Taj Al-Ma'rifa Journal مجلة تاج المعرفة
ISSN : 3104-8846, ISSN-L: 3104-8838

Effect Of Ambient Environment on The Engine Power Output

*** Abdulhamid Omar Salem Benghuzzi**

Higher Institute of Science and Technology - Misrata

Hamid200619@gmail.com

*Corresponding Author: * Abdulhamid Omar Salem Benghuzzi

Keyword

engines, air temperature, relative humidity, altitude, power output

Abstract

In internal combustion engines, thermal and chemical energy are converted into mechanical energy. Ambient weather conditions, such as air temperature, relative humidity, and altitude above sea level, affect air density and therefore the oxygen levels required for combustion, which in turn effects on the power Output that produced, This study conducted by a theoretical investigation to observed the effect of these factors on the hypothetical engine its power 100 kW .to finding the impact of temperatures by chosen among 10 to 48 C^0 at sea level, then make correction by added altitude at 100 meters, with 65% relative humidity and atmospheric pressure equal 98.8 kPa, then altitude of 800 meters with 50% relative humidity and atmospheric pressure 91 kPa, where observed decreases in that engine power Output with each increases in temperature and less of density were recorded approximately 7%, 11% and 17%, at 48 C^0 respectively compared to its power output, under standard conditions.

Received : 11/02/2026 Accepted : 24/02/2026

DOI: https://doi.org/10.64943/jkc.2026.040107

تأثير البيئة المحيطة بالمحرك على قدرته الخارجية

* عبد الحميد عمر سالم بن غزى
المعهد العالي للعلوم والتقنية - مصراتة
Hamid200619@gmail.com

*الباحث المرسل: * عبد الحميد عمر سالم بن غزى

الكلمة المفتاحية	الملخص
المحركات، درجة حرارة الهواء، الرطوبة النسبية، الارتفاع، قوة إنتاج الطاقة	في محركات الاحتراق الداخلي، يتم تحويل الطاقة الحرارية والكيميائية إلى طاقة ميكانيكية، حيث تؤثر الظروف الجوية المحيطة، مثل درجة حرارة الهواء والرطوبة النسبية والارتفاع عن مستوى سطح البحر، على كثافة الهواء وبالتالي على مستويات الأكسجين المطلوبة للاحتراق، مما يؤثر على القدرة الناتجة عنها في هذه الدراسة اجريت دراسة نظرية لتأثير هذه العوامل على محرك افتراضي بقدرة 100 كيلووات وذلك بدراسة تأثير درجات الحرارة ما بين 10 الى 48درجة مئوية وذلك عند مستوى سطح البحر. ثم إضافة التصحيح عند ارتفاع 100متر، رطوبة نسبة 65% وضغط جوى 98.8 كيلو باسكال وعند ارتقاع 800 متر, رطوبة نسبيه50 % وضغط جوى91 باسكال حيث لوحظ انخفاض في القدرة الخارجة من المحرك على التوالي 7% و11% 17% عند درجة حرارة 48 درجة مئوية, مقارنة بقدرته الخارجة التصميمة , وايضا مع كل ارتفاع لدرجات الحرارة وانخفاض للكثافة

تاريخ الإستقبال: 2026/02/11 تاريخ القبول: 2026/02/24
DOI: https://doi.org/10.64943/jkc.2026.040107

1. Introduction:

The performance and stability of power engines are highly dependent on some environmental factors, such as the ambient temperature, humidity, altitude of the air pressure above sea level. These are the very parameters which precisely influence thermodynamic cycle, air density and combustion properties resulting into off-set of considerable amounts of engine power output and fuel consumption [1] Working process The internal-combustion engine transforms into mechanical work the thermal and chemical energy of fuel whose combustion takes place within a cylinder. A variety of conditions, such as the ambient temperature surrounding the engine can influence the performance of a practical engine and its ability to burn these mixtures, volumetric efficiency decreases as the inlet air temperature increases [2] [3].

This phenomenon is occurring because the warm air is less dense then the cold air, and so less of it per pound by weight enters the cylinder to mix with an equal amount by weight going out. [4].

Engine performance is significantly impacted by the surrounding environment. Elevation, air temperature, and air humidity are a few variables that affect internal engine performance. Humidity is the most significant factor in combustion since it lowers combustion velocity and the highest temperatures attained during combustion. Depending on how much of these factors are present, the effect may be either positive or negative.[5] Also, the variation of pressure and the high temperature of the air entering the system may have a crucial role in the overall performance. Although this system may help in restoring the margin of combustion and the formation of nitrogen oxides, it may also adversely affect the engine efficiency. The high temperature of the inlet air has an adverse effect on efficiency, leading to a decrease in the performance output of the engine and further increasing the stress on the cooling system [3]. The increase in the atmospheric pressure causes an increase in the air density, hence an increase in the engine entry pressure charge, this increases the engine's power output due to the increase in the volumetric efficiency. The cars were tested, and they had a four-cylinder gasoline engine with multipoint fuel injection. The tests were conducted in temperatures ranging from 20 °C to 30 °C, both near sea level and at a height of 827 meters, taking into account the acceleration times and distances. The consequences showed that atmospheric pressure has a more impact on vehicle performance than temperature, about 3% distinction in the time taken to journey 1000 meters at a constant temperature.[6] Inversely, elevated ambient temperatures decrease the density of air, which worsens the power loss by reducing the mass of oxygen obtainable for combustion [7]. Related studies have shown that the power performance and fuel economy are lessened by 4.0 %–13.0 % and 2.7 % – 12.9 % for each 1000m that increases in altitude, respectively[8]. The effect of climate on fuel consumption and its alteration, in America, Europe, and Asia, extensive research has been conducted on the impact of weather conditions on fuel usage. In terms of weather conditions, the most important factor is the temperature[2].

The performance of a vehicle's engine is significantly influenced by the fluctuations in surrounding temperatures throughout the year. This highlights the necessity to focus on the engine's cooling system in order to achieve optimal efficiency corresponding to the required power output. Therefore, it became essential to analyze how ambient temperature, along with various factors, affects engine performance. This research aims to explore the influence of environmental conditions, such as temperature, humidity, and pressure, on the engine's power output by examining the changes in air temperatures, air density, air moisture, and altitude in Libya.

2. Methodology:

The research utilized data pertaining to a theoretical engine, as illustrated in Table 1. This information was sourced from an automotive industry website, such as that of Toyota. Selected temperature ranges between 10 °C and 48 °C were identified, corresponding to the typical climate conditions experienced throughout the year in Libya. Subsequently, the study examined the influence of these temperatures variations at sea level on the power production of the hypothetical engine. Following this, adjustments were made by incorporating both altitude and humidity levels in order to assess the impact of the identical temperature range on engine power output at an elevation of 100 m, with an average humidity of 65% and a pressure of 98.8 kPa, and at 800 m altitude, with an average humidity of 50% and a pressure of 91 kPa, respectively.

Table 1 : Characterization data of hypothetical engine

Specifications	Value
Volume (V)	2 L
No of cylinder	4
Pressure (P)	101135 Pascal
Power output	100kW

2.1 Density (ρ):

Density serves as a crucial factor since it influences the volume of air that e nters the engine and the overall fuel consumption based on a reference de nsity at 25°C.

(ambient temperature for laboratory experiments, commonly utilized by aut omotive manufacturers).

$\rho = P/RT$

where is:

R_{air}) constant of air $R_{air} = 287$ J/Kg.K(

Density of air kg / m^3 (T_k) temperature of air, (P) Pressure (Pascal) ρ)

2.2 Calculate the correction of air pressure at height and humidity:

The equation displayed below was utilized to calculate the atmospheric pressure at the specified elevation with a temperature of 288.15 K. Subsequently, the saturation vapor pressure was obtained from tables thermal data standards, while at the same time assessing the partial pressure of water vapor and the partial pressure of dry air through the following investigations[9][10][11][12] :

$P_{h.} = P_0 \ (1 - h\ 0.0065/ T_0)^{5.256}$

P_h) presser at height (Pa)

P_0) presser at sea level (Pa)

h) height (m)

T_0) = 288 k (standard reference temperature of atmosphere)

2.3 pressure of water vapor (P_v) :

Pressure of water vapor was the pressure employed by water vapor molecules in the air (whether pure or in an admixture air) to find it applied following equation[5] :

$P_v = \phi \times P_{saturated}$

ϕ: relative humidity (0 - 1 %)

Partial Pressure of dry air (P_d): 2.4

To determine the partial pressure of dry air in a moist sample, subtract the

pressurere of water vapor from the atmospheric pressure using, the equatio n below:

$P_d = P_h - P_v$

density of humid air (ρ): 2.5

To calculate the actual density of humid air, the formula of an ideal gas was used, taking into account the partial pressure of dry air added to the pressure of water vapor, which applied the following of this equation:

$\rho_{actual} = P_d / R_d T + P_v / R_v T$

$R_d = 287$ J/Kg.K (constant of air)

$R_v = 461$ J/Kg.K (constant of water vapor)

T = Temperature (K)

2.6 Determine correction factor for both density and power [13] :

The power generated by the engine depends directly on the density of the incoming air. A correction factor was applied to assess engine power output recorded under varying atmospheric conditions against standard conditions, leading to the determination of the corrected power output as follows:

$Cf = \rho_{actual} / \rho_{0\ rev}$ correction factor

$P_{correction} = P_{rated} \times Cf$

Table 2: Effect of variations in temperature among 10C⁰ to 48 C⁰ on the power output of the engine at the level of sea

C^0	ρ kg/m^3	P kW
10	1.2305	105
15	1.2092	103
20	1.1885	101
25	1.1686	100
30	1.1493	98
35	1.1307	97
40	1.1126	95
48	1.0849	93

Table 3: Effect of variations in temperature on the power output of the engine among 10 C^0 to 48 C^0 at 100 m height, humidity 65%, and Pressure 98.8 KP

T C^0	P_{sat} kp	P_v kp	P_d kp	ρ_{acul} kg/m^3	Cf %	P kW
10	1.23	0.799	98	1.21	1.03	103
15	1.71	1.11	97.69	1.18	1	101
20	2.34	1.51	97.29	1.17	1	100
25	3.17	2.06	96.74	1.15	0.98	98
30	4.24	2.76	96.04	1.12	0.95	96
35	5.63	3.66	95.14	1.10	0.94	94
40	7.4	4.81	94.62	1.09	0.93	93
48	11.30	7.35	91.45	1.04	0.89	89

Table 4: Effect of variations of temperatures on the power output of the engine among 10 C^0 and 48 C^0 at a height of 800 m, humidity 50 %, and Pressure 91 KP

T C^0	P_{sat} kp	P_v kp	P_d kp	ρ_{acul} kg/m^3	Cf %	P kW
10	1.23	0.615	90.4	1.11	0.95	95
15	1.71	0.855	90.1	1.09	0.93	93
20	2.34	1.17	89.8	1.076	0.92	92
25	3.17	1.59	89.41	1.058	0.90	90
30	4.24	2.12	88.88	1.040	0.89	89
35	5.63	2.82	88.18	1.02	0.87	87
40	7.4	3.70	87.30	1.00	0.86	86
48	11.30	5.65	85.35	0.971	0.83	83

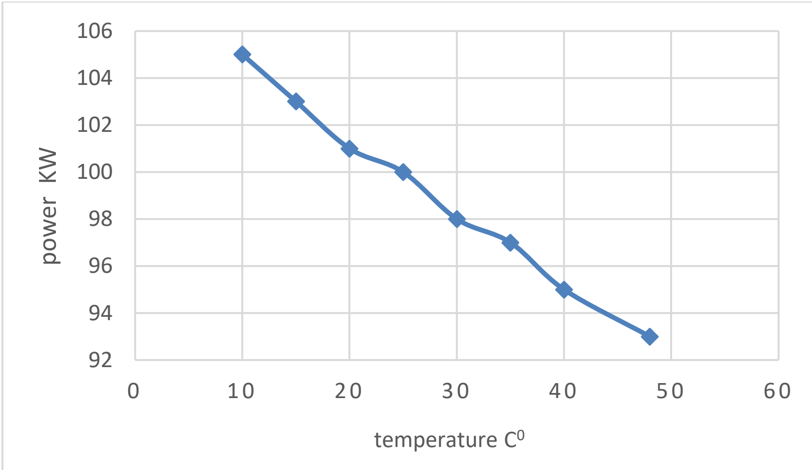

Figure 1 : temperature and power output at sea level

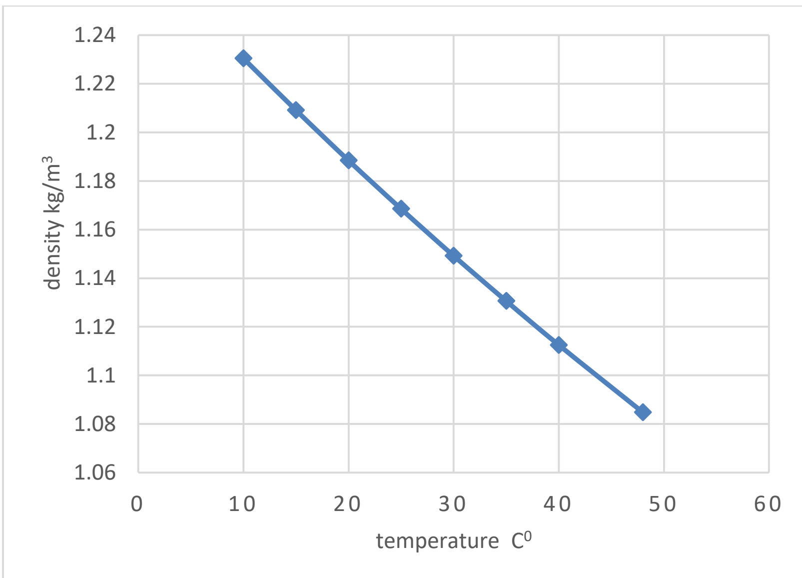

Figure 2: Effect of temperatures on the density at sea level

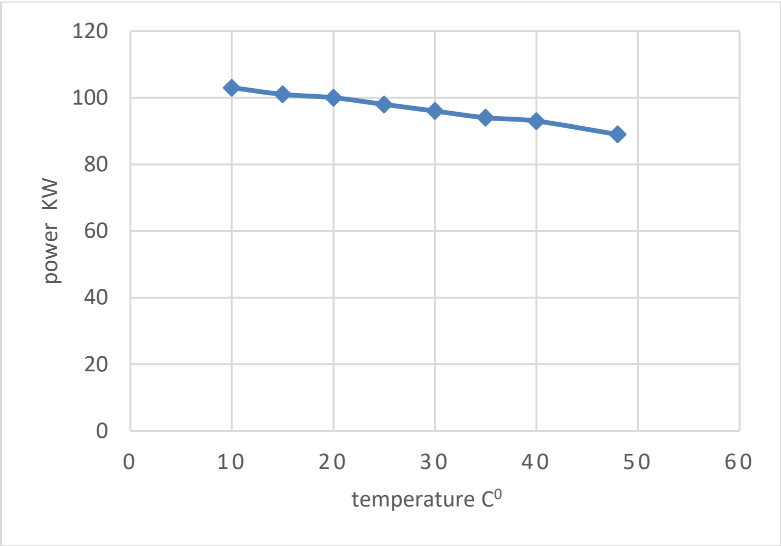

Figure 3 : Effect of temperatures on the power output at height 100 m

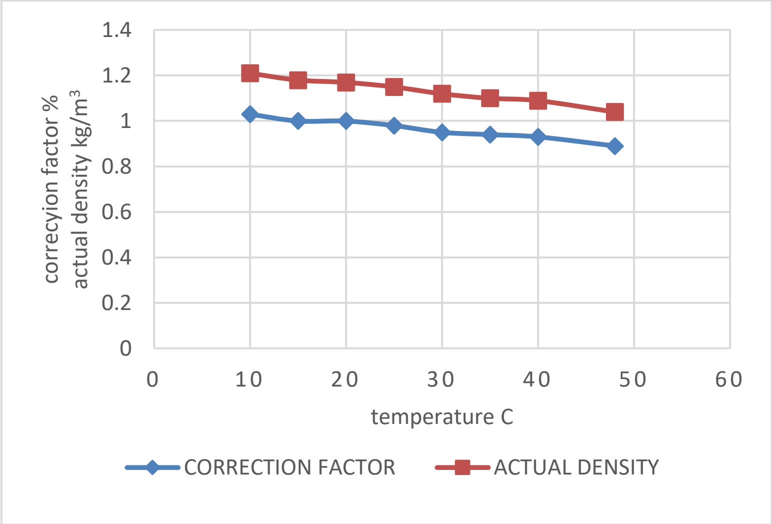

Figure 4: Effect of temperatures on the actual density and correction factor at a height of 100 m

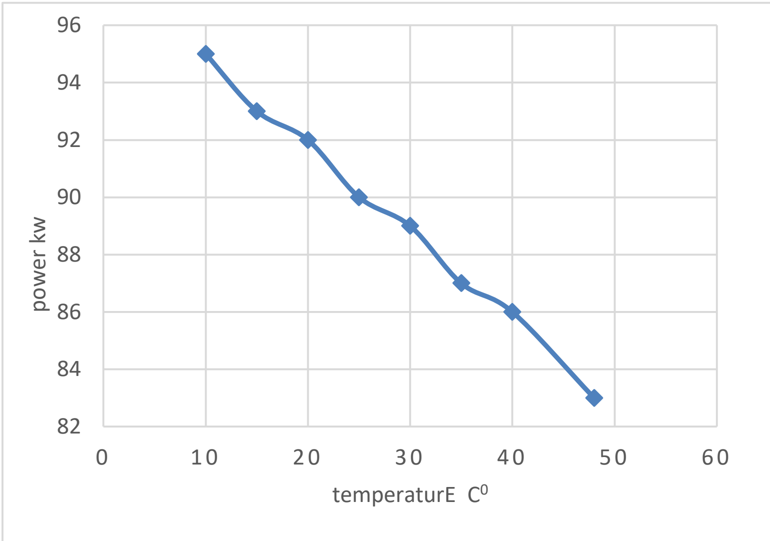

Figure 5: Effect of temperatures on the power output at height 800 m

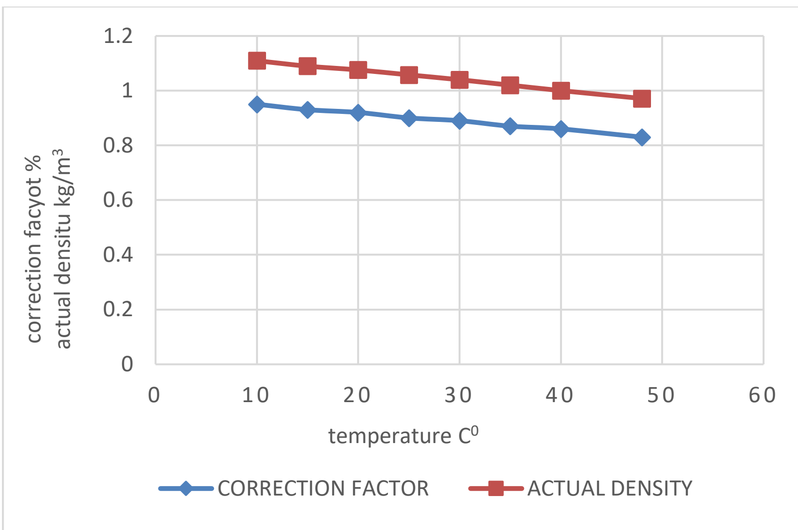

Figure 6: Effect of temperatures on the actual density and correction factor at height 800 m

3. Discussion:

Figure 1 & 2 showed that with the rise of temperatures with constant sea levels, the power output of the engine decreases, due to the decrease in density, resulting in a decrease in power output of approximately 7% at 48 C. Also, from figure 3&4 observed that the power output decreases from the engine. As a result, the density decreases with constant height at 100 m above sea-level, it was observed that with an increase in height to 800 m, the power output from the engine decreases, and that clear observed from the results, reaching approximately 17%. The effect of humidity is not as significant as that of altitude, according to computation, in generally the effect of that elevation lessening atmospheric pressure and influence on the density of air, on the other hand little by little reducing power output at high elevations because lesser levels of oxygen and lower of air density, leads to less the oxygen that was needed for combustion, which directly results in lower engine power output[7] [14]. Accordingly, Leads to increased fuel consumption and air pollution, which are causes in older cars or those with faulty control systems[15].

4. Conclusions:

Generally, with higher air temperatures results in the expanding of air and a decline in air density, thereby leading to a decrease in the engine's output compared to the design data.

At an altitude of 800 m above of the sea level, a relative humidity of 5% with constant lower atmospheric pressure, which causes an engine at 10 °C to encounter a power output reduction of approximately 5%, and a drop of around 17% at 48 °C.

Temperature, Relative humidity, and Elevation play a role in limiting airflow into the engine, thus collectively diminishing the engine's power output and potentially escalating fuel consumption.

Most important to keep an eye on the engine's cooling system and to ensure that engines are designed to operate with equivalent efficiency under such environments.

5. References

[1] R. R. Ibraheem And K. A. Abdullah, “Effect Of Ambient Air Temperature On The Performance Of Petrol Engine,” Vol. 12, No. 01, Pp. 7–11, 2019, Doi: 10.24237/Djes.2019.12102.

[2] J. A. Osei, “Climate Variability And Change Impacts On Vehicular Fuel Consumption And Emissions: A Systematic Overview In Africa,” Vol. 5, No. May, Pp. 50–77, 2023, Doi: 10.7251/Sted2305050o.

[3] M.H.Abbod, H.J.Kurjib and M.S.Imran"The Effect Of Intake Air Temperayure On Ignition Engine Performance."14 (10):3295-3302,2019

[4] A. The, I. Of, A. Conditions, P. Of, And G. A. S. Engines, "About The Influence Of Ambient Conditions On," No. X, Pp. 1–4, 2009.

[5] L. A. Vyacheslavovich, K. A. Ashatovich, And S. A. Aleksandrovich, "Causes Of Engine Oil Humidification," Vol. 838, Pp. 56–62, 2016, Doi: 10.4028/Www.Scientific.Net/Amm.838.56.

[6] S. M. C. Soares And J. R. Sodre, "E V Ects Of Atmospheric Temperature And Pressure On The," Vol. 216, Pp. 473–477, 2015.

[7] J. Martínez, L. Robles, F. Montalvo, D. Baño, And I. Zambrano, "Materials Today : Proceedings Effects Of Altitude In The Performance Of A Spark Ignition Internal Combustion Engine," Vol. 49, Pp. 72–78, 2022, Doi: 10.1016/J.Matpr.2021.07.475.

[8] Z. Song, L. Xu, L. Zhang, L. Zhao, J. Ba, And W. Wei, "Heliyon Operation Parameters Investigation On Combustion And Emission Of A Non-Road Diesel Engine Based On Orthogonal Experiment Design At Different Altitudes," *Heliyon*, Vol. 10, No. 21, P. E40086, 2024, Doi: 10.1016/J.Heliyon.2024.E40086.

[9] L. Umr, I. É. Écologie, And N. Cedex, "Original Article Multiscale Computation Of Solar Radiation For Predictive Vegetation Modelling," Vol. 64, Pp. 899–909, 2007.

[10] Z. M. Rittersma, "Recent Achievements In Miniaturised Humidity Sensorsða Review Of Transduction Techniques," Vol. 96, Pp. 196–210, 2002.

[11] T. Hyhlík, "Engineering Model Of High Pressure Moist Air," Vol. 02041, Pp. 1–8, 2017.

[12] P. P. Lynch, "M . Sc . In Meteorology Physical Meteorology Part 2 Atmospheric Thermodynamics Outline Of Material The Kinetic Theory Of Gases I . The Gas Laws".

[13] S. M. C. Soares, "Comparison Of Engine Power Correction Factors For Varying Atmospheric Conditions," Vol. Xxv, No. 3, Pp. 279–285, 2003.

[14] F. Consumption And A. D. Engine, "Influence Of Environmental Changes Due To Altitude On Performance , Fuel Consumption And Emissions Of A Naturally Aspirated Diesel Engine," 2021.

[15] E. V. Rojas-Reinoso, S. Masaquiza, D. Calderón, And J. A. Soriano, "Study The Torque Behaviour Of The Engine When Varying The Air And Fuel Injection Pressure Parame- ters to improve fuel economy in a conventional spark-ignited engine," vol. 11.