Experiment no: 5

Experiment Name: STUDY OF GAS ENGINE OF BUET POWER PLANT

Objectives:

The Key objectives of this experiment are:

(i) IC Engine Specification
(ii) Engine Mounting
(iii) Starting System
(iv) Air Intake System
(v) Fuel Supply Unit
(vi) Ignition System
(vii) Cooling System
(viii) Lubrication System
(ix) Exhaust System
(x) Engine Control System
(xi) Engine Protection System
(xii) Engine Governing

Engine Name Plate Data:

Caterpiller
Gas Generator Set G3516
LEAN BURN Gas Engine
Low Energy Gas Continuous 1020
CKW 1287 kVA
50 HZ 1500 rpm 400 volts

Engine Specification for 1 MW Engine

CAT LEAN BURN GAS ENGINE:
G3516 LE SCAC 4 STROKE CYCLE SPARK IGNITED ENGINE

Number of Cylinders	V16
Bore, mm (in)	170 (6-7)
Stroke, mm (in)	190 (7-5)
Displacement, L	69 (4210)
Compression Ratio	11:1
Cylinders and arrangement	65 degree V-16
Rotation (flywheel end)	Counterclockwise rotation is standard
Inlet Valve Lash	0.51 mm (0.02 inch)
Exhaust Valve Lash	1.27 mm (0.05 inch)
Firing Order (Standard)	1-2-5-6-3-4-9-10-15-16-11-12-13-14-9-8
Firing Order (Optional)	1-6-5-4-3-10-9-16-15-12-11-14-13-8-7-2

Table 1: Engine Specification for 1 MW Engine

Generator Specifcation

CAT SR4B GENERATOR

Frame Size	697
Excitation	Permanent Magnet
Construction	Star-Delta
Pitch	0.7333
Number of Poles	4
Number of bearings	1
Number of leads	6
IP Rating	Dip Proof IP22
Alignment	Pitot Shaft
Lever speed capability	125%
Wave form deviation line to line, no lead	less than 3%
Voltage Regulator	CDVR
Voltage Level Alignment	+/- 5.0%
Voltage Regulation Steady State	+/- 5.0%
Voltage Regulation with 3% speed change	+/- 5.0%
Telephone influence factor	less than 50

Table 2: Engine Specification for Generator

Engine Mounting

Standard	330 mm, industrial type rail, engine generation mounting
Optional	Spring type vibration isolators, Rubber type
Function	To damper vibration generated by the engine

Starting System

1. Air Intake System
2. Air Pressure Regulator
3. Air Silencer
4. Electric Air Start Controls
5. Electric Starting Motors - Dual 24 Volt
6. Starting Aids
7. Battery Sets [24 volt dry], Cables and Rack

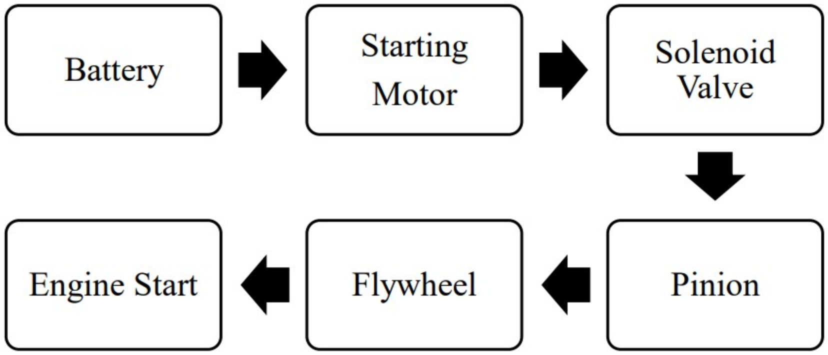


Figure 1: Starting System

Air Intake System

The air intake system filters the intake air to ensure fresh air charge into the engine every cycle. It consists of the following components:

- Air Cleaner - intermediate duty with service indicator
- Remote Air Inlet Adapters
- Pre-cleaner

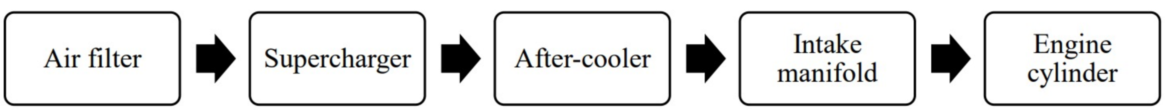


Figure 2: Air Intake System

Fuel Supply System

The fuel supply system provides a continuous supply of clean fuel to the engine. It consists of the following components:

- Gas Pressure Regulators
- Natural Gas Regulator
- Fuel Filter
- Propane gas valve and jet kits

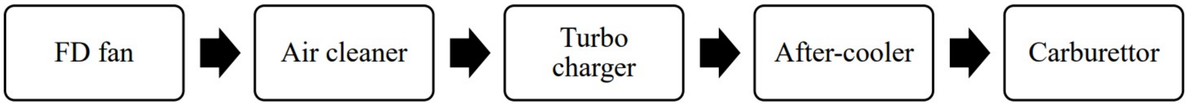


Figure 3: Air Supply System

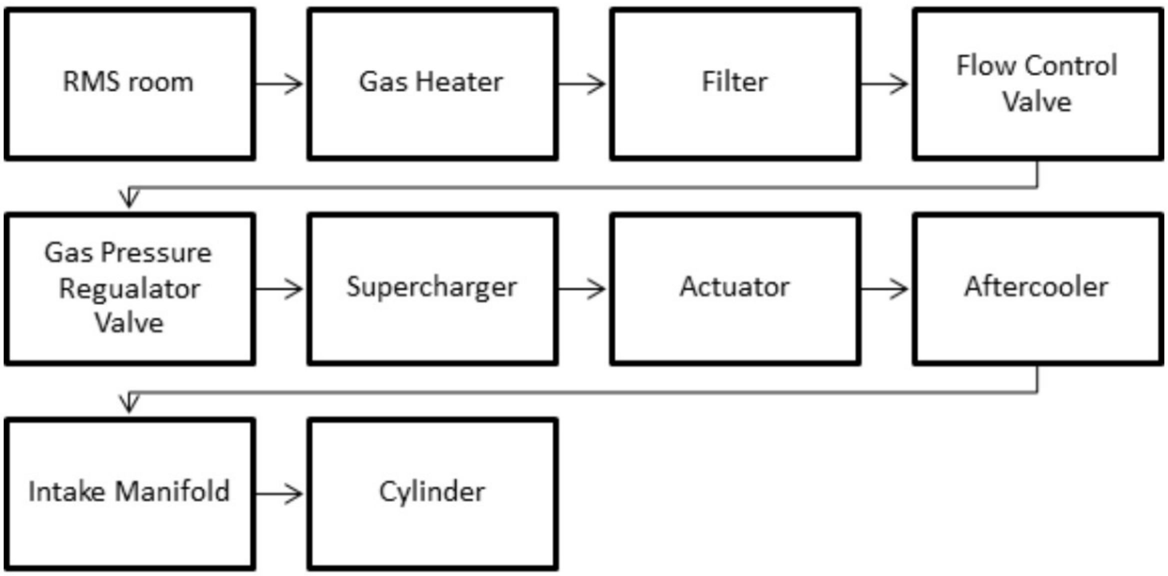


Figure 4: Fuel Supply System

The fuel filter is used to ensure clean fuel intake while the regulators are used to ensure proper gas pressure intake and accurate mixing process.

Ignition System

The ignition system provides a high energy spark to ignite the air/fuel mixture in the combustion chamber. It consists of the following components:

- The electronic ignition system
- The detonation sensing timing

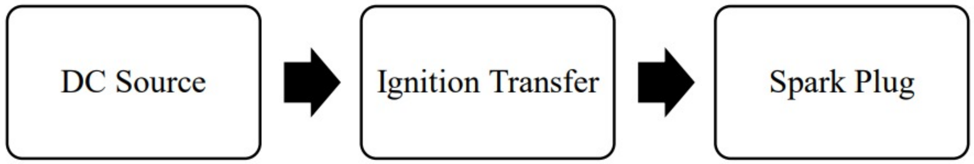


Figure 5: Ignition System in SI engine

Cooling System

The primary purpose of the cooling system is to remove excess heat and hence maintain a safe temperature in the system so that all the components of the engine can function properly. It consists of the following components:

- Thermostats
- Jacket water pump
- After cooler water pump
- After cooler Thermostats
- Housing

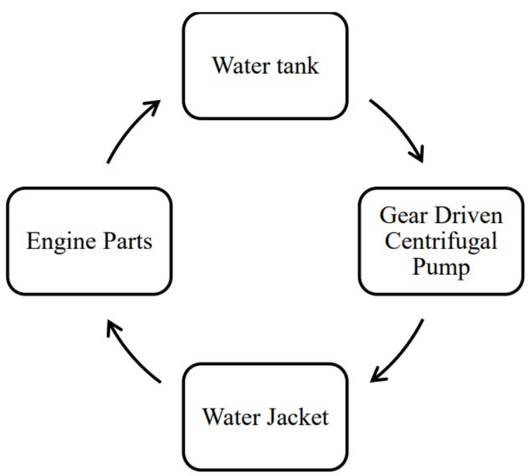


Figure 6: Cooling System in SI engine

Lubrication System

The lubrication system provides a continuous supply of filtered oil to all the moving parts of the engine. It consists of the following components:

- Oil bypass filter removal
- Oil pan
- Sump pump
- Air prelude pump
- Lubricating oil

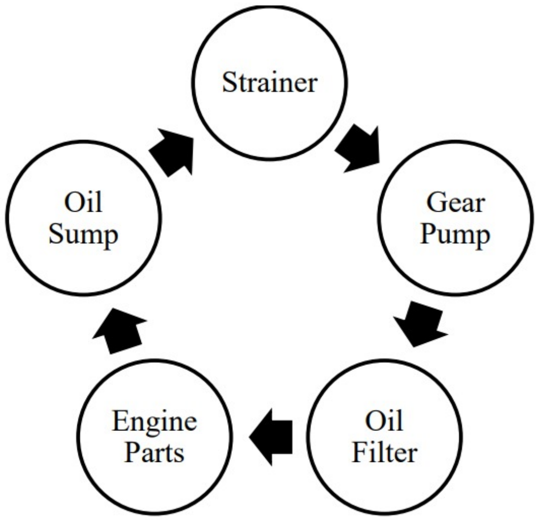


Figure 7: Lubrication System

The lubricating oil is used to reduce friction, heat and wear between the moving parts of the engine.

Exhaust System

The exhaust system removes the exhaust gases from the engine. It consists of the following components:

- Water cooled exhaust manifold
- Flexible Fittings

Water cooled exhaust manifold is used to cool the exhaust gases before they are released into the atmosphere.

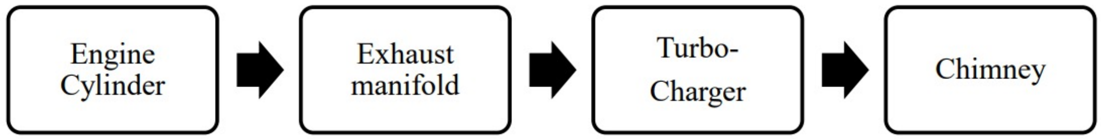


Figure 8: Exhaust System

Engine Protection System

The engine protection system monitors the engine and shuts it down if any of the conditions occur, like - rise in temperature or pressure, low oil pressure, low coolant level, etc. It consists of the following components:

- Electric Shutoff System
- Gas Shutoff System
- Relief Valves
- Wiring System

Engine Control System

The engine control system controls the engine speed and monitors the engine operating conditions. It consists of the following components:

- Air-fuel Ratio Control
- A3 Electronic Control Unit (ECU)
- Instrument Panel

Power Distribution System

The power distribution system distributes the power generated by the engine to the load. The generators are operated in isochronous mode i.e. the supply frequency is kept constant. When load increases, frequency drops. The drop is sensed by governor and it increases fuel supply. When the 2 generators are operated simulataneously, they must be sysnchronized.

There are 9 substations for distributing power:

1. Main Substation I
2. Main Substation II
3. Main Substation III
4. Dr. Rashid Hall Substation
5. Nazrul Islam Hall Substation [old]
6. Nazrul Islam Hall Substation [new]

7. New Academic Building Substation I
8. New Academic Building Substation II
9. New Academic Building Substation III

Data Sheet

Time	Gas consumption (Nm^3/hr)	Electric power output (kW)	Bkw	Bsfc ($Nm^3/Bkw\text{-}hr$)	Exhaust gas temperature (°C)	Cooling water inlet temperature (°C)	Cooling water outlet temperature (°C)
06:00		216.24	216.24	1.83	585.5	55	65
07:00		187.73	187.73	2.11	584.5	56	66
08:00		205.19	205.19	1.93	582.5	57	68
14:00		253.59	253.59	1.56	473.0	52	60
17:00	396	292.90	292.90	1.35	465.0	60	70
19:00		386.63	386.63	1.02	471.5	58	66
22:00		369.41	369.41	1.07	464.0	42	60
01:00		278.94	278.94	1.42	500.0	46	56
05:00		252.32	252.32	1.57	480.0	41	60

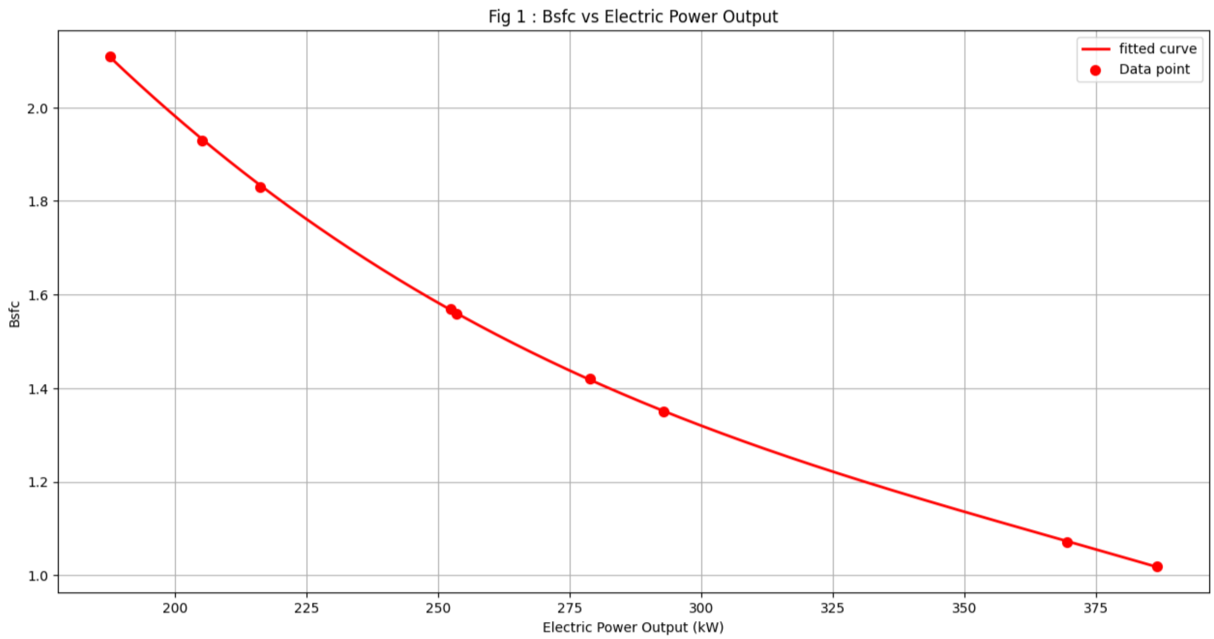
Table 3: Performance data of the engines at various times of the day.

Sample Calculation

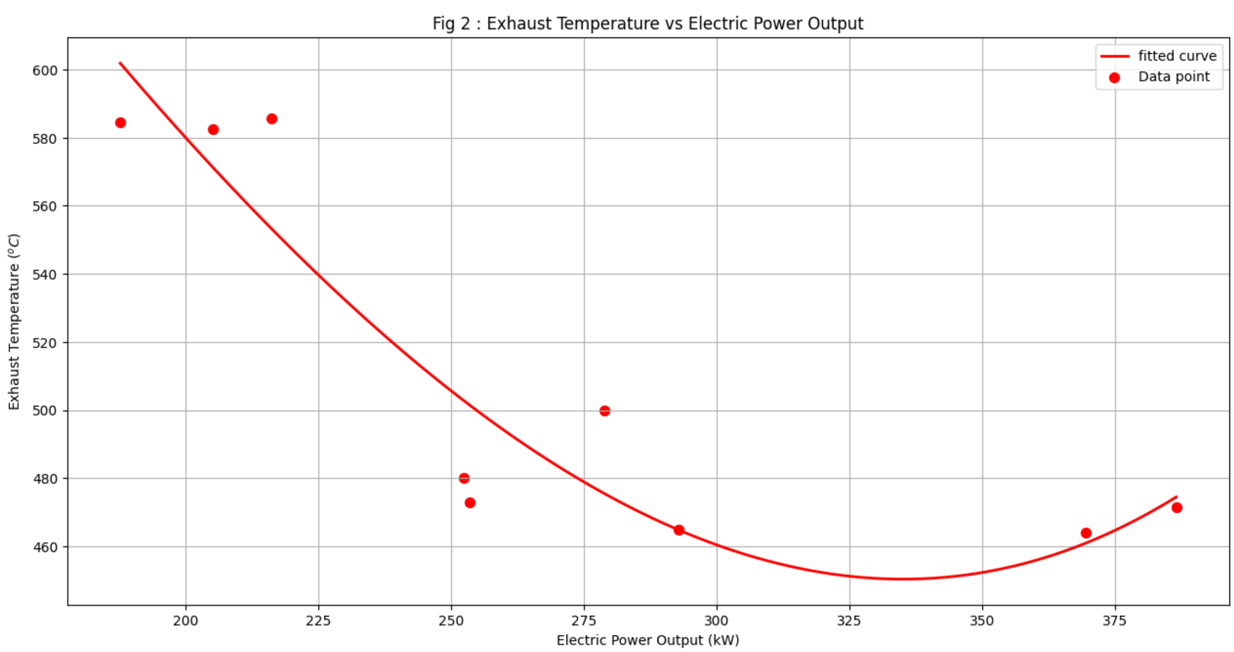
For observation no : 5
Time: 17:00 hr
Gas consumption = 396 Nm^3/hr
Electric Power Output = Bkw = 292.90 kW

$$\therefore \text{Bsfc} = \frac{\text{Gas consumption}}{Bkw} = 396/292.90 = 1.35\ Nm^3/kW - hr$$

Graph



Bsfc vs Electric Output Power



Exhaust Gas Temperature vs Electric Output Power

Discussion

In this experiment, we went to the BUET power plant, which is on the BUET west campus. It can produce 5MW of electricity using three units: one that can make 1MW and two that can make 2MW each. These units all use engines that run on gas.

When they start the engine, they check the level of lubricating oil. They also manually increase the oil pressure to make sure it reaches all parts of the engine. There's a 24V DC power source that provides electricity to the engine before it connects to the generator.

Under the generator, there are springs to help absorb shock. There are pipes: a blue one for cool water going in and a red one for hot water coming out of the engine. The power plant has a cooling tower. The two 2MW units use a forced draft fan, while the 1MW unit uses an induced draft fan in the cooling tower.

The engine is never pushed beyond 80% of its capacity to make it last longer. Running it at full power would harm both the engine and the power plant.

Normally, when an engine produces more power, its exhaust gas gets hotter. But in this case, looking at a graph of exhaust gas temperature versus power, we see that the temperature actually goes down as power increases. The graph isn't perfect because the power didn't change smoothly over time, causing the temperature to change unevenly.

Another graph shows that as the power produced by the engine (Bkw) goes up, the fuel consumption (Bsfc) goes down. However, after a certain point, Bsfc starts to increase again. This is a common behavior in internal combustion engines.

In general, the BUET power plant supplies electricity to teachers' homes, student halls, and academic buildings. This experiment was important for understanding how power plants are built and run. It helped us visualize what we learned from books to real-life situations.