International Journal of Engineering & Technology, 7 (4.39) (2018) 475-477

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Cogeneration Possibilities in Academic Institutions: an Experimental Study

Sumit Tiwari[1]*, Ashish Gupta[2], Om Prakash Yadav[3]

[1,2,3] G. L. Bajaj Institute of Technology & Management, INDIA
**Corresponding author E-mail: tiwsumit@hotmail.com*

Abstract

In present paper, concept of cogeneration has been implemented experimentally. Internal combustion engine (ICE) working on diesel fuel taken for energy production although it is found that out of total energy 42% is wasted through exhaust gasses and 28% energy is wasted due to engine cooling. Energy wasted through exhaust and cooling can be recovered through water or some fluid heating. Present study is done in academic institute (KIET, Ghaziabad, UP, India) in which time table has been arranged so that ICE energy can be utilize in ICE lab and energy of exhaust gasses and engine cooling can be utilize in heat and mass transfer lab for study of heat exchanger working in parallel and counter flow condition. It is seen from the result that thermal efficiency has been increased by 40% at higher loading conditions.

Keywords: *Use about five key words or phrases in alphabetical order, Separated by Semicolon.*

1. Introduction

In present era, energy is becoming the necessity of human being like, water, air and food. Energy demand is increasing day by day which encourage for best utilization of available resources. Co-generation is a tool which can promotes the best utilization of the waste energy. The spreading out cleaner and recovered energy are essential to overcome global warming and fossil fuel dependency [1]. Cogeneration is important in terms of decrease in the cost of total power resulting from replacement of superannuated power plants [2]. An innovative collective power and cooling cogeneration system driven by geothermal hot water is proposed and results showed the reduced overall cost of system [3]. The pollutants from emission threaten the fitness of human being in various means, immediate action is needed to overcome this problem [4-6]. One of the solution to reduce greenhouse gasses is to reduce the temperature of exhaust gasses.

In the present system, the heat of exhaust gasses and cylinder head are used to heat the water. Further, this heated water can be utilize for other purposes especially in present case heat exchanger apparatus is used to utilize the heat. In this way, two types of energy can be achieved namely, heat and power and system can be consider as cogeneration.

2. Experimental Setup

In the experimental setup VCR engine has been taken into consideration and output of water has been connected with heat exchanger system. First, engine has been analyzed on the basis of its performance. From the engine major heat loss occur in two ways:-

1. Heat loss through cylinder head
2. Heat loss through exhaust gases

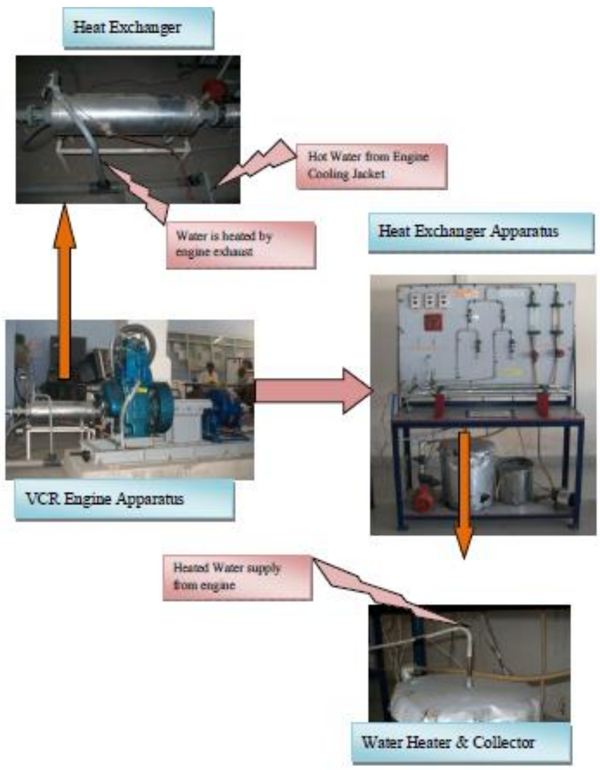

Fig. 1: Cogeneration system

In the experimental setup, VCR engine has been taken into consideration and output of water has been connected with heat exchanger system. First, engine has been analyzed on the basis of its performance. From the engine major heat loss occur in two ways:-

3. Heat loss through cylinder head
4. Heat loss through exhaust gases

By utilizing these two losses we can increase the efficiency of engine. So for this we can take the heated water from cylinder head and also heat energy of exhaust can be utilized to heat water. In our experiment, we utilized this trapped heat energy into heat exchanger experiment performed in heat and mass transfer lab.

Engine Details:

IC Engine set up with power 3.50 kW @ 1500 rpm which is 1 Cylinder, Constant Speed, Connecting Rod length 234.00(mm), Four stroke , Diesel Engine, with Cylinder Bore 87.50(mm), Water Cooled, Stroke Length 110.00(mm), Swept volume 661.45 (cc), Compression Ratio 17.00,

Combustion Parameters:

Air Density (kg/m^3): 1.17, Specific Gas Constant (kJ/kgK): 1.00, Adiabatic Index: 1.41, Number of Cycles: 10, Polytrophic Index: 1.07, Smoothing 2, Cylinder Pressure Reference: 3, TDC Reference: 1

Performance Parameters:

Orifice Coefficient. of Discharge: 0.60, Fuel Pipe dia (mm): 12.40,Orifice Diameter (mm): 20.00, Dynamometer Arm Length (mm): 185, Pulses Per revolution: 360, Ambient Temp. (Deg C): 27, Fuel Type: Diesel, Calorific Value of Fuel (kj/kg): 42000. Fuel Density (Kg/m^3): 830,

3. Thermal Modelling

3.1. Performance of I.C.Engines:

(a) Indicated thermal efficiency (η_t): Indicated thermal efficiency can be defined as the ratio of energy through indicated power to the combustible fuel energy.

$$\eta_t = IndicatedPower / FuelEnergy$$

$$\eta_t(\%) = \frac{IndicatedPower(KW) \times 3600}{FuelFlow(Kg/Hr) \times CalorificValue(KJ/Kg)} \times 100$$

(b) Brake thermal efficiency (η_{bth}): The overall efficiency engine efficiency can be defined as brake thermal efficiency. It is the ratio of energy in the brake power to the fuel energy.

$$\eta_{bth} = BrakePower / FuelEnergy$$

$$\eta_{bth}(\%) = \frac{BrakePower(KW) \times 3600}{FuelFlow(Kg/Hr) \times CalorificValue(KJ/Kg)} \times 100$$

(c) Mechanical efficiency (η_m): Mechanical efficiency is the ratio of brake horse power (delivered power) to the indicated horsepower (power provided to the piston).

$$\eta_m = BrakePower / IndicatedPower$$

Frictional power = Indicated power – Brake power

(d) Volumetric efficiency (η_v): Volumetric efficiency shows the 'breathing' capability of an engine and it can be defined as the ratio of the air brought at ambient circumstances to the swept volume of the engine. In general, the engine does not persuade a whole cylinder full of air on every stroke, and volumetric efficiency can be represented as:

$$\eta_v(\%) = \frac{\text{Mass of air consumed}}{\text{mass of flow of air to fill swept volume at atmospheric conditions}}$$

$$\eta_v(\%) = \frac{AirFlow(Kg/Hr)}{\pi/4 \times D^2 L(m^3) \times N(RPM)/n \times NoofCyl \times AirDen(Kg/m^3) \times 60} \times 100$$

Where n= 1 for 2 stroke engine and n= 2 for 4 stroke engine.

(e) Air flow:

For air consumption measurement air box with orifice is used.

Where C_d = Coefficient of discharge of orifice

D = Orifice diameter in m

g = Acceleration due to gravity (m/s^2) = 9.81 m/s^2

h = Differential head across orifice (m of water)

W_{den} = Water density (kg/m^3) =@1000 kg/m^3

W_{air} = Air density at working condition (kg/m^3) = p/RT

Where

p= Atmospheric pressure in kgf/m^2 (1 Standard atm. = 1.0332X104 kgf/m^2)

R= Gas constant = 29.27 kgf.m/kg^{0}k

T= Atmospheric temperature in ^{0}k

(f) Specific fuel consumption (SFC): Brake specific fuel consumption (BSFC) and indicated specific fuel consumption (ISFC), are the fuel intakes as per brake power and indicated power respectively.

(g) Fuel-air (F/A) or air-fuel (A/F) ratio: It can be defind as the ratio of the fuel mass to that the air or vice versa.

(h) Power and Mechanical efficiency: Power is the rate of doing work and defined as the product of force or torque and linear velocity or angular velocity. The power given by an engine at the output shaft is called brake power such as

Power = NT/60,000 in kW

where T= torque in Nm = WR

W = 9.81 * Net mass applied in kg, R= Radius in m

N is speed in RPM

(i) Mean effective pressure and torque: It is well-defined as a hypothetical pressure, which is supposed to be performing on the piston throughout the power stroke.

Power in kW = (Pm LAN/n 100)/60

where, Pm = mean effective pressure in bar

L = length of the stroke in m

A = area of the piston in m2

N = Rotational speed of engine RPM

n= number of revolutions required to complete one engine cycle

n= 1 (for two stroke engine)

n= 2 (for four stroke engine)

Similarly, the friction means effective pressure (FMEP) can be defined as

FMEP= IMEP – BME

(j) Cogeneration efficiency: It can be defined as the ratio of power generated by engine and heat recovered to the total energy coming from fuel burning.

4. Results and Discussions

Figure 2 shows the variation of IP, BP, and FP with respect to the load. It can be seen from the graph that the value of IP, BP, and FP increases with increment of load.

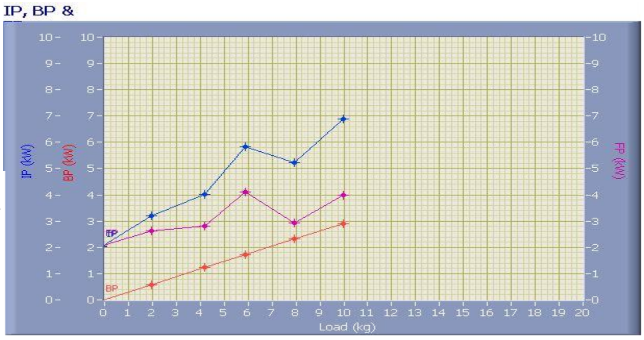

Fig. 2: Variation of IP, BP, FP with respect load

Figure 3 represents the variation of torque, mechanical and volumetric efficiency. It can be seen from the graph torque and mechanical efficiency is increasing with time whereas volumetric efficiency is decreasing as expected.

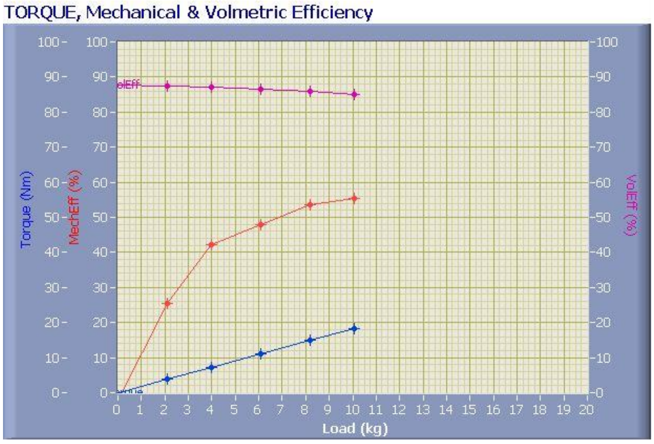

Fig.3: Variation of Torque, Mechanical and volumetric efficiency

Tables 1 and 2 shows the calculation of thermal and cogeneration efficiency. In cogeneration efficiency, heat recovered from the calorimeter and the water circulated in engine head have been taken. The heated water has been utilized in other experiment based on heat and mass transfer lab. In this way the extra electrical energy required in heat and mass transfer can be saved.
Figure 4 shows the variation of thermal and cogeneration efficiency with load It can be seen from the maximum themal efficiency has been found at maximum load i.e. nearly 50% whereas cogeneration efficiency reaches about to 90% which is large recovery in terms of energy saving.

Table 1: Total heat recovered through engine head and calorimeter (exhaust gasses)

Water Flow Engine (kg/hr.)	Energy given by engine head (w1)	Water Flow Cal (kg/hr)	Energy given by calorimeter (w2)	Total energy (w_1+w_2) in kJ/hr	Total energy (w_1+w_2) in kW
120	6592.32	70	1743.42	8335.74	2.32
120	7338.24	70	1837.5	9175.74	2.55
120	7862.4	70	2166.78	10029.18	2.79
120	8986.32	70	2819.46	11805.78	3.28
120	9908.64	70	3281.04	13189.68	3.66
120	10725.1	70	3813.18	14538.30	4.04

Table 2: Thermal and cogeneration efficiency with respect to fuel amount

Fuel (kg/h)	Heat input to engine (M_f*C_V)	IP (kW)	Thermal efficiency (%)	Cogeneration efficiency (%)
0.35	4.08	1.01	24.73	81.44
0.5	5.83	2.4	41.14	84.84
0.55	6.42	2.77	43.17	86.59
0.7	8.17	3.69	45.18	85.34
0.75	8.75	4.42	50.51	92.39
0.9	10.50	5.27	50.19	88.65

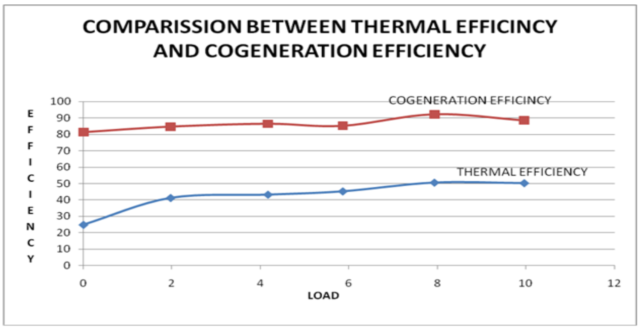

Fig. 4: Variation of thermal and cogeneration efficiency with load (kg)

5. Conclusion

It is seen from the above analysis that if in academic institutions little bit of lab timetable can manage then energy coming from one lab can utilize to run apparatus of other lab. As our country is facing energy crisis situation, small change in terms of energy saving can make a difference. It can be seen that the highest cogeneration efficiency found to be more than 90% compared to 50% thermal efficiency.

Acknowledgement

I am very thankful to KIET, Ghaziabad for proving the experimental facility. I am also thankful to Prof. Ajay Verma for his technical support.

References

[1] Saini Vineet, Tiwari Sumit, Tiwari GN (2017), Environ economic analysis of various types of photovoltaic technologies integrated with greenhouse solar drying system. Journal of Cleaner Production 156, 30-40.

[2] Fauci Daisuke Tomofuji, Yoshinori Morimoto, Eitaro Sugiura Toshiya, suIshii Atsushi (2017), The prospects of the expanded diffusion of cogeneration to 2030 – Study on new value in cogeneration. Applied Thermal Energy, 114, 1403-1413.

[3] Kordlar M. Akbari, Mahmoudi S.M.S (2017), Exergeoconomic analysis and optimization of a novel cogeneration system producing power and refrigeration. Energy and conversion management 134, 208-220.

[4] Li N, Hao M, Phalen RF, Hinds WC, Nel AE (2003). Particulate air pollutants and asthma: A paradigm for the role of oxidative stress in PM-induced adverse health effects. Clin Immunol 109(3), 250–65.

[5] Zhang JJ, McCreanor JE, Cullinan P, Chung KF, Ohman-Strickland P, Han IK, Järup L, Nieuwenhuijsen MJ (2009). Health effects of real-world exposure to diesel exhaust in persons with asthma. Res Rep Health Eff Inst, 138, 5–109.

[6] Attfield Michael D, Schleiff Patricia L, Lubin Jay H, Blair Aaron , Stewart Patricia A, Vermeulen Roel , Coble Joseph B, Coble Debra T Silverman (2012). The diesel exhaust in miners study: a cohort mortality study with emphasis on lung cancer. JNCI: J Natl Cancer Inst, 104(11), 869–83.