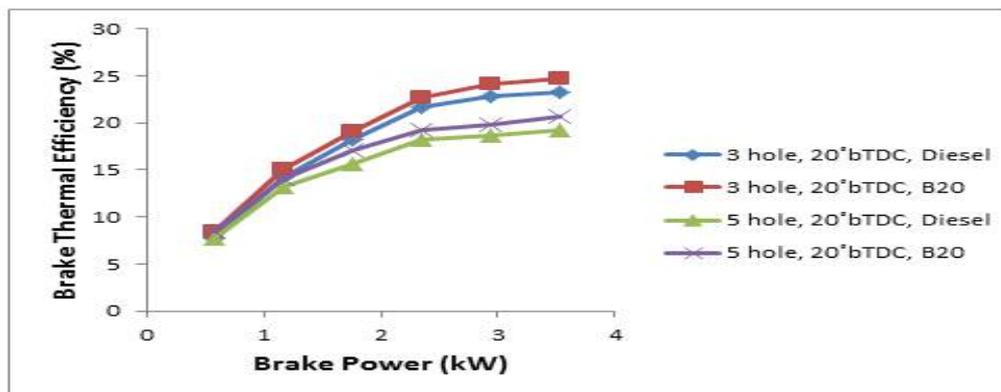


Fig-9: Variation of brake thermal efficiency with brake power for different nozzle at 20°bTDC injection timing

Fig-9 shows the variation of brake thermal efficiency with brake power for different nozzle at 230 bar injection pressure and at 20°bTDC injection timing. At 20°bTDC injection timing, for 3 hole nozzle the maximum BTE was found to be 23.31% and 24.75% for diesel and B20 fuel respectively at 3.52 kW of BP. For 5 hole nozzle the maximum BTE was found to be 19.25% and 20.62% for diesel and B20 fuel respectively at 3.52 kW of BP.

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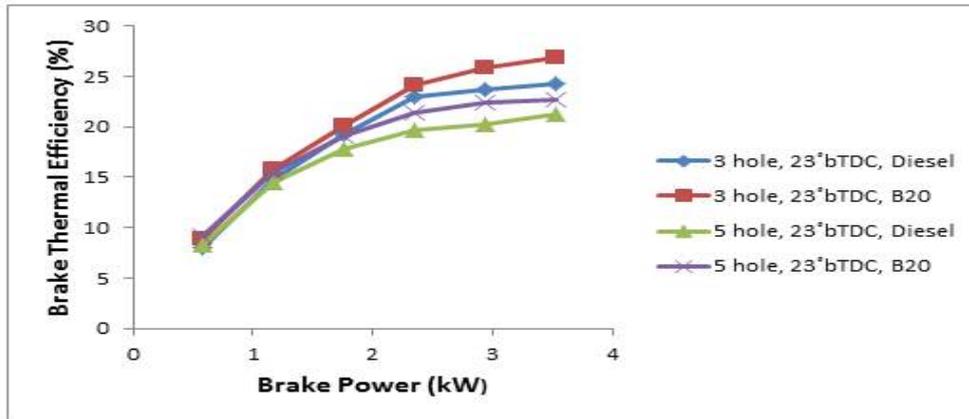


Fig-10: Variation of brake thermal efficiency with brake power for different nozzle at 23°bTDC injection timing

Fig-10 shows the variation of brake thermal efficiency with brake power for different nozzle at 230 bar injection pressure and at 23°bTDC injection timing. At 23°bTDC injection timing, for 3 hole nozzle the maximum BTE was found to be 24.32% and 26.82% for diesel and B20 fuel respectively at 3.52 kW of BP. For 5 hole nozzle the maximum BTE was found to be 21.28% and 22.69% for diesel and B20 fuel at 3.52 kW of BP.

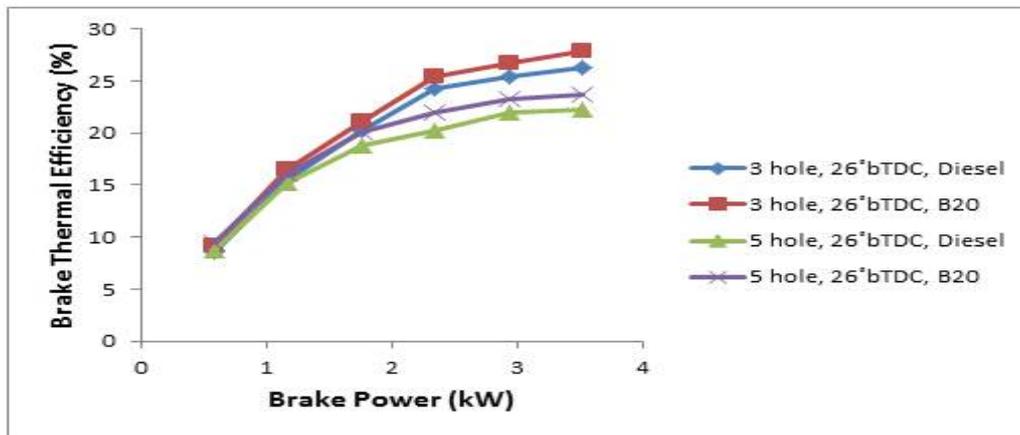


Fig-11: Variation of brake thermal efficiency with brake power for different nozzle at 26°bTDC injection timing

Fig-11 shows the variation of brake thermal efficiency with brake power for different nozzle at 230 bar injection pressure and at 26°bTDC injection timing. At 26°bTDC injection timing, for 3 hole nozzle the maximum BTE was found to be 26.35% and 27.85% for diesel and B20 fuel respectively at 3.52 kW of BP. For 5 hole nozzle the maximum BTE was found to be 22.29% and 23.72% for diesel and B20 fuel at 3.52 kW of BP.

B. BRAKE SPECIFIC FUEL CONSUMPTION (BSFC)

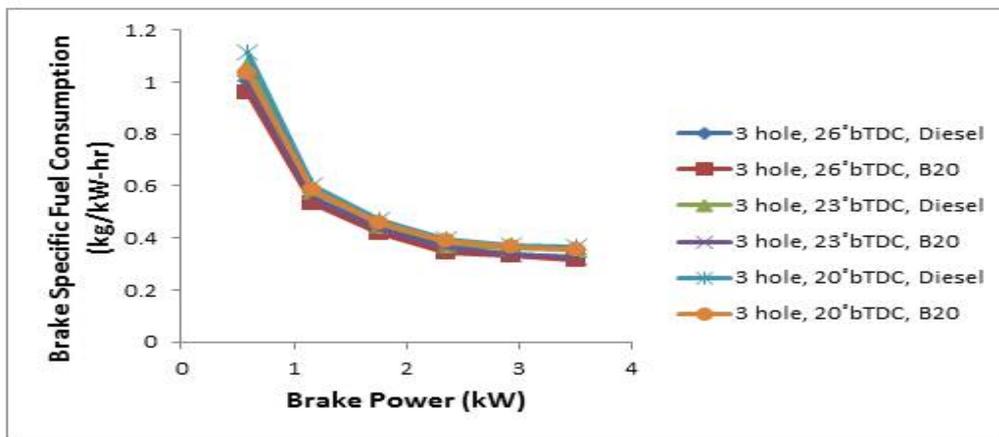


Fig-12: Variation of brake specific fuel consumption with brake power for 3 hole nozzle at different injection timings

Fig-12 shows the variation of brake specific fuel consumption with brake power for 3 hole nozzle at 230 bar injection pressure and at different injection timings. BSFC decreases as the BP increases. BSFC for B20 blend is slightly lower than diesel because of extra oxygen present in the blend is taking part in combustion process. For 3 hole nozzle 26°bTDC injection timing gives lower BSFC as compared to other injection timings such as 23°bTDC and 20°bTDC. This reduction in BSFC may be due to sufficient time availability for evaporation and mixing of fuel and air with increased premixed combustion and lower diffusion combustion. On the other hand, retarding the injection timing resulted in increased the specific fuel consumption due to late combustion. For diesel fuel at 3.52 kW of BP the minimum BSFC was found to be 0.325 kg/kW-hr, 0.352 kg/kW-hr, 0.367 kg/kW-hr at 26°bTDC, 23°bTDC, 20°bTDC injection timings respectively. For B20 fuel at 3.52 kW of BP the minimum BSFC was found to be 0.316 kg/kW-hr, 0.328 kg/kW-hr, 0.355 kg/kW-hr at 26°bTDC, 23°bTDC, 20°bTDC injection timings respectively.

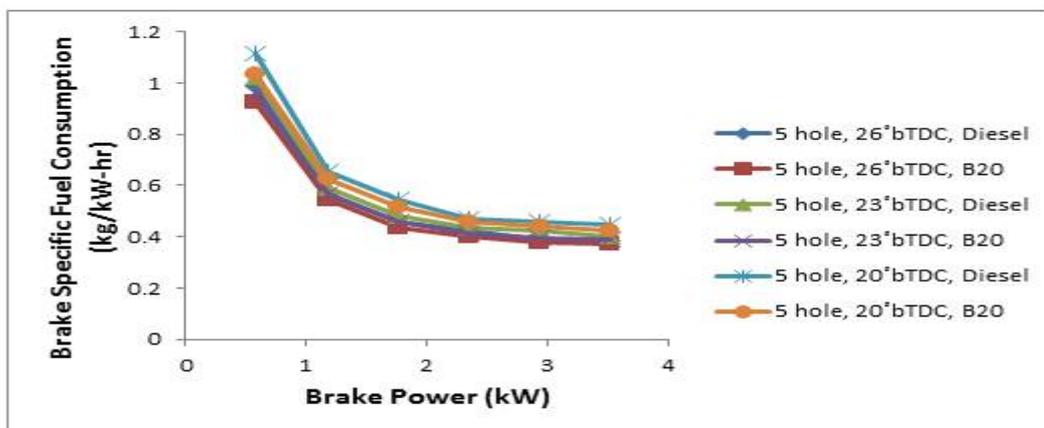


Fig-13: Variation of brake specific fuel consumption with brake power for 5 hole nozzle at different injection timings

Fig-13 shows the variation of brake specific fuel consumption with brake power for 5 hole nozzle at 230 bar injection pressure and at different injection timings. BSFC decreases as the BP increases. BSFC for B20 blend is slightly lower than diesel because of extra oxygen present in the blend is taking part in combustion process. For 5 hole nozzle 26°bTDC injection timing gives lower BSFC as compared to other injection timings such as 23°bTDC and 20°bTDC. This reduction in BSFC may be due to sufficient time availability for evaporation and mixing of fuel and air with increased premixed combustion and lower diffusion combustion. On the other hand, retarding the injection timing

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resulted in increased the specific fuel consumption due to late combustion. For diesel fuel at 3.52 kW of BP the minimum BSFC was found to be 0.384 kg/kW-hr, 0.402 kg/kW-hr, 0.445 kg/kW-hr at 26°bTDC, 23°bTDC, 20°bTDC injection timings respectively. For B20 fuel at 3.52 kW of BP the minimum BSFC was found to be 0.371 kg/kW-hr, 0.388 kg/kW-hr, 0.426 kg/kW-hr at 26°bTDC, 23°bTDC, 20°bTDC injection timings respectively.

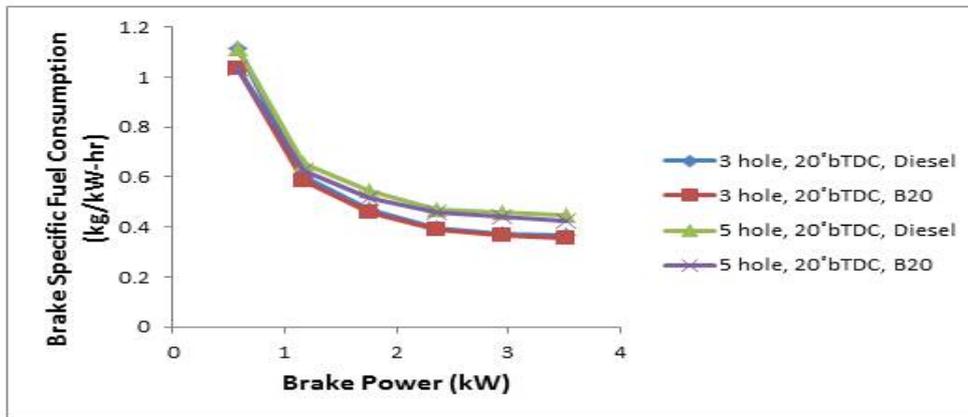


Fig-14: Variation of brake specific fuel consumption with brake power for different nozzle at 20°bTDC injection timing

Fig-14 shows the variation of brake specific fuel consumption with brake power for different nozzle at 230 bar injection pressure and at 20°bTDC injection timing. At 20°bTDC injection timing 3 hole nozzle gives lower BSFC as compared to 5 hole nozzle. At 20°bTDC injection timing, for 3 hole nozzle the minimum BSFC was found to be 0.367 kg/kW-hr and 0.355 kg/kW-hr for diesel and B20 fuel respectively at 3.52 kW of BP. For 5 hole nozzle the minimum BSFC was found to be 0.445 kg/kW-hr and 0.426 kg/kW-hr for diesel and B20 fuel respectively at 3.52 kW of BP.

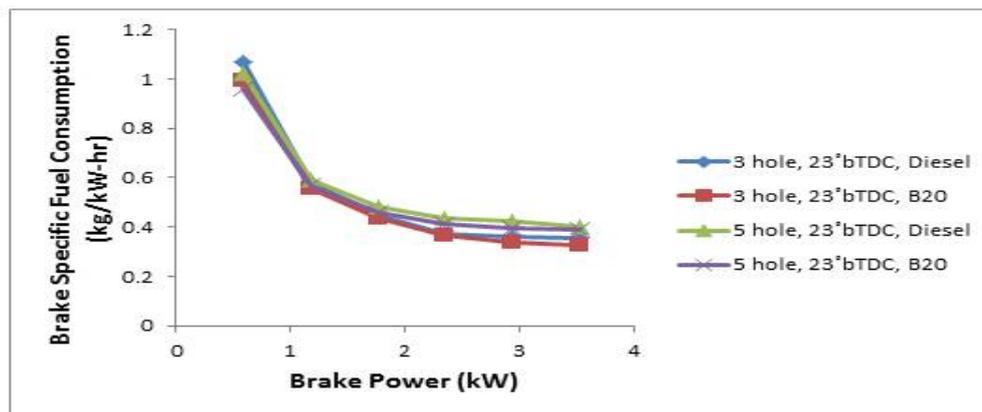


Fig-15: Variation of brake specific fuel consumption with brake power for different nozzle at 23°bTDC injection timing

Fig-15 shows the variation of brake specific fuel consumption with brake power for different nozzle at 230 bar injection pressure and at 23°bTDC injection timing. At 23°bTDC injection timing 3 hole nozzle gives lower BSFC as compared to and 5 hole nozzle. At 23°bTDC injection timing, for 3 hole nozzle the minimum BSFC was found to be 0.352 kg/kW-hr and 0.328 kg/kW-hr for diesel and B20 fuel respectively at 3.52 kW of BP. For 5 hole nozzle the minimum BSFC was found to be 0.402 kg/kW-hr and 0.388 kg/kW-hr for diesel and B20 fuel respectively at 3.52 kW of BP.

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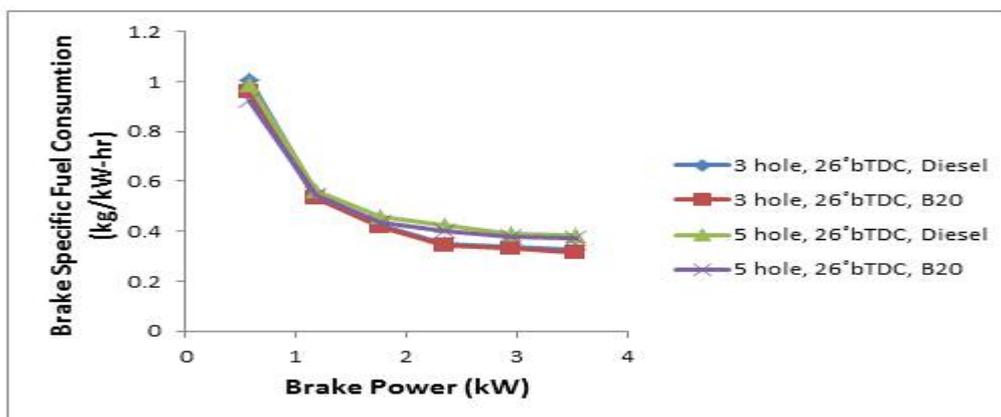


Fig-16: Variation of brake specific fuel consumption with brake power for different nozzle at 26°bTDC injection timing

Fig-16 shows the variation of brake specific fuel consumption with brake power for different nozzle at 230 bar injection pressure and at 26°bTDC injection timing. At 26°bTDC injection timing 3 hole nozzle gives lower BSFC as compared to 5 hole nozzle. At 26°bTDC injection timing, for 3 hole nozzle the minimum BSFC was found to be 0.325 kg/kW-hr and 0.316 kg/kW-hr for diesel and B20 fuel respectively at 3.52 kW of BP. For 5 hole nozzle the minimum BSFC was found to be 0.384 kg/kW-hr and 0.371 kg/kW-hr for diesel and B20 fuel respectively at 3.52 kW of BP.

IV. CONCLUSION

- For 3 hole nozzle, maximum BTE was found to be 26.35% for diesel fuel, 27.85% for B20 fuel and minimum BSFC was found to be 0.325 kg/kW-hr for diesel fuel, 0.316 kg/kW-hr for B20 fuel at 3.52 kW of BP and at 26°bTDC injection timing.
- For 5 hole nozzle, maximum BTE was found to be 22.29% for diesel fuel, 23.72% for B20 fuel and minimum BSFC was found to be 0.384 kg/kW-hr for diesel fuel, 0.371 kg/kW-hr for B20 fuel at 3.52 kW of BP and at 26°bTDC injection timing.

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