Parala Maharaja Engineering College
A CONSTITUENT COLLEGE OF B.P.U.T GOVT. OF ODISHA

LABORATORY MANUAL

(PC) RAU4C202 Automotive Engine Laboratory (AE)

PARALA MAHARAJA ENGINEERING COLLEGE
BRAHMAPUR
BPUT, ODISHA
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Department of

Automobile Engineering

Laboratory Location: Ground floor of workshop 2, Room no- LB-2/104

SEMISTAR-IV

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ପାରଳା ମହାରାଜା ଯାନ୍ତ୍ରିକ ମହାବିଦ୍ୟାଳୟ, ବ୍ରହ୍ମପୁର
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SAFETY IN THE LAB

- You are only allowed in the laboratory when there is a 'responsible person' present such as a demonstrator or the laboratory staff.

- Do not touch any equipment or machines kept in the lab unless you are asked to do so.

- A tidy laboratory is generally safer than an untidy one, so make sure that you do not have a confused tangle of electrical cables. Electrical equipment is legally required to be regularly checked, which means it should be safe and reasonably reliable: do not tamper or attempt to repair any electrical equipment (in particular, do not rewire a mains plug or change a fuse - ask one of the laboratory staff to do it). Never switch off the mains using the master switches mounted on the walls. Please make yourself aware of the fire exits when you first come into the lab. When the alarm sounds please leave whatever you are doing and make your way quickly, calmly and quietly out of the lab. You must always follow instructions from your demonstrators and the laboratory staff.

- You must keep walkways clear at all times and in particular coats and bags must be stowed away safely and must not pose a trip hazard.

- It is important that you make a point of reading the "Risk Assessment" sheet included in the manuscript of each experiment before you start work on the experiment.

- Please take notice of any safety information given in your scripts. If an experiment or project requires you to wear PPE (personal protective equipment) such as gloves and safety glasses, then wear them.

- Always enter the lab wearing your shoes. It is strictly prohibited to enter the lab without shoes.

- There must be NO smoking, eating, drinking, use of mobile phones or using personal headphones in the laboratory. This last point is not because we dislike your choice of music but because you must remain aware of all activity around you and be able to hear people trying to warn you of problems.

- Keep the lab neat and clean.

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Experiment-1

Dismantling and study of petrol engine

Aim of the experiment:

- To study the construction, working principles, and components of a petrol engine.
- To dismantle, inspect the petrol engine.

Tools and Equipment Required:

- Socket wrench set
- Spanners and screwdrivers
- Torque wrench
- Pliers and circlip pliers
- Feeler gauge and micrometer
- Engine stand or workbench
- Cleaning agents and lubricants

Theory:

A petrol engine is an internal combustion engine that uses petrol as fuel. It operates on the Otto cycle, generating power through the combustion of an air-fuel mixture inside the combustion chamber.

Engine Components:

Main Parts of a Petrol Engine:

1. Cylinder Block: Houses the cylinders and forms the engine's main body.
2. Cylinder Head: Covers the cylinders and contains the combustion chambers.
3. Piston: Moves up and down inside the cylinder.
4. Connecting Rod: Connects the piston to the crankshaft.
5. Crankshaft: Converts reciprocating motion into rotary motion.
6. Camshaft: Controls valve timing and movement.
7. Valves: Allow air-fuel intake and exhaust gas exit.
8. Spark Plug: Ignites the air-fuel mixture.
9. Fuel Injector/Carburettor: Supplies the air-fuel mixture.
10. Timing Belt/Chain: Synchronizes the camshaft and crankshaft

Dismantling Procedure:

1. Preparation:
    - Place the engine on a stand or workbench.
    - Clean the engine exterior.
2. Step 1: Remove External Components
    - Disconnect fuel lines, spark plugs, and electrical connectors.
    - Remove the alternator, air filter, and cooling fan.
3. Step 2: Dismantle the Cylinder Head
    - Remove the cylinder head bolts using a torque wrench.
    - Take out the cylinder head carefully to avoid damaging the gasket.
4. Step 3: Remove the Valves and Camshaft
    - Compress the valve springs and remove the valves using a valve spring compressor.
    - Take out the camshaft and timing belt/chain.
5. Step 4: Remove Pistons and Connecting Rods
    - Detach the oil sump at the bottom of the engine.
    - Unscrew connecting rod bolts and remove the pistons.
6. Step 5: Remove the Crankshaft
    - Remove main bearing caps.
    - Lift out the crankshaft.
7. Step 6: Inspect Engine Components
    - Check the pistons for wear, cracks, and carbon deposits.
    - Inspect cylinder walls for scoring or scratches.
    - Measure crankshaft and camshaft journals for wear.
    - Inspect the gasket and oil seals for leaks.

Precautions:

- Use safety gear such as gloves and safety glasses.
- Ensure the engine is secure on a stable workbench.
- Follow the correct sequence when tightening bolts.
- Apply lubricants to reduce wear and prevent corrosion.
- Label components and store them in a clean environment.

Conclusion:

Experiment-2

Assembling of petrol engine

Aim of the experiment:

- To study the construction, working principles, and components of a petrol engine.
- To dismantle, inspect and reassembling of the petrol engine.

Tools and Equipment Required:

- Socket wrench set
- Spanners and screwdrivers
- Torque wrench
- Pliers and circlip pliers
- Feeler gauge and micrometer
- Engine stand or workbench
- Cleaning agents and lubricants

Theory:

Spark-ignition engines normally use volatile liquid fuels. Preparation of fuel-air mixture is done outside the engine cylinder and formation of a homogeneous mixture is normally not completed in the inlet manifold. Fuel droplets, which remain in suspension, continue to evaporate and mix with air even during suction and compression processes. The process of mixture preparation is extremely important for spark-ignition engines. The purpose of carburetion is to provide a combustible mixture of fuel and air in the required quantity and quality for efficient operation of the engine under all conditions.

The process of formation of a combustible fuel-air mixture by mixing the proper amount of fuel with air before admission to engine cylinder is called carburetion and the device which does this job is called a carburettor.

Assembly Procedure:

1. Reinstall the Crankshaft:
    - Apply engine oil to bearings.
    - Secure crankshaft with bearing caps.
2. Install Pistons and Connecting Rods:
    - Install new piston rings if required.
    - Attach connecting rods to the crankshaft.
3. Reinstall the Valves and Camshaft:
    - Insert valves and springs.
    - Align and attach the camshaft.
4. Reinstall the Cylinder Head:
    - Replace the cylinder head gasket if necessary.
    - Tighten the cylinder head bolts in a crisscross pattern using the correct torque.

5. Install External Components:
    - Reconnect spark plugs, fuel lines, and wiring.
    - Reinstall the alternator, air filter, and cooling system components.
6. Final Inspection and Testing:
    - Check oil levels and refill engine oil.
    - Start the engine and check for smooth operation.

Precautions:

- Use safety gear such as gloves and safety glasses.
- Ensure the engine is secure on a stable workbench.
- Follow the correct sequence when tightening bolts.
- Apply lubricants to reduce wear and prevent corrosion.
- Label components and store them in a clean environment.

Conclusion:

Experiment-3

Dismantling and study of diesel engine

Aim of the experiment:

- To study the construction and working of a diesel engine.
- To dismantle, inspect of the diesel engine.
- To understand engine components, their functions, and maintenance practices.

Tools and Equipment Required:

- Socket wrench set
- Spanners and screwdrivers
- Torque wrench
- Pliers and circlip pliers
- Feeler gauge and micrometer
- Engine stand or workbench
- Cleaning agents and lubricants

Theory:

A diesel engine is an internal combustion engine that uses diesel fuel. It operates on the Diesel cycle**,** where combustion occurs due to the heat generated by compressing air in the cylinder, eliminating the need for spark plugs.

Main Parts of a Diesel Engine:

1. Cylinder Block**:** Contains the engine's cylinders and crankcase.
2. Cylinder Head: Covers the cylinder block and contains the combustion chambers, valves, and injectors.
3. Piston: Moves inside the cylinder, transferring combustion energy.
4. Connecting Rod: Connects the piston to the crankshaft.
5. Crankshaft: Converts reciprocating motion into rotational motion.
6. Camshaft: Controls valve operation and timing.
7. Valves: Control air intake and exhaust gas expulsion.
8. Fuel Injector: Injects diesel fuel into the combustion chamber.
9. Glow Plug (if present): Helps start the engine in cold conditions.
10. Timing Gear/Chain: Synchronizes the camshaft and crankshaft.
11. Oil Pump: Circulates lubricating oil.
12. Turbocharger (if applicable): Increases engine power by forcing more air into the cylinders.

Dismantling Procedure:

Step 1: Preparation

- Mount the engine on a secure workbench or engine stand.
- Disconnect the battery if installed.

Step 2: Remove External Components

- Detach the air filter, fuel lines, and electrical connectors.
- Remove the exhaust manifold, alternator, and turbocharger (if present).

Step 3: Remove Cylinder Head

- Unscrew cylinder head bolts in a crisscross pattern using a torque wrench.
- Carefully lift off the cylinder head to avoid damaging the gasket.

Step 4: Remove the Valve Mechanism

- Use a valve spring compressor to remove valves and springs.
- Extract the camshaft, timing gear/chain, and pushrods (if applicable).

Step 5: Remove the Pistons and Connecting Rods

- Detach the oil sump.
- Unscrew connecting rod caps and push out the pistons through the top of the cylinders.

Step 6: Remove the Crankshaft

- Remove the main bearing caps.
- Lift out the crankshaft carefully.

Step 7: Inspect Components

- Inspect the following components for wear, cracks, and deposits:
    - Pistons and rings
    - Cylinder walls for scoring
    - Valves and seats
    - Crankshaft and camshaft journals
    - Fuel injectors and glow plugs

Conclusion:

Experiment-4

Assembling of diesel engine

Aim of the experiment:

- To study the construction and working of a diesel engine.
- To dismantle, inspect of the diesel engine.
- To understand engine components, their functions, and maintenance practices.

Tools and Equipment Required:

- Socket wrench set
- Spanners and screwdrivers
- Torque wrench
- Pliers and circlip pliers
- Feeler gauge and micrometer
- Engine stand or workbench
- Cleaning agents and lubricants

Theory:

The diesel engine gains its energy by burning fuel injected or sprayed into the compressed, hot air charge within the cylinder. The air must be heated to a temperature greater than the temperature at which the injected fuel can ignite. Fuel sprayed into air that has a temperature higher than the "auto-ignition" temperature of the fuel spontaneously reacts with the oxygen in the air and burns. Air temperatures are typically in excess of 526 °C (979 °F); however, at engine start-up, supplemental heating of the cylinders is sometimes employed, since the temperature of the air within the cylinders is determined by both the engine's compression ratio and its current operating temperature. Diesel engines are sometimes called compression-ignition engines because initiation of combustion relies on air heated by compression rather than on an electric spark.

In a diesel engine, fuel is introduced as the piston approaches the top dead centre of its stroke. The fuel is introduced under high pressure either into a precombustion chamber or directly into the piston-cylinder combustion chamber. With the exception of small, high-speed systems, diesel engines use direct injection.

The combustion process in a diesel engine is heterogeneous—that is, the fuel and air are not premixed prior to initiation of combustion. Consequently, rapid vaporization and mixing of fuel in air is very important to thorough burning of the injected fuel. This places much emphasis on injector nozzle design, especially in direct-injection engines.

Assembly Procedure:

Step 1: Reinstall the Crankshaft

- Oil the crankshaft journals.
- Place the crankshaft and secure it with main bearing caps.

Step 2: Install Pistons and Connecting Rods

- Fit piston rings if needed.
- Insert pistons into cylinders and secure connecting rods.

Step 3: Install Valves and Camshaft

- Place valves, valve springs, and retainers.
- Install the camshaft and timing gear/chain.

Step 4: Attach the Cylinder Head

- Use a new cylinder head gasket if required.
- Tighten head bolts to the recommended torque in a crisscross pattern.

Step 5: Reinstall External Components

- Attach injectors, fuel lines, air intake manifold, and exhaust system.
- Reconnect the cooling system and turbocharger if present.

Step 6: Final Inspection and Testing

- Check oil levels and refill engine oil.
- Perform a dry run by rotating the crankshaft manually.
- Start the engine and observe its operation

Conclusion:

Experiment-5

Study of petrol engine fuel system

Aim of the experiment:

- To understand the components and working of the petrol engine fuel system.
- To study different types of fuel supply systems used in petrol engines.
- To learn about fuel delivery, mixing, and injection processes.

Tools and Equipment Required:

- Petrol engine model or cut-section
- Fuel tank, fuel pump, and fuel injector setup
- Carburettor assembly (if applicable)
- Multi meter for electrical checks
- Fuel pressure gauge
- Safety equipment (gloves, goggles

Theory:

The petrol engine fuel system delivers a precise air-fuel mixture to the engine cylinders for combustion. It ensures proper fuel delivery under varying engine loads and speeds.
The fuel supply system in SI engines or petrol engines helps deliver optimum fuel and air to the combustion chamber for power generation. It consists of several components such as the fuel tank, fuel pump, fuel filters, fuel lines, fuel injectors, carburettor, etc. All these parts work together and ensure sufficient fuel reaches the engine. Here's a list of the parts of a petrol engine fuel system.

Types of Fuel Systems:

1. Carburetor System (Conventional):

- Mixes air and fuel mechanically before entering the engine.
- Used in older engines.

Main Parts of the Carburettor System:

- Fuel tank
- Fuel pump (mechanical or electric)
- Carburetor (main jet, throttle valve, venturi)
- Air filter

2. Fuel Injection System (Modern):

a. Single Point Injection (Throttle Body Injection):

- Fuel is injected into the throttle body.

b. Multi-Point Fuel Injection (MPFI):

- Fuel is injected directly into each intake port of the cylinder.

c. Gasoline Direct Injection (GDI):

- Fuel is injected directly into the combustion chamber for precise control.

Main Parts of the Fuel Injection System:

- Fuel tank
- Fuel pump (in-tank or inline)
- Fuel filter
- Fuel injectors
- Fuel pressure regulator
- Electronic Control Unit (ECU)
- Sensors (MAP, TPS, oxygen, crankshaft position)

Working of the Fuel System:

1. Fuel Delivery:
    - The fuel pump draws fuel from the tank and delivers it to the fuel injectors or carburettor.
2. Air-Fuel Mixing:
    - In carburettor engines, fuel mixes with air in the venturi.
    - In fuel-injected engines, fuel injectors spray fuel into the intake ports or combustion chamber.
3. Fuel Injection Control:
    - Sensors monitor engine parameters.
    - The ECU adjusts fuel delivery based on engine load, speed, and throttle position.
4. Combustion:
    - The air-fuel mixture enters the cylinder, where it ignites due to the spark plug.

Fuel System Components and Functions:

Component	Function
Fuel Tank	Stores fuel.
Fuel Pump	Delivers fuel from the tank to the engine.
Fuel Filter	Removes impurities from the fuel.
Carburettor/Fuel Injector	Mixes fuel and air for combustion.
Fuel Pressure Regulator	Maintains constant fuel pressure in the fuel rail.
Air Filter	Removes dust and debris from the intake air.
Throttle Body	Controls airflow into the engine.

Conclusion:

Experiment-6

Study of diesel engine fuel system

Aim of the experiment:

- To study the construction, working, and components of the diesel engine fuel system.
- To understand fuel delivery, injection, and combustion processes.
- To learn about different types of diesel fuel injection systems.

Tools and Equipment Required:

- Diesel engine model or cut-section
- Fuel pump, fuel injector test bench
- Multi meter and fuel pressure gauge
- Diesel engine diagnostic tools
- Safety equipment (gloves, goggles)

Theory:

The diesel engine fuel system delivers and injects diesel fuel into the combustion chamber under high pressure. It relies on compression ignition, where the fuel-air mixture ignites due to high temperatures generated by compressing air in the cylinder.

Types of Diesel Fuel Systems:

1. Common Rail Direct Injection (CRDI):

- Used in modern engines for better efficiency and reduced emissions.
- Common rail maintains constant fuel pressure, allowing precise fuel injection.

2. Individual Pump System:

- Each cylinder has its own fuel pump and injector.

3. Distributor (Rotary) Pump System:

- A single fuel pump supplies fuel to all injectors through a distributor mechanism.

4. Unit Injector System:

- Combines the injector and pump into a single unit per cylinder.

Observation Procedure:

Step 1: Fuel Supply System Inspection

- Inspect the fuel tank, fuel lines, and fuel pump.
- Note the position of the fuel filter and water separator.

Step 2: Fuel Injection System Study

- Identify the high-pressure fuel pump and injectors.
- Observe the arrangement of fuel rails in a CRDI system.

Step 3: Fuel Injection Process Demonstration

- Use a fuel injector test bench to observe spray patterns.
- Measure fuel injection pressure and atomization quality.

Step 4: Sensors and ECU Operation (if applicable)

- Identify key sensors such as the crankshaft position sensor (CPS), manifold absolute pressure (MAP), and fuel pressure sensor.
- Observe how the ECU manages injection timing based on sensor data.

Working of the Diesel Fuel System:

1. Fuel Delivery:
    - The low-pressure fuel pump draws diesel fuel from the tank through the filter.
2. Fuel Pressurization:
    - The high-pressure pump compresses the fuel and sends it to the injectors or common rail.
3. Fuel Injection:
    - Injectors spray fuel into the combustion chamber at precise timing and pressure.
    - In CRDI systems, the ECU electronically controls fuel injection based on engine load, speed, and throttle position.
4. Combustion:
    - Due to high compression, fuel ignites automatically, generating power

Conclusion:

Experiment-7

Study of cooling system

Aim of the experiment: To study the working principles and components of a cooling tower.

Tools required:

- Pressurised cooling system
- Air cooling system
- Forced air cooling system

Theory:

Radiator-

It is the key component of the engine cooling system. Its main role is to dissipate a mix of anti freeze and water throughout its fin. Cross flow heat exchanger used in automobile radiator.

Thermostat-

Different types of thermostat line voltage thermostat and low voltage thermostat. Each of these thermostat type work within certain type work within certain type system.

Water pump-

The water is pumped from the lower elevation to a storage area where it is controlled until it is needed.

Hose pipe-

Engine hose pipe serves a critical role in the overall functioning of the AC system by transferring refrigerant and facilitate the cooling system process.

Result:

From the above experiment we studied about the forced air cooling and pressurised liquid cooling system.

Experiment-8

Study of lubrication system

Aim of the experiment:

- To study the components, working, and types of engine lubrication systems.
- To understand the role of lubrication in reducing friction, wear, and cooling engine components.
- To learn about lubrication system performance parameters and maintenance.

Tools and Equipment Required:

- Engine lubrication system model or working setup
- Oil pressure gauge
- Oil filter, oil pump, and sump
- Multi meter for electrical checks (if applicable)

Theory:

A lubrication system reduces friction between engine components, minimizes wear, and assists in cooling by transferring heat away from moving parts. It maintains a continuous supply of lubricating oil to various engine components.

Types of Lubrication Systems:

1. **Splash System:** Oil is splashed onto engine components using dipper rods.
2. **Pressure System:** Oil is forced under pressure to various engine components.
3. **Combined System:** Uses both splash and pressure mechanisms.

Lubrication Process:

1. Oil Storage:
   - Oil is stored in the sump (oil pan).
2. Oil Circulation:
   - The oil pump draws oil from the sump and forces it through the oil filter.
3. Oil Filtration:
   - The oil filter removes contaminants and debris from the oil.
4. Oil Distribution:
   - Oil is sent to engine parts through oil galleries, lubricating the crankshaft, camshaft, bearings, and valve mechanisms.
5. Oil Cooling:
   - If an oil cooler is present, the oil passes through it before returning to the sump.

Procedure:

Experimental Procedure:

Step 1: System Inspection

- Inspect the lubrication system layout and components.
- Identify the oil pump, oil filter, and pressure relief valve.

Step 2: Initial Readings

- Check the oil level using the dipstick.
- Measure oil pressure using an oil pressure gauge.

Step 3: System Operation

- Start the engine (if operational) or use a simulation setup.
- Observe oil flow through various components.
- Note oil pressure readings at idle and under load conditions.

Step 4: Data Collection

- Record oil pressure, oil temperature, and engine RPM readings.

Conclusion:

Experiment-9

Study of turbo charger and super charger

Aim of the experiment:

- To study the construction, working, and components of turbochargers and superchargers.
- To understand their role in engine performance enhancement.
- To compare the working principles, advantages, and applications of both systems.

Tools and Equipment Required:

- Turbocharger and supercharger models or working setups
- Engine setup with forced induction (if available)
- Tachometer
- Pressure gauge or boost pressure meter
- Temperature sensors (for inlet and outlet air temperature)

Theory:

Turbocharger:

- A turbocharger is a forced induction device that uses exhaust gas energy to drive a turbine, compressing incoming air into the engine. This increases air density, resulting in more fuel combustion and increased engine power.

Supercharger:

- A supercharger is a mechanically driven forced induction device powered by the engine's crankshaft. It compresses the incoming air, enhancing engine performance by delivering more oxygen for combustion.

Working Principles:

Turbocharger Working:

1. Hot exhaust gases pass through the turbine side.
2. The turbine spins the compressor, drawing in fresh air.
3. The compressed air is forced into the engine’s intake manifold.
4. An intercooler cools the air, making it denser for better combustion.

Supercharger Working:

1. The engine crankshaft drives the supercharger using a belt.
2. The supercharger compresses incoming air.
3. The compressed air is delivered directly into the intake manifold.
4. An intercooler may be used to cool the compressed air.

Experimental Procedure:

Step 1: Setup Inspection

- Check the installation of the turbocharger or supercharger on the engine.
- Ensure all gauges, sensors, and meters are operational.

Step 2: System Operation (if operational setup is available)

- Start the engine at idle speed.
- Gradually increase the engine RPM and observe the boost pressure.
- Measure air temperatures at the intake and after compression.

Step 3: Data Collection

- Record engine RPM, boost pressure, and air temperatures before and after the compressor.
- Note any changes in exhaust temperature (for turbocharger).

Conclusion:

Experiment-10

Morse test

Aim of the experiment:

To determine the Indicated Power (IP), Brake Power (BP), Friction Power (FP), and Mechanical Efficiency (ηm) of a multi-cylinder engine using the Morse Test method

Tools and Equipment Required:

- Multi-cylinder engine test setup
- Dynamometer (for measuring brake power)
- Tachometer (for measuring engine speed)
- Fuel flow meter (for fuel consumption measurement)

Morse Test Principle:

The Morse test is used to calculate the friction power of a multi-cylinder engine by cutting off one cylinder at a time. When a cylinder is disabled, the engine continues running on the remaining active cylinders. The reduction in brake power is measured, and the indicated power of the disabled cylinder is estimated.

Important Terms:

- Brake Power (BP): Actual power available at the crankshaft.
- Indicated Power (IP): Total power generated within the engine cylinders.
- Friction Power (FP): Power lost due to friction in engine components.

Formulas:

1. **Brake Power (BP):**

   $BP = 2\pi NT/60$ (in kW)

   Where:

   - N: Engine speed in RPM
   - T: Torque in Nm

2. **Indicated Power (IP):**

   $IP = \sum$(BP with all cylinders − BP of each disabled cylinder

3. **Friction Power (FP):**

   $FP = IP - BP$

4. **Mechanical Efficiency (η_m):**

   H_m=BP/IP×100

Procedure:

A. Preliminary Checks:

1. Check that all components are properly connected.
2. Ensure fuel and oil levels are adequate.
3. Start the engine and allow it to warm up.

B. Experimental Procedure:

Step 1: Measure BP with All Cylinders Active

- Run the engine at a constant speed.
- Measure torque (T) and engine speed (N).
- Calculate the brake power (BP).

Step 2: Disable One Cylinder

- Disable the first cylinder (by cutting off its spark plug or fuel supply).
- Record the reduced brake power as BP1.

Step 3: Repeat for All Cylinders

- Disable each cylinder one by one.
- Record brake power values BP2, BP3, BP4, etc., for the respective cylinders.

Calculations:

1. Indicated Power (IP):

   IP=BP with all cylinders + Sum of BP losses for each cylinder

2. Friction Power (FP):

   FP= I.P−B.P

3. Mechanical Efficiency (ηm):

   η=BP/IP×100

Precautions:

- Ensure the engine is properly lubricated and cooled.
- Do not run the engine with a disabled cylinder for too long to avoid damage.
- Measure torque and speed accurately.
- Use appropriate safety gear like gloves and goggles.

Conclusion: