Impact Factor (SJIF): 3.632

International Journal of Advance Research in Engineering, Science & Technology

e-ISSN: 2393-9877, p-ISSN: 2394-2444

Volume 3, Issue 5, May-2016

Experimental investigation on effect of dehumidified inlet air on the performance and emission of C.I. engine

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Abstract *— Ambient conditions depend on the geographical location and may vary with time of the year. Engine controls may compensate for some effects of these variations, but engine performance deviations are to be expected. Humidity is important parameter affecting on engine performance. During summer it's effect become significant, Generally higher humidity lowers combustion rates and decrease peak temperature and pressure that is why car's performance is much better in winter than summer. Although humidity effects on engine performance, it effect becomes significantly lower with increase combustion temperature This works investigates the performance of single cylinder air cooled diesel engine with dehumidifier in inlet manifold to compensate inlet air humidity near target value during summer. Dry air increase peak temperature during combustion hence increase chances of complete combustion and reduce HC and CO in exhaust also increase peak pressure meanwhile it increase NOx in exhaust.*

Keywords- *Atmospheric condition; Humidity; Engine performance; desiccant dehumidifier; CI engine.*

I. INTRODUCTION

IC Engine performance varies with many parameters. Among them ambient condition is one that cannot be changed and it also change from place to place. In order to understand behaviour of engine under different condition lots of tests are carried out on different IC engine. Test results shows that higher temperature and humidity decrease fuel economy. Overall efficiency of engine also decreases with increase in both parameters. In order to increase engine performance control in both or either one parameter is required. From present literature it can be said that controlling humidity up to certain level it increases peak combustion temperature and meanwhile reduce un-burnt HC and CO from exhaust. It can be done by introducing silica gel porous medium into inlet manifold. Aim is to reduce humidity of inlet air during summer and keep it to near target value.

II. NEED OF DEHUMIDIFICATION

- Literature shows that during summer because of high inlet air temperature and humidity overall engine performance decrease.
- Because more humid air slower combustion rate and increase THC and CO however it decreases NOx in emission.
- It is desirable to introduce cool and dry air into inlet manifold to increase volumetric efficiency and reduce delay period.
- Particular in this topic objective is to concentrate on dry air with the use of dehumidifier in intake manifold

III. MODIFICATION IN INLET MANIFOLD

As shown in figure 1 inlet manifold need to be modified in order to introduce some kind of dehumidifying medium in a way of inlet manifold. Here in this case silica gel used to reduce moisture content from inlet air

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Figure 1. New inlet manifold with provision of silica gel medium

All dehumidified solution works on simple principle of dehumidification with heating or dehumidification with cooling but silica gel is such types of material which can dehumidify air without changing temperature of air by just adsorb moisture from air.

Anything which comes into way of air in inlet manifold will retards velocity of inlet air coming into engine during suction stroke. Here after introducing silica gel in inlet manifold same thing happens. But to increase speed of here one small nozzle shape part introduced. With ID of 70 mm and OD of 35 mm for air, which increase speed of inlet air four times that of normal speed after silica gel medium. This increase in speed is necessary in order to maintain volumetric efficiency after interference of silica gel in path of air. Vacuum gauge need to be installed in order to monitor pressure drop in inlet manifold due to silica gel.

IV. EXPERIMENTATION WITH VARIOUS ATMOSPHERIC CONDITION

Experiments have been carried out with silica gel in inlet manifold and with various atmospheric conditions with the help of diesel engine test rig and suitable instrumentation for measuring different parameters like speed, fuel consumption etc. Load is varied but speed of the engine is kept constant at 1500 rpm. The engine performance of dehumidified inlet air compared to normal atmospheric condition engine performance.

3.1 Engine Specifications

1. Make: Power-lite
2. Rated power output: 5.65KW
3. Speed: 1500 rpm
4. Stroke: 110 mm
5. Bore: 87.5mm
6. Compression ratio: 18:1
7. Method of cooling: Air cooled

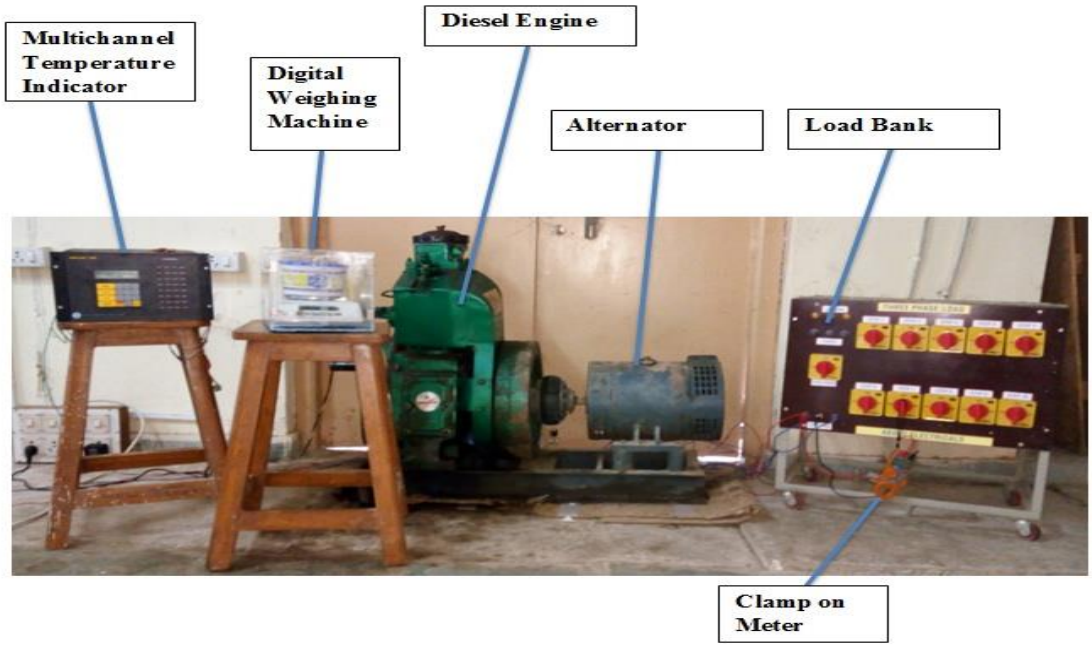

Figure 2. Diesel engine test rig

V. RESULTS AND DISCUSSION

5.1 Performance characteristics

The following performance parameter has been evaluated and compared:
Brake power
Fuel consumption
Brake specific fuel consumption
Brake thermal efficiency

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5.2 Variation in fuel consumption with brake power

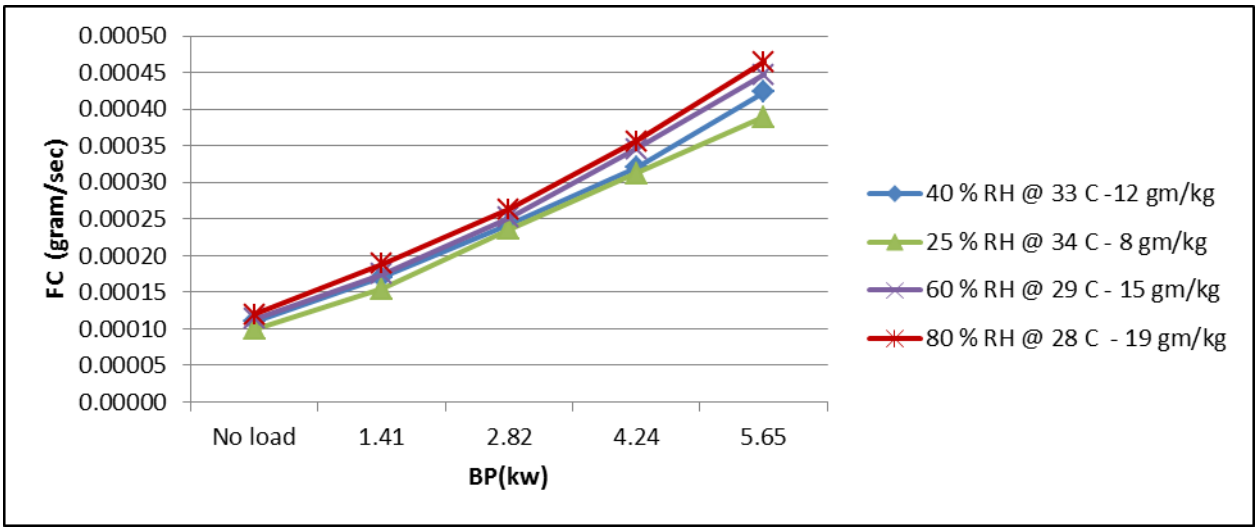

Figure 3. Variations in FC with BP

As shown in figure 3, the fuel consumption increases with increase in brake power. The fuel consumption at high humidity is higher than what is at low humidity which is due to presence of diluents H2O in combustion chamber which reduce peak temperature during combustion and due to which complete combustion cannot be possible.

5.3 Variation in brake specific fuel consumption with brake power

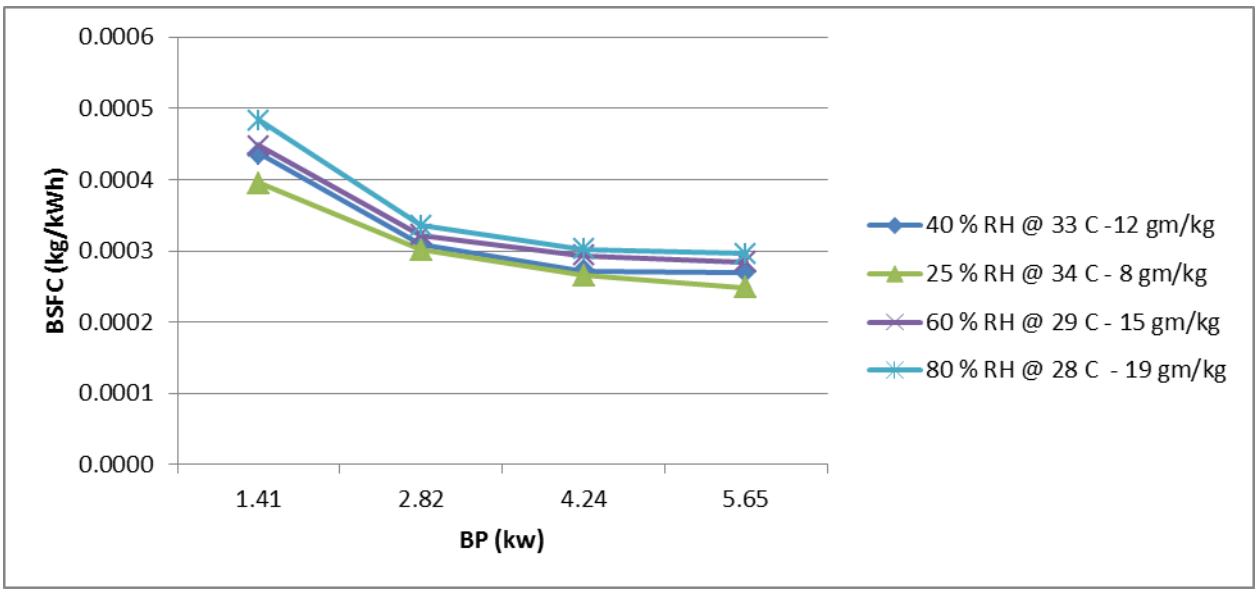

Figure 4. Variations in BSFC with BP

As shown in figure 4 increase in BP there is decrease in BSFC and this decrement is high in testing with dehumidified air compared to normal atmospheric air which is also due to complete combustion and absence of diluent H2O.

5.4 Variation in brake thermal efficiency with brake power

As shown in figure 5 BTE increase with increase in break power. It is shown that BTE for dehumidified inlet air is higher than what is at normal atmospheric air because of complete combustion and higher combustion temperature in dehumidified inlet air engine performance.

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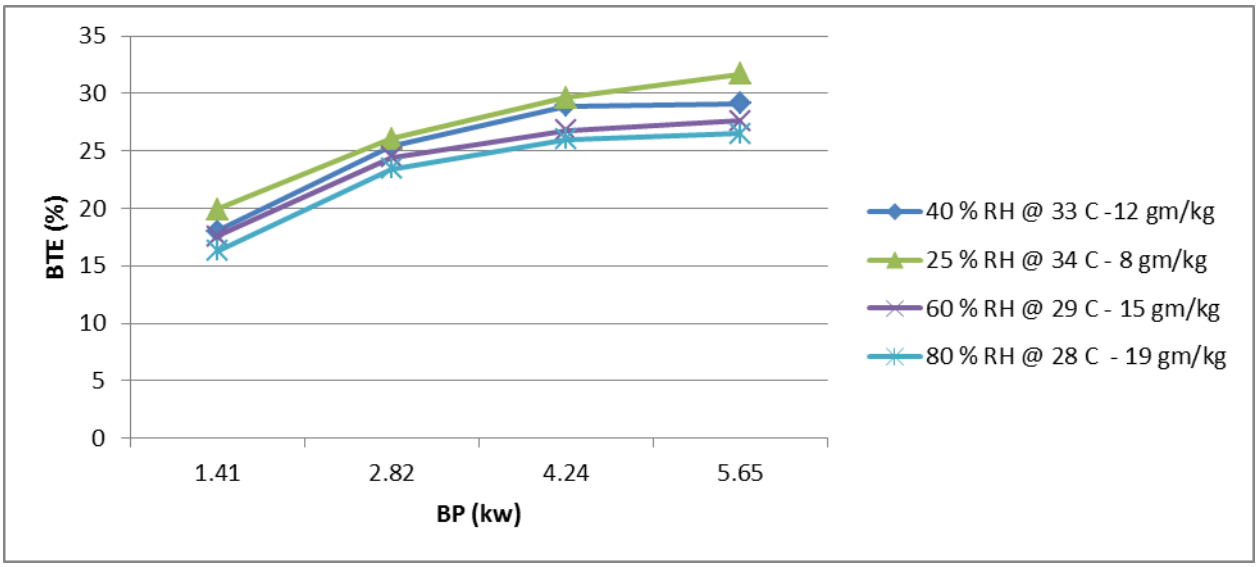

Figure 5. Variations in BTE with BP

5.5 Emission characteristics

The pollutants from diesel engine include CO, HC, NOx, SO2, partially oxidized organics and odours when engine running on pure diesel with various atmospheric conditions.

5.6 Variation in CO2 with BP

As shown in Fig.6, CO2 emission level increase with increase in break power as more load increase combustion temperature process tends to complete combustion and more CO converts to CO2. Here in more humid air due to moisture content in atmospheric air, CO2 is lower than what is in dehumidified inlet air. CO2 is comparatively less toxic than CO so emission of CO2 should not be problem as far as emission norms concerned.

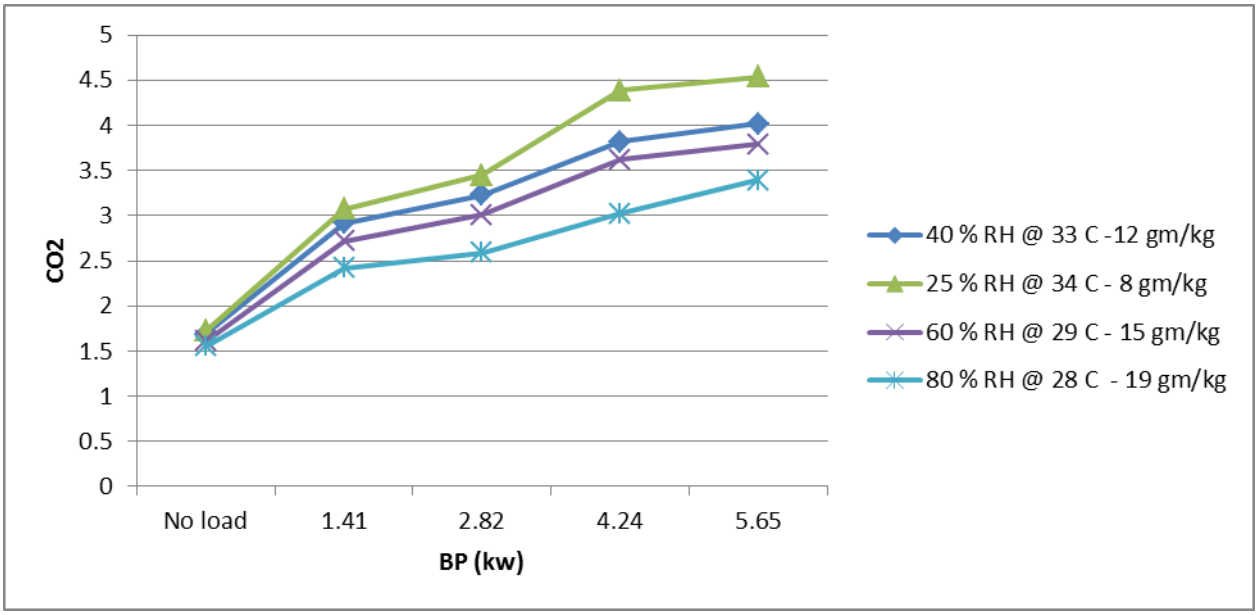

Figure 6. Variations in CO_2 with BP

5.7 Variation in CO with BP

As shown in Fig.7, CO is formed when there is insufficient oxygen to oxidize the fuel fully during the combustion of fuel or temperature during combustion wasn't sufficient for complete combustion. The value of CO emission is lower in dehumidified inlet air engine performance than normal or humid air engine performance which is due to low combustion temperature and uncompleted combustion during combustion.

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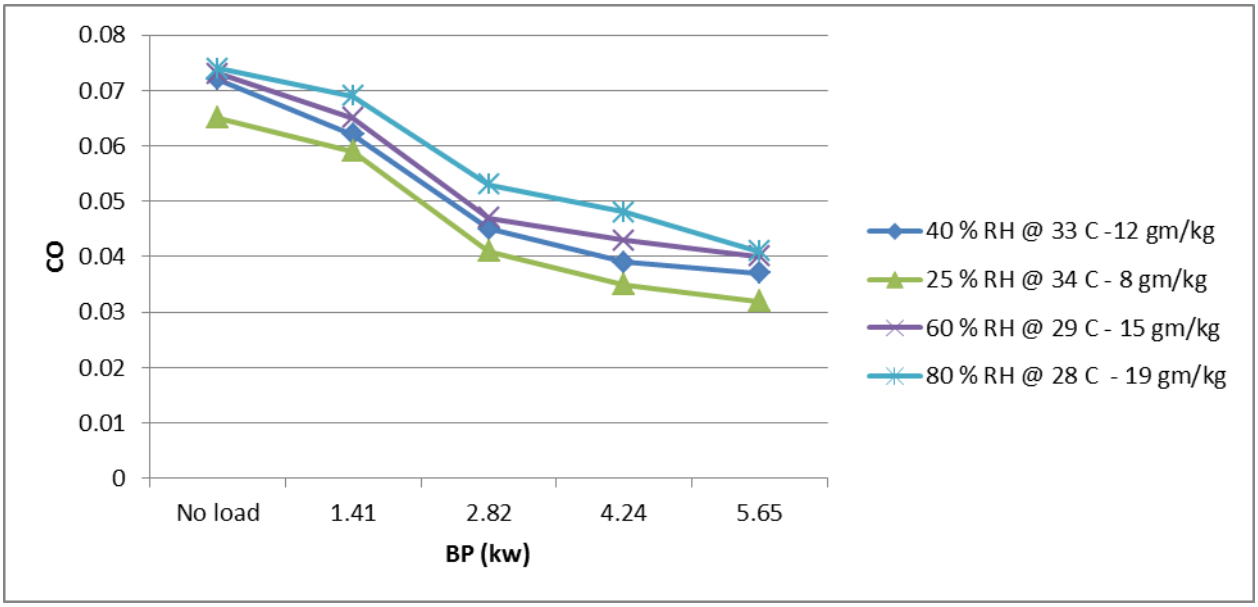

Figure 7. Variations in CO with BP

5.8 Variation in NO_x with BP

As shown in fig.8, the concentration of NOx emission in the exhaust is closely related to peak cycle temperature. Humidity or moisture content in air work as diluent in combustion chamber which will retards combustion rate due to which combustion process will slower down ultimately peak temperature, it is known that NOx¬ emission is directly proportional to temperature of combustion chamber and thus for humid air NOx emission will be less compared to dehumidified inlet air because of combustion temperature is high in dehumidified inlet air.

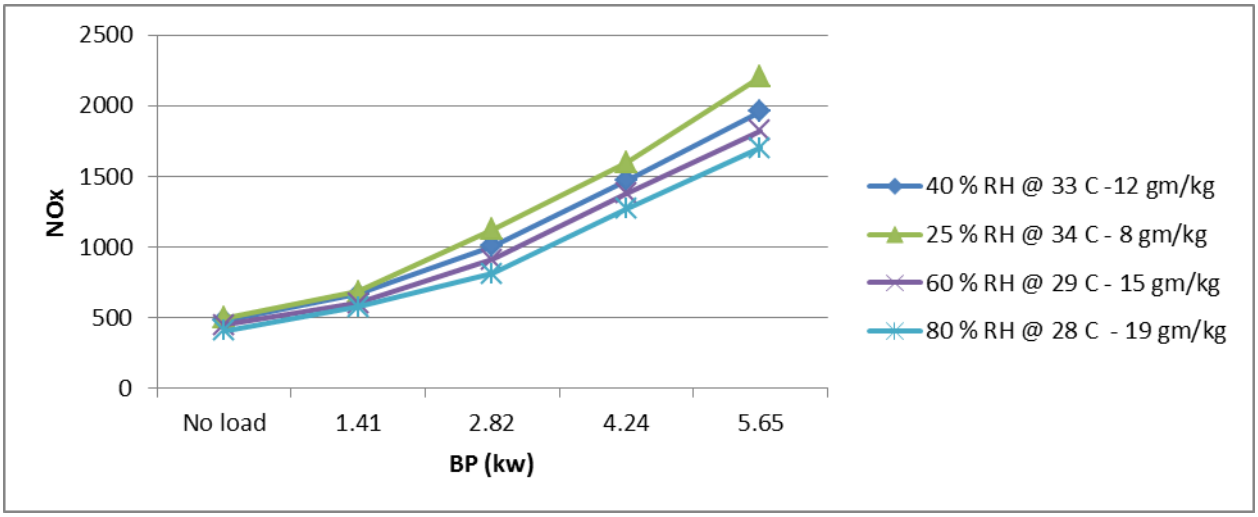

Figure 8. Variations in NO_x with BP

5.9 Variation in HC with BP

As shown in fig.9, the un-burnt HC emission is the direct result of incomplete combustion. The concentration of HC emission in the exhaust is closely related to cycle average temperature. For humid and moisture air mostly during summer and winter due to diluent H2O in combustion chamber and incomplete combustion take place. Due to fuel cannot burn completely in combustion chamber emission of HC increase. HC emission decrease with increase in B.P. up to certain level because temperature increase with load but after some limit it increase with increase in B.P. because afterwards at high load more fuel will be supplied to engine which cannot be burn completely which increase HC emission.

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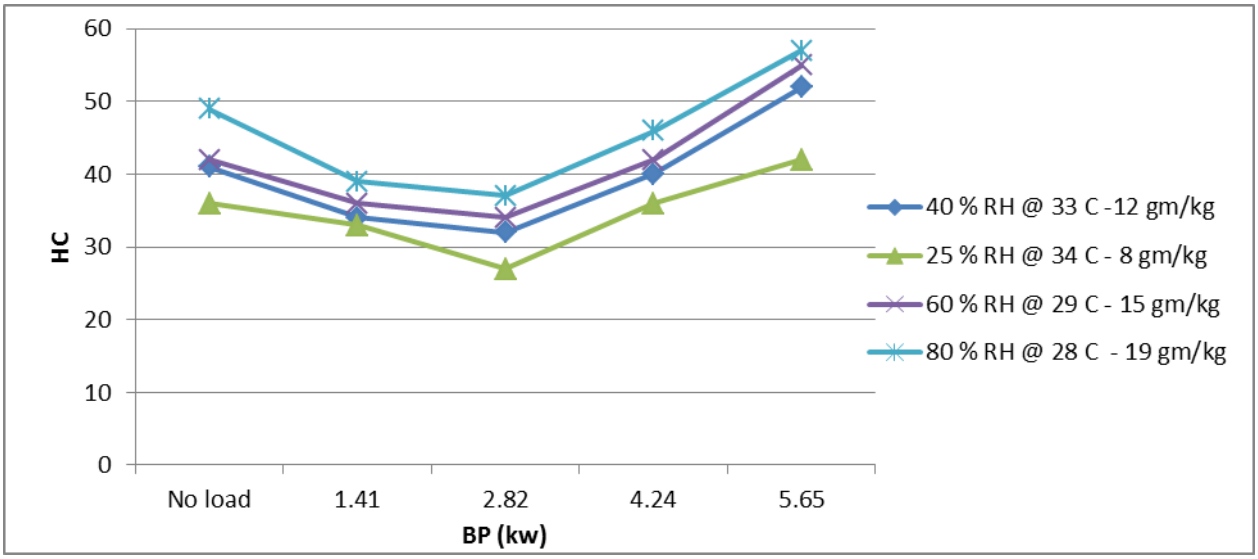

Figure 9. Variations in HC with BP

VI. CONCLUSION

- Dehumidified inlet air affects engine performance parameters like bsfc, fuel consumption and BTE in positive manner as dehumidification level is increased chances of complete combustion is more.
- As moisture content of air is reduced in exhaust gas CO and HC level is decreased while CO2 and NOx¬ are inceresed. Rise in CO2 and NOx is due to rise in peak temperature of combustion chamber.
- Reduction in the level of H2O in combustion chamber produce more CO2 by converting CO into CO2.
- Engine performance can be improved by reducing humidity of air during summer and monsoon.

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