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Review Paper on Effect of Humidity on IC Engine Performance and Emission Characteristics

[1]Prof. Rushi B. Rawal, Hiren G. Akhaja[2]

[1]Assistant professor, Mechanical Engineering Department, GEC-Bhuj
[2]PG Student, Mechanical Engineering Department, GEC-Bhuj

Abstract

This work investigates the effect of inlet air humidity changes on the specific power output, specific fuel Consumption and the emissions of nitric oxide and smoke from IC engine. 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 generally higher humidity lowers combustion rates and decrease peak temperature and pressure that's 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 work also included effect of humidity on engine performance at high altitude.

Keywords- *Humidity, Engine performance, Emission, Ambient condition, IC Engine.*

I. INTRODUCTION

Performance of IC engine 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's performance it need be control both or either one parameter. From 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. LITERATURE REVIEW

C. D. RAKOPOULOS [1] investigates the effect of temperature and humidity on performance of LISTER LV1 single cylinder, four stroke and air cooled diesel engine. At 2500 RPM it is shown that substantial increase of NO_x (up to 100 ppm) with increase in temperature (up to 15°C) and a decrease of NO (up to 100 ppm) with increase in humidity ratio (0.010) increase. However, attention should be paid to the fact that, since in this investigation, the increase of fuel-air equivalence ratio with humidity ratio and temperature increases is taken into account, the corresponding increase of NO with temperature is stronger, and the decrease of NO with humidity ratio is milder in this investigation than in others where fuel-air ratio is considered constant.

A substantial increase of smoke density (0.10 g/m^3) with ambient temperature increase (15°C) and also an increase of SD (0.05 g/m^3) with humidity ratio increase (0.010). Substantial increase of SD with temperature is certainly due to increase in fuel air ratio with temperature.

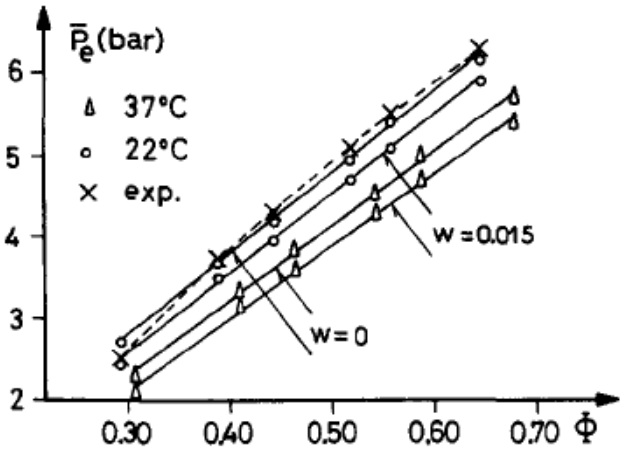

Figure 1 Break Mean effective pressure values Vs equivalence ratio for various values of ambient temperature and humidity [1]

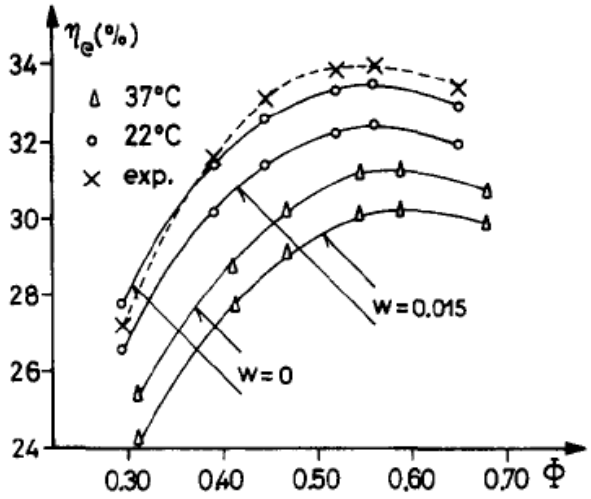

Figure 2 Brake efficiency Vs equivalence ratio for various values of ambient temperature and humidity ratio.[1]

It shows that there is a decrease of the pressure (up to 1 bar) with temperature (15^{o}C) and humidity ratio increases (0.015) which is due to the smaller amount of the engine charge and the presence of diluent H_2O, Actually, this decrease would have been stronger if the increase of fuel air ratio with temperature and humidity ratio increases had not been taken into consideration (figure1).

It shows that there is a decrease of the efficiency (2% to 3%) with temperature (15^{o}C) and humidity ratio (0.015) increases. Actually, this decrease would have been much milder if the increase of fuel air ratio with temperature and humidity ratio had not been taken into consideration (figure2).

Zehra Sahin et al. [2] study, the effects of water injection (WI) into intake air on the performance and exhaust emissions were experimentally investigated in a Renault K9K 700 type turbocharged common-rail DI automotive diesel engine.

At 2000 rpm water ratio up to 4% WR increase bsfc and power then at 6% WR it decrease and again more water contain increase bsfc and decrease power. Efficiency decrease up to 4% WR and it increase at 6% WR and again more water decrease efficiency. NO_x emission decrease up to 13% at 8% WR and again it increase as more water is injected into air.

C. D. RAKOPOULOS [3] investigates the effect of temperature and humidity on performance of single cylinder Ricardo E-6 Otto engine. At fully open throttle, at compression ration CR=9, at a speed of 2500 RPM and a spark advance at 30^0 BTDC, decrease in NO concentration observed with humidity ratio increase (approximately 400 ppm NO decrease per 0.005 units of humidity ratio increase). It is also observed a rather substantial increase of NO concentration with ambient temperature increase, which measures approximately 400 ppm NO increase for an ambient temperature change from 22C to 37'C.

It is observed that there is a mild decrease of the specific power output with temperature and humidity ratio increase, which is due to the smaller amount of the engine charge and the presence of diluent (H_2O) respectively.

D. B. Brooks, et al [4] investigates the effect of humidity and engine power on 12 Cylinder Curtis D-12engine at a pressure corresponding to altitude from sea level to 25000 ft at constant temperature 30^{o}C. At sea level loss in power is 2.6 in percentage of total power when humidity increases 2 in percentage of total pressure. But with increase in altitude effect of humidity on power loss reduces. When dry air pressure vary from 685 to 760 mm of Hg then humidity varies from 50 mmHg to zero and it increases Indicated Horse power from 2.94 to 3.14.

CIMAC WORKING GROUP [5] investigates the influence of ambient conditions on performance of gas engines. The absolute air humidity has an influence on the combustion since an increase in humidity is slowing down the combustion speed as well as reducing the maximum combustion temperature. On the one hand this will influence the knock margin and the NOx emissions in a positive way, but on the other hand the efficiency of the engine is affected negatively (figure 4). Although different engine types and sizes may show different sensitivity to air humidity fluctuation, the general trend is much the same for all. typical trends from a lean burn gas engine running in Europe without compensation for ambient humidity variations over the year. The influence on the NOx emissions is particularly strong and must be considered when measurements are made. Another effect of high humidity is the possible condensation of water in the charge air cooler if the temperature drops below the dew point temperature at the given pressure. Without drain, this can have harmful effects on the engine operation and must be avoided

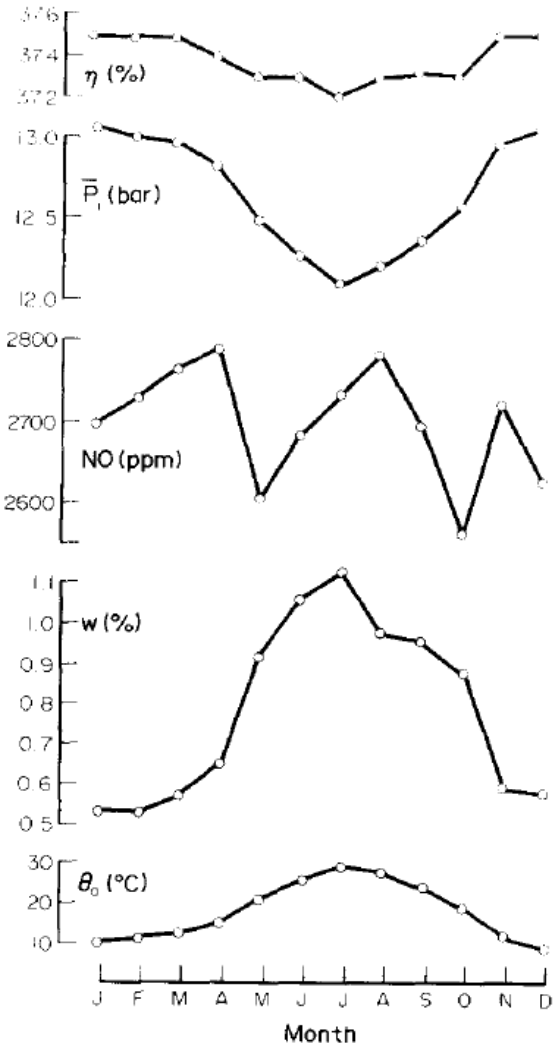

Figure 3 Variation of nitric oxide concentration, indicated mean effective pressure and indicated efficiency of a spark ignition engine during a typical year in Athens.[3]

Gayan Kahandagamage [6] investigates the effect of charge air temperature and humidity on the combustion process of diesel engines at 100MW Diesel Power Plant consists of six 18V46 Wartsila turbocharged air cooled engines, Puttalam, Sri Lanka. This study was conducted as per the requirement to find out the reasons behind this variation of the fuel consumption and to quantify the effects on the efficiency with respect to the charge air properties in relation to temperature and humidity. It is observed humidity in charge air affects positively on the fuel consumption while efficiency is negatively affected.

J. R. Sodre, et al [7] investigates methods to correct engine power output as a function of atmospheric conditions. The analysis was made through experiments carried out in a vehicle on the road, under different temperature, pressure and air humidity conditions.

The vehicle had a four cylinder gasoline fuelled engine, with multipoint fuel injection system, variable intake pipe length and variable intake valve camshaft position. The vehicle was tested at sea level and at 827 m above sea level, corresponding to atmospheric pressures between 1027 and 926 mbar. Air temperature varied from 22,8 to 33,8 °C at the test locations. The measured performance parameter in the tests was the vehicle acceleration time. Acceleration time increase with increase in ambient temperature and decrease in humidity.

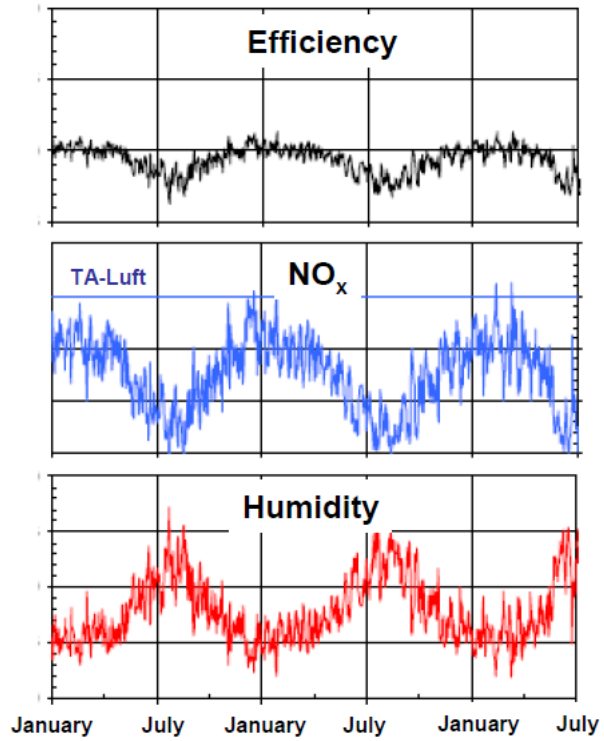

Figure 4 Variation in Efficiency and NO_x with Humidity [5]

Donald B. Brooks [8] investigates about correcting engine tests for humidity Data obtained on a Tests were made on a 6-cylinder, 3-port, overhead valve engine of 3%-inch bore and 4%-inch stroke, coupled to a Sprague electric dynamometer and spark accelerometer automobile engine indicate a loss of engine power with increasing humidity proportional to the volumetric loss of oxygen content of the atmosphere. It is shown that power and fuel consumption may be corrected by subtracting observed water vapor pressure from atmospheric pressure and using the result in place of barometric pressure in the usual correction formula. The humidity correction may be as large as that due to changes in barometric pressure. It is observed that higher humidity increase water vapour pressure inside cylinder and water vapour pressure from 0 to 30 mmHg reduces indicated horse power up to 4 % of total power.

It is observed that for same fuel consumption engine power increase with decrease in humidity ultimately it reduces fuel consumption. Increase in humidity also slower combustion inside cylinder and thus spark advance should be increase.

R.L. McCormick, et al [9] investigates Effect of Humidity on Heavy-Duty Transient Emissions from Diesel and Natural Gas Engines at High Altitude. He used 1988 Detroit Diesel Series 60 engine and a 1995 Cummins B5.9G natural gas engine for experiment.

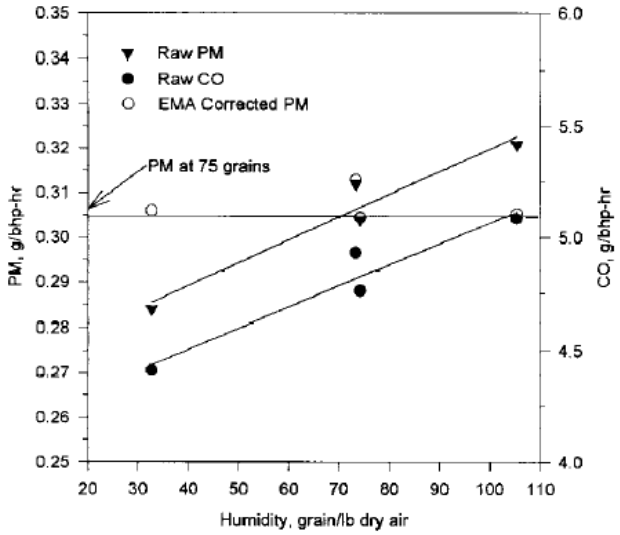

Figure 5 Diesel PM and CO emissions as a function of humidity [9]

When humidity increase from 35 to 95 grains/lb of dry air then NOx decreases from 6 to 5 gm/bhp-hr, CO increase 0.27 to 0.305 gm/bhp-hr and PM increase from 0.29 to 0.32 gm/bhp-hr (figure5). It also affects total Hydrocarbon from exhaust with same increase in humidity THC increase from 7 to11 gm/bhp-hr (figure 6).

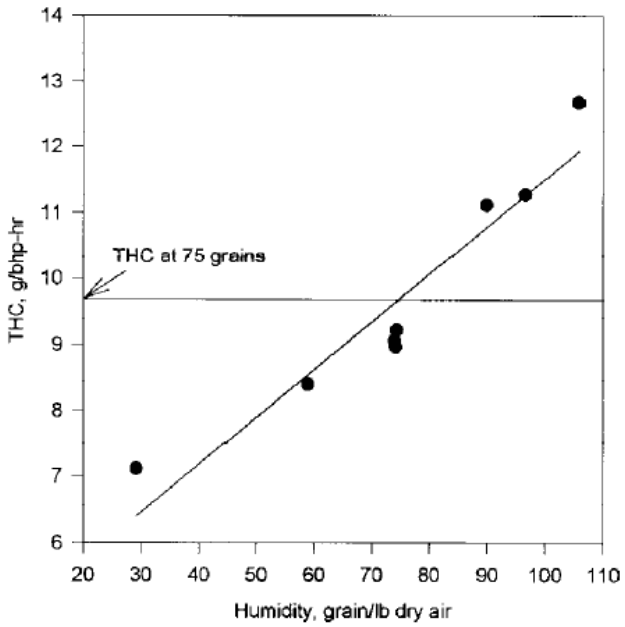

Figure 6 THC Emission as a function of humidity [9]

III. CONCLUSION

This study shows that the air consumption rate, brake torque, and nitrogen oxides decrease, while the brake specific fuel consumption, carbon monoxide, and sulfur dioxide increase with both the temperature and humidity of the charge air. Thus lower inlet air humidity increase overall engine performance except one disadvantage of increase in NOx emission which can further reduces by implementation of proper catalytic converter in exhaust system.

REFERENCES

[1] C. D. RAKOPOULOS, "Influence of ambient temperature and Humidity on the performance and emissions of nitric oxide and smoke of high speed diesel engines in the athens/greece region", Energy Convers. Mgmt Vol. 31, No. 5, pp. 447-458, 1991.

[2] Zehra S_ahin, Mustafa Tuti, Orhan Durgun, "Experimental investigation of the effects of water adding to the intake air on the engine performance and exhaust emissions in a DI automotive diesel engine", Fuel 115 (2014) 884–895.

[3] C. D. RAKOPOULOS, "Ambient temperature and humidity effects on the performance and nitric oxide emission of spark ignition engined vehicles in Athens/Greece", Solar & Wind Technology Vol. 5, No. 3, pp. 315- 320, 1988.

[4] D. B. Brooks and E. A. Garlock, "The effect of humidity and engine power at altitude" Report national advisory committee for aeronautics, Report no-426,pp.523-529.

[5] cimac working group, "about the influence of ambient conditions on performance of gas engines" international council on combustion engines, 2009.

[6] Gayan Kahandagamage " Analysis of the effect of charge air temperature and humidity on the combustion process of diesel engines at Heladhanavi Power Plant, Puttalam, Sri Lanka" Master of Science Thesis, KTH School of Industrial Engineering and Management.2015

[7] J. R. Sodre, S. M. C. Soares "Comparison of engine power correction factors for varying atmospheric conditions" journal of Brazilian society of mechanical science and engineering,vol-25,2003

[8] Donald B. Brooks, "correcting engine tests for humidity" T.N. No. 309, N.A.C.A. 1929

[9] R.L. McCormick , M.S. Graboski , A.W. Newlin & J.D. Ross. "Effect of Humidity on Heavy -Duty Transient Emissions from Diesel and Natural Gas Engines at High Altitude", Journal of the Air & Waste Management Association 47:784-791