Improving Thermal Efficiency by Varying Input Parameters of a Four Stroke Single Cylinder S.I Engine

Rahul Ajitkumar, Sumit Sharma and Vipin Kaushik

Abstract The use of automobiles is growing day by day and so does the need to improve efficiency in all stages. Thermal efficiency is a factor that is measured by work done by the heat supplied to it. For improving the efficiency of an S.I engine, the inlet air conditions were altered to support various parameters. Kirloskar TV1 variable compression engine was used to run the tests. Using a variable compression engine helps us to alter the compression ratio without stopping the engine by using the tilted cylinder arrangement. The engine can be run easily at variable load as well as rpm. The orifice was modified to equip the alterations and to run the tests. Atmospheric air contains moisture, and since this air gets inside the engine, initial test was based on to reduce this moisture content and alter the temperature of the air. Various conditions were taken into consideration on how to vary the inlet air parameters. Various modes were sequenced to test out the efficiency. Test 1 involved humidifying the inlet air. Test 2 involved cooling the inlet air. Test 3 involved dehumidifying the inlet air. Test 4 involved altering oxygen content in an inlet air, and test 5 involved a combination of cooling the inlet air and dehumidifying it. The engine was run at constant load and at variable rpm, and test 5 gave optimum results.

Keywords Thermal efficiency · Dehumidification · Variable compression engine

1 Introduction

Manufacturers have been going on researching various methods on how to increase efficiency. Spark ignition engine lowers fuel change efficiency contrasted with compressed control units, yet a few upgrades can be gotten by utilizing diverse control systems. Here, altering the inlet air was the main criteria of testing. The reason behind is that since the engine breathes, the air quality alters the actual

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engine efficiency [1]. When the moisture quantity of the air increases, it gets densified inside the engine and water particles get mixed with fuel leading to a change in proportion of the fuel. This leads to higher carbon content and thus reduces efficiency.

The temperature of air is also another criterion which alters the engine efficiency. When the density becomes very low, availability of oxygen reduces which results in lesser thermal efficiency. There are odds of pre-start and thumping if temperature of the inlet air is higher than ordinary. As the temperature of the air will be higher, the temperature of air–fuel charge will likewise be higher (petrol engine) which implies there are odds of start of air–fuel blend even before the cylinder achieves its exact point during typical burning. It is distinguishable that the air inlet mass stream rate shrivels when the engine power diminishes. At higher temperature, charge thickness can endure and ignition temperatures can turn out to be too high. This can constrain motor yield. In the event that temperatures are too low, beginning the motor at low temperatures can be tricky. Lower admission air temperatures tend to cause poor carburetion, in some cases notwithstanding prompting carburetor icing, particularly under full load activity. Moreover, the admission of extremely chill crude air will likewise defer the warm-up of the engine amid cool begin, along these lines drawing out activity in an inadequately greased upstate. In conclusion, a speedy warm-up is vital on the grounds that the emanation of fumes toxins is significantly higher when the motor runs chilly. In any case, the expansion of charge air temperature in another way could conceivably enhance the fuel vaporization in engine. Difference of ignition and motor execution will be introduced efficiently with changes in channel air temperature. In this research, tests were done to explore the impacts of inlet air temperature and coolant temperature on brake thermal efficiency in a four-stroke S.I engine. Test comes about demonstrated that, inlet air temperature lightly affects brake thermal efficiency during partial load activity. During high load, a diminishing in admission air temperature enhanced brake warm proficiency because of a change in showed warm effectiveness and reduction in debilitating misfortune. It was additionally uncovered that the blend of high-temperature cooling water for the motor square and low-temperature cooling water for the chamber warm is powerful to improve brake thermal efficiency.

2 Methodology

The setup comprises of single cylinder, four strokes, variable compression ratio (VCR) petroleum motor associated with eddy current compose dynamometer for stacking. The pressure proportion can be changed without ceasing the motor and without adjusting the ignition chamber geometry by exceptionally composed tilting cylinder square course of action. Setup is furnished with fundamental instruments for burning weight and wrench edge estimations. These signs are interfaced to PC through motor marker for PV graphs. Arrangement is additionally made for interfacing wind current, fuel stream, temperatures, and load estimation. The setup has remained solitary board box comprising of air box, two fuel tanks for dual fuel test, manometer, fuel estimating unit, transmitters for air and fuel stream estimations, process marker, and motor pointer. Rotameters are accommodated cooling water and calorimeter water stream estimation. The setup empowers investigation of VCR motor execution for brake control, showed control, frictional power, BMEP, IMEP, brake warm productivity, demonstrated warm proficiency, mechanical effectiveness, volumetric proficiency, particular fuel utilization, A/F proportion, and warmth adjust. LabVIEW-based Engine Performance Analysis programming bundle "Motor delicate LV" is accommodated online execution assessment. An electronic diesel infusion weight estimation is alternatively given.

2.1 Humidification Test

After the device was set up, the engine was on run on variable speed (rpm) at a fixed load (variable up to 1 kg). The results were drawn using I.C engine soft 2.0. Here, the test results show that brake thermal efficiency was reduced. When the steam was passed through the inlet hose, the quality of air is being decreased as the density of air decreases and the mass of air decreases. This results in choking of the engine as the amount of air decreases. Thus, the brake thermal efficiency is reduced drastically. The emission results show an improvement in nitrogen oxides and particulate emission. Expansion of water into the petrol burning procedure is a known strategy to decrease NOx and, in a few executions, at the same time lessen NOx and PM discharges. The very idea of bringing water into the chamber of the diesel motor may sound dubious. All things considered, engineers have been taking awesome care to achieve the correct inverse and shield the ignition chamber from water pollution, be it from the fuel or from water buildup in consumption air coolers. The debate around water expansion is established on the perception that water beads impinging on the barrel dividers can instantly obliterate the grease oil film. This risk nonetheless, albeit genuine, is postured only by fluid water. When water is dissipated, it can never again influence the lube oil film. Consequently, water expansion techniques which guarantee that water beads cannot contact the chamber liner surface might be viewed as innocuous. Additionally, concerns have been raised that expanded convergences of water vapor in motor chamber may bring about buildup of water or potentially sulfuric corrosive prompting consumption issues. Evidently, these doubts are not supported either, as the dew purpose of sulfuric corrosive at high water: Fuel proportion of 1:1 is expanded by just up to 15 °C. Thinking about the temperatures in petrol ignition, buildup in the burning chamber is not conceivable whenever.

2.2 Dehumidification Test

Since moisture gets inside the cylinder and there are chances of improper burning, the idea of dehumidification was developed. The process in which the moisture or water vapor or the humidity is removed from the air keeping its dry bulb (DB) temperature constant is called the dehumidification process. The mode of dehumidification in this test was by using a desiccant inside an air filter. The main idea of using a desiccant was to avoid any chemicals participating in the combustion process. Here, activated alumina was used. Activated alumina is made from aluminum hydroxide by dehydroxylating it in a way that delivers a profoundly permeable material; this material can have a surface region fundamentally more than 200 m^2/g. The compound is utilized as a desiccant (to keep things dry by engrossing water from the air) and as a channel of fluoride, arsenic, and selenium in drinking water. It is made of aluminum oxide (alumina; Al_2O_3), an indistinguishable compound substance from sapphire and ruby (however without the polluting influences that give those diamonds their shading). It has a high surface territory-to-weight proportion, because of many “passage-like” pores that it has. Utilized as a desiccant, it works by a procedure called adsorption. The water noticeable all around really adheres to the alumina itself in the middle of the little entries as the air goes through them. The water particles wind up caught with the goal that the air is dried out as it goes through the channel. This procedure is reversible. On the off chance that the alumina desiccant is warmed to $\sim$200 °C, it will discharge the caught water. Activated alumina was used as the desiccant because of its easy availability, cost, and shelf life. Here, activated alumina balls ranging from 3 to 5 mm were used. The balls were placed inside an air filter, and the porous fiber was soaked in liquid alumina and dried. The air filter was sealed using a bond and was placed inside air filter housing. One end on the filter housing was connected to the orifice, while the other was left open so that air gets in through (Figs. 1 and 2).

Fig. 1 Activated alumina

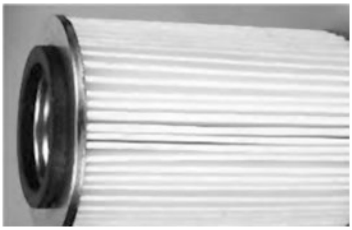

Fig. 2 Dehumidifier

2.3 Density Test

Density of air is an important factor in the combustion process. The actual amount of oxygen available for combustion depends on the density of the air. As the density of air increases, the molecules of air are closer and that means there is more amount of oxygen available for burning. When the humidity of the air increases, density falls resulting in improper combustion. Here, density of the air was increased by cooling the inlet air. For this, dry ice was used. Dry ice is the strong type of carbon dioxide. It is utilized principally as a cooling specialist. Its points of interest incorporate lower temperature than that of water ice not leaving any buildup. Dry ice was placed inside an air filter and was closed with a porous fiber. The air filter was placed inside a manifold. One end of the manifold was connected to the orifice, while the other end was left for the engine to breathe.

2.4 Dehumidification–Density Test

Here, a combination of both density and dehumidification tests is used. Initially, the density test is set up as in Sect. 2.3 and its outlet is connected to the air filter housing of the dehumidifier. The outlet of the dehumidifier is connected to the orifice. This is done so that temperature of the air is reduced as well as the moisture is trapped.

3 Results and Discussion

3.1 Humidification Test

The performance test shows us that the brake thermal efficiency is reduced. This is because of the presence of water droplets in the inlet air due to moisture. Water gets mixed in combustion and causes improper combustion resulting in lesser efficiency. Emission results show a better change in hydrocarbon emission and nitrogen oxide. This is because of conversion of molecules into CO_2 and O_2 (Table 1 and Fig. 3).

Table 1 Emission levels at variable speed (rpm)

Speed (rpm)	Normal condition		Humidified air	
1810	CO	0.01% vol	CO	0.02% vol
	HC	22 ppm	HC	16 ppm
	CO_2	0.40% vol	CO_2	0.40% vol
	O_2	21.12% vol	O_2	20.95% vol
	NO	116 ppm	NO	50 ppm
1710	CO	0.02% vol	CO	0.02% vol
	HC	14 ppm	HC	13 ppm
	CO_2	0.60% vol	CO_2	0.50% vol
	O_2	21.12% vol	O_2	21.31% vol
	NO	204 ppm	NO	116 ppm
1610	CO	0.02% vol	CO	0.02% vol
	HC	17 ppm	HC	21 ppm
	CO_2	1.10% vol	CO_2	1.10% vol
	O_2	21.5% vol	O_2	21.72% vol
	NO	370 ppm	NO	310 ppm

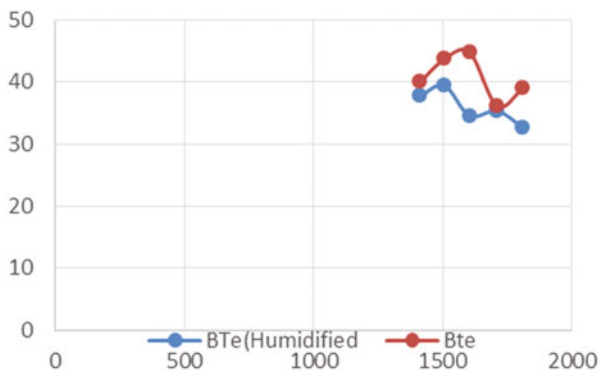

Fig. 3 Speed (rpm) versus brake thermal efficiency

3.2 *Dehumidification Test*

See Fig. 4 and Table 2.

Upon testing, brake thermal efficiency has increased at an average of 6–8% at variable rpms. This is because dry air is being passed in for combustion resulting in better efficiency. Emission stats have also shown better results. Hydrocarbon as well as nitrogen oxide is reduced effectively.

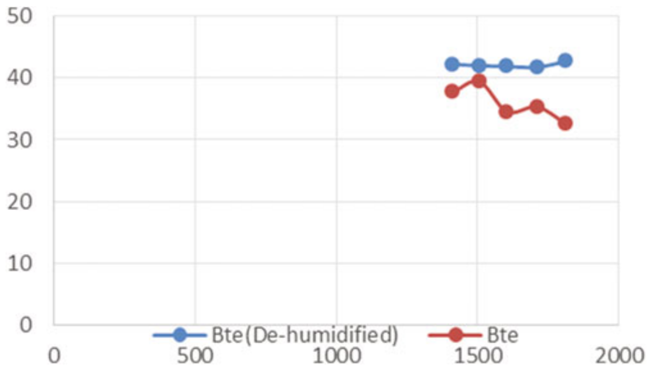

Fig. 4 Speed (rpm) versus brake thermal efficiency

Table 2 Emission levels at variable speed (rpm)

Speed (rpm)	Normal condition		Dehumidified air	
1810	CO	0.01% vol	CO	0.01% vol
	HC	22 ppm	HC	8 ppm
	CO_2	0.40% vol	CO_2	0.30% vol
	O_2	21.12% vol	O_2	19.83% vol
	NO	116 ppm	NO	88 ppm
1710	CO	0.02% vol	CO	0.01% vol
	HC	14 ppm	HC	3 ppm
	CO_2	0.60% vol	CO_2	0.40% vol
	O_2	21.12% vol	O_2	21.15% vol
	NO	204 ppm	NO	151 ppm
1610	CO	0.02% vol	CO	0.02% vol
	HC	17 ppm	HC	2 ppm
	CO_2	1.10% vol	CO_2	1.10% vol
	O_2	21.5% vol	O_2	19.82% vol
	NO	370 ppm	NO	440 ppm

3.3 Density Test

See Fig. 5.

After carrying out the density test, the engine ran very smooth and the air was densified properly. Densified air had better amount of oxygen, and it helps to give a proper fuel-to-air ratio leading to a better combustion and thus efficiency.

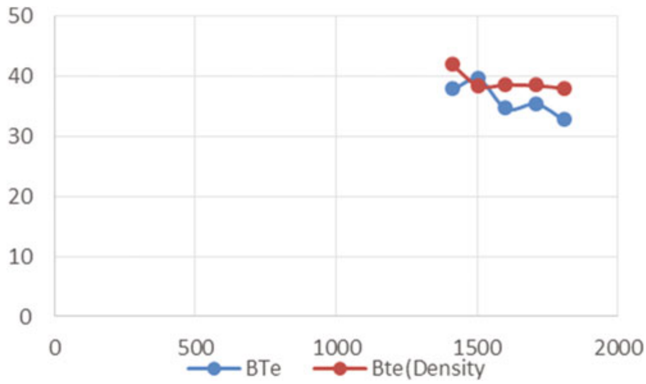

Fig. 5 Speed (rpm) versus brake thermal efficiency

3.4 Dehumidified–Densified Test

See Fig. 6 and Table 3.

The combination of using dehumidified and densified air gave better combustion results leading to better efficiency. Dry ice was used to cool the inlet air, and further the moisture was captured leading to dry cold air resulting in better efficiency. Emission stats also show a good progress in limiting the levels.

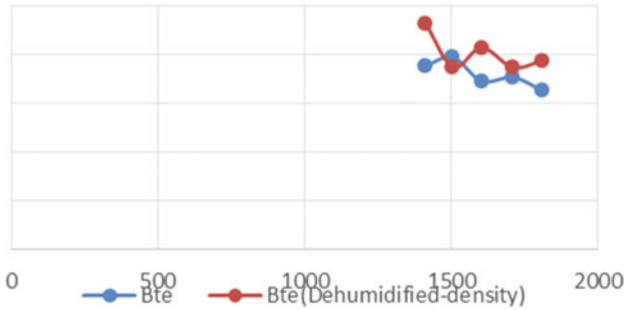

Fig. 6 Speed (rpm) versus brake thermal efficiency

Table 3 Emission levels at variable speed (rpm)

Speed (rpm)	Normal condition		Dehumidified–densified condition	
1810	CO	0.01% vol	CO	0.01% vol
	HC	22 ppm	HC	11 ppm
	CO_2	0.40% vol	CO_2	0.30% vol
	O_2	21.12% vol	O_2	20.95% vol
	NO	116 ppm	NO	66 ppm
1710	CO	0.02% vol	CO	0.02% vol
	HC	14 ppm	HC	12 ppm
	CO_2	0.60% vol	CO_2	0.40% vol
	O_2	21.12% vol	O_2	20.84% vol
	NO	204 ppm	NO	118 ppm
1610	CO	0.02% vol	CO	0.01% vol
	HC	17 ppm	HC	9 ppm
	CO_2	1.10% vol	CO_2	0.90% vol
	O_2	21.5% vol	O_2	20.85% vol
	NO	370 ppm	NO	280 ppm

4 Conclusion

The air the engine breathes is altered on various bases, and results were plotted out. The combination of using a dehumidifier and a densifier resulted in better efficiency. The basis of such results is because when densified air goes in for combustion, the amount of oxygen molecules available is better and richer. The current fuel-to-air ratio can be delivered easily. Furthermore, dehumidifying the air helps us to trap all the moisture present in the air, and reducing the amount of water particles makes the fuel to burn better leading to hassle-free combustion. Efficiency of an engine is the most sought, and for this many techniques are being developed to improve the combustion characteristics of the engine. Emission characteristics are also tested out in all conditions; a proper work is dined in developing so. This imperative method of using dehumidified–densified air will result in greater mileage as well as lesser pollution levels.

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