Journal of
Aerospace Engineering & Technology
https://journals.stmjournals.com/joaet
ISSN: 2231-038X (Online)
ISSN: 2348-7887 (Print)
Volume 15, Issue 1, 2025
January–April
DOI (Journal): 10.37591/JoAET
Review JoAET

# Enhancing Engine Efficiency and Reducing Emissions: A Comprehensive Review of Air Calorimeter Technology

Rajkumar Panchal[1,*], Veerbhadrappa Sulepeth[2], Pranali Bhosale[2], Harshada Chougule[2], Onkar Kambar[2], Pranav Butla[2]

***Abstract***

*The article talks about the idea behind this project to pre-heat the intake air that passes through the carburettor to increase a petrol engine's fuel efficiency. The vaporization of petrol in the carburettor is influenced by the humidity of the surrounding air. Therefore, vaporization can be facilitated, and full combustion can be accomplished by preheating the carburettor's incoming air for a significant amount of time. Additionally, by lowering the amount of water vapour entering the engine, steam generation can be decreased, which will lessen engine cylinder, piston, and exhaust pipe pitting. By installing a heat exchanger inside the exhaust pipe, the engine's inlet air can be pre-heated. The exhaust gas calorimeter is a heat exchanger that reduces exhaust gas dispersion and increases the rate of heat transfer. To obtain somewhat better outcomes, this study identifies and links a reduction in the quantity of heat produced by emissions to the current model. Several calorimeters have been designed and tested with analytical software. To outperform the current one, compare the two. The improved calorimeter has been manufactured following design modifications. It shows that both the overall heat transfer rate and the rate per unit area are higher than the present rate.*

**Keywords:** Air preheater, engine efficiency, water vapor, HCCI engine, fuel efficiency

## INTRODUCTION

A portion of the energy in the current system is wasted because of air heating. Here, the silencer eliminates the hot air from exhaust, which lowers the vehicle's average. Here, researcher create a calorimeter model of a system that uses an air-preheated system to increase fuel efficiency. The internal combustion engine powers the two-wheeler. It is an apparatus that transforms exhaust thermal heat energy into air heating. Here, we use an air-preheated system to create a model of a system that increases fuel efficiency. The internal combustion engine powers the two-wheeler. It is an apparatus that transforms exhaust thermal energy into air heating. To supply the carburetor with hot air, an ambient air inlet is also installed above the silencer. A portion of the energy waste in the current system is caused by air heating. Here, the silencer eliminates the hot air from exhaust, which lowers the vehicle's average. Here, we will use an air-preheated system to manufacture the air calorimeter model of the fuel efficiency-boosting system. The internal combustion engine powers the two-wheeler. It is an apparatus that transforms exhaust thermal energy into air heating.

***Author for Correspondence**
Rajkumar Panchal
E-mail: hod_mech@pgmcoepune.com

[1]Faculty (Professor), Department of Mechanical Engineering, Parvatibai Genba Moze College of Engineering, Pune, Maharashtra, India
[2]Student, Department of Mechanical Engineering, Parvatibai Genba Moze College of Engineering, Pune, Maharashtra, India

Receiving Date: December 30, 2024
Accepted Date: January 05, 2025
Published Date: January 25, 2025

**Citation:** Rajkumar Panchal, Veerbhadrappa Sulepeth, Pranali Bhosale, Harshada Chougule, Onkar Kambar, Pranav Butla. Enhancing Engine Efficiency and Reducing Emissions: A Comprehensive Review of Air Calorimeter Technology. Journal of Aerospace Engineering & Technology. 2025; 15(1): 8–13p.

 

## AIR CALORIMETERS' IMPORTANCE

The following are some ways that air calorimeters support engine systems:

- *Improved combustion efficiency:* They aid in optimizing combustion processes by offering precise heat exchange data.
- *Emission reduction:* Reduced emissions of pollutants and greenhouse gases are the result of optimized combustion.
- *Energy conservation:* They make it possible to use fuel more effectively, which lowers total energy usage.
- *Performance monitoring:* Consistent engine performance is ensured by ongoing heat exchange monitoring.

## LITERATURE REVIEW

Examine the current fuel supplies will eventually run out, and given the rate of consumer growth, their extinction is all but certain. Furthermore, our fuel supplies, which are primarily composed of fossil fuels, are not naturally replenishable. Fossil fuels are currently consumed 100,000 times more quickly than they are naturally produced worldwide. It is predicted that within a few millennia, the demand for these fuels would abruptly surpass their supply. Carbon dioxide is also released during the burning of fossil fuels [1].

Durcansky et al. also address the various application possibilities and individual factors that influence this Stirling engine's waste heat recovery efficiency. This type of engine's potential use with solar energy is determined by its ability to recover and use heat above 300°C, according to the analysis [2]. The impact of preheating and/or post weld heat treatment (PWHT) on the mechanical characteristics or maximal heat affected zone (HAZ) hardness, cold cracking dependence, and residual stresses of different steel types was presented by Srivastava et al. [3].

Simonson and Besant presented and verified a computational model for coupled heat and moisture transport with sorption, condensation, and icing in rotary energy exchangers using experimental data. Condensation and icing in energy wheels were investigated using the model. Water/frost will continuously build up in the wheel at a certain humidity level since condensation/frosting rises with humidity. Wheel speed and desiccant type were examined in relation to the sensitivity of icing and condensation. For a desiccant coating with a Type I sorption isotherm (such as a molecular sieve) and a linear sorption isotherm (such as silica gel), the energy wheel performance was also demonstrated under both sorption and saturation situations. According to simulation studies, a desiccant with a linear sorption curve is superior for energy recovery since it performs better and produces less condensation and frothing under harsh working circumstances [4]. The main issues with the HCCI engine, the application of renewable fuels, and their effect on engine-out emissions were all studied by Chaudhari and Deshmukh [5].

## DESIGN APPROACH

Steel is heated throughout the welding process; this heated area is known as the Heat Affected Zone (HAZ) and has a microstructure distinct from the base metal. Rapid heating and cooling during welding results in a severe thermal cycle close to the welding line. The weld metal and base metal are more susceptible to cold cracking, residual stress, and a harder heat-affected zone because of the thermal cycle's uneven heating and cooling of the material. After the results are displayed, detrimental residual strains frequently take effect [6].

The project includes a heat absorber, carburetor, silencer, and engine kit. The silencer heats up when the engine runs because of the hot exhaust gas. When the atmosphere's intake air passes over the silencer, it becomes heated, and the heated air is then sent to the carburetor. This gives us high efficiency and a decent fuel combination [7].

 

Various elements of setup are:

- Angle frame
- Carburetor
- Fuel tank
- Engine
- Connecting tube
- Silencer with heat exchanger

**Angle Frame**

This component makes up the machine's fundamental framework. An angle is used to create the frame. The strength of the angle determines the choice, and the load supported by the angle must have favourable physical characteristics. Mild steel is the angle's substance. The angles used for the frame's development are 140, 105, 35 cm. The angle plates were brought into dimension using a bandsaw machine. This frame was constructed using gas cutting, arc welding, and other techniques [8].

**Carburetor**

In essence, a carburetor is an open pipe that allows air to enter the engine through the intake. Because the pipe is shaped like a venture, the airflow increases in the narrowest region as it narrows and then widens again. The throttle valve, a butterfly valve located beneath the venturi, is a revolving disc that can be turned end-on to the airflow to barely impede it at all or rotated to (almost) totally stop it. Engine power and speed are controlled by this valve, which also regulates the amount of air/fuel mixture the system will provide by controlling the flow of air through the carburetor throat. The throttle corresponds to the accelerator pedal on an automobile or the comparable control on other automobiles or equipment, typically via a cable, a mechanical linkage of rods and joints, or infrequently by a pneumatic link [9].

**Fuel Tank**

Fuel tanks, often known as fuel tanks, are safe places to store combustible liquids. Although the phrase can refer to any fuel storage tank, it usually refers to the portion of an engine system where fuel is kept and then either released or driven into an engine. From the little plastic tank of a butane lighter to the multi-chambered exterior tank of a cryogenic space shuttle, fuel tanks vary widely in size and complexity. For flammable and combustible liquids, most tank types are covered by the national standard UL-142. It also holds true for steel tanks that are above ground. These specifications are applicable to tanks of different shapes, such as spherical, cylindrical, or rectangular. It is cylindrical in our situation [10].

**Heat Exchanger**

The TVS 50XL 50cc bike's original exhaust pipe is divided into three sections. The pipe's stay plates and silencer are taken out. There are no leaks, and they are flawlessly bonded together. The two concentric pipes are separated by a spiral baffle plate that is welded. For each inlet and exit, two 18 mm M.S. tubes, each 20 mm in length, are welded to the outer pipe's extreme ends in the opposite direction.

The muffler tube is where the entire arrangement is placed. The exhaust pipe pieces are gas welded and maintained in their proper positions without leaking. Outside of the exhaust pipe, the air input and exit pipes are welded.

The engine exhaust pipe contains the heat exchanger. A silencer, stay plates and other components make up the exhaust pipe. There are eighteen SWG M.S. plates in the heat exchanger. Tightly fit the inner tube onto the muffler tube. To create a spiral path for the entering air, a spiral baffle plate arrangement is placed between the two concentric tubes in order to enhance the flow of heat to the air. Effective heat transmission is also possible since the air is flowing in the opposite direction of the exhaust gas.

 

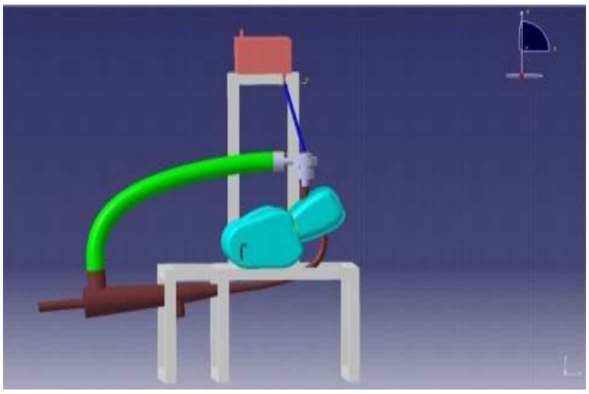

**Figure 1.** Calorimeter design approach.

A pre-filter is installed at the heat exchanger's input. A hose pipe connects the exit to a bypass device. The carburetor intake is linked to the bypass mechanism. For a specific degree Celsius, the temperature of the air entering the carburetor can be kept constant. The thermal relay opens the butterfly valve (4-wheeler application) when the air temperature rises above the preset valve, allowing the heater air from the heat exchanger to mingle with the ambient air. Thus, the temperature is lowered by diluting the hot air with ambient air. By using an adjustable screw to pre-test, the thermal relay for the necessary temperature, the hot air temperature to the carburetor can be kept at a specific level.

The exhaust gas calorimeter is a heat exchanger that reduces exhaust gas dispersion and increases the rate of heat transfer. In order to obtain somewhat better outcomes, this study identifies and links a reduction in the quantity of heat produced by emissions to the current model. Several calorimeters have been designed and tested with analytical software. To outperform the current one, compare the two. The improved calorimeter has been manufactured following design modifications as shown in Figure 1. It shows that both the overall heat transfer rate and the rate per unit area are higher than the present rate. Ultimately, we computed and experimentally confirmed that the heat transfer rate and overall heat transfer rate were more efficient than the previous one. In this modified exhaust gas calorimeter design, it is observed that higher material densities result in lower hot gas temperatures, which limit the number of gases such as NOx, CO (nitrogen oxides, carbon mono oxide), etc. that scatter directly into the atmosphere.

**CALCULATE FUEL CONSUMPTION**

1. Verify the amount of fuel.
2. A 50 ml fuel level is ideal.
3. To allow fuel to flow to the engine tank, open the way cock.
4. Turn on the motor.
5. Use a speedometer to maintain rpm at a steady speed and record it.
6. Record the air temperature at the carburetor’s inlet in degrees Celsius at different engine speeds.
7. The test is first conducted without the preheater setup, after which the engine is run at different rpms for 50 milliliters of fuel, timing is recorded (the rpm recorded here is crankshaft rpm), and the outcomes are recorded.
8. The second test for actual fuel usage (with air pre-heater connection): The test is then carried out by attaching the preheating setup and the carburetor. The hot air from the air preheating setup is transferred using a hose pipe, which has one end attached to the carburetor and the other to the air preheating setup. This way, when the air enters the carburetor, it is preheated by the exhaust gas heat recuperation setup, allowing hot air to enter the carburetor. The engine is set to run at a different rpm for the same amount of fuel (50 ml), and the engine's running time.
9. Open the throttle valve to get the engine's pickup speed up to the necessary 300 rpm.
10. For varying speeds, repeat step 4.
11. Repeat steps 1-4 for both the air-preheater and non-air-preheater conditions.

## EXPERIMENTAL RESULTS

- Engine speed = 5000 rpm
- Torque = 43 N-m
- Area of fuel tank = 0.1361 $m^2$
- Density of fuel (petrol) = 740 $kg/m^3$
- Break Power = 2πNT/60*1000 = 2*π*5000*43/60*1000 = 22.51 kW

## CALCULATION FOR READING

Time for reading = 5 min

*Case 1: without preheating system*

Initial petrol level in fuel tank = 0.120 m
Final petrol level in fuel tank = 0.09 m
Difference between initial level and final level (L) =0.03 m
Mass of fuel (mf): - mf = ρ*Area*L/Time
mf = 740*0.01272*0.03/5 m
f = 0.0564 Kg/min
Thermal efficiency (ŋ): - η= B.P./mf*C.V. η = 22.51*60/0.0564*42000
η=59.94%.

*Case 2: with preheating system*

Initial petrol level in fuel tank = 0.120 m
Final petrol level in fuel tank =0.095 m
Difference between initial level and final level (L) =0.025 m
Mass of fuel (mf):- mf = ρ*Area*L/Time
mf = 740*0.01272*0.025/5
mf = 0.0470 kg/min
Thermal efficiency (ŋ): - η= B.P./mf*C.V. η=22.51*60/0.0470*42000
η = 68.32%

## RESULT AND OBSERVATION OF EMISSION TEST

### Emission Test Results

According to the observation Table 1, the percentage of $CO_2$ and CO volume in exhaust gas decreased as the carburetor's air temperature rose. As the temperature of the carburetor inlet air rises, the amount of HC matter in the exhaust gas somewhat increases.

**Table 1.** Observation table.

| Condition | CO (%) | HC (ppm) | $CO_2$ (%) |
|---|---|---|---|
| Without air preheater | 2.3 | 464 | 3.2 |
| With air preheater | 1.8 | 470 | 2.8 |

## CONCLUSION

This initiative was an attempt to design and deploy the new technologies that will propel us into the future, as well as to lessen our reliance on foreign oil and automotive tailpipe emissions. Compared to the present national average, the use of manufacturing preheating will minimize smog-forming pollutants. The market's first hybrid will reduce emissions of pollutants that cause global warming by a third to a half, and subsequent models may reduce emissions even further. There are numerous advantages to charging beforehand. Because of the high homogeneity of the combination of air and fuel in the cylinder throughout the power stroke, an 11–15% improvement in engine power output will be expected. The engine's thermal efficiency has increased as a result of this, as the fuel's specific heat (C.V. = 42000 KJ/Kg) is maximized.

 

**REFERENCES**


1. Sudhakaran R, Aravinthkumar G, Naveenkumar M. Enhancing the I.C. Engine Performance by Using the Electrolysis and Preheating Process. IOSR J Comput Eng. May-Jun. 2014; 16 (3): 102–106.
2. Durcansky P, Nosek R, Jandacka J. Use of Stirling Engine for Waste Heat Recovery. Energies. 2020; 13(16): 4133. https://doi.org/10.3390/en13164133
3. Bipin Kumar Srivastava, Tewari SP, Jyoti Prakash. A review on effect of preheating and/or post weld heat treatment (Pwht) on mechanical behavior of ferrous metals. Int J Eng Sci Technol. 2010; 2(4): 625–631.
4. Simonson CJ, Besant RW. Heat and Moisture Transfer in Energy Wheels During Sorption, Condensation, and Frosting Conditions. ASME. J. Heat Transfer. August 1998; 120(3): 699–708. https://doi.org/10.1115/1.2824339
5. Chaudhari VD, Deshmukh D. Challenges in charge preparation and combustion in homogeneous charge compression ignition engines with biodiesel: A review. Energy Reports. November 2019; 5: 960–968.
6. Raja K, Karthik K, Naveen S, Madhan JS, Kumar MC, Sakthi LG. Design and fabrication of convergent exhaust gas calorimeter. Materials Today: Proceedings. 2023 Jan 1; 90: 267–72.
7. Patil TB, Prakash Gore, Parvez Mulani, Atharva Kumbharka, Hritik Bahirat. Design and Manufacturing of Air Calorimeter to Enhance Engine Efficiency and Reduce Pollution, Int J Emerg Technol Innov Res. May-2023; 10(5): 924–928, (www.jetir.org), ISSN:2349-5162, Available: http://www.jetir.org/papers/JETIRFX06164.pdf
8. Rajpoot AS, Choudhary T, Chelladurai HM, Sinha AA, Pachori H. Comparative thermal assessment and emission analysis of various green biodiesel from novel feedstocks for CI engines: a sustainable approach towards emission reduction. Environ Sci Pollut Res. 2024 Jun; 3: 1–3.
9. Mirzajanzadeh M, Tabatabaei M, Ardjmand M, Rashidi A, Ghobadian B, Barkhi M, Pazouki M. A novel soluble nano-catalysts in diesel–biodiesel fuel blends to improve diesel engines performance and reduce exhaust emissions. Fuel. 2015 Jan 1; 139: 374–82.
10. Khanam S, Khan O, Ahmad S, Sherwani AF, Khan ZA, Yadav AK, Ağbulut Ü. A Taguchi-based hybrid multi-criteria decision-making approach for optimization of performance characteristics of diesel engine fuelled with blends of biodiesel-diesel and cerium oxide nano-additive. J Therm Anal Calorim. 2024 Apr; 149(8): 3657–76.


 