MARRI LAXMAN REDDY
INSTITUTE OF TECHNOLOGY AND MANAGEMENT
(AN AUTONOMOUS INSTITUTION)
(Approved by AICTE, New Delhi & Affiliated to JNTUH, Hyderabad)
Accredited by NBA and NAAC with 'A' Grade & Recognized Under Section2(f) & 12(B)of the UGC act,1956

DEPARTMENT MECHANICAL ENGINEERING

THERMAL ENGINEERING

LAB MANUAL

SUBJECT NAME	**Thermal Engineering Lab**
SUBJECT CODE	**2040377**
COURSE-BRANCH	**B. Tech - Mechanical Engineering**
YEAR-SEMESTER	**II - II**
ACADEMIC YEAR	**2021-2022**
REGULATION	**MLRS-R20**

MARRI LAXAMAN REDDY

INSTITUTE OF TECHNOLOGY AND MANAGEMENT

MISSION AND VISION OF THE INSTITUTE:

Our Vision:

To establish as an ideal academic institutions in the service of the nation the world and the humanity by graduating talented engineers to be ethically strong globally competent by conducting high quality research, developing breakthrough technologies and disseminating and preserving technical knowledge.

Our Mission:

To fulfill the promised vision through the following strategic characteristics and aspirations:

- Contemporary and rigorous educational experiences that develop the engineers and managers;
- An atmosphere that facilitates personal commitment to the educational success of students in an environment that values diversity and community;
- Prudent and accountable resource management;
- Undergraduate programs that integrate global awareness, communication skills and team building across the curriculum;
- Leadership and service to meet society's needs;
- Education and research partnerships with colleges, universities, and industries to graduate education and training that prepares students for interdisciplinary engineering research and advanced problem solving;
- Highly successful alumni who contribute to the profession in the global society.

Vision and Mission statements of the Department of Mechanical Engineering:

Vision Statement:

"The Mechanical Engineering Department strives immense success in the field of education, research and development by nurturing the budding minds of young engineers inventing sets of new designs and new products which may be envisaged as the modalities to bring about a green future for humanity"

Mission Statement:

1. Equipping the students with manifold technical knowledge to make them efficient and independent thinkers and designers in national and international arena.
2. Encouraging students and faculties to be creative and to develop analytical abilities and efficiency in applying theories into practice, to develop and disseminate new knowledge.

3. Pursuing collaborative work in research and development organizations, industrial enterprises, Research and academic institutions of national and international, to introduce new knowledge and methods in engineering teaching and research in order to orient young minds towards industrial development.

PROGRAM EDUCATIONAL OBJECTIVE

PEO 1: Graduates shall have knowledge and skills to succeed as Mechanical engineer's for their career development.

PEO 2: Graduates will explore in research.

PEO 3: Mechanical Graduates shall have the ability to design products with various interdisciplinary skills

PEO 4: Graduates will serve the society with their professional skills

PROGRAM OUTCOMES

- **A.** Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization for the solution of complex engineering problems.
- **B.** Problem Analysis: Identify, formulate, research, review the available literature and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural science and engineering sciences.
- **C.** Design and development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specific needs with appropriate considerations for public health safety and cultural, societal and environmental considerations.
- **D.** Conduct investigations of complex problems: Use research based knowledge and research methods including design of experiments, analysis and interpretation of data and synthesis of the information to provide valid conclusions.
- **E.** Modern tool usage: Create, select and apply appropriate techniques, resources and modern engineering and IT tools including predictions and modeling to complex engineering activities with an understanding of the limitations.
- **F.** The Engineer and society: Apply reasoning, informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practices.
- **G.** Environment and sustainability: Understand the impact of the professional engineering solutions in society and environmental context and demonstrate the knowledge of and need for sustainable development.
- **H.** Ethics: Apply ethical principles and commitment to professional ethics, responsibilities and norms of the engineering practice.
- **I.** Individual and team work: Function effectively as an individual and as a member or leader in diverse teams and in multi disciplinary settings.
- **J.** Communication: Communicate effectively on complex engineering activities with the engineering community and with the society at large, such as being able to comprehend, write effective reports, design documentation, make effective presentations, give and receive clear instructions.
- **K.** Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
- **L.** Life – long learning: Recognize the need and have the preparation, ability to engage in independent and life – long learning in the broadest context of technological change.

PROGRAMME SPECIFIC OUTCOMES:

PS01: Students acquire necessary technical skills in mechanical engineering that make them employable graduate.
PSO2: An ability to impart technological inputs towards development of society by becoming an entrepreneur.

COURSE OBJECTIVES:

1. To understand the basic principles of fluid mechanics.

2. To identify various types of flows.

3. To understand boundary layer concepts and flow through pipes.

4. To evaluate the performance of hydraulic turbines.

5. To understand the functioning and characteristic curves of pumps.

COURSE OUTCOMES:

ME 377.1 Identify the various parts of an IC Engine.

ME 377.2 Sketch the valve and port timing diagrams for IC Engine.

ME 377.3 Determine the performance of various types of IC Engine.

ME 377.4 Prepare the heat balance sheet for various types of IC Engines.

ME 377.5 Calculate the frictional power in various types of IC Engines.

ME 377.6 Analyze the performance of reciprocating air compressor.

INSTRUCTIONS TO THE STUDENTS

1. Every student should obtain a copy of the laboratory manual.
2. It is important that all students arrive at each session on time.
3. Dress code: Students must come to the laboratory wearing:
    - Trousers.
    - half-sleeve tops.
    - Leather shoes.
    - Half pants, loosely hanging garments and slippers are not allowed.
4. Students should come with thorough preparation for the experiment to be conducted.
5. Students will not be permitted to attend the laboratory unless they bring the practical record fully completed in all respects pertaining to the experiment conducted in the previous class.
6. Experiment should be started only after the staff-in-charge has checked the experimental setup.
7. All the calculations should be made in the observation book. Specimen calculations for one set of readings have to be shown in the practical record.
8. Wherever graphs are to be drawn, A-4 size graphs only should be used and the same should be firmly attached to the practical record.
9. Practical record and observation should be neatly maintained.
10. They should obtain the signature of the staff-in-charge in the observation book after completing each experiment.
11. Theory regarding each experiment should be written in the practical record before procedure in your own words.

LABORATORY SAFETY PRECAUTIONS

1. Laboratory uniform, shoes & safety glasses are compulsory in the lab.
2. Do not touch anything with which you are not completely familiar. Carelessness may not only break the valuable equipment in the lab but may also cause serious injury to you and others in the lab.
3. Please follow instructions precisely as instructed by your supervisor. Do not start the experiment unless your setup is verified & approved by your supervisor.
4. Do not leave the experiments unattended while in progress.
5. Do not crowd around the equipment's & run inside the laboratory.
6. During experiments material may fail and disperse, please wear safety glasses and maintain a safe distance from the experiment.
7. If any part of the equipment fails while being used, report it immediately to your supervisor. Never try to fix the problem yourself because you could further damage the equipment and harm yourself and others in the lab.
8. Keep the work area clear of all materials except those needed for your work and cleanup after your work.

LIST OF EXPERIMENTS:

1. Draw the valve and port timing diagrams for four and two stroke engines.
2. Evaluate the performance of 4-stroke Diesel engines.
3. Evaluate the performance of 2-stroke Petrol engines.
4. Evaluate the performance of 4-stroke Petrol engines.
5. Evaluation of frictional power by conducting Morse test on 4-stroke multi cylinder petrol engine.
6. Draw the heat balance sheet for 4-stroke Single cylinder Diesel engine.
7. Draw the heat balance sheet for 4-stroke multi cylinder petrol engine.
8. Calculate the performance of variable compression ration engines.
9. Performance test on reciprocating air compressor unit.
10. Study of Steam boilers.
11. Disassembly / assembly of engines

CONTENTS

History of IC engines

An **internal combustion engine** (**ICE** or **IC engine**) is a heat engine in which the combustion of a fuel occurs with an oxidizer (usually air) in a combustion chamber that is an integral part of the working fluid flow circuit. In an internal combustion engine, the expansion of the high-temperature and high-pressure gases produced by combustion applies direct force to some component of the engine. The force is applied typically to pistons, turbine blades, a rotor, or a nozzle. This force moves the component over a distance, transforming chemical energy into useful kinetic energy and is used to propel, move or power whatever the engine is attached to. This replaced the external combustion engine for applications where weight or size of the engine is important.

The first commercially successful internal combustion engine was created by Étienne Lenoir around 1860 and the first modern internal combustion engine was created in 1876 by **Nicolaus Otto**.

The term internal combustion engine usually refers to an engine in which combustion is intermittent, such as the more familiar four-stroke and two-stroke piston engines, along with variants, such as the six-stroke piston engine and the Wankel rotary engine. A second class of internal combustion engines use continuous combustion: gas turbines, jet engines and most rocket engines, each of which are internal combustion engines on the same principle as previously described. Firearms are also a form of internal combustion engine, though of a type so specialized that they are commonly treated as a separate category, along with weaponry such as mortars and anti-aircraft cannons.

In contrast, in external combustion engines, such as steam or Stirling engines, energy is delivered to a working fluid not consisting of, mixed with, or contaminated by combustion products. Working fluids for external combustion engines include air, hot water, pressurized water or even liquid sodium, heated in a boiler.

Latest engines

1.Hybrid Engine:

Quite simply, a hybrid combines at least one electric motor with a gasoline engine to move the car, and its system recaptures energy via regenerative braking. The result is less gasoline burned and, therefore, better fuel economy. Adding electric power can even boost performance in certain instances. Hybrid electric vehicles are powered by an internal combustion engine and an electric motor, which uses energy stored in batteries. A hybrid electric vehicle cannot be plugged in to charge the battery. Instead, the battery is charged through regenerative braking and by the internal combustion engine.

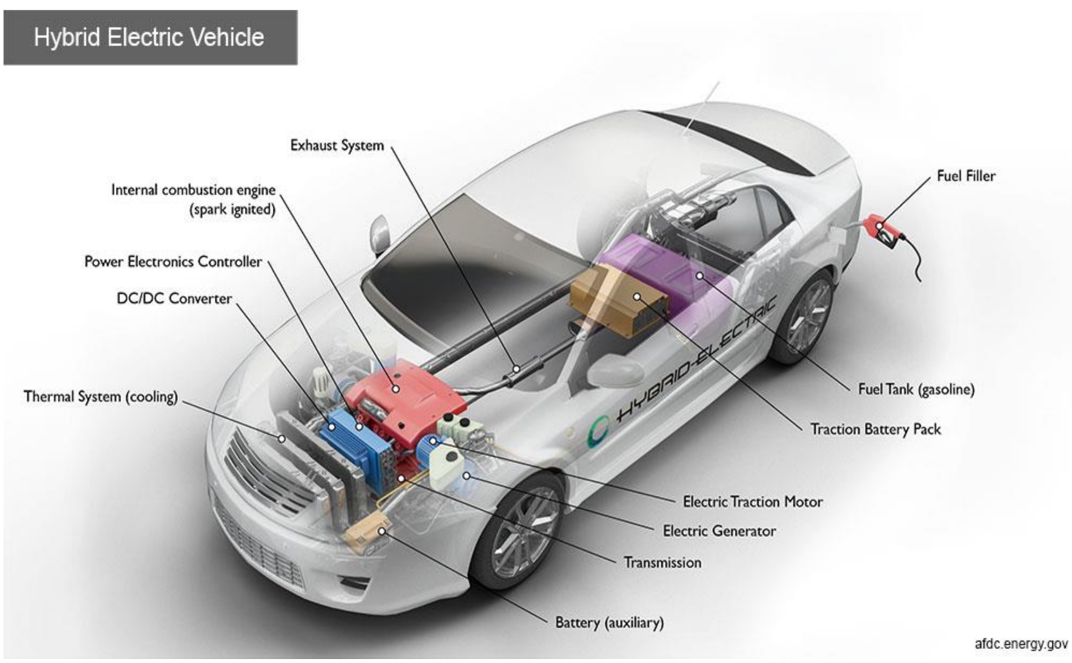
In addition to vehicles that use two or more different devices for propulsion, some also consider vehicles that use distinct energy sources or input types ("fuels") using the same engine to be hybrids, although to avoid confusion with hybrids as described above and to use correctly the terms, these are perhaps more correctly described as dual mode vehicles. Some electric trolleybuses can switch between an onboard diesel engine and overhead electrical power depending on conditions (see dual mode bus). In principle, this could be combined with a battery subsystem to create a true plug-in hybrid trolleybus, although as of 2006, no such design seems to have been announced.

Flexible-fuel vehicles can use a mixture of input fuels mixed in one tank — typically gasoline and ethanol, methanol, or biobutanol. Bi-fuel vehicle: Liquified petroleum gas and natural gas are very different from petroleum or diesel and cannot be used in the same tanks, so it would be challenging to build an (LPG or NG) flexible fuel system. Instead, vehicles are built with two, parallel, fuel systems feeding one engine. For example, some Chevrolet Silverado 2500 HDs can effortlessly switch between petroleum and natural gas, offering a range of over 1000 km (650 miles). While the duplicated tanks cost space in some applications, the increased range, decreased cost of fuel, and flexibility where LPG or CNG infrastructure is incomplete may be a significant incentive to purchase. While the US Natural gas infrastructure is partially incomplete, it is increasing and in 2013 had 2600 CNG stations in place. Rising gas prices may push consumers to purchase these vehicles. In 2013 when gas prices traded around US$1.1 per litre ($4.0/US gal), the price of gasoline was US$95.5 per megawatt-hour ($28.00 per million British thermal units), compared to natural gas's $13.6/MWh ($4.00 per million British thermal units). On a per unit of energy comparative basis, this makes natural gas much cheaper than gasoline.

Some vehicles have been modified to use another fuel source if it is available, such as cars modified to run on Autogas (LPG) and diesels modified to run on waste vegetable oil that has not been processed into biodiesel.

Two-wheeled and cycle-type vehicles

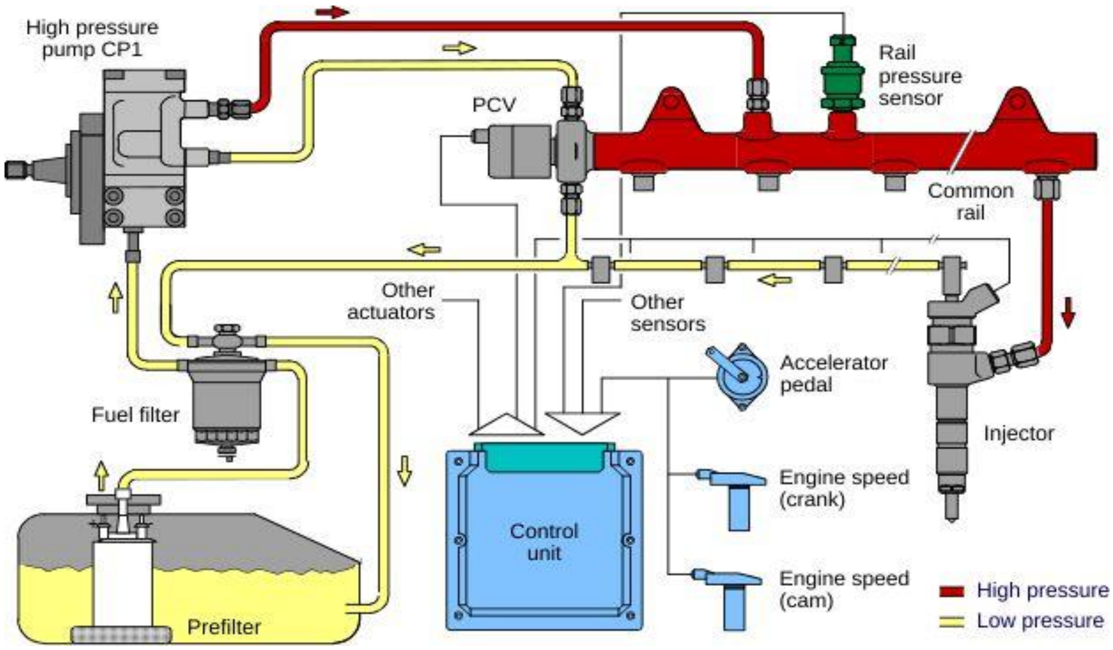
Mopeds, electric bicycles, and even electric kick scooters are a simple form of a hybrid, powered by an internal combustion engine or electric motor and the rider's muscles. Early prototype motorcycles in the late 19th century used the same principle. In a parallel hybrid bicycle human and motor torques are mechanically coupled at the pedal or one of the wheels, e.g. using a hub motor, a roller pressing onto a tire, or a connection to a wheel using a transmission element. Most motorized bicycles, mopeds are of this type. In a series hybrid bicycle (SHB) (a kind of chainless bicycle) the user pedals a generator, charging a battery or feeding the motor, which delivers all of the torque required. They are commercially available, being simple in theory and manufacturing. The first published prototype of an SHB is by Augustus Kinzel (US Patent 3'884'317) in 1975. In 1994 Bernie MacDonalds conceived the Electrolyte. SHB with power electronics allowing regenerative braking and pedaling while stationary.



VOLVO XC 90

2. Gasoline Direct-Injection System

Gasoline direct injection (GDI), also known as petrol direct injection (PDI),is a mixture formation system for internal combustion engines that run on gasoline (petrol), where fuel is injected into the combustion chamber. This is distinct from manifold fuel injection systems, which inject fuel into the intake manifold.The first GDI engine to reach production was introduced in 1925 for a low-compression truck engine. Several German cars used a Bosch mechanical GDI system in the 1950s, however usage of the technology remained rare until an electronic GDI system was introduced in 1996 by Mitsubishi for mass-produced cars. GDI has seen rapid adoption by the automotive industry in recent years, increasing in the United States from 2.3% of production for model year 2008 vehicles to approximately 50% for model year 2016.



Nissan to end most development of new gasoline engines

Nissan's Fairlady Z sports car

3.Hydrogen cars

A hydrogen vehicle is a type of alternative fuel vehicle that uses hydrogen fuel for motive power. Hydrogen vehicles include hydrogen-fueled space rockets, as well as automobiles and other transportation vehicles. Power is generated by converting the chemical energy of hydrogen to mechanical energy, either by reacting hydrogen with oxygen in a fuel cell to power electric motors or, less commonly, by burning hydrogen in an internal combustion engine. The technical problems with the storage of hydrogen are considered solved today. Methods such as pressurized and liquid hydrogen storage and storage in metal hydrides are in commercial use. In addition, there are other methods such as storage in nanotubes or as a chemical compound (N -Ethylcarbazol), which are still in the development stage or in basic research.

Hyundai Nexo (2018)

Bike Engines

1.Variable valve timing Engine

In internal combustion engines, **variable valve timing** (**VVT**) is the process of altering the timing of a valve lift event, and is often used to improve performance, fuel economy or emissions. It is increasingly being used in combination with variable valve lift systems. There are many ways in which this can be achieved, ranging from mechanical devices to electro-hydraulic and camless systems. Increasingly strict emissions regulations are causing many automotive manufacturers to use VVT systems.

Two-stroke engines use a power valve system to get similar results to VVT.

The valves within an internal combustion engine are used to control the flow of the intake and exhaust gases into and out of the combustion chamber. The timing, duration and lift of these valve events has a significant impact on engine performance. Without variable valve timing or variable valve lift, the valve timing is the same for all engine speeds and conditions, therefore compromises are necessary. An engine equipped with a variable valve timing actuation system is freed from this constraint, allowing performance to be improved over the engine operating range. Piston engines normally use valves which are driven by camshafts. The cams open (*lift*) the valves for a certain amount of time (*duration*) during each intake and exhaust cycle. The *timing* of the valve opening and closing, relative to the position of the crankshaft, is important. The camshaft is driven by the crankshaft through timing belts, gears or chains. An engine requires large amounts of air when operating at high speeds. However, the intake valves may close before enough air has entered each combustion chamber, reducing performance. On the other hand, if the camshaft keeps the valves open for longer periods of time, as with a racing cam, problems start to occur at the lower engine speeds. Opening the intake valve while the exhaust valve is still open may cause unburnt fuel to exit the engine, leading to lower engine performance and increased emissions. According to engineer David Vizard's book "Building Horsepower", when both intake & exhaust are open simultaneously, the much-higher-pressure exhaust pushes the intake-charge back, out from the cylinder, polluting the intake-manifold with exhaust, in worst cases.

Cam phasing versus variable duration

The simplest form of VVT is *cam-phasing*, whereby the phase angle of the camshaft is rotated forwards or backwards relative to the crankshaft. Thus the valves open and close earlier or later; however, the camshaft lift and duration cannot be altered solely with a cam-phasing system.

Late intake valve closing (LIVC) The first variation of continuous variable valve timing involves holding the intake valve open slightly longer than a traditional engine. This results in the piston actually pushing air out of the cylinder and back into the intake manifold during the compression stroke. The air which is expelled fills the manifold with higher pressure, and on subsequent intake strokes the air which is taken in is at a higher pressure. Late intake valve closing has been shown to reduce pumping losses by 40% during partial load conditions, and to decrease nitric oxide (NOx) emissions by 24%. Peak engine torque showed only a 1% decline, and hydrocarbon emissions were unchanged.

Early intake valve closing (EIVC) Another way to decrease the pumping losses associated with low engine speed, high vacuum conditions is by closing the intake valve earlier than normal. This involves closing the intake valve midway through the intake stroke. Air/fuel demands are so low at low-load conditions and the work required to fill the cylinder is relatively high, so Early intake valve closing greatly reduces pumping losses.[2] Studies have shown early intake valve closing reduces pumping losses by 40%, and increases fuel economy by 7%. It also reduced nitric oxide emissions by 24% at partial load conditions. A possible downside to early intake valve closing is that it significantly lowers the temperature of the combustion chamber, which can increase hydrocarbon emissions.

Early intake valve opening Early intake valve opening is another variation that has significant potential to reduce emissions. In a traditional engine, a process called valve overlap is used to aid in controlling the cylinder temperature. By opening the intake valve early, some of the inert/combusted exhaust gas will back flow out of the cylinder, via the intake valve, where it cools momentarily in the intake manifold. This inert gas then fills the cylinder in the subsequent intake stroke, which aids in controlling the temperature of the cylinder and nitric oxide emissions. It also improves volumetric efficiency, because there is less exhaust gas to be expelled on the exhaust stroke.

Early/late exhaust valve closing Early and late exhaust valve closing timing can be manipulated to reduce emissions. Traditionally, the exhaust valve opens, and exhaust gas is pushed out of the cylinder and into the exhaust manifold by the piston as it travels upward. By manipulating the timing of the exhaust valve, engineers can control how much exhaust gas is left in the cylinder. By holding the exhaust valve open slightly longer, the cylinder is emptied more and ready to be filled with a bigger air/fuel charge on the intake stroke. By closing the valve slightly early, more exhaust gas remains in the cylinder which increases fuel efficiency. This allows for more efficient operation under all conditions.

Variable valve timing has been applied to motorcycle engines but was considered a non-useful "technological showpiece" as late as 2004 due to the system's weight penalty. Since then, motorcycles including VVT have included the Kawasaki 1400GTR/Concours 14 (2007), the Ducati Multistrada 1200 (2015),the BMW R1250GS (2019) and the Yamaha YZF-R15 V3.0 (2017), the Suzuki GSX-R1000R 2017 L7.

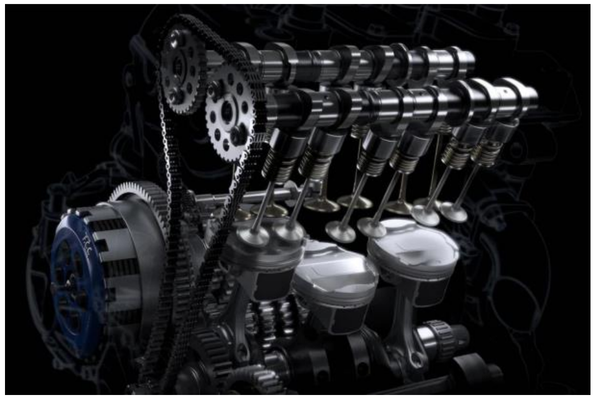
Kawasaki 1400GTR

BMW R1250GS

2. Parallel-twin Engine:

3. Inline-triple Engine:

An inline-three mill uses three parallel pistons housed within the same cylinder block. The main advantage of this type of configuration is that it offers somewhat of a middle ground between a V-twin and an inline-four engine. It's a lot smoother compared to a V-twin and is narrower than an inline-four, making it easier to shoe into the compact dimensions of a sportbike. This configuration does have the tendency to rock end-to-end slightly as cylinders one and three are near the opposite ends of their strokes. Also, unlike an inline-four mill, the vibes cannot be cancelled out thanks to the odd number of cylinders. The Triumph Street Triple and the MV Agusta Brutale 800 are two such examples.



MV Agusta Brutale

MV Agusta Brutale 800 Highlights

Official sources have confirmed small capacity MV Agusta motorcycles will reach our shores by the later part of 2020 or early 2021. Kinetic-owned Motoroyale had launched the MV Agusta Brutale 800 RR at Rs 18.99 lakh (ex-showroom Delhi), a premium of Rs 3.4 lakh over the standard model. The 'RR' badge here stands for more horsepower -- that's to say around 30PS more than the standard model. Other than the power and price bump, the 800 RR is identical to the standard variant. On the styling front, the standard Brutale 800 gets a sleek headlamp with LED DRLs and a larger, more legible instrument console. Its 16.5-litre fuel tank is sharper and gets deeper knee recesses that should make it more comfortable for taller riders. The tail section is new and sits on a completely new swingarm. The first thing that will grab your attention when you view it from the side is the gaping hole between the seat and the frame - a design concept until now seen only on concept bikes. The tailpiece and number plate holder are now incorporated into the tyre hugger for a cleaner rear section. The Brutale 800 RR gets a 796cc inline three-cylinder motor which makes 140PS (up by 30PS from the Std model) at 11,500rpm. Torque has also been improved and now stands at 87Nm, which is now made at 10,100rpm instead of 83Nm at 7600rpm on its standard Brutale. Power output on the standard Brutale 800 is measured at 110PS at 11,500rpm. Both the bikes come mated to a 6-speed transmission assisted by a slipper clutch for clutchless up and downshifts. Weight is up due to a larger exhaust for Euro 4 compliance and now stands at 175kg (dry). MV Agusta claims a top speed of 237kmph for the Brutale 800 and 244kmph for the 800 RR. Its 10-spoke alloy wheels are shod with 120/70 x R17 and 180/55 x R17 Pirelli twin compound Diablo Rosso II tubeless tyres. Suspension duties are handled by fully adjustable 43mm upside-down Marzocchi forks up front and semi-adjustable Sachs monoshock at the rear with rebound and compression damping as well as spring preload adjustment. Braking duties are handled by twin 320mm discs with Brembo 4-piston radial calipers at the front and a 220mm disc brake clamped with a two-piston Brembo caliper at the rear. The bike gets dual-channel ABS with rear lift mitigation. Electronics include an 8-stage traction control and four riding modes. The Brutale 800 RR will compete with the Kawasaki Z900, Yamaha MT-09, Ducati Monster 1200 and Triumph Street Triple 765. While the standard Brutale 800 goes up against the Yamaha MT-09, Ducati Monster 821 and the upcoming KTM 790 Duke.

MV Agusta Brutale 800

4.Inline-four

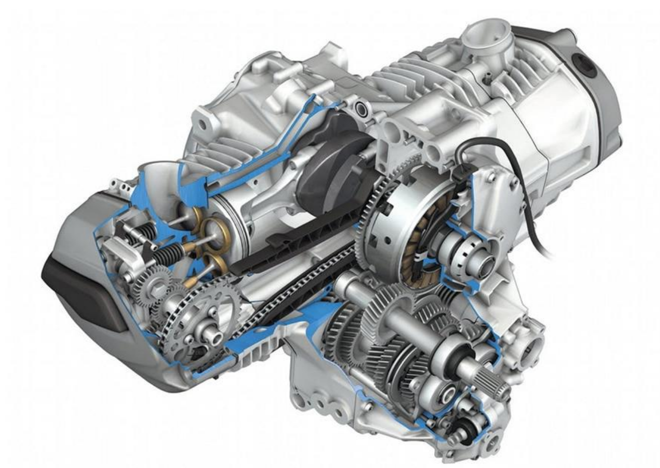
When you have four parallel cylinders packaged in a single cylinder block, you get an inline-four engine. With an even number of pistons, the movement of the pistons can be balanced out really well, making them one of the smoothest running engines on a bike. This smoothness allows them to be revved very high without risking damage to engine components through vibrations, and hence these have some of the best power-to-weight characteristics of any motorcycle engine configuration, although that does make power delivery quite peaky. No wonder then that this is the go-to configuration for almost all 600-1000cc sportbikes. The Benelli 600i, Kawasaki Z900 and the Honda CBR1000RR are some examples.

Benelli 2021 TNT 600 Highlights

Benelli will expand its mid-capacity motorcycle lineup later this year with the launch of the 2021 TNT 600. The new bike is expected to feature some cosmetic tweaks, alongside a cleaner running engine. The previous bike made around 85PS of power and 56.4Nm of torque. We expect similar numbers from the 2021 model as well. We recently covered what the new bike could look like. You can read the story here. Sources suggest that Benelli will launch the BS6 TNT 600i in India by the end of this year. Following this, the brand could even introduce other larger capacity motorcycles like the Benelli 600RR, TRK 800 and Leoncino 800. The facelifted version of the Benelli TNT 600i is likely to be launched soon in China. New pictures reveal a full-colour instrument cluster and keyless ignition along with illuminated switchgear. Check out more details about the bike here.The Italian bikemaker is expected to launch the next generation TNT 600i here by late 2021. It is expected to carry forward the same trellis frame, upside-down forks and side-mounted monoshock. Braking too is expected to be the dual front disc and single rear disc setup with dual-channel ABS. The 600cc in-line four-cylinder motor is expected to be Euro 5 / BS6 compliant and produce around 85PS and 54.6Nm. The upcoming next-generation Benelli TNT 600i will compete with the Kawasaki Z650 BS6, CFMoto 650NK, Royal Enfield Interceptor 650 BS6 and Honda CBR650R.

Benelli 2021 TNT 600

5.Flat-twin Engine:



The horizontal or “flat” layout of the engine is commonly known as a boxer engine. Here, the two pistons are laid out on opposite sides of the crankshaft. A flat-twin’s firing order is the same as a 360-degree parallel twin; however, in this case, the pistons are moving away from each other rather than in sync. The complicated setup is expensive to manufacture, maintain and fix. Also, since their crankshaft is in the motorcycle’s longitudinal axis, these bikes are known to have a ‘torque reaction’, where the bike is pushed in the opposite direction of the crank’s rotation when the throttle is opened. But the advantages of this layout are that it keeps the bike’s centre of gravity low and allows for better air-cooling of the cylinders as they are exposed to more air on each side of the bike when in motion. The BMW R nineT and GS use boxer engines.

BMW R 1200GS:

The BMW R 1200GS proves to be completely fuel efficient showing an efficiency of 16 kmpl. The bike is loaded with air cooling technology and an electric start. The fuel tank capacity of BMW R 1200GS is 20 litres with a reserve of 4 Ltr and the type of fuel to be used is petrol. The bike offers good mileage on roads.The all new BMW R 1200GS is equipped with an engine capacity of 1170 cc displacement providing good mileage with better performance to its users. The 4 Stroke engine of the BMW R 1200GS is very powerful in generating zipper acceleration and pick up without any sort of vibration and noises even at higher speed.

The dynamic BMW R 1200GS is packed with flat Twin cylinder of 1170 cc displacement with air/oil cooled engine. The engine of the new BMW R 1200GS is bestowed with advanced technologies to emboss the performance of the bike. The engine has been furnished with 101 mm Cylinder Bore and 73 mm Stoke. The 6 Speed Transmission present in the bike certifies smoother changing of gears as and when required. The engine offers a maximum power of 81 kW (110 hp) ar 7,750 rpm and a beating torque of 120 Nm at 6,000 rpm.

BMW R 1200 GS

6.V-4 Engine:

A V4 engine is basically two V-twins stuck together. It has some of the smoothness of an inline-four mill and the raw bottom-end torque delivery of a V-twin. All this while sounding like a raging bull. It's also more compact than a transverse inline-four, which makes for a snug fit inside the motorcycle frame. Although, having two sets of cylinders at opposite ends means manufacturing two intake and exhaust systems, cylinder heads etc. which makes a V4 engine more expensive to produce than an inline-four motor. The 2019 Aprilia RSV4 1100 Factory or the Ducati Panigale V4 should ring a bell.

OBJECTIVES OF THERMAL ENGINEERING LABORATORY

The objective of the thermal engineering laboratory is to introduce the student the fundamental theories and the industrial applications of thermodynamics, Thermal engineering-1and fluid mechanics. This laboratory supports the courses for the undergraduate and graduate studies. Moreover, this laboratory also supports the advanced research in the area of thermal engineering, heat transfer, and fluid mechanics.

OUT COMES OF THERMAL ENGINEERING LABORATORY

1	Able to apply the basic principles of thermodynamics, Zeroth law, First law and Second law.
2	Will be Analyze the working of petrol engine
3	Will be Analyze the working of diesel engine
4	Will be analyze the working of various boilers
5	Will be analyze the working of various compressors

EXPERIMENT-1

1(a) VALVE TIMING AND PORT TIMING DIAGRAM OF ENGINES

OBJECTIVE: To Find out The Valve Timing And Port Timing Diagram Of An Engine

OUT COME: Will be analyze how to draw valve and port timing diagram.

VALVE TIMING DIAGRAM
AIM:

The experiment is conducted to

- Determine the actual valve timing for a 4-stroke diesel engine and hence draw the diagram.

PROCEDURE:

1. Keep the decompression lever in vertical position.
2. Bring the TDC mark to the pointer level closed.
3. Rotate the flywheel till the inlet valves moves down i.e., opened.
4. Draw a line on the flywheel in front of the pointer and take the reading.
5. Continue to rotate the flywheel till the inlet valve goes down and comes to horizontal position and take reading.
6. continue to rotate the flywheel till the outlet valve opens, take the reading.
7. Continue to rotate the flywheel till the exhaust valve gets closed and take the reading.

THEORY:

1). Four – stroke cycle diesel engine:

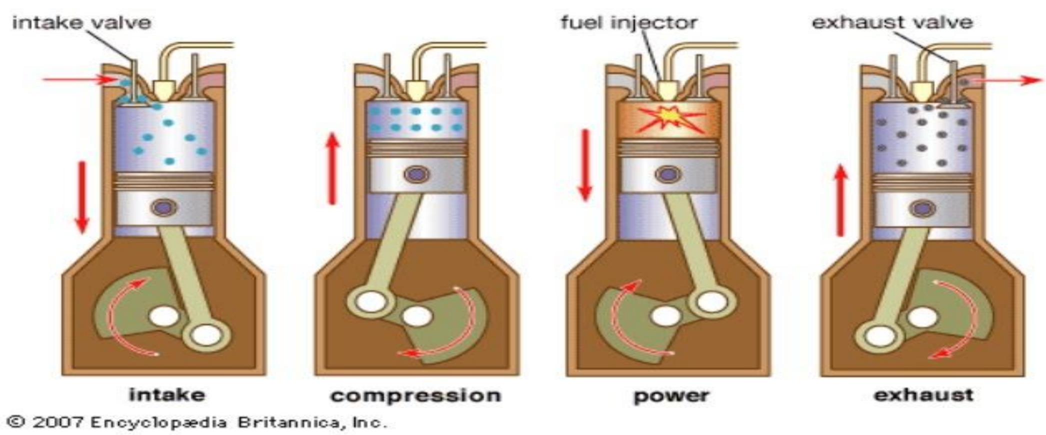
It is also known as *compression ignition engine* because the ignition takes place due to the heat produced in the engine cylinder at the end of compression stroke. The four strokes of a diesel engine sucking pure air are described below:

1. ***Suction or charging stroke:*** In this stroke, the inlet valve opens and pure air is sucked into the cylinder as the piston moves down wards from the top dead center (TDC). It continues till the piston reaches its bottom dead center (BDC) as shown in the Figure 1 (a).

2. ***Compression stroke:*** In this stroke, both valves are closed on the air is compressed as the piston moves upwards from BDC to TDC. As a result compression, pressure and temperature of the air increases considerably (the actual value depends upon the compression ratio). This completes one revolution of the crank shaft. The compression stroke is shown in Figure 1 (b).

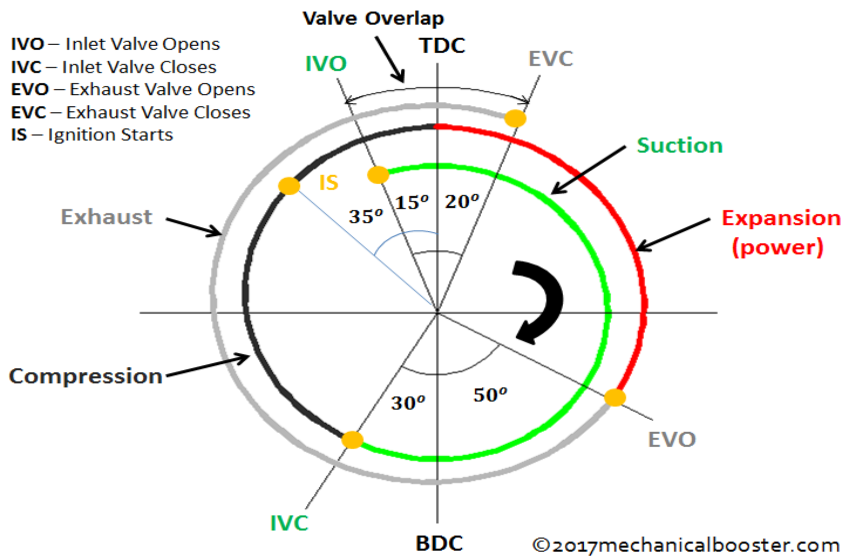
3. ***Expansion or working stroke:*** Shortly before the piston reaches the TDC (during the compression stroke), fuel oil is injected in the form of very fine spray into the engine cylinder, through the nozzle, known as fuel injection valve. At this moment, temperature of the compressed air is sufficiently high to ignite the fuel. It suddenly increases the pressure and temperature of the products of combustion. The fuel oil is continuously injected for a fraction of the revolution. The fuel oil is assumed to be burnt at constant pressure. Due to increased pressure, the piston is pushed down with a great force. The hot burnt gases expand due to high speed of the piston. During this expansion, some of the heat energy is transformed into mechanical work. It may be noted that during the working stroke, both the valves are closed and the (Piston moves from T.D.C to B.D.C (as shown in figure 1 (c))

4. ***Exhaust stroke:*** In this stroke, the exhaust valve is open as the piston moves from BDC to TDC. This movement of the piston pushes out the products of combustion from the engine cylinder through the exhaust valve into the atmosphere. This completes the cycle and the engine cylinder is ready to suck the fresh air again. (as shown in Figure 1 (d)).



2) Valve timing diagram for a four-stroke cycle diesel engine

In the valve timing diagram as shown in Figure-2, we see that the inlet valve opens before the piston reaches TDC; or in other words while the piston is still moving up before the beginning of the suction stroke. Now the piston reaches the TDC and the suction stroke starts. The piston reaches the BDC and then starts moving up. The inlet valve closes, when the crank has moved a little beyond the BDC. This is done as the incoming air continues to flow into the cylinder although the piston is moving upwards from BDC. Now the air is compressed with both valves closed. Fuel valve opens a little before the piston reaches the TDC. Now the fuel is injected in the form of very fine spray, into the engine cylinder, which gets ignited due to high temperature of the compressed air. The fuel valve closes after the piston has come down a little from the TDC. This is done as the required quantity of fuel is injected into the engine cylinder. The burnt gases (under high pressure and temperature) push the piston downwards, and the expansion or working stroke takes place. Now the exhaust valve opens before the piston again reaches BDC and the burnt gases start leaving the engine cylinder. Now the piston reaches BDC and then starts moving up thus performing the exhaust stroke. The inlet valve opens before the piston reaches TDC to start suction stroke. This is done as the fresh air helps in pushing out the burnt gases. Now the piston again reaches TDC, and the suction starts. The exhaust valve closes when the crank has moved a little beyond the TDC. This is done as the burnt gases continue to leave the engine cylinder although the piston is moving downwards.



Valve Timing Diagram of 4 Stroke Petrol Engine

OBSERVATIONS

Sl. No.	Valve Position	Arc Length, S		Angle 'θ' in degrees
		cm	mm	
1	TDC – Inlet Valve open	2	20	5.85
2	BDC – Inlet Valve Close	69	690	201.95
3	TDC – Exhaust Valve Open	179	1790	523.90
4	BDC – Exhaust Valve Close	248	2480	725.85

CALCULATIONS

1. Diameter of the flywheel, D

D = Circumference of the flywheel

π

2. Angle 'θ' in degrees,

$$\theta = \frac{S \times 360}{D \times \pi}$$

Where,

S = Arc length, mm

SAMPLE CALCULATION:

1. Diameter of the flywheel, D

$$D = \frac{123X10}{\pi}$$

D = 391.52 mm

2. Angle 'θ' in degrees,

$$\theta = \frac{S \times 360}{D \times \pi}$$

$$\theta 1 = \frac{20 \times 360}{391.52 \times \pi}$$

$$= 5.85$$

$$\theta 2 = \frac{690 \times 360}{391.52 \times \pi}$$

$$= 201.95$$

$$\theta 3 = \frac{1790 \times 360}{391.52 \times \pi}$$

$$= 523.90$$

$$\theta 4 = \frac{2480 \times 360}{391.52 \times \pi}$$

$$= 725.85$$

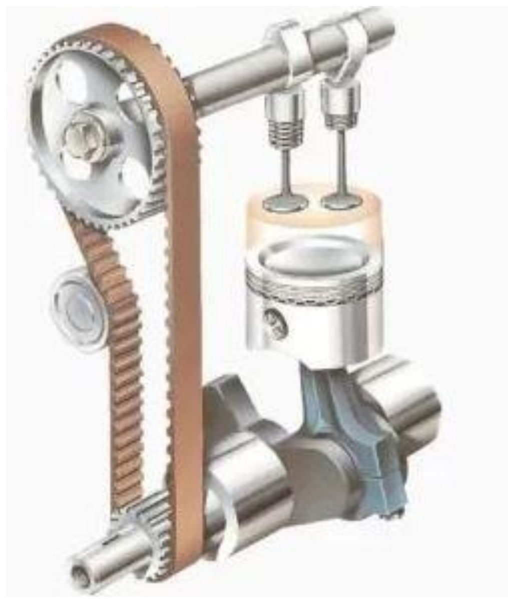
RESULTS:

Draw the Valve Timing diagram

NOTE:

A **valve timing diagram** is a graphical representation of the opening and closing of the intake and exhaust valve of the engine, The opening and closing of the valves of the engine depend upon the movement of piston from TDC to BDC, This relation between piston and valves is controlled by setting a graphical representation between these two, which is known as valve timing diagram

Applications: 4-Stroke engines



Valve timing diagram

1(b) PORT TIMING DIAGRAM

AIM:

The experiment is conducted to

- Determine the actual PORT timing for a 2-stroke Petrol engine and hence draw the diagram.

THEORY:

Two-stroke cycle petrol engine

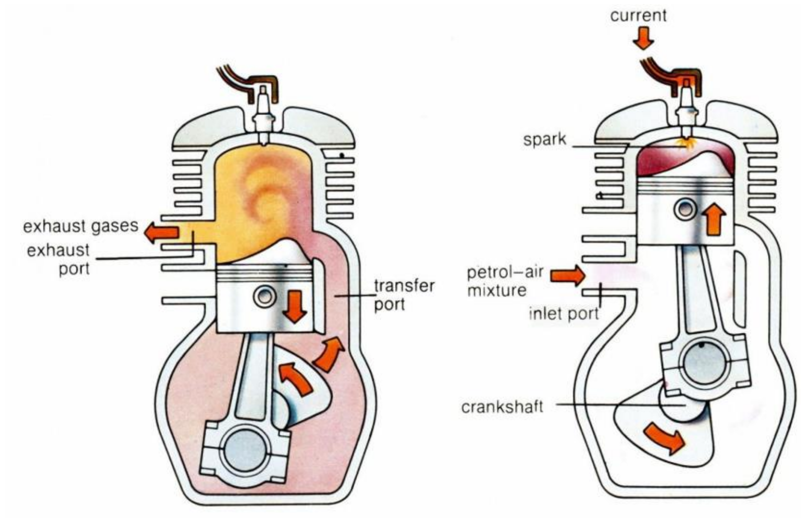
A Two-Stroke cycle petrol engine was devised by Duglad Clerk in 1880. In this cycle, the suction, compression, expansion and exhaust takes place during two strokes of the piston. It means that there is one working stroke after every revolution of the crank shaft. A two stroke engine has ports instead of valve. All the four stages of a two petrol engine are described below:

1) **Suction stage:** In this stage, the piston, while going down towards BDC, uncovers both the transfer port and the exhaust port. The fresh fuel-air mixture flows into the engine cylinder from the crank case, as shown in the Figure-3(a).

2) **Compression stage:** In this stage, the piston, while moving up, first covers the transfer port and then exhaust port. After that the fuel is compressed as the piston moves upwards as shown in the Figure-3(b). In this stage, the inlet port opens and fresh fuel air mixture enters into the crank case.

3) **Expansion stage:** Shortly before this piston reaches the TDC (during compression stroke), the charge is ignited with the help of a spark plug. It suddenly increases the pressure temperature of the products of combustion. But the volume practically remains constant. Due to rise in the pressure, the piston is pushed downwards with a great force a shown in Figure-3(C). The hot burnt gases expand due to high speed of the piston. During the expansion, some of the heat energy produced is transformed into mechanical work.

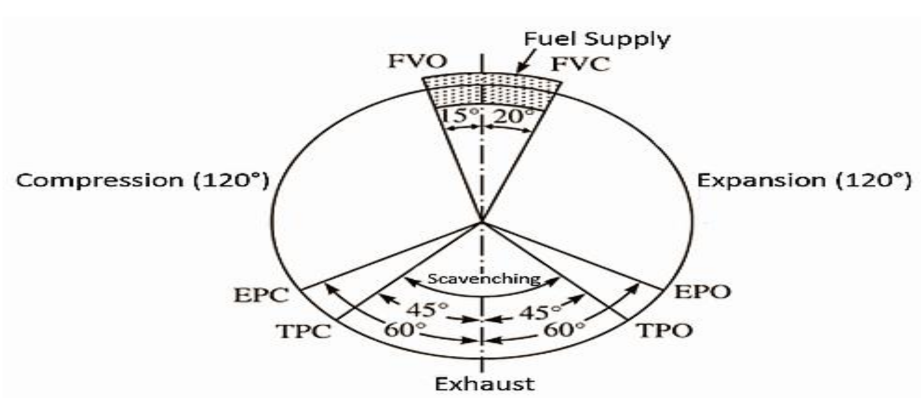
4) **Exhaust stage:** In this stage, the exhaust port is opened as the piston moves downwards. The products of combustion, from the engine cylinder are exhausted through the exhaust port into the atmosphere, as shown in the Figure-3(d). This completes the cycle and the engine cylinder is ready to suck the charge again.



Working of stroke engines

Port timing diagram for a two-stroke cycle petrol engine:

In the Port timing diagram, as shown in the Figure-4, we see that the expansion of the charge (after ignition) starts as the piston moves from TDC towards BDC. First of all, the exhaust port opens before the piston reaches BDC and the burnt gases start leaving the cylinder. After a small fraction of the crank revolution, the transfer port also opens and the fresh fuel-air mixture enters into the engine cylinder. This is done as the fresh incoming charge helps in pushing out the burnt gases. Now the piston reaches BDC, and then starts moving upwards. As the crank moves a little beyond BDC, first the transfer port closes and then the exhaust port also closes. This is done to suck fresh charge through the transfer port and to exhaust the burnt gases through the exhaust port simultaneously. Now the charge is compressed with both ports closed, and then ignited with the help of a spark plug before the end of compression stroke. This is done as the charge requires some time to ignite. By the time the piston reaches TDC, the burnt gases (under high pressure and temperature) push the piston downwards with full force and expansion of the burnt gases takes place. It may be noted that the exhaust and transfer ports open and close at equal angles on either side of the BDC position.



II.PROCEDURE:

1. Bring the Piston to Top and start as if from the spark.
2. Rotate the flywheel till the Exhaust port opens and note the reading.
3. Continue the same way and note the reading for the Transfer port.
4. Continue to rotate the flywheel till the Piston moves from BDC to TDC and note down the closing of Transfer and Exhaust port readings.

III. OBSERVATIONS:

Sl. No.	Valve Position	Arc Length, S		Angle 'θ' in degrees
		Cm	mm	
1	Transfer Port open	-	-	140
2	Transfer Port Close	-	-	240
3	Exhaust Port Open	-	-	130
4	Exhaust Port Close	-	-	250

IV. CALCULATIONS:

1. Diameter of the flywheel, D

$$D = \frac{\text{Circumference of the flywheel}}{\pi}$$

2. Angle 'θ' in degrees,

$$\theta = \frac{S \times 360}{D \times \pi}$$

Where,

S = Arc length, mm

V. RESULTS:

Draw the Port Timing diagram

Applications; -

1) Knowledge of IC engines
2) Proper control over the valve/port timing diagram for achieving better performance of engine.

3) Comparison of actual valve/port timing diagram with theoretical valve/port timing diagram
4) The settings are determined on the prototype of the actual engine and actual engine valve/port timings are modified accordingly.

VIVA QUESTIONS

1.Explain The Working Principle Of Diesel Engine.

2. Explain The Working Principle Of Petrol Engine.

3.What Is The Function Of Fly Wheel.

4.What Is Tdc & Bdc.

5.Define Compression Ratio.

6.What Is The Difference Between Valve And Port

7. Draw The P-V Diagram Of Otto Cycle

8. Draw The P-V Diagram Of Diesel Cycle

9. . Draw The P-V Diagram Of Dual Cycle

10. Define Mep.

11. What Is Thermodynamic System?

12.What Do You Mean By Property Of A System?

13.Differentiate Between Open System, Closed System And Isolated System?

14.What Are The Laws Of Thermodynamics(Zeroth Law, First Law, Second Law)?

15. Explain The Working Principle Of Single Cylinder Diesel Engine.

16.Define Cut-Off Ratio

17.What Is The Function Of Calorimeter

18.Define Mechanical Efficiency

19.Define Brake Thermal Efficiency

20.Define Volumetric Efficiency.

EXPERIMENT-2

SINGLE CYLINDER 4 - STROKE HIGH SPEED DIESEL ENGINE TEST RIG

OBJECTIVE: To Find out The performance characteristics of diesel engine

OUT COME : Will be analyze how to calculate performance characteristics of diesel engine

INTRODUCTION

A machine, which uses heat energy obtained from combustion of fuel and converts it into mechanical energy, is known as a Heat Engine. They are classified as External and Internal Combustion Engine. In an External Combustion Engine, combustion takes place outside the cylinder and the heat generated from the combustion of the fuel is transferred to the working fluid which is then expanded to develop the power. An Internal Combustion Engine is one where combustion of the fuel takes place inside the cylinder and converts heat energy into mechanical energy. IC engines may be classified based on the working cycle, thermodynamic cycle, speed, fuel, cooling, method of ignition, mounting of engine cylinder and application.

Diesel Engine is an internal combustion engine, which uses heavy oil or diesel oil as a fuel and operates on two or four stroke. In a 4-stroke Diesel engine, the working cycle takes place in two revolutions of the crankshaft or 4 strokes of the piston. In this engine, pure air is sucked to the engine and the fuel is injected with the combustion taking place at the end of the compression stroke. The power developed and the performance of the engine depends on the condition of operation. So it is necessary to test an engine for different conditions based on the requirement.

DESCRIPTION OF THE APPARATUS:

The test rig is built for loading mentioned below:

a. Mechanical Loading (Water cooled)

1. The equipment consists of a Brand new **KIRLOSKAR** make AV1 model Diesel Engine (Crank started) of **5hp (3.7kW)** capacity and is Water cooled. The Engine is coupled to a Rope Brake Drum Dynamometer for Loading purposes. Coupling is done by an extension shaft in a separate bearing house. The dynamometer is connected to the spring load assembly for varying the load.
2. Thermocouples are provided at appropriate positions and are read by a digital temperature indicator with channel selector to select the position.
3. Rota meters of range 15LPM & 10LPM are used for direct measurement of water flow rate to the engine and calorimeter respectively.
4. Engine Speed and the load applied at various conditions is determined by a Digital RPM Indicator and spring balance reading.
5. A separate air box with orifice assembly is provided for regularizing and measuring the flow rate of air. The pressure difference at the orifice is measured by means of an ACRYLIC Manometer.
6. A volumetric flask with a fuel distributor is provided for measurement and directing the fuel to the engine respectively.
7. The testing arrangement is mounted on an aesthetically designed self sustained sturdy frame made of MS channels with anti vibration mounts.
8. The test rig comes with a separate control panel made of NOVAPAN board that houses all the indicators, accessories and necessary instrumentations at appropriate positions.

EXPERIMENTATION:

AIM:

The experiment is conducted to

a. To study and understand the performance characteristics of the engine.

b. To draw Performance curves and compare with standards.

PROCEDURE:

1. Give the necessary electrical connections to the panel.
2. Check the lubricating oil level in the engine.
3. Check the fuel level in the tank.
4. Allow the water to flow to the engine and the calorimeter and adjust the flowrate to 6lpm & 3lpm respectively.
5. Release the load if any on the dynamometer.
6. Open the three-way cock so that fuel flows to the engine.
7. Start the engine by cranking.
8. Allow to attain the steady state.
9. Load the engine by slowly tightening the yoke rod handle of the Rope brake drum.
10. Note the following readings for particular condition,
    a. Engine Speed
    b. Time taken for ____cc of diesel consumption
    c. Rotameter reading.
    d. Manometer readings, in cms of water &
    e. Temperatures at different locations.
11. Repeat the experiment for different loads and note down the above readings.
12. After the completion release the load and then switch of the engine.
13. Allow the water to flow for few minutes and then turn it off.

OBSERVATIONS:

Sl. No.	Speed, rpm	Load Applied			Manometer Reading			Time for 10cc of fuel collected, t sec
		F1	F2	F= (F1~ F2)	h1 mm	h2 mm	hw = (h1+h2) mm	
1	1588	15	0	15	1	2.5	3.5	64

CALCULATIONS:

1. **Mass of fuel consumed, mf**

$$mf = \frac{Xcc \times \text{Specific gravity of the fuel}}{1000 \times t} \text{ kg/sec}$$

Where,

SG of Diesel is = 0.827

Xcc is the volume of fuel consumed = 10ml

t is time taken in seconds

2. **Heat Input, HI**

HI = mf x Calorific Value of Fuel kW

Where,

Calorific Value of Diesel = 44631.96 KJ/Kg

3. **Output or Brake Power, BP**

$$\text{Engine output BP} = 2\Pi \frac{NT}{60000} \text{ kW}$$

Where,

N is speed in rpm

T = F x r x 9.81 N-m

r = 0.15m

4. **Specific Fuel Consumption, SFC**

$$SFC = \frac{mf \times 3600}{BP} \text{ kg/kW – hr}$$

5. **Brake Thermal Efficiency, ηbth%**

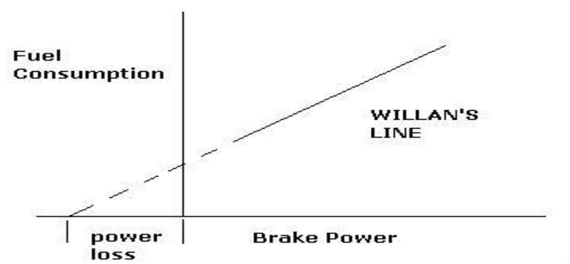
$$\eta bth\% = \frac{3600 \times 100}{SFC \times CV}$$

6. Mechanical Efficiency, ηmech%

$$\eta_{mech}\% = \frac{BP}{IP} \times 100$$

Determine the IP = Indicated Power, using WILLAN'S LINE method and the procedure is as below:

- Draw the Graph of Fuel consumption Vs Brake power
- Extend the line obtained till it cuts the Brake power axis
- The point where it cuts the brake power axis till the zero point will give the Power losses (Friction Power loss)
- With this the IP can be found using the relation: IP = BP + FP



7. Calculation of head of air, Ha

$$Ha = hw \frac{\rho water}{\rho air}$$

Where,

ρwater = 1000 Kg/m□

ρair = 1.2 Kg/m□ @ R.T.P

hw is the head in water column in 'm' of water

8. Volumetric efficiency, ηvol%

$$\eta_{vol}\% = \frac{Qa}{Q_{th}} \times 100$$

where,

Qa = Actual volume of air taken = Cd a √ (2gHa)

Where,

Cd = Coefficient of discharge of orifice = 0.62

a = area at the orifice, = (∏(0.02)□/4)

Ha = head in air column, m of air.

Qth = Theoretical volume of air taken

$$Qth = \frac{(\prod/4) \times D^{□} \times L \times N}{60 \times 2}$$

Where,

D = Bore diameter of the engine = 0.08m

L = Length of the Stroke = 0.110m

N is speed of the engine in rpm.

SAMPLE CALCULATION:

1. **Mass of fuel consumed, m_f**

$$m_f = \frac{Xcc \times \text{Specific gravity of the fuel}}{1000 \times t} \text{ kg/sec}$$

$$m_f = \frac{10X0.827}{1000 \times 64} \text{ kg/sec}$$

$m_f = 1.29 \times 10^{-4}$ kg/sec

2. **Heat Input, HI**

HI = m_f x Calorific Value of Fuel kW

HI = $1.29 \times 10^{-4} \times 44631.96$

HI = 57.57 kj/kg

Where,

Calorific Value of Diesel = 44631.96 KJ/Kg

3. **Output or Brake Power, BP**

$$\text{Engine output BP} = \frac{2\Pi NT}{60000} \text{ kW}$$

$$BP = \frac{2\Pi (1588) X 22.07}{60000} \text{ kW}$$

BP = 3.67 kw

Where,

N is speed in rpm

T = F x r x 9.81 N-m

r = 0.15m

4. Specific Fuel Consumption, SFC

$$SFC = \frac{m_f \times 3600}{BP} \quad kg/kW - hr$$

$$SFC = \frac{1.29 \times 10^{-4} \times 3600}{3.67} \quad kg/kW - hr$$

$$SFC = 0.26 \ kg/kW - hr$$

5. Brake Thermal Efficiency, $\eta_{bth\%}$

$$\eta_{bth\%} = \frac{3600 \times 100}{SFC \times CV}$$

$$\eta_{bth\%} = \frac{3600 \times 100}{0.26 \times 44631.96}$$

$$\eta_{bth\%} = 31.02$$

6. Mechanical Efficiency, $\eta_{mech\%}$

$$\eta_{mech\%} = \frac{BP}{IP} \times 100$$

Determine the IP = Indicated Power, using WILLAN'S LINE method and the procedure is as below:

- Draw the Graph of Fuel consumption Vs Brake power
- Extend the line obtained till it cuts the Brake power axis
- The point where it cuts the brake power axis till the zero point will give the Power losses (Friction Power loss)
- With this the IP can be found using the relation:

$$IP = BP + FP$$

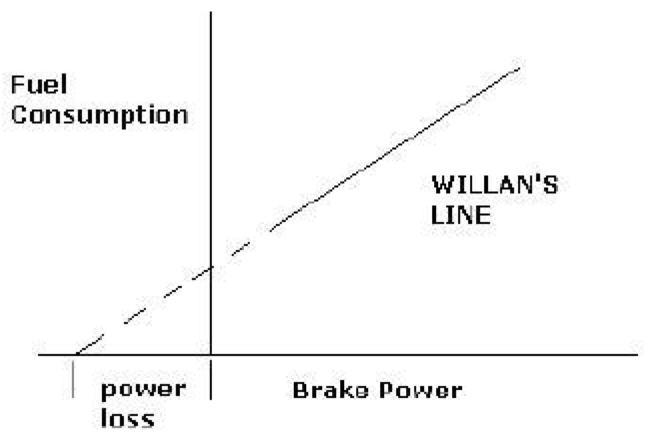
$$IP = 3.67 + 1$$

$$IP = 4.67$$

$$\eta_{mech}\% = \frac{BP}{IP} \times 100$$

$$\eta_{mech}\% = \frac{3.67}{4.67} \times 100$$

$$\eta_{mech}\% = 78.5\ \%$$



7. Calculation of head of air, H_a

$$H_a = \frac{h_w\ \rho_{water}}{\rho_{air}}$$

$$H_a = \frac{0.035 \times 1000}{1.2}$$

$$H_a = 29.16$$

Where,

ρ_{water} = 1000 Kg/m☐

ρ_{air} = 1.2 Kg/m☐ @ R.T.P

h_w is the head in water column in 'm' of water

8. <u>Volumetric efficiency, ηvol%</u>

$$\eta_{vol}\ \% = \frac{Q_a}{Q_{th}} \times 100$$

Qa = Actual volume of air taken = $C_d\, a \sqrt{(2gH_a)}$

$Q_a = 0.62 \times (\Pi/4)\,(0.02)^2 \times \sqrt{(2 \times 9.81 \times 29.16)}$

$Q_a = 4.65 \times 10^{-3}$

Qth = Theoretical volume of air taken

$$Q_{th} = \frac{(\Pi/4) \times D\square \times L \times N}{60}$$

$$Q_{th} = \frac{(\Pi/4) \times 0.08^2 \times 0.110 \times 1588}{60}$$

$Q_{th} = 14.63 \times 10^{-3}$

$$\eta_{vol}\ \% = \frac{Q_a}{Q_{th}} \times 100$$

$$\eta_{vol}\ \% = \frac{4.65 \times 10^{-3} \times 100}{14.63 \times 10^{-3}}$$

TABULATION:

Sl.	Input Power	Output Power	SFC	Brake Thermal Efficiency	Mechanical Efficiency	Volumetric efficiency
1	57.57	3.67	0.26	31.02	78.5	31.78

RESULT: The performance characteristics of the engine are studied.

Graphs to be plotted:

1) SFC v/s BP
2) ηbth v/s BP

3) ηmech v/s BP
4) ηvol v/s BP

PRECAUTIONS:

1. Do not run the engine if supply voltage is less than 180V
2. Do not run the engine without the supply of water.
3. Supply water free from dust to prevent blockage in rotameters, engine head and calorimeter.
4. Note that the range for water supply provided is an approximate standard values, however the user may select the operating range to his convenience not less than 3 & 2 LPM for engine and calorimeter respectively.
5. Do not forget to give electrical earth and neutral connections correctly.
6. Frequently, at least once in three months, grease all visual moving parts.
7. At least once in week, operate the unit for five minutes to prevent any clogging of moving parts.
8. It is recommended to run the engine at **1500rpm** otherwise the rotating parts and bearing of engine may run out.

Applications:

High-speed engines, with rated speeds of 900 to 1,200 revolutions per minute, are used in a **few cases in ships**, but engines of this class are almost always found in small craft such as tugs, fishing vessels, and high-speed ferries

VIVA QUESTIONS

1.Explain The Working Principle Of Single Cylinder Diesel Engine.

2.Define Cut-Off Ratio

3.What Is The Function Of Calorimeter

4.Define Mechanical Efficiency

5.Define Brake Thermal Efficiency

6.What Is Compression Ratio

7. What Is Meant By Variable Compression Ratio.

8.What Is Meant By Motoring Test

9.What Are The Various Performance Characteristics .

10. What Are The Various Methods Used In Cooling Systems

12.What Is The Function Of Fly Wheel.

13.What Is TDC & BDC.

14.Define Compression Ratio.

15.What Is The Difference Between Valve And Port

16. Draw The P-V Diagram Of Otto Cycle

17. Draw The P-V Diagram Of Diesel Cycle

18.Define Calorific Value

19.Define SFC

20.Define Volumetric Efficiency

EXPERIMENT-3

SINGLE CYLINDER, 2 – STROKE PETROL ENGINE TEST RIG

OBJECTIVE: To Find out The performance characteristics of petrol engine

OUT COME : Will be analyze how to calculate performance characteristics of petrol engine

AIM:

The experiment is conducted to

c. To study and understand the performance characteristics of the engine AND

d. To draw Performance curves and compare with standards.

THEORY :

INTRODUCTION

A machine, which uses heat energy obtained from combustion of fuel and converts it into mechanical energy, is known as a Heat Engine. They are classified as External and Internal Combustion Engine. In an External Combustion Engine, combustion takes place outside the cylinder and the heat generated from the combustion of the fuel is transferred to the working fluid which is then expanded to develop the power. An Internal Combustion Engine is one where combustion of the fuel takes place inside the cylinder and converts heat energy into mechanical energy. IC engines may be classified based on the working cycle, thermodynamic cycle, speed, fuel, cooling, method of ignition, mounting of engine cylinder and application.

THE APPARATUS:

The test rig is built for loading mentioned below:

a. Electrical Dynamometer Loading (AC)

1. The equipment consists of a Brand new **BAJAJ** make 5 port model Petrol Engine (Kick Start) of **3hp(2.2kW)** capacity and is Air cooled The Engine is coupled to a **AC Alternator** for Loading purposes. Coupling is done by an extension shaft in a separate bearing house and is belt driven. The dynamometer is provided with load controller switches for varying the load.

2. The engine is provided with modified head with cooling arrangement for different compression ratio and also has an attachment for varying the spark timing.

3. Thermocouples are provided at appropriate positions and are read by a digital temperature indicator with channel selector to select the position.

4. Engine Speed at various condition s is determined by a Digital RPM Indicator.

5. Load on the engine is measured by means of Electrical Energy meter.

6. A separate air box with orifice assembly is provided for regularizing and measuring the flow rate of air. The pressure difference at the orifice is measured by means of an ACRYLIC Manometer.

7. A volumetric flask with a fuel distributor is provided for measurement and directing the fuel to the engine respectively.

8. The testing arrangement is mounted on an aesthetically designed self sustained sturdy frame made of MS channels with anti vibration mounts.

9. The test rig comes with a separate control panel made of NOVAPAN board which houses all indicators, accessories and necessary instrumentations at appropriate positions.

PROCEDURE:

1. Give the necessary electrical connections to the panel.
2. Check the lubricating oil level in the engine.
3. Check the fuel level in the tank.
4. Release the load if any on the dynamometer.
5. Open the three-way cock so that fuel flows to the engine.
6. Set the accelerator to the minimum condition.
7. Start the engine by cranking.(KICK START)
8. Allow to attain the steady state.
9. Load the engine by switching on the Load controller switches provided. (Each loading is incremental of 0.5kW)
10. Note the following readings for particular condition,

a) Engine Speed
b) Time taken for ____cc of petrol consumption
c) Water meter readings.
d) Manometer readings, in cms of water &
e) Temperatures at different locations.

11. Repeat the experiment for different loads and note down the above readings.

12. After the completion release the load (while doing so release the accelerator) and then switch of the engine by pressing the ignition cut – off switch and then turnoff the panel.

OBSERVATIONS:

Sl. No.	Speed, rpm	Load Applied	Manometer Reading, cm of water			Time for 10cc of fuel collected, t sec	Time for 5 rev of Energy meter,
		'F' kW	h1	h2	hw = (h1+h2)		
1	1094	0.5	3.8	2	5.8	59	140

CALCULATIONS:

1. **Mass of fuel consumed, mf**

$$\mathbf{mf} = \frac{\text{Xcc x Specific gravity of the fuel}}{1000 \times t} \text{ kg/sec}$$

Where,

SG of Petrol is = 0.71

Xcc is the volume of fuel consumed = 10ml

t is time taken in seconds

2. **Heat Input, HI**

HI = mf x Calorific Value of Fuel kW

Where,

Calorific Value of Petrol = 43,120 KJ/Kg

3. Output or Brake Power, BP

$$BP = \frac{n \times 3600}{K \times T \times \eta_m} \text{ kW}$$

Where,

n = No. of revolutions of energy meter (Say 5)

K = Energy meter constant = 750 revs/kW-hr

T = time for 5 rev. of energy meter in seconds

ηm = efficiency of belt transmission = 80%

4. Specific Fuel Consumption, SFC

$$SFC = \frac{mf \times 3600}{BP} \text{ kg/kW – hr}$$

5. Brake Thermal Efficiency, ηbth%

$$\eta bth\% = \frac{3600 \times 100}{SFC \times CV}$$

6. Calculation of head of air, Ha

$$Ha = hw \frac{\rho water}{\rho air}$$

Where,

ρ_{water} = 1000 Kg/m□

ρ_{air} = 1.2 Kg/m□ @ R.T.P

h_w is the head in water column in ‘m’ of water

7. Volumetric efficiency, ηvol%

$$\eta_{vol}\% = \frac{Qa}{Q_{th}} \times 100$$

where,

Qa = Actual volume of air taken

$$\mathbf{Qa} = Cd\ a\ \sqrt{(2gHa)}$$

Where,

Cd = Coefficient of discharge of orifice = 0.62

a = area at the orifice, = $(\prod (0.015)^2/4)$

Ha = head in air column, m of air.

Qth = Theoretical volume of air taken

$$\mathbf{Qth} = \frac{(\prod/4) \times D^2 \times L \times Gr \times 0.5N}{60}$$

Where,

D = Bore diameter of the engine = 0.057m

L = Length of the Stroke = 0.057m

N is speed of the engine in rpm.

<u>Gr = gear ratio</u>

1^{st} gear = 14.47:1

2^{nd} gear = 10.28:1

3^{rd} gear = 7.31:1

4^{th} gear = 5.36:1

SAMPLE CALCULATION:

1. **Mass of fuel consumed, m_f**

$$m_f = \frac{Xcc \times \text{Specific gravity of the fuel}}{1000 \times t} \text{ kg/sec}$$

$$m_f = \frac{10 \times 0.71}{1000 \times 59} \text{ kg/sec}$$

$m_f = 1.20 \times 10^{-4}$ kg/sec

2. **Heat Input, HI**

HI = m_f x Calorific Value of Fuel kW

HI = $1.20 \times 10^{-4} \times 43120$

HI = 5.17

3. Output or Brake Power, BP

$$BP = \frac{n \times 3600}{K \times T \times \eta_m} \text{ kW}$$

$$BP = \frac{5 \times 3600}{750 \times 140 \times 0.8} \text{ kW}$$

BP = 0.21

4. Specific Fuel Consumption, SFC

$$SFC = \frac{m_f \times 3600}{BP} \text{ kg/kW – hr}$$

$$SFC = \frac{1.20 \times 10^{-4} \times 3600}{0.21} \text{ kg/kW – hr}$$

SFC = 2.05

5. Brake Thermal Efficiency, $\eta_{bth\%}$

$$\eta_{bth\%} = \frac{3600 \times 100}{SFC \times CV}$$

$$\eta_{bth\%} = \frac{3600 \times 100}{2.05 \times 43120}$$

$\eta_{bth\%}$ = 4.07

6. Calculation of head of air, H_a

$$H_a = h_w \frac{\rho_{water}}{P_{air}}$$

$$H_a = \frac{5.8 \times 1000}{100 \times 1.2}$$

H_a = 48.33

7. <u>Volumetric efficiency, ηvol%</u>

$$\eta_{vol}\ \% = \frac{Q_a}{Q_{th}} \times 100$$

$$Q_a = C_d\, a \sqrt{(2gH_a)}$$

$$Q_{th} = \frac{(\Pi/4) \times D\square \times L \times Gr \times 0.5N}{60}$$

$$\eta_{vol}\ \% = \frac{0.62 \, X((\Pi X 0.015^2)/4) X \sqrt{(2 \, X \, 9.81 \, X \, 48.33)}}{\frac{(\Pi/4) \, X \, 0.057^2 \, X \, 0.057 \, X \, 7.31 \, X \, 0.5 \, X \, 1094}{60}}$$

$$\eta_{vol}\ \% = 0.34$$

TABULATION:

Sl.	Input Power	Output Power, BP	SFC	Brake Thermal Efficiency	Volumetric efficiency
1	5.17	0.21	2.05	4.07	0.34

<u>RESULT:</u> Performance characteristics of petrol engine is determined

Graphs to be plotted:

5) SFC v/s BP
6) ηbth v/s BP
7) ηvol v/s BP

4. <u>PRECAUTIONS</u>:

1. Do not run the engine if supply voltage is less than 180V
2. Do not run the engine without the supply of water.

3. Supply water free from dust to prevent blockage in rotameters, engine head and calorimeter.
4. Note that the range for water supply provided is an approximate standard values, however the user may select the operating range to his convenience not less than 3 & 2 LPM for engine and calorimeter respectively.
5. Always set the accelerator knob to the minimum condition and start the engine.
6. Switch off the ignition of AUXILLARY while doing in the engine arrangement.
7. Do not forget to give electrical earth and neutral connections correctly.

Applications: Bikes

2-stroke engines are generally used in **handheld lawn equipment** because the power per weight is greater than 4-stroke engines; this means that a smaller engine will pack more power than a smaller 4-stroke engine

VIVA QUESTIONS

1.Explain The Working Principle Of Petrol Engine.

2.Define Volumetric Efficiency

3.What Is The Function Of Spark Plug

4. What Is The Function Of Carburetor

5.Define Calorific Value. 6.What Is Compression Ratio

7. What Is Meant By Variable Compression Ratio.

8. Define Brake Thermal Efficiency

9.What Are The Various Performance Characteristics .

10. What Are The Various Methods Used In Cooling Systems

12.What Is The Function Of Fly Wheel.

13.What Is TDC & BDC.

14.Define Compression Ratio.

15.What Is The Difference Between Valve And Port.

16.Define Cut-Off Ratio

17.What Is The Function Of Calorimeter

18.Define Mechanical Efficiency

19.Define Indicated Thermal Efficiency

20.Define Volumetric Efficiency

EXPERIMENT-4

4–CYLINDER, 4 - STROKE PETROL ENGINE TEST RIG

OBJECTIVE: To find out the performance characteristics of 4 stroke 4 cylinder petrol engine

OUT COME: Will be analyze how to calculate performance characteristics of 4 stroke 4 cylinder petrol engine.

AIM:

The experiment is conducted to

a. To study and understand the performance characteristics of the engine.

b. To draw Performance curves and compare with standards.

THEORY:

INTRODUCTION

A machine, which uses heat energy obtained from combustion of fuel and converts it into mechanical energy, is known as a Heat Engine. They are classified as External and Internal Combustion Engine. In an External Combustion Engine, combustion takes place outside the cylinder and the heat generated from the combustion of the fuel is transferred to the working fluid which is then expanded to develop the power. An Internal Combustion Engine is one where combustion of the fuel takes place inside the cylinder and converts heat energy into mechanical energy. IC engines may be classified based on the working cycle, thermodynamic cycle, speed, fuel, cooling, method of ignition, mounting of engine cylinder and application.

APPARATUS:

a. Hydraulic Dynamometer Loading

1. The equipment consists of a Brand new **ISUZU (Ambassador) make Carburetor Version Engine** (Self started) of capacity **30kW at the charsy and 7.5kW at the crankshaft** .

2. The Engine is coupled to a Hydraulic Dynamometer for Loading purposes. The coupling is done by an **universal coupling** in a bearing house.
3. Thermocouples are provided at appropriate positions and are read by a **digital temperature indicator** with **channel selector**.
4. Rota meters of range 15LPM & 10LPM are used for direct measurement of water flow rate to the engine and calorimeter respectively.
5. The Engine Speed and the load applied at various conditions is determined by a Digital RPM Indicator and **Load cell arrangement**.
6. A separate air box with orifice assembly is provided for regularizing and measuring the flow rate of air. The pressure difference is measured by means of an **ACRYLIC** Manometer.
7. A volumetric flask with a fuel distributor is provided for measurement and directing the fuel to the engine respectively.
8. The testing arrangement is mounted on an aesthetically designed self sustained frame made of MS channels with **A-Type** anti vibration mounts.
9. The test rig comes with a separate control panel made of NOVAPAN board that houses all the indicators, accessories and necessary instrumentations at appropriate positions.

PROCEDURE:

1. Check the lubricating oil level.
2. Check the fuel level.
3. Check and Release the load on the dynamometer if loaded.
4. Check the necessary electrical connections and switch on the panel.
5. Provide the Battery Connections.
6. Allow cooling water to engine and calorimeter and set the flow to 6 & 3 LPM respectively.
7. Open the three-way cock so that fuel flows to the engine.
8. Start the engine using the starter key.
9. Set the speed of the engine. (Do not exceed 3000rpm)
10. Now slowly load the engine using the loading wheel of the dynamometer.

11. Set the engine speed to before rating.
12. Note the following readings.
    a. Engine Speed.
    b. Time taken for ____cc of petrol consumption
    c. Rotameter readings.
    d. Manometer readings, in 'm' of water &
    e. Temperatures.
13. Repeat the experiment for other loadings.
14. After the completion release the load (while doing so release the accelerator) and then switch of the engine
    i. and the panel.
15. *Allow the water to flow for few minutes and then turn it off.

    ***Note:**

    a. Allow water only to the calorimeter and not to the engine.
16. Remove earthing connection of the battery and the starter key.

OBSERVATIONS:

Sl. No.	Speed, rpm	Load Applied	Manometer Reading			Time for 10 cc of fuel collected, t sec
			h1	h2	hw = (h1∾h2)	
1	1462	5.52	0.5	0.2	0.3	13.31

Sl. No.	Engine water flowrate, LPM1	Calorimeter water flowrate, LPM2
1	6 litpermin	3 litpermin

CALCULATIONS:

1. **Mass of fuel consumed, mf**

$$\textbf{mf} = \frac{\text{Xcc x Specific gravity of the fuel}}{1000 \text{ x t}} \text{ kg/sec}$$

Where,

SG of Petrol is = 0.71

Xcc is the volume of fuel consumed = 10ml

t is time taken in seconds

2. **Heat Input, HI**

$$\textbf{HI = mf x Calorific Value of Fuel} \quad \text{kW}$$

Where,

Calorific Value of Petrol= 43120 kJ/kg

3. **Output or Brake Power, BP**

$$BP = \frac{W \times N \times 0.80}{2000} \text{ kW}$$

Where,

W = Load carried by the dynamometer

= Load indicator Reading in kg

N = Speed of the engine, rpm

4. **Specific Fuel Consumption, SFC**

$$SFC = \frac{mf \times 3600}{BP} \text{ kg/kW – hr}$$

5. **Brake Thermal Efficiency, ηbth%**

$$\eta bth\% = \frac{3600 \times 100}{SFC \times CV}$$

6. **Mechanical Efficiency, ηmech%**

$$\eta mech\% = \frac{BP}{IP} \times 100$$

IP is calculated using the Morse test facility

7. **Calculation of head of air, Ha**

$$Ha = hw \frac{\rho water}{\rho air}$$

Where,

ρwater = 1000 Kg/m□

ρair = 1.2 Kg/m□ @ R.T.P

hw is the head in water column in ‘m’ of water

8. Volumetric efficiency, ηvol%

$$\eta vol\ \% = \frac{Qa}{Qth} \times 100$$

where,

Qa = Actual volume of air taken = Cd a √ (2gHa)

Where,

Cd = Coefficient of discharge of orifice = 0.62

a = area at the orifice, = (∏(0.025)□/4)

Ha = head in air column, m of air.

Qth = Theoretical volume of air taken

$$Qth = \frac{(\prod/4) \times D\square \times L \times N}{60 \times 2}$$

Where,

D = Bore diameter of the engine = 0.084m

L = Length of the Stroke = 0.082m

N is speed of the engine in rpm.

SAMPLE CALCULATION:

1. <u>Mass of fuel consumed, mf</u>

$$m_f = \frac{Xcc \times \text{Specific gravity of the fuel}}{1000 \times t} \text{ kg/sec}$$

$$m_f = \frac{10 \times 0.71}{1000 \times 13.31} \text{ kg/sec}$$

$$m_f = 5.33 \times 10^{-4} \text{ kg/sec}$$

2. <u>Heat Input, HI</u>

HI = m_f x Calorific Value of Fuel kW

HI = $5.33 \times 10^{-4} \times 43120$ kj/kg

HI = 22.98

3. Output or Brake Power, BP

$$BP = \frac{W \times N \times 0.80}{2000} \text{ kW}$$

$$BP = \frac{5.52 \times 1462 \times 0.80}{2000} \text{ kW}$$

BP = 3.22 kW

4. Specific Fuel Consumption, SFC

$$SFC = \frac{m_f \times 3600}{BP} \text{ kg/kW – hr}$$

$$SFC = \frac{5.33 \times 10^{-4} \times 3600}{3.22} \text{ kg/kW – hr}$$

SFC = 0.59 kg/kW-hr

5. Brake Thermal Efficiency, $\eta_{bth\%}$

$$\eta_{bth\%} = \frac{3600 \times 100}{SFC \times CV}$$

$$\eta_{bth\%} = \frac{3600 \times 100}{0.59 \times 43120}$$

$\eta_{bth\%}$ = 14.15

6. Mechanical Efficiency, $\eta_{mech\%}$

$$\eta_{mech\%} = \frac{BP}{IP} \times 100$$

IP is calculated using the Morse test facility

$$\eta_{mech\%} = \frac{3.22}{22.98} \times 100$$

$\eta_{mech\%}$ = 14.01

7. **Calculation of head of air, H_a**

$$H_a = h_w \frac{\rho_{water}}{\rho_{air}}$$

$$H_a = \frac{0.03 \times 1000}{1.2}$$

$$H_a = 2.5$$

8. **Volumetric efficiency, $\eta_{vol\%}$**

$$\eta_{vol}\ \% = \frac{Q_a}{Q_{th}} \times 100$$

Q_a = Actual volume of air taken = $C_d\ a \sqrt{(2gH_a)}$

Q_{th} = Theoretical volume of air taken

$$Q_{th} = \frac{(\pi/4) \times D^2 \times L \times N}{60 \times 2}$$

$$\eta_{vol}\ \% = \frac{0.62 \times (\pi/4) \times 0.025^2 \times \sqrt{(2 \times 9.81 \times 2.5)} \times 100}{5.53 \times 10^{-3}}$$

$$\eta_{vol}\ \% = 38.51$$

TABULATION:

Sl.	Input Power	Output Power	SFC	Brake Thermal Efficiency	Mechanical Efficiency	Volumetric efficiency
1	22.98	3.22	0.59	14.15	14.01	38.51

RESULT: Determined the performance characteristics of 4 stroke 4 cylinder petrol engine

Graphs to be plotted:

1) SFC v/s BP

2) ηbth v/s BP
3) ηmech v/s BP
4) ηvol v/s BP

4. PRECAUTIONS:

1. Do not run the engine if supply voltage is less than 180V
2. Do not run the engine without the supply of water.
3. Supply water free from dust to prevent blockage in rotameters, engine head and calorimeter.
4. Note that the range for water supply provided is an approximate standard values, however the user may select the operating range to his convenience not less than 3 & 2 LPM for engine and calorimeter respectively.
5. Always set the accelerator knob to the minimum condition and start the engine.
6. Do not forget to give electrical earth and neutral connections correctly.
7. Frequently, at least once in three months, grease all visual moving parts.
8. At least once in week, operate the unit for five minutes to prevent any clogging of moving parts.
9. It is recommended to run the engine below **3000rpm** otherwise the rotating parts and bearing of dynamometer may run out.

Applications: The four-stroke petrol engine is the most common types of internal combustion engines and is used in various automobiles (that specifically use gasoline as fuel) like cars, trucks, and some motorbikes

VIVA QUESTIONS

1.What is the difference between 2 stroke and 4 stroke petrol engines.

2.What do you meant by characteristics of an engine

3.What is the function of thermocouple.

4. Draw the otto cycle PV & TS diagrams

5.Define specific fuel consumption

6.Define Cut-Off Ratio

7.What Is The Function Of Calorimeter

8.Define Mechanical Efficiency

9.Define Brake Thermal Efficiency

10.Define Volumetric Efficiency

11.Explain The Working Principle Of Petrol Engine.

12.Define Volumetric Efficiency

13.What Is The Function Of Spark Plug

14. What Is The Function Of Carburetor

15.Define Calorific Value. 6.What Is Compression Ratio

16. What Is Meant By Variable Compression Ratio.

17. Define Brake Thermal Efficiency

18.What Are The Various Performance Characteristics .

19. What Are The Various Methods Used In Cooling Systems

20.What Is The Function Of Calorimeter

EXPERIMENT-5

RECIPROCATING AIR COMPRESSOR

OBJECTIVE: To Find out The performance characteristics of ***Reciprocating air compressor***

OUT COME: Will be analyze how to calculate performance characteristics of air compressor.

AIM:

The experiment is conducted at various pressures to

a. Determine the Volumetric efficiency.

b. Determine the Isothermal efficiency.

THEORY:

INTRODUCTION

A *COMPRESSOR* is a device, which sucks in air at atmospheric pressure & increases its pressure by compressing it. If the air is compressed in a single cylinder it is called as a Single Stage Compressor. If the air is compressed in two or more cylinders it is called as a Multi Stage Compressor.

In a Two Stage Compressor the air is sucked from atmosphere & compressed in the first cylinder called the low-pressure cylinder. The compressed air then passes through an inter cooler where its temperature is reduced. The air is then passed into the second cylinder where it is further compressed. The air further goes to the air reservoir where it is stored.

DESCRIPTION OF THE APPARATUS:

1. Consists of Two Stage ELGI make Reciprocating air compressor of 3hp capacity. The compressor is fitted with similar capacity Motor as a driver and 160lt capacity reservoir tank.

2. Air tank with orifice plate assembly is provided to measure the volume of air taken and is done using the Acrylic Manometer provided.

3. Compressed air is stored in an air reservoir, which is provided with a pressure gauge and automatic cut-off.

4. Necessary Pressure and Temperature tappings are made on the compressor for making different measurements

5. Temperature is read using the Digital temperature indicator and speed by Digital RPM indicator.

6. All the measurements and controls are placed in a separate NOVAPAN board control panel unit with all necessary instrumentations.

PROCEDURE:

1. Check the necessary electrical connections and also for the direction of the motor.

3. Check the lubricating oil level in the compressor.

4. Start the compressor by switching on the motor.

5. The slow increase of the pressure inside the air reservoir in observed.

6. Maintain the required pressure by slowly operating the discharge valve (open/close). (Note there may be slight variations in the pressure readings since it is a dynamic process and the reservoir will be filled continuously till the cut-off.)

7. Now note down the following readings in the respective units,

    - Speed of the compressor.
    - Manometer readings.
    - Delivery pressure.
    - Temperatures.
    - Energy meter reading.

8. Repeat the experiment for different delivery pressures.

9. Once the set of readings are taken switch of the compressor.

10. The air stored in the tank is discharged. Be careful while doing so, because the compressed air passing through the small area also acts as a air jet which may damage you or your surroundings.

11. Repeat the above two steps after every experiment.

OBSERVATIONS:

Sl. No.	Compressor Speed, N rpm	Delivery Pressure, 'P' kg/cm^2	Time for 'n' revolutions of energy meter, 'T' sec	Manometer meter reading in 'm'		
				h1	h2	Hw
1	914.3	2 =19.62	42.91 =214.55	0.5	2	2.5 =0.025

CALCULATIONS:

1. Air head causing flow, **ha**

$$h_a = \frac{h_w \rho_{water}}{\rho_{air}} \text{ m of air}$$

Where,

hw is Water column reading in **m** of water.

ρwater is density of the water = 1000 kg/m^3

ρair is the density of the air = 1.293 kg/m^3

2. Actual vol. of air compressed at RTP, **Qa**

$$Q_a = C_d\, a \sqrt{2gh_a} \text{ } m^3/s$$

Where,

ha is air head causing the flow in **m** of air.

Cd = co efficient of discharge of orifice = 0.62

a = Area of orifice = $(\pi d^2) / 4$

Where , d = diameter of orifice = 0.02m

3. Theoritical volume of air compressed Qth,

$$\mathbf{Qth} = \frac{(\pi/4) \times D^2 \times L \times N}{60} \quad m^3/s$$

Where,

D is the diameter of the LP cylinder = 0.07m.

L is Stroke Length = 0.085m

N is speed of the compressor in rpm

4. Input Power, **IP**

$$\textbf{Input Power} = \frac{3600 \times n \times \eta m}{K \times T}, \quad kW$$

Where,

n = No. of revolutions of energy meter (Say 5)

K = Energy meter constant ___ revs/kW-hr

T = time for 5 rev. of energy meter in seconds

ηm = efficiency of belt transmission = 75%

5. Isothermal Work done, **WD**

$$\mathbf{WD = \rho a \times Qa \ln r} \quad kW$$

Where,

ρa = is the density of the air = 1.293 kg/m³

Qa = Actual volume of air compressed.

r = Compression ratio

r = Delivery gauge pressure + Atmospheric pressure

Atmospheric pressure

Where Atmospheric pressure = 101.325 kPa

NOTE: To convert delivery pressure from kg/cm² to kPa multiply by 98.1

6. **Volumetric efficiency, ηvol**

$$\eta_{vol} = Q_a/Q_{th} \times 100$$

7. **Isothermal efficiency, ηiso**

$$\eta_{iso} = \frac{\text{Isothermal work done} \times 100}{IP}$$

SAMPLE CALCULATION:

1. Air head causing flow, h_a

$$h_a = h_w \frac{\rho_{water}}{\rho_{air}} \text{ m of air}$$

$$h_a = \frac{2.5 \times 1000}{1.293} \text{ m of air}$$

$$h_a = 19.33 \text{ m of air}$$

2. Actual vol. of air compressed at RTP, Q_a

$$Q_a = C_d\, a \sqrt{(2gh_a)} \text{ m}^3/\text{s}$$

$$Q_a = 0.62 \times (\pi/4) \times (0.02)^2 \times \sqrt{(2 \times 9.81 \times 19.33)} \text{ m}^3/\text{s}$$

$$Q_a = 3.79 \times 10^{-3} \text{ m}^3/\text{s}$$

3. Theoritical volume of air compressed Q_{th},

$$Q_{th} = \frac{(\pi/4) \times D^2 \times L \times N}{60} \quad m^3/s$$

$$Q_{th} = \frac{(\pi/4) \times 0.07^2 \times 0.085 \times 914.3}{60} \quad m^3/s$$

$Q_{th} = 4.98 \times 10^{-3}$ m^3/s

4. <u>Input Power, **IP**</u>

$$\text{Input Power} = \frac{3600 \times n \times \eta_m,}{K \times T} \quad kW$$

$$IP = \frac{3600 \times 5 \times 0.75}{60 \times 214.55} \quad kW$$

IP = 1.04 kW

5. <u>Isothermal Work done, **WD**</u>

$WD = \rho_a \times Q_a \ln r$ kW

$WD = 1.293 \times 3.71 \times 10^3 \times \ln(1.19)$ kW

$WD = 8.52 \times 10^{-4}$ kW

6. **Volumetric efficiency, η_{vol}**

$\eta_{vol} = Q_a/Q_{th} \times 100$

$\eta_{vol} = ((3.79 \times 10^{-3})/(4.98 \times 10^{-3})) \times 100$

$\eta_{vol} = 90.45$

7. **Isothermal efficiency, η_{iso}**

$$\eta_{iso} = \frac{\text{Isothermal work done} \times 100}{\text{IP}}$$

$$\eta_{iso} = \frac{8.52 \times 10^{-4} \times 100}{1.04} \quad \text{kW}$$

$$\eta_{iso} = 0.08$$

TABULATIONS:

Sl. No	Head of air h_a, m	Act. Vol. of air compressed Q_a m^3/s	Theo. Vol. of air compressed Q_{th}, m^3/s	Isothermal work done kW	Iso Thermal Efficiency η_{iso}, %	Volumetric Efficiency, η_{vol}, %
1	19.33	3.79×10^{-3}	4.98×10^{-3}	8.52×10^{-4}	0.08	90.45

GRAPHS TO BE PLOTTED:

1. Delivery Pressure vs. η_{vol}
2. Delivery Pressure vs. η_{iso}

V. RESULT: The volumetric efficiency and isothermal efficiency at various pressures are determined.

PRECAUTIONS:

1. Do not run the blower if supply voltage is less than 380V
2. Check the direction of the motor, if the motor runs in opposite direction change the phase line of the motor to run in appropriate direction.
3. Do not forget to give electrical earth and neutral connections correctly.
4. Frequently, at least once in three months, grease all visual moving parts.
5. At least once in week, operate the unit for five minutes to prevent any clogging of moving parts.
6. In case of any major faults, Please write to the manufacturers and do not attempt to repair.

Applications:

It is widely used in oil refineries, gas pipelines, natural gas processing plants, chemical plants, etc. it is also used in blowing of the plastic bottle

VIVA QUESTIONS

1. What is function of compressor.
2. Explain different types of compressors
3. What is the Difference between single stage and multi stage compressor.
4. Define isothermal efficiency
5. Define volumetric efficiency
6. Petrol engine is also called as __.
7. Why fuel injectors are not required in petrol engines?
8. Why carburettor is required inpetrol engine?
9. What is the self-ignition temperature of petrol?
10. Why spark plug is required in petrol engines?
11. How ignition of fuel is done in SI engines?
12. What is the source of heat that ignites fuel in petrol engine?
13. Why diesel engines are heavy when compared to petrol engines?
14. What is the type of heat addition inOtto cycle?
15. Air standard efficiency of Otto cycle is?
16. What is the range of efficiency of petrol engines?
17. Why petrol engines have low compression ratio?
18. What is the range of compression ratio for petrol engines?
19. What are the applications of petrol engines?
20. What is battery ignition?

EXPERIMENT-6

MORSE TEST ON 4 CYLINDER 4 STROKE PETROL ENGINE

OBJECTIVE: To Find out friction power of 4 cylinder 4 stroke petrol engine by using morse test method

OUT COME : Will be analyze how to friction power by using more test method in 4 stroke 4 cylinder petrol engine.

AIM:

To conduct Morse Test on 4-Cylinder 4-stroke petrol engine and hence to determine the FRICTIONAL POWER (FP) and MECHANICAL EFFICIENCY (η mech) of the engine.

MORSE TEST:

1. Start the engine and set to one particular speed and note down the readings and calculate the B.P of the engine for the particular load and speed.
2. Cut - off the 1st cylinder, now the speed reduces , so set the speed to the before value by releasing the load and subtract the previous value to get the IP of 1st cylinder.
3. Now, repeat the step 2 for other cylinders.

OBSERVATION:

Sl. No.	Speed	Initial Load	Final Load after cylinder cut – off			
			1st Cyl	2nd Cyl.	3rd Cyl	4th Cyl
1.	1296	9.31	4.98	5.22	5.28	5.30

CALCULATION:

1. **Brake Power , BP**

$$BP = \frac{W \times N \times 0.8}{2000} \text{ kW}$$

Where,

W = Load carried by the dynamometer

= Load indicator Reading in kg

N = Speed of the engine, rpm

Note: Calculate BP for full load as well as cut-off loads

2. Indicated Power , BP

IP = IP1 + IP2 + IP3 + IP4 kW

Where,

IP1 = BP – BP1

IP2 = BP – BP2

IP3 = BP – BP3

IP4 = BP – BP4

SAMPLE CALCULATION:

1. Brake Power , BP

$$BP = \frac{W \times N \times 0.8}{2000} \text{ kW}$$

$$BP = \frac{9.81 \times 1296 \times 0.8}{2000} \text{ kW}$$

BP = 4.84 kW

$$BP1 = \frac{W1 \times N1 \times 0.8}{2000} \text{ kW}$$

$$BP1 = \frac{4.98 \times 1296 \times 0.8}{2000} \quad kW$$

BP1 = 2.58 kW

$$BP2 = \frac{W2 \times N2 \times 0.8}{2000} \quad kW$$

$$BP2 = \frac{5.22 \times 1296 \times 0.8}{2000} \quad kW$$

BP2 = 2.70 kW

$$BP3 = \frac{W3 \times N3 \times 0.8}{2000} \quad kW$$

$$BP3 = \frac{5.28 \times 1296 \times 0.8}{2000} \quad kW$$

BP3 = 2.73 kW

$$BP4 = \frac{W4 \times N4 \times 0.8}{2000} \quad kW$$

$$BP4 = \frac{5.30 \times 1296 \times 0.8}{2000} \quad kW$$

BP4 = 2.74 kW

2. Indicated Power , BP

IP = IP1 + IP2 + IP3 + IP4 kW

Where,

IP1 = BP – BP1 = 4.84 – 2.58 = 2.26

IP2 = BP – BP2 = 4.84 – 2.70 = 2.14

IP3 = BP – BP3 = 4.84 – 2.73 = 2.11

IP4 = BP – BP4 = 4.84 – 2.74 = 2.1

RESULT TABLE:

S.NO	CYLINDER No.	IP (KW)
1	1	2.26
2	2	2.14
3	3	2.11
4	4	2.1

RESULT: The frictional power (FP) and mechanical efficiency of the engine are determined.

Applications:

The purpose of Morse Test is **to obtain the approximate Indicated Power of a Multi-cylinder Engine**. It consists of running the engine against a dynamometer at a particular speed, cutting out the firing of each cylinder in turn and noting the fall in BP each time while maintaining the speed constant

VIVA QUESTIONS

1. Briefly discuss the various efficiency terms associated with an engine?
2. What are the methods available for improving the performance of an engine?
3. List various methods available for finding frictional power of an engine?
4. Why Morse test is not suitable for single cylinders engine?
5. Explain the principle involved in the measurement of brake power?
6. What is electronic ignition?
7. What is the advantage of electronic ignition over battery ignition?
8. Who invented petrol engine?
9. What are the stages of combustion in a SI engine?
10. What is ignition delay in SI engine?
11. What is propagation of flame in SI engine?
12. What is after burning in petrol engines?
13. How many stages of combustion are present in petrol engine?
14. How are SI engine fuels rated?
15. What is the calorific value of petrol?
16. What is specific gravity of petrol?
17. What is flash point of petrol?
18. What is fire point of petrol?
19. What is pre ignition?
20. What is knocking in SI engines?

EXPERIMENT-7

HEAT BALANCE TEST ON SINGLE SYLINDER FOUR STROKE DIESEL ENGINE

OBJECTIVE: To Find out The heat balance sheet of single cylinder 4 stroke diesel engine.

OUT COME : Will be analyze how to calculate heat balance sheet of asingle cylinder 4 stroke diesel engine

AIM:

The experiment is conducted to calculate the heat balance sheet of single cylinder Four Stroke Diesel Engine

INTRODUCTION

A machine, which uses heat energy obtained from combustion of fuel and converts it into mechanical energy, is known as a Heat Engine. They are classified as External and Internal Combustion Engine. In an External Combustion Engine, combustion takes place outside the cylinder and the heat generated from the combustion of the fuel is transferred to the working fluid which is then expanded to develop the power. An Internal Combustion Engine is one where combustion of the fuel takes place inside the cylinder and converts heat energy into mechanical energy. IC engines may be classified based on the working cycle, thermodynamic cycle, speed, fuel, cooling, method of ignition, mounting of engine cylinder and application.

Diesel Engine is an internal combustion engine, which uses heavy oil or diesel oil as a fuel and operates on two or four stroke. In a 4-stroke Diesel engine, the working cycle takes place in two revolutions of the crankshaft or 4 strokes of the piston. In this engine, pure air is sucked to the engine and the fuel is injected with the combustion taking place at the end of the compression stroke. The power developed and the performance of the engine depends on the condition of operation. So it is necessary to test an engine for different conditions based on the requirement.

DESCRIPTION OF THE APPARATUS:

The test rig is built for loading mentioned below:

a. Mechanical Loading (Water cooled)

9. The equipment consists of a Brand new **KIRLOSKAR** make AV1 model Diesel Engine (Crank started) of **5hp (3.7kW)** capacity and is Water cooled. The Engine is coupled to a Rope Brake Drum Dynamometer for Loading purposes. Coupling is done by an extension shaft in a separate bearing house. The dynamometer is connected to the spring load assembly for varying the load.
10. Thermocouples are provided at appropriate positions and are read by a digital temperature indicator with channel selector to select the position.
11. Rota meters of range 15LPM & 10LPM are used for direct measurement of water flow rate to the engine and calorimeter respectively.
12. Engine Speed and the load applied at various conditions is determined by a Digital RPM Indicator and spring balance reading.
13. A separate air box with orifice assembly is provided for regularizing and measuring the flow rate of air. The pressure difference at the orifice is measured by means of an ACRYLIC Manometer.
14. A volumetric flask with a fuel distributor is provided for measurement and directing the fuel to the engine respectively.

15. The testing arrangement is mounted on an aesthetically designed self sustained sturdy frame made of MS channels with anti vibration mounts.
16. The test rig comes with a separate control panel made of NOVAPAN board that houses all the indicators, accessories and necessary instrumentations at appropriate positions.

.

PROCEDURE:

14. Give the necessary electrical connections to the panel.

15. Check the lubricating oil level in the engine.
16. Check the fuel level in the tank.
17. Allow the water to flow to the engine and the calorimeter and adjust the flowrate to 6lpm & 3lpm respectively.
18. Release the load if any on the dynamometer.
19. Open the three-way cock so that fuel flows to the engine.
20. Start the engine by cranking.
21. Allow to attain the steady state.
22. Load the engine by slowly tightening the yoke rod handle of the Rope brake drum.
23. Note the following readings for particular condition,
    a. Engine Speed
    b. Time taken for ____cc of diesel consumption
    c. Rotameter reading.
    d. Manometer readings, in cms of water &
    e. Temperatures at different locations.
24. Repeat the experiment for different loads and note down the above readings.
25. After the completion release the load and then switch of the engine.
26. Allow the water to flow for few minutes and then turn it off.

OBSERVATIONS:

Sl. No.	Speed , rpm	Load Applied			Manometer Reading			Time for 10cc of fuel collected, t sec
		F1	F2	F= (F1~F2)	h1	h2	hw = (h1+h2)	
1	1533	10	5	5	1	1	2=0.02	55

Sl. No.	T1	T2	T3	T4	T5	T6
1	28	30	33	34	102	87

Sl. No.	Engine water flowrate, LPM1	Calorimeter water flowrate, LPM2
1	6 Lit	3 Lit

i. CALCULATIONS:

1.Mass of fuel consumed, mf

$$\mathbf{mf} = \frac{\text{Xcc x Specific gravity of the fuel}}{1000 \times t} \text{ kg/sec}$$

Where,

SG of Diesel is = 0.827

Xcc is the volume of fuel consumed = 10ml

t is time taken in seconds

Calorific Value of Diesel = 44631.96 KJ/Kg

2.Output or Brake Power, BP

Engine output BP = $2\Pi \frac{NT}{60000}$ kW

Where,

N is speed in rpm

T = F x r x 9.81 N-m

r = 0.15m

Heat Balance Sheet Calculations IN SECONDS basis:

3.Heat Input --- A

A = mf x Calorific Value kW

4.Heat to BP --- B

B = kW

5.Heat to cooling water --- C

$$C = m_{we} \times C_{pw} \times (T_{ei} - T_{eo}) \quad kW$$

Where

mwe = cooling water flow rate to the engine from Rotameter

= LPM1/60 kg/sec

Cpw = Specific Heat of water = 4.18 kJ/kg

1. Heat to exhaust gases --- D

D = mwc x Cpw x (Tci – Tco) x [(Tgci – Ta)/ (Tgco – Tgci)] kW

Where

mwc = water flow rate in kg/sec

= LPM2/60 kg/sec

Cpw = Specific Heat of water

Ta = Engine surrounding temperature.

Tgci = Gas inlet temp to calorimeter

Tgco = Gas outlet temp from calorimeter

Tci = Water Inlet temp to calorimeter

Tco = Water outlet temp from calorimeter

2. Heat Unaccounted

E = A – (B+C+D) kW

SAMPLE CALCULATION:

1.Mass of fuel consumed, m_f

$$m_f = \frac{Xcc \times \text{Specific gravity of the fuel}}{1000 \times t} \quad kg/sec$$

$$m_f = \frac{10 \times 0.827}{1000 \times 55} \quad kg/sec$$

$m_f = 1.50 \times 10^{-4}$ kg/sec

2.Output or Brake Power, BP

Engine output $BP = \frac{2\Pi NT}{60000}$ kW

$BP = \frac{2\Pi \times 1533 \times 5 \times 0.15 \times 9.81}{60000}$ kW

BP = 1.18 kW

Heat Balance Sheet Calculations IN SECONDS basis:

3.Heat Input --- A

A = $m_f \times$ Calorific Value kW

A = $1.50 \times 10^{-4} \times 44631.96$

A = 6.69 kW

4.Heat to BP --- B

B = 1.18 kW

5.Heat to cooling water --- C

$C = m_{we} \times C_{pw} \times (T_{ei} - T_{eo})$ kW

$C = 0.1 \times 4.18 \times (30 - 33)$ kW

C = 1.254 kW

6. Heat to exhaust gases --- D

$D = m_{wc} \times C_{pw} \times (T_{ci} - T_{co}) \times [(T_{gci} - T_a)/ (T_{gco} - T_{gci})]$ kW

$D = 0.05 \times 4.18 \times (30 - 34) \times [(102 - 28)/ (87 - 102)]$ kW

D = 4.122 kW

7. Heat Unaccounted

E = A – (B+C+D) kW

E = 6.69 – (1.18 + 1.254 + 4.122)

E = 0.036

HEAT BALANCE SHEET:

Sl. No.	Particulars	Heat Content kW	%
1	Heat Input -- A	6.69	100
2	Heat to BP -- B	1.18	B/A = 17.63
3	Heat to Cooling Water -- C	1.254	C/A =18.74
4	Heat to Exhaust Gases -- D	4.22	D/A = 63.07
5	Heat Unaccounted -- E	0.578	E/A =0.538

PRECAUTIONS:

9. Do not run the engine if supply voltage is less than 180V
10. Do not run the engine without the supply of water.
11. Supply water free from dust to prevent blockage in rotameters, engine head and calorimeter.
12. Note that the range for water supply provided is an approximate standard values, however the user may select the operating range to his convenience not less than 3 & 2 LPM for engine and calorimeter respectively.
13. Do not forget to give electrical earth and neutral connections correctly.
14. Frequently, at least once in three months, grease all visual moving parts.
15. At least once in week, operate the unit for five minutes to prevent any clogging of moving parts.

RESULT: The heat balance sheet of single cylinder four stroke diesel engines is performed.

Applications:

To analyze the various heat losses in four stroke diesel engines

VIVA QUESTIONS

1. Define indicated power.
2. Define break power.
3. What is friction power?
4. Write the relation between IP, BP & FP.
5. What are different type of Dynamometers?

6. Which type of dynamometer is used in 4 stroke single cylinder diesel engine?
7. In CI engines the mixture is ___.
8. What is flame front?
9. What is rich mixture?
10. What is lean mixture?
11. What is the calorific value of petrol?
12. What is specific gravity of petrol?
13. What is flash point of petrol?
14. What is fire point of petrol?
15. What is pre ignition?
16. What is knocking in SI engines?
17. How does air fuel ratio effect flame speed?
18. How does compression ratio effect flame speed?
19. At what mixture strength maximum flame speed occurs?
20. What is turbulence?
21. In which engines air fuel mixture is homogeneous?

EXPERIMENT-8

HEAT BALANCE SHEET OF 4–CYLINDER, 4 - STROKE PETROL ENGINE TEST RIG

OBJECTIVE: To Find out The heat balance sheet of 4 cylinder 4 stroke petrol engine

OUT COME : Will be analyze how to calculate heat balance sheet of a 4 cylinder 4 stroke petrol engine.

AIM:

The experiment is conducted to
To Calaculate the heat balance sheet of 4-cylinder 4-stroke petrol engine

THEORY:

INTRODUCTION

A machine, which uses heat energy obtained from combustion of fuel and converts it into mechanical energy, is known as a Heat Engine. They are classified as External and Internal Combustion Engine. In an External Combustion Engine, combustion takes place outside the cylinder and the heat generated from the combustion of the fuel is transferred to the working fluid which is then expanded to develop the power. An Internal Combustion Engine is one where combustion of the fuel takes place inside the cylinder and converts heat energy into mechanical energy. IC engines may be classified based on the working cycle, thermodynamic cycle, speed, fuel, cooling, method of ignition, mounting of engine cylinder and application.

APPARATUS:

Hydraulic Dynamometer Loading

VI. The equipment consists of a Brand new **ISUZU (Ambassador) make Carburetor Version Engine** (Self started) of capacity **30kW at the charsy and 7.5kW at the crankshaft** .

VII. The Engine is coupled to a Hydraulic Dynamometer for Loading purposes. The coupling is done by an **universal coupling** in a bearing house.

VIII. Thermocouples are provided at appropriate positions and are read by a **digital temperature indicator** with **channel selector**.

IX. Rota meters of range 15LPM & 10LPM are used for direct measurement of water flow rate to the engine and calorimeter respectively.

X. The Engine Speed and the load applied at various conditions is determined by a Digital RPM Indicator and **Load cell arrangement**.

XI. A separate air box with orifice assembly is provided for regularizing and measuring the flow rate of air. The pressure difference is measured by means of an **ACRYLIC** Manometer.

XII. A volumetric flask with a fuel distributor is provided for measurement and directing the fuel to the engine respectively.

XIII. The testing arrangement is mounted on an aesthetically designed self sustained frame made of MS channels with **A-Type** anti vibration mounts.

XIV. The test rig comes with a separate control panel made of NOVAPAN board that houses all the indicators, accessories and necessary instrumentations at appropriate positions.

PROCEDURE:

1. Check the lubricating oil level.
2. Check the fuel level.
3. Check and Release the load on the dynamometer if loaded.
4. Check the necessary electrical connections and switch on the panel.
5. Provide the Battery Connections.
6. Allow cooling water to engine and calorimeter and set the flow to 6 & 3 LPM respectively.

7. Open the three-way cock so that fuel flows to the engine.
8. Start the engine using the starter key.
9. Set the speed of the engine. (Do not exceed 3000rpm)
10. Now slowly load the engine using the loading wheel of the dynamometer.
11. Set the engine speed to before rating.
12. Note the following readings.
    a. Engine Speed.
    b. Time taken for ____cc of petrol consumption
    c. Rotameter readings.
    d. Manometer readings, in 'm' of water &
    e. Temperatures.
13. Repeat the experiment for other loadings.
14. After the completion release the load (while doing so release the accelerator) and then switch of the engine
    i. and the panel.
15. *Allow the water to flow for few minutes and then turn it off.
    a. *Note:
    b. Allow water only to the calorimeter and not to the engine.
16. Remove earthing connection of the battery and the starter key.

OBSERVATIONS:

Sl. No.	Speed, rpm	Load Applied	Manometer Reading			Time for 10 cc of fuel collected, t sec
			h1	h2	hw = (h1∼h2)	
1	1421	5.40	1.5	0.5	2=0.02	16.75

Sl. No.	T1	T2	T3	T4	T5	T6
1	28	29	39	42	164	65

Sl. No.	Engine water flowrate, LPM1	Calorimeter water flowrate, LPM2
1	6 Lit per min	3 Lit per min

CALCULATIONS:

1.Mass of fuel consumed, mf

$$\textbf{mf} = \frac{\text{Xcc x Specific gravity of the fuel}}{1000 \times t} \text{ kg/sec}$$

Where,

SG of Petrol is = 0.71

Xcc is the volume of fuel consumed = 10ml

t is time taken in seconds

Where,

Calorific Value of Petrol= 43120 kJ/kg

2.Output or Brake Power, BP

$$BP = \frac{W \times N \times 0.80}{2000} \text{ kW}$$

Where,

W = Load carried by the dynamometer

= Load indicator Reading in kg

N = Speed of the engine, rpm

Heat Balance Sheet Calculations IN SECONDS basis:

3.Heat Input --- A

A = mf x Calorific Value kW

4.Heat to BP --- B

B = kW

5.Heat to cooling water --- C

$$C = m_{we} \times C_{pw} \times (T_{ei} - T_{eo}) \quad kW$$

Where

m_{we} = cooling water flow rate to the engine from Rotameter

= LPM1/60 kg/sec

Cpw = Specific Heat of water = 4.18 kJ/kg

1. Heat to exhaust gases --- D

D = mwc x Cpw x (Tci – Tco) x [(Tgci – Ta)/ (Tgco – Tgci)] kW

Where

mwc = water flow rate in kg/sec

= LPM2/60 kg/sec

Cpw = Specific Heat of water

Ta = Engine surrounding temperature.

Tgci = Gas inlet temp to calorimeter

Tgco = Gas outlet temp from calorimeter

Tci = Water Inlet temp to calorimeter

Tco = Water outlet temp from calorimeter

2. Heat Unaccounted

E = A – (B+C+D) kW

SAMPLE CALCULATION:

1.Mass of fuel consumed, mf

$$m_f = \frac{\text{Xcc x Specific gravity of the fuel}}{1000 \times t} \text{ kg/sec}$$

$$m_f = \frac{10 \times 0.71}{1000 \times 16.75} \text{ kg/sec}$$

$$m_f = 4.23 \times 10^{-4} \text{ Kg/sec}$$

2.Output or Brake Power, BP

$$BP = \frac{W \times N \times 0.80}{2000} \text{ kW}$$

$$BP = \frac{5.40 \times 1421 \times 0.80}{2000} \text{ kW}$$

BP = 3.06 kW

Heat Balance Sheet Calculations IN SECONDS basis:

3.Heat Input --- A

$A = m_f \times \text{Calorific Value}$ kW

$A = 4.23 \times 10^{-4} \times 43120$ kW

$A = 18.239$ kW

4.Heat to BP --- B

$B = 3.06$ kW

5.Heat to cooling water --- C

$C = m_{we} \times C_{pw} \times (T_{ei} - T_{eo})$ kW

$m_{we} = 6/60$ kg/sec

mwe = 0.1 kg/sec

$C = 0.1 \times 4.18 \times (29 - 39)$ kW

C = -4.18 kW

6. Heat to exhaust gases --- D

$D = m_{wc} \times C_{pw} \times (T_{ci} - T_{co}) \times [(T_{gci} - T_a)/ (T_{gco} - T_{gci})]$ kW

$m_{wc} = 3/60 = 0.05$ kg/sec

$D = 0.05 \times 4.18 \times (29 - 39) \times [(164 - 28)/ (65 - 164)]$ kW

D = 2.87 kW

7. Heat Unaccounted

E = A – (B+C+D) kW

E = 18.239 – (3.06+4.18+2.87) kW

E = 16.489 kW

HEAT BALANCE SHEET:

Sl. No.	Particulars	Heat Content kW	%
1	Heat Input -- A	25.09	100
2	Heat to BP -- B	3.04	B/A = 13.55
3	Heat to Cooling Water -- C	-4.59	C/A =- 18.29
4	Heat to Exhaust Gases -- D	3.36	D/A =13.39
5	Heat Unaccounted -- E	22.92	E/A = 19.35

PRECAUTIONS:

1. Do not run the engine if supply voltage is less than 180V
2. Do not run the engine without the supply of water.
3. Supply water free from dust to prevent blockage in rotameters, engine head and calorimeter.
4. Note that the range for water supply provided is an approximate standard values, however the user may select the operating range to his convenience not less than 3 & 2 LPM for engine and calorimeter respectively.
5. Always set the accelerator knob to the minimum condition and start the engine.
6. Do not forget to give electrical earth and neutral connections correctly.
7. Frequently, at least once in three months, grease all visual moving parts.
8. At least once in week, operate the unit for five minutes to prevent any clogging of moving parts.
9. It is recommended to run the engine below **3000rpm** otherwise the rotating parts and bearing of dynamometer may run out.

RESULT: The heat balance sheet on four cylinder four stroke petrol engine is calculated.
Applications:

To analyze the various heat losses in four stroke petrol engine.

VIVA QUESTIONS

1. For same compression ratio and heat input ___ cycle has maximum efficiency.
2. Morse test is used to determine ___.
3. Draw the PV diagram of Otto cycle.
4. On which cycle petrol engine works?
5. Draw the TS diagram of Otto cycle.
6. Petrol engine is also called as __.
7. Why fuel injectors are not required in petrol engines?
8. Why carburettor is required inpetrol engine?
9. What is the self-ignition temperature of petrol?
10. Why spark plug is required in petrol engines?
11. How ignition of fuel is done in SI engines?
12. What is the source of heat that ignites fuel in petrol engine?
13. Why diesel engines are heavy when compared to petrol engines?
14. What is the type of heat addition inOtto cycle?
15. Air standard efficiency of Otto cycle is?
16. What is the range of efficiency of petrol engines?
17. Why petrol engines have low compression ratio?
18. What is the range of compression ratio for petrol engines?
19. What are the applications of petrol engines?
20. What is battery ignition?

EXPERIMENT-9

STUDY OF STEAM BOILERS

OBJECTIVE: To know the working of various boilers and its mountings and accessories.

OUT COME : Will be analyze working of various boilers and its mountings and accessories.

AIM:

A steam generator or boiler is, usually, a closed vessel made of steel. Its function is to transfer the heat produced by the combustion of fuel (solid, liquid or gaseous) to water, and ultimately to generate steam. The steam produced may be supplied.

1. To an external combustion engine, i.e. steam engines and turbines.
2. At low pressures for industrial process work in cotton mills, sugar factories, breweries, etc.
3. For producing hot water, this can be used for heating installations at much lower pressure.

IMPORTANT TERMS:

1. **Boiler shell:** It is made up of steel plates bent into cylindrical form and riveted or welded together. The ends of the shell are closed by means of end plates. A boiler shell should have sufficient capacity to contain water and steam.

2. **Combustion chamber:** It is the space, generally below the boiler shell, meant for burning fuel in order to produce steam from the water contained in the shell.

3. **Grate:** It is a platform, in the combustion chamber, upon which fuel (coal or wood) is burnt. The grate, generally, consists of cast iron bars which are spaced apart so that air (required for combustion) can pass through them. The surface area of the grate, over which the fire takes place, is called grate surface.

4. **Furnace:** It is the space, above the grate and below the boiler shell, in which the fuel is actually burnt. The furnace is also called *fire box.*

5. **Heating surface:** It is that part of boiler surface, which is exposed to the fire (or hot gases from the fire).

6. **Mountings:** These are the fittings which are mounted on the boiler for its proper functioning. They include water level indicator, pressure gauge, safety valve etc. It may be noted that a boiler cannot function safely without the mountings.

1. **Accessories:** These are the devices, which form an integral part of a boiler, but are not mounted on it. They include super heater, economizer, feed pump etc. It may be noted that the accessories help in controlling and running the boiler efficiently.

CLASSIFICATION OF STEAM BOILERS.

Though there are many classifications of steam boilers, yet the following are important from the subject point of view.

1. **According to the contents in the tube:** The steam boilers, according to the contents in the tube may be classified as:

   (a) Fire tube or smoke tube boiler, and (b) Water tube boiler.

   In *fire tube steam boilers,* the flames and hot gasses, produced by the combustion of fuels, pass through the tubes (called multi-tubes) which are surrounded by water. The heat is conducted through the walls of the tubes from the hot gases to the surrounding water. Examples of fire tube boilers are: Simple vertical boiler, Cochran boiler, Lancashire boiler, Cornish boiler, Scotch marine boiler, Locomotive boiler, and Velcon boiler.

   In *Water tube steam boilers,* the water is contained inside the tubes (called water tubes) which are surrounded by flames and hot gases from outside. Examples of water tube boilers are: Babcock and Wilcox boiler, Stirling boiler, La-Mont boiler, Benson boiler, Yarrow boiler and Loeffler boiler.

2. **According to the position of the furnace:** The steam boilers, according to the position of the furnace are classified as:

(a) Internally fired boilers, and (b) externally boilers.
In *Internally fired steam boilers,* the furnace is located inside the boiler shell.
Most of the fire tube steam boilers are internally fired.

In externally fired steam boilers, the furnace is arranged underneath in a brick work setting. Water tube steam boilers are always externally fired.

3. **According to the axis of the shell:** The steam boilers, according to the axis of the shell, may be classified as:

   (b) Vertical boilers and (b) Horizontal boilers.

   In *vertical steam boilers,* the axis of the shell is vertical. Simple vertical boiler and Cochran boiler are vertical boilers.

In *horizontal steam boilers,* the axis of the shell is horizontal. Lancashire boiler, Locomotive boiler and Babcock and Wilcox boiler are horizontal boilers.

4. **According to the number of tubes:** The steam boilers, according to the number of tubes, may be classified as:

   (a) Single tube boilers, and (b) Multitubular boilers.

   In *single tube steam boilers,* there is only one fire tube or water tube. Simple vertical boiler and Cornish boiler are single tube boilers.

   In *multitubular steam boilers*, there are two or more fire tubes or water tubes. Lancashire boiler, Locomotive boiler, Cochran boiler, Babcock and Wilcox boiler are multitubular boilers.

5. **According to the method of circulation of water and steam:**

   The steam boilers, according to the method of circulation of water and steam, may be classified as:

(a) Natural circulation boilers and (b) Forced circulation boilers.

   In *Natural circulation steam boilers,* the circulation of water is by natural convection currents, which are set up during the heating of water. In most of the steam boilers, there is a natural circulation of water.

   In *forced circulation steam boilers,* there is a forced circulation of water by a centrifugal pump driven by some external power. Use of forced circulation is made in high pressure boilers such as La-Mont boiler, Benson Boiler, Loffler boiler and Velcon boiler.

7. **According to the use:** The steam boilers, according to their use, may be classified as:
   (a) Stationary boilers, and (b) Mobile boilers.

   The *Stationary steam boilers* are used in power plants, and in industrial process work. These are called stationary because they do not move from one place to another.

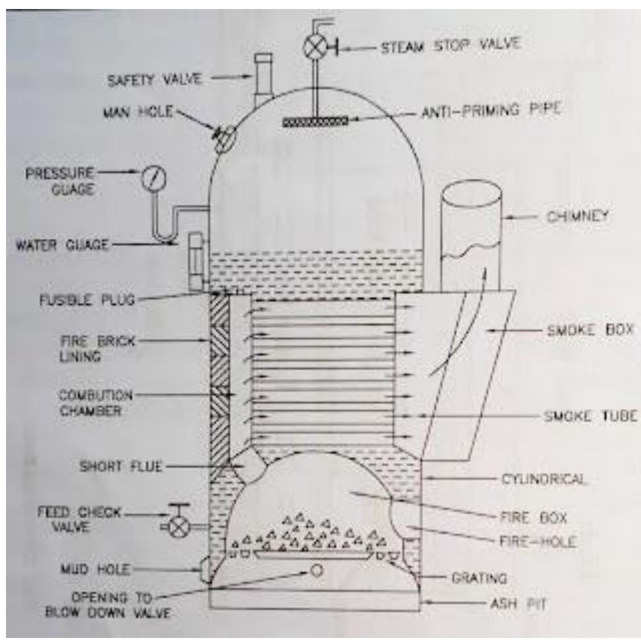
   The *mobile steam boilers* are those which move from one place to another. These boilers are locomotive and marine boilers.

8. **According to the source of heat:** The steam boilers may also be classified according to the source of heat supplied for producing steam. These sources may be the combustion of solid, liquid or gaseous fuel, hot waste gases as by products of other chemical processes, electrical energy or nuclear energy etc.

1) CONSTRUCTIONAL DETAILS OF COCHRAN BOILER:

This boiler consists of an external cylindrical shell and a fire box as shown in the Figure 1. The shell and fire box are both hemispherical. The hemispherical crown of the boiler shell gives maximum space and strength to withstand the pressure of steam inside the boiler. The hemispherical crown of the fire box is also advantageous for resisting intense heat. The fire box and the combustion chamber is connected through a short pipe. The flue gases from the combustion chamber flow to the smoke box through a number of smoke tubes. These tubes generally have 62.5 mm external diameter and are 165 in number. The gases from the smoke box pass to the atmosphere through a chimney. The combustion chamber is lined with firebricks on the shell side. A manhole near the top of the crown on the shell is provided for cleaning.

At the bottom of the fire box, there is a grate (in case of coal firing) and the coal is fed through the fire hole. If the boiler is used for oil firing, no grate is provided, but the bottom of the fire box is lined with firebricks. The oil burner is fitted at the fire hole.



2) CONSTRUCTIONAL DETAILS OF LACAHIRE BOILER:

It is a stationary, fire tube, internally fired, horizontal and natural circulation boiler. It is used where working pressure and power required are moderate. These boilers have a cylindrical shell of 1.75 m to 2.75 m diameter. Its length varies from 7.25 m to 9m, it has two internal flue tubes having diameter about 0.4 times that of shell. This type of boiler is set in brick work forming external flue so that part of the heating surface is on the external shell.

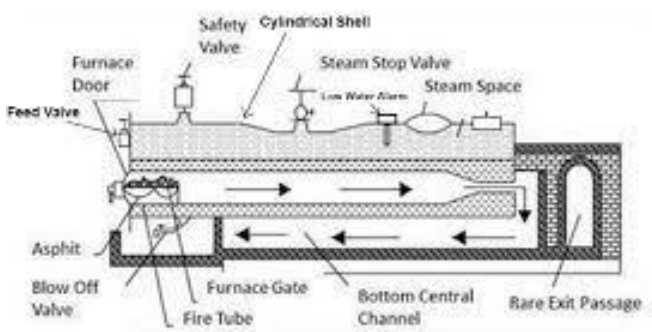
A Lancashire boiler with brick work setting is shown in the Figure - 2. This boiler consists of a long cylindrical external shell built of steel plates, in sections riveted together. It has two large internal flue tubes . These are reduced in diameter at the back end to provide access to the lower part of the boiler. A fire grate also called furnace, is provided at one end of the flue tubes on which solid fuel is burnt. At the end of the fire grate, there is a brick arch to deflect the flue gases upwards. The hot flue gases, after leaving the internal flue tubes pass down to the bottom tube . These flue gases move to the front of the boiler where they divided and flow into the side flue . The flue gases then enter the main flue , which leads them to chimney.

The damper is fitted at the end of side flues to control the draught (i.e. rate of flow of air) and thus regulate the rate of generation of steam. These dampers are operated by chain passing over a pulley on the front of the boiler.

A spring loaded safety valve and a stop value is mounted as shown in the Figure-2. The stop valve supplied steam to the engine as required. A high steam and low water safely valve is also provided.

A performed feed pipe controlled by a feed valve is used for feeding water uniformly. When the boiler is strongly heated, the steam generated carries a large quantity of water in the steam space, known as *printing.* An antipriming pipe is provided to separate out water as far as possible. The stop valve thus receives dry steam.

A blow-off cock removes mud, etc., that settled down at the bottom of the boiler, by forcing out some of the water. It is also used to empty water in the boiler, whenever required for inspection. Manholes are provided at the top and bottom of the boiler for cleaning and repair purposes.



Lancashire Boiler

3) CONSTRUCTIONAL DETAILS OF BABCOCK & WILCOX BOILER:

It is a straight tube, stationary type water tube boiler, as shown in the Figure-3. It consists of a steam and water drum It is connected by a short tube with up take header or riser At the back end.

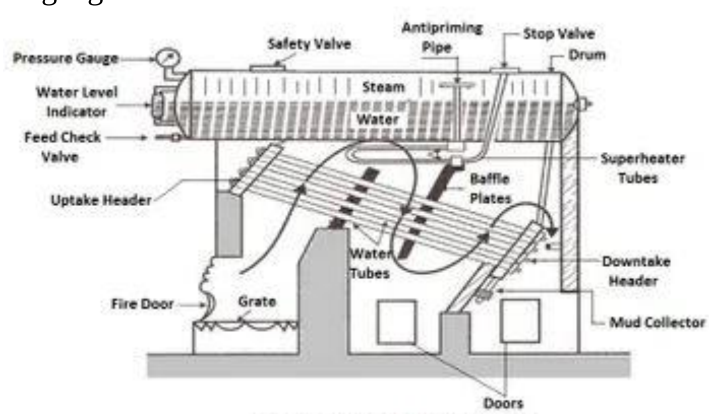
The water tubes 10 mm diameter, are inclined to the horizontal and connects the uptake header to the down take header. Each row of the tubes is connected with two headers, and there are plenty of such rows. The headers are curved when viewed in the direction of tubes so that one tube is not in the space of other, and hot gases can pass properly after heating all the tubes. The headers are provided with hand holes in the front of the tubes and are covered with caps .

A mud box is provided with each down take header and the mud, that settles down is removed. There is a slow moving automatic chain grate on which the coal is fed from the hopper . A fire bricks baffle causes hot gases to move upwards and downwards and again upwards before leaving the chimney. The dampers are operated by a chain which passes over a pulley to the front of a boiler to regulate the draught.

The boiler is suspended on steel girders, and surrounded on all the four sides by fire brick walls. The doors are provided for a man to enter the boiler for repairing and cleaning. Water circulates from the drum into the header and through the tubes to header and again to the drum. Water continues to circulate like this till it is evaporated. A steam super heater consists of a large number of steel tubes and contains two boxes one is superheated steam box and other is saturated steam box .

The steam generated above the water level in the drum flows in the dry pipe and through the inlet tubes into the superheated steam box . It then passes through the tubes into the saturated steam box . The steam, during its passage through tubes , gets further heated and becomes superheated. The steam is now taken through the outlet pipe to the stop valve .

The boiler is fitted with usual mountings, such as safety valve , feed valve , water level indicator and pressure gauge.



Babcock and Wilcox Boiler

RESULT: The working of various boilers and its mounting and accessories are studied

Applications :

- Operating room sterilization.
- Equipment sterilization.
- Production of clean steam.

- Providing heat for the building.
- Humidification for emergency rooms.
- Industrial laundry.
- Food preparation.

VIVA QUESTIONS

1. What is the function of boiler
2. Explain different types of boilers.
3. What is the difference between fire tube boiler and water tube boiler.
4. What are the various boiler mountings.
5. What are the various boiler accessories
6. What is the difference between boiler mountings and accessories
7. What is electronic ignition?
8. What is the advantage of electronic ignition over battery ignition?
9. Who invented petrol engine?
10. What are the stages of combustion in a SI engine?
11. What is ignition delay in SI engine?
12. What is propagation of flame in SI engine?
13. What is after burning in petrol engines?
14. How many stages of combustion are present in petrol engine?
15. How are SI engine fuels rated?
16. What is the calorific value of petrol?
17. What is specific gravity of petrol?
18. What is flash point of petrol?
19. What is fire point of petrol?
20. What is pre ignition?

EXPERIMENT-10

ASSEMBLY & DIS-ASSEMBLY OF AN ENGINE

OBJECTIVE: To get clear idea on different parts of a engine by dis-assembling it and again assembling the same engine to its original state

OUT COME: Will be analyze working of various boilers and its mountings and accessories.

SCOPE OF THE EXPERIMENT:
A steam boiler is a closed vessel, generally made of steel, in which water is heated by some source of heat produced by combustion of fuel and ultimately to generate steam. The steam produced may be supplied at low pressure for industrial process work in cotton mills, sugar industries etc.

AIM:
To study the procedure for assembly and dis-assembly of a specific engine by making a practical trail on it.

THEORY:
The main parts of any engine are

Cylinder block
1. It forms the basic frame work of the engine
2. It houses the engine cylinders
3. Serves as bearing or support and guides the piston reciprocating it
4. Block contains passengers for circulation of cooling water and lubricating oil. These are two types of rings
a) Compression ring
b) Oil control ring

Connecting rod
It connects the piston with the crank shaft thus facilitative the transmission of power combustion chamber to the crank shaft is also converts the reciprocating motion of the piston into rotary motion of crank shaft.

Fly wheel
The fly wheel absorbs the energy power source and gives out this energy the other 3-strokes keeping the crank shaft rotating at uniform speed through out.

Cam shaft
A shaft is responsible for opening the valves on addition the crank shaft operates.

Cylinder head
1. The head is mono block casting

2. It contains spark plug notes and cooling water jackets, valve opening mechanism is mounted.
3. Complete valve opening mechanism is mounted on the head.

Piston
The top of the piston is called head or crown it may be either done are may specially to form a desired shape of combustion chamber jointly with the cylinder block.

Piston Pin
It provides a seal between the piston fuel pump. Oil pump and distributor valves

Valves
These are accurate by the cams which in turn are operated by crank shaft and perform following function.

PROCEDURE FOR ENGINE DIS-ASSEMBLY:
For dis-assembly the engine, it should be mounted in a suitable stand. Engine disassembly is carried out in a sequence as follows and engine is out of the vehicle and anll the accessories have been removed and oil has been drained.
1. Remove water drained
2. Remove exhaust manifold
3. Remove oil filter
4. Remove water outlet fitting
5. Remove thermostat
6. Remove crank shaft pulley
7. Remove oil pump
8. Remove crank case ventilation valve
9. Remove rocker arm assembly
10. Remove cylinder head
11. Remove oil pan
12. Remove piston rod and connecting rod
13. Remove timing gear cover
14. Remove front end plate
15. Remove fly wheel housing
16. Remove fly wheel clutch
17. Remove crank shaft
18. Remove exhaust valve and springs
19. Remove camshaft, valve tappers
20. Remove oil gallery plugs

PROCEDURE FOR ENGINE ASSEMBLY:
For Assembly of the engine, it should be mounted in a suitable stand. Engine assembly is carried out in a sequence as follows and engine is out of the vehicle and all the accessories have been assembled.
1. First clean the cylinder block with fresh oil piston is connected to connecting rod with guide pin
2. The piston is fitted the piston rings

3. After fixing the rings piston is inserted into the cylinder block with help of ring compressor.
4. These rings are fitted in the piston grooves with help of calipers.
5. The crank shaft has been placed on the bottom of the cylinder block the connecting rod is connected to its crank.
6. The fly wheel is attached to the crank shaft one side
7. On the other side of the crank shaft timing gear is fitted for valve operating
8. This equipment is placed on the sump of the engine
9. After fixing on the sump the cam shafts are fitted in the cylinder head in the inlet valve and exhaust valves are fitted with help of GClamp
10. To the cylinder the intake manifold and injectors are fitted one side. Other side of the cylinder head the exhaust manifold is fitted
11. Fill the sump with new oil. After fill up the oil the water pump is fitted.
12. The thermostat is also fitted to this engine then the re-assembly of the given engine is completed.

RESULT:
The dis-assembly and assembly of IC engine is successfully performed

VIVA QUESTIONS
1. list out the various parts in engine
2. what is the function of spark plug.
3. What is the function of carburetor
4. what is the use of inlet and out let valves.
5. what is the use of ports
6. What is valve timing diagram?
7. What is port timing diagram?
8. What is difference between 2 stroke & 4 Stroke engines?
9. What is decompression lever?
10. Expand TDC.
11. Expand BDC.
12. What is the purpose of fly wheel?
13. Write the significance of inlet valve.
14. Write the significance of outlet valve.
15. Why CI engines are called so?
16. Why SI engines are called so?
17. What is a stroke?
18. Define piston speed.
19. What is bore?
20. What is swept volume
21. What is clearance volume?
22. Define compression ratio.

EXPERIMENT-11

PERFORMANCE TEST ON VARIABLE COMPRESSION RATIO TEST RIG

OBJECTIVE:
1. To demonstrate working of a variable compression ratio petrol engine.
2.To conduct performance test on the VCR engine under different compression ratio from 2.5: 1 to 8: 1 & to draw the heat balance sheet.

OUTCOME:
Performance of IC engine is analyzed by conducting the variable compression ratio test.

AIM:
The experiment is conducted to a) Study the performance characteristic of the engine and b) To draw performance curves and compare with standards.

THEORY:
A machine which uses heat energy obtained from combustion of fuel and converts it into mechanical energy is known as a heat engine. They are classified as external and internal combustion engine. In an external combustion engine, combustion takes place outside the cylinder and the heat generated from the combustion of the fuel is transferred to the working fluid which is then expanded to develop the power. IC engines may be classified based on the working cycle, thermodynamic cycle, speed, fuel, cooling, method of ignition, mounting of engine cylinder and application.

PROCEDURE:
1. Give the necessary electrical connections to the power
2. Check the lubrication level in the engine
3. Check the fuel level in the tank
4. Release the load it any on the dynamometer
5. Open the three way cock so that fuel flow to the engine
6. Set the accelerator to the minimum condition
7. Start the engine by cranking or by DC dynamometer
8. Allow to attain the steady state
9. Load the engine by switching on the load controller switches provided.

Note the following reading for particular condition

a) Engine speed
b) Time taken for CC of petrol consumption
c) Water meter readings
d) Manometer readings in cms of water
e) Temperature at different locations

f) Voltmeter and ammeter readings

10. Repeat the experiment for different loads and note down the above readings.

FORMULAS USED:

1. Mass of fuel consumed, m_f

$$m_f = \frac{X_{cc} \times \text{Specific gravity of the fuel}}{1000 \times t} \text{ kg/sec}$$

Where,

SG of Petrol is = 0.71

Xcc is the volume of fuel consumed = 10ml

t is time taken in seconds

1. Heat Input, HI

$$HI = m_f \times \text{Calorific Value of Fuel} \quad \text{kW}$$

Where,

Calorific Value of Petrol= 43120 kJ/kg

2. Output or Brake Power, BP

$$BP = V \times I \quad \text{kW}$$

Where,

V = voltage, volts

I = Current, amps

3. Specific Fuel Consumption, SFC

$$SFC = \frac{m_f \times 3600}{BP} \quad \text{kg/kW – hr}$$

4. Brake Thermal Efficiency, $\eta_{bth\%}$

$$\eta_{bth\%} = \frac{3600 \times 100}{SFC \times CV}$$

5. Mechanical Efficiency, $\eta_{mech\%}$

$$\eta_{mech\%} = \frac{BP}{IP} \times 100$$

IP is calculated using the Morse test facility

6. Calculation of head of air, H_a

$$H_a = h_w \frac{\rho_{water}}{\rho_{air}}$$

Where,

ρ_{water} = 1000 Kg/m3

ρ_{air} = 1.2 Kg/m3 @ R.T.P

h_w is the head in water column in 'm' of water

7. Volumetric efficiency, $\eta_{vol\%}$

$$\eta_{vol\,\%} = \frac{Q_a}{Q_{th}} \times 100$$

where,

Q_a = Actual volume of air taken = $C_d\, a \sqrt{(2gH_a)}$

Where,

C_d = Coefficient of discharge of orifice = 0.62

a = area at the orifice, = $(\Pi(0.025)^2/4)$

H_a = head in air column, m of air.

Q_{th} = Theoretical volume of air taken

$$Q_{th} = \frac{(\Pi/4) \times D^2 \times L \times 0.5\, N}{60}$$

Where,

D = Bore diameter of the engine = 0.07m

L = Length of the Stroke = 0.0667 m

N is speed of the engine in rpm.

OBSERVATION TABLE:

Sl. No.	Speed, rpm	Load Applied	Manometer Reading			Time for 10 cc of fuel collected, t sec	Voltage (v) volts	Current (I) Amp
			h1	h2	h_w = (h1~h2)			
1	2969	0.5	2	1	3=0.03	11.81	263	2.48

FRICTION POWER:

N	V	I
2745	195	5.23

Friction Power = (V X I)/1000 = (195 X 5.23)/1000

SAMPLE CALCULATIONS:

1. Mass of fuel consumed, m_f

$$m_f = \frac{Xcc \times \text{Specific gravity of the fuel}}{1000 \times t} \text{ kg/sec}$$

$$m_f = \frac{10 \times 0.71}{1000 \times 11.81} \text{ kg/sec}$$

$$m_f = 6.35 \times 10^{-4} \text{ kg/sec}$$

2. Heat Input, HI

$$HI = m_f \times \text{Calorific Value of Fuel} \quad kW$$

$$HI = 6.35 \times 10^{-4} \times 43120$$

$$HI = 27.381 \text{ kW}$$

3. Output or Brake Power, BP

$$BP = \frac{V \times I}{1000} \quad kW$$

$$BP = \frac{263 \times 2.48}{1000} \quad kW$$

$$BP = 0.65 \text{ kW}$$

4. Specific Fuel Consumption, SFC

$$SFC = \frac{m_f \times 3600}{BP} \quad kg/kW-hr$$

$$SFC = \frac{6.35 \times 10^{-4} \times 3600}{0.65} \quad kg/kW - hr$$

SFC = 2.93 kg/kW-hr

5. Brake Thermal Efficiency, $\eta_{bth\%}$

$$\eta_{bth\%} = \frac{3600 \times 1000}{SFC \times CV}$$

$$\eta_{bth\%} = \frac{3600 \times 1000}{2.93 \times 47120}$$

$\eta_{bth\%}$ = 26.07

6. Mechanical Efficiency, $\eta_{mech\%}$

$$\eta_{mech\%} = \frac{BP}{IP} \times 100$$

IP is calculated using the Morse test facility

$$\eta_{mech\%} = \frac{0.65}{1.669} \times 100$$

$\eta_{mech\%}$ = 38.94

7. Calculation of head of air, H_a

$$H_a = h_w \frac{\rho_{water}}{\rho_{air}}$$

$$H_a = \frac{0.03 \times 1000}{1.2}$$

H_a = 2.5

8. Volumetric efficiency, $\eta_{vol\%}$

$$\eta_{vol}\ \% = \frac{Q_a}{Q_{th}} \times 100$$

Q_a = Actual volume of air taken = C_d a √ (2gH_a)

= 0.62 X $(\Pi/4) X (0.015)^2$ **√ (2 X 9.81 X 2.5)**

= 2.42 X 10^{-3}

Q_{th} = Theoretical volume of air taken

$$Q_{th} = \frac{(\Pi/4) \times D^2 \times L \times N}{60 \times 2}$$

$$Q_{th} = \frac{(\Pi/4) \times 0.07^2 \times 0.0667 \times 0.5 \times 2969}{60}$$

$$Q_{th} = 6.35 \times 10^{-3}$$

$$\eta_{vol}\ \% = \frac{2.42 \times 10^{-3}}{6.35 \times 10^{-3}} \times 100$$

$$\eta_{vol}\ \% = 38\ \%$$

TABULATION:

Sl.	Input Power	Output Power	SFC	Brake Thermal Efficiency	Mechanical Efficiency	Volumetric efficiency
1	1.669	0.65	2.93	26.07	38.94	38

PRECAUTIONS:

1. Do not run the engine if supply voltage is less than 180V
2. Do not run the engine without the supply of water.
3. Supply water free from dust to prevent blockage in rotameters, engine head and calorimeter.
4. Note that the range for water supply provided is an approximate standard values, however the user may select the operating range to his convenience not less than 3 & 2 LPM for engine and calorimeter respectively.
5. Always set the accelerator knob to the minimum condition and start the engine.
6. Do not forget to give electrical earth and neutral connections correctly.
7. Frequently, at least once in three months, grease all visual moving parts.

GRAPHS TO BE PLOTTED:

1) SFC v/s BP

2) η_{bth} v/s BP

3) η_{vol} v/s BP

RESULT:
Determined the performance test on variable compression ratio

VIVA QUESTIONS
1. For same compression ratio and heat input ___ cycle has maximum efficiency.
2. Morse test is used to determine ___.
3. Draw the PV diagram of Otto cycle.
4. On which cycle petrol engine works?
5. Draw the TS diagram of Otto cycle.
6. Petrol engine is also called as __.
7. Why fuel injectors are not required in petrol engines?
8. Why carburettor is required inpetrol engine?
9. What is the self-ignition temperature of petrol?
10. Why spark plug is required in petrol engines?
11. How ignition of fuel is done in SI engines?
12. What is the source of heat that ignites fuel in petrol engine?
13. Why diesel engines are heavy when compared to petrol engines?
14. What is the type of heat addition inOtto cycle?
15. Air standard efficiency of Otto cycle is?
16. What is the range of efficiency of petrol engines?
17. Why petrol engines have low compression ratio?
18. What is the range of compression ratio for petrol engines?
19. What are the applications of petrol engines?
20. What is battery ignition?

EXPERIMENT-12

ECONOMICAL SPEED TEST ON 4-STROKE, MULTI CYLINDER PETROL ENGINE TEST RIG

OBJECTIVE:

1. To conduct a economical speed test on 4-stroke,4-cylinder petrol engine at various loads
2. To draw graphs

OUTCOME:

Performance of IC engine is analyzed by conducting the economical speed test.

AIM: To conduct a economical speed test on 4-stroke,4-cylinder petrol engine at various loads, for a given output

EQUIPMENT REQUIRED:

1. 4-stroke, 4 -cylinder petrol engine with a hydraulic dynamometer.
2. Tachometer (0-2000 rpm)
3. Stop watch

SPECIFICATIONS:

Make	:	Ambassador
No. of cylinders	:	4
Bore	:	73 mm
Stroke	:	90 mm
Rated Speed	:	1500 rpm
B. P.	:	7.35 KW(10 HP)
Orifice Diameter	:	35mm
Fuel	:	Petrol
Specific Gravity of petrol	:	0.716
Density of petrol	:	716 kg/m3
Caloric value of petrol	:	47100 KJ/kg

DESCRIPTION:

The test rig consists of a multi cylinder petrol engine coupled to a hydraulic dynamometer. The engine is Ambassador Brand and is 4-cylinder 4-stroke vertical engine developing 7.35 KW(10HP) at 1500 rpm. This type of engine is best suited for automobiles which operate at varying speed. The engine is fitted on a rigid bed and is coupled through a flexible coupling to a hydraulic dynamometer, acts as the loading device. All the instruments are mounted on a suitable panel board. Fuel consumption is measured with a burette and a 3-way cock which regulates the flow of fuel from the tank to the engine.

Air consumption is measured by using a M.S. tank, which is fitted with a standard orifice and a U-tube water manometer that measures the pressures inside the tank.

STARTING THE ENGINE:

1. Disengage the clutch and start the engine using the ignition key.

2. Engage the clutch slowly.
3. Adjust the throttle valve, so that the engine attains rated speed.

PROCEDURE:

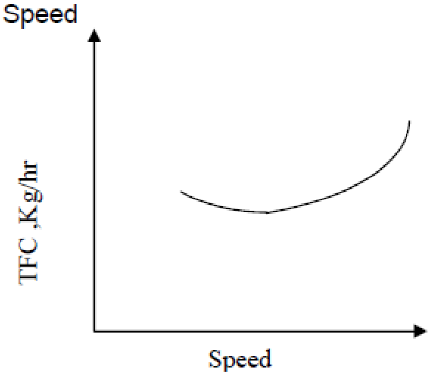
1. Before stating the engine, calculate the net load to be applied on hydraulic dynamometer at different speeds for maintaining constant B.P of the engine
2. Open the three way cock so that fuel flows to the engine directly from the tank.
3. Open the cooling water valves and ensure water flows through the engine.
4. Open the water line to the hydraulic dynamometer.
5. Start the engine and allow it to run on no load for a few minutes.
6. Operate the throttle valve so that the engine picks up the speed to the required level.
7. The engine is loaded to the calculated value with hydraulic dynamometer is done by turning the handle in the direction marked. If sufficient loaded is not absorbed by the dynamometer at the required speed, the outlet valve in the dynamometer can be closed to increase the pressure (as indicated by the pressure gauge) and hence the load.
8. Regulate the speed to the desired value by controlling the fuel supply to the engine
9. Note down the time taken for 10cc fuel consumption
10.Repeat the above procedure at different speeds under constant B.P of the engine 11.Repeat the above procedure for another constant B.P

PRECAUTIONS:

1. Before stating the engine check all the systems such as cooling, lubrication and fuel system
2. Ensure oil level is maintained in the engine upto recommended level always. Never run the engine with insufficient oil.
3. Never run the engine with insufficient engine cooling water and exhaust gas calorimeter cooling water.
4. For stopping the engine, load on the engine should be removed.

GRAPHS:

1. T.F.C Vs Speed



OBSERVATIONS:

SI.NO.	Load on the Dynamometer W kg	Speed RPM	Time for 10 CC of fuel (sec)	T.F.C kg/hr
1	1.5	1452	54	14.74
2	2	1396	68	16.12

SAMPLE CALCULATIONS:

Brake Power (BP_{max}) = $\frac{W\max\times N}{2000\times 1.36}$ …….KW

Where,

N= rated speed …… rpm,

W_{max}= Full load on the Dynamometer …….. Kg

Full Load, W_{max}= $\frac{B.P\times 2000\times 1.36}{N}$ ……. Kg

If Output power, B.P = l/2 $B.P_{max}$

Load on Dynamometer, W = $\frac{B.P\times 2000\times 1.36N}{N}$

Time for 10cc of fuel consumption, t = ……. Sec,

Mass of fuel consumption per min, m_f = $\frac{10}{t}\times\frac{density\ of\ diesel}{1000}\times 60$ …kg/ min.

Total Fuel consumption, TFC = mf × 60….kg / hr.

RESULT: Conducted a economical speed test on 4-stroke,4-cylinder petrol engine at various loads and plotted graph.

VIVA QUESTIONS:

1. What is an IC Engine?
2. Is open cycle gas turbine a IC engine or not?
3. Then subsequently asked what type of Engine is closed cycle Gas Turbine whether IC or EC
4. Which engine requires more maintenance 4 stroke or 2 stroke?
5. What are the unaccounted heat loss in an engine?
6. What is the difference between Knocking phenomenon in CI and SI engines?
7. What is the procedure followed to conduct the experiment of calculating
8. what is coolant classify its types
9. knocking and detonation
10. octane number and cetane number
11. What is electronic ignition?
12. What is the advantage of electronic ignition over battery ignition?
13. Who invented petrol engine?
14. What are the stages of combustion in a SI engine?

15. What is ignition delay in SI engine?
16. What is propagation of flame in SI engine?
17. What is after burning in petrol engines?
18. How many stages of combustion are present in petrol engine?
19. How are SI engine fuels rated?
20. What is the calorific value of petrol?