LABORATORY MANUAL

APPLIED THERMODYNAMICS LAB

SUBJECT CODE: KME-451

B.TECH. (ME) SEMESTER -IV

Academic Session: 2022-23, Even Semester

Student Name:	
Roll. No.:	
Branch/Section:	

Dronacharya Group of Institutions
Plot No. 27, Knowledge Park-3, Greater Noida, Uttar Pradesh 201308
Affiliated to
Dr. A P J Abdul Kalam Technical University
Lucknow, Uttar Pradesh 226031

Table of Contents

Vision and Mission of the Institute

Vision:

"Dronacharya Group of Institutions, Greater Noida aims to become an Institution of excellence in imparting quality Outcome Based Education that empowers the young generation with Knowledge, Skills, Research, Aptitude and Ethical values to solve Contemporary Challenging Problems"

Mission:

We, at Dronacharya Group of Institutions, are absolutely committed to serve the society and improve the mode of life by imparting high quality education in the field of Engineering and Management catering to the explicit needs of the students, society, humanity, and industry. 'Shiksha evam Sahayata' i.e. Education and help are the two words etched on our banner soaring higher year after year.

Vision and Mission of the Department

Vision:

"To become a Centre of Excellence in teaching and research in Mechanical Engineering for producing skilled professionals having a zeal to serve society"

Mission:

M1: To create an environment where students can be equipped with strong fundamental concepts.

M2: To provide an exposure to emerging technologies by providing hands on experience for generating competent professionals.

M3: To promote Research and Development in the frontier areas of Mechanical Engineering and encourage students for pursuing higher education

M4: To inculcate in students ethics, professional values, team work and leadership skills.

Program Educational Objectives (PEOs)

PEO 1. Engineers will practice the profession of engineering using a systems perspective and analyze, design, develop, optimize & implement engineering solutions and work productively as engineers, including supportive and leadership roles on multidisciplinary teams.

PEO 2. Continue their education in leading graduate programs in engineering & interdisciplinary areas to emerge as researchers, experts, educators & entrepreneurs and recognize the need for, and an ability to engage in continuing professional development and life-long learning.

PEO 3. Engineers, guided by the principles of sustainable development and global interconnectedness, will understand how engineering projects affect society and the environment.

PEO 4. Promote Design, Research, and implementation of products and services in the field of Engineering through Strong Communication and Entrepreneurial Skills.

PEO 5. Re-learn and innovate in ever-changing global economic and technological environments of the 21st century.

Program Outcomes (POs)

PO1: Engineering knowledge: Apply knowledge of mathematics, science, and engineering in Mechanical Engineering.

PO2: Problem analysis: Design and conduct experiments, as well as to analyze and interpret data.

PO3: Design/development of solutions: To design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

PO4: 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.

PO5: Modern tool usage: Apply principles of engineering, basic science, and mathematics to design and realize physical systems, components, or processes.

Use the techniques, skills, and modern engineering tools necessary for engineering practice like AUTOCAD.

PO6: 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 practice.

PO7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.

PO9: Individual and teamwork: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11: 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.

PO12: Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs)

PSO 1: Graduates of the program will achieve excellence in product design, thermal engineering and manufacturing system by acquiring knowledge in mathematics, science and designing principles.

PSO 2: Graduate will be able to analyze, interpret and provide solutions to the real life mechanical engineering problems.

PSO 3: Graduate will develop an approach to solve multidisciplinary problems of manufacturing and allied industries.

PSO 4: Graduates will learn managerial skills to work effectively in a team and in a society by following ethical and environmental practices.

University Syllabus

1. Study of Fire Tube boiler.
2. Study of Water Tube boiler.
3. Study and working of Two stroke petrol Engine.
4. Study and working of Four stroke petrol Engine.
5. Determination of Indicated H.P. of I.C. Engine by Morse Test.
6. Prepare the heat balance sheet for Diesel Engine test rig.
7. Prepare the heat balance sheet for Petrol Engine test rig.
8. Study and working of two stroke Diesel Engine.
9. Study and working of four stroke Diesel Engine.
10. Study of Velocity compounded steam turbine.
11. Study of Pressure compounded steam turbine.
12. Study of Impulse & Reaction turbine.
13. Study of steam Engine model.
14. Study of Gas Turbine Model.

Course Outcomes

CO 1	After completing this course, the students will get a good understanding of various practical power cycles and heat pump cycles.
CO 2	They will be able to analyze energy conversion in various thermal devices such as combustors, air coolers, nozzles, diffusers, steam turbines and reciprocating compressors.
CO 3	They will be able to understand phenomena occurring in high speed compressible flows.

CO-PO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO 1	1		1		3			2	3	1	3	1
CO 2	1		3		3			2	3	1	3	1
CO 3	1		3		3			2	3	1	3	1

CO-PSO Mapping

	PSO1	PSO2	PSO3
CO 1	2		2
CO 2	2		2
CO 3	2		2

Course Overview

1. To understand the construction and working of Bomb calorimeter, steam engine, turbine, boiler mountings, boiler accessories.

2. To understand working principle and performance of boiler, draught, steam nozzle and reciprocating air compressor.

3. To study and understand working of steam turbines.

4. To understand the concept of heat balance sheet for boiler.

List of Experiments mapped with COs

S. No	Aim of the Experiment	COs
1.	Study of fire tube boiler	**CO2**
2.	Study of water tube boiler	**CO2**
3.	Study and working of four stroke petrol Engine.	**CO1**
4.	Study and working of four stroke diesel Engine.	**CO1**
5.	Study and working of two stroke petrol Engine.	**CO1**
6.	Study and working of two stroke diesel Engine.	**CO1**
7.	Study of gas turbine model.	**CO3**

DOs and DON'Ts

DOs

1. Student must carry record and observation.
2. Take signature of lab in charge after completion of observation and record.
3. If any equipment fails in the experiment report it to the supervisor immediately.
4. Students should come to the lab with thorough theoretical knowledge.
5. Put your bags in the designated area.

DON'Ts

1. Don't touch the equipment without instructions from lab supervisor.
2. Don't crowd around the experiment and behave in-disciplinary.
3. Using the mobile phone in the laboratory is strictly prohibited.

General Safety Precautions

Precautions (In case of Injury or Electric Shock)

1. To break the victim with live electric source, use an insulator such as firewood or plastic to break the contact. Do not touch the victim with bare hands to avoid the risk of electrifying yourself.
2. Unplug the risk of faulty equipment. If the main circuit breaker is accessible, turn the circuit off.
3. If the victim is unconscious, start resuscitation immediately, use your hands to press the chest in and out to continue breathing function. Use mouth-to-mouth resuscitation if necessary.

Precautions (In case of Fire)

1. Turn the equipment off. If the power switch is not immediately accessible, take plug off.
2. If fire continues, try to curb the fire if possible, by using the fire extinguisher or by covering it with a heavy cloth if possible isolate the burning equipment from the other surrounding equipment.
3. Sound the fire alarm by activating the nearest alarm switch located in the hallway.

Guidelines to Students for Report Preparation

All students are required to maintain a record of the experiments conducted by them. Guidelines for its preparation are as follows:-

1) All files must contain a title page followed by an index page. ***The files will not be signed by the faculty without an entry in the index page.***

2) Student's Name, Roll number and date of conduction of experiment must be written on all pages.

3) For each experiment, the record must contain the following

(i) Aim/Objective of the experiment

(ii) Pre-experiment work (as given by the faculty)

(iii) Lab assignment questions and their solutions

(iv) Test cases (if applicable to the course)

(v) Results/ output

Note:

1. Students must bring their lab record along with them whenever they come for the lab.

2. Students must ensure that their lab record is regularly evaluated.

Lab Assessment Criteria

An estimated 10 lab classes are conducted in a semester for each lab course. These lab classes are assessed continuously. Each lab experiment is evaluated based on 5 assessment criteria as shown in following table. Assessed performance in each experiment is used to compute CO attainment as well as internal marks in the lab course.

Grading Criteria	**Exemplary (4)**	**Competent (3)**	**Needs Improvement (2)**	**Poor (1)**
AC1: Pre-Lab written work (this may be assessed through viva)	Complete procedure with underlined concept is properly written	Underlined concept is written but procedure is incomplete	Not able to write concept and procedure	Underlined concept is not clearly understood
AC2: Program Writing/ Modeling	Assigned problem is properly analyzed, correct solution designed, appropriate language constructs/ tools are applied, Program/solution written is readable	Assigned problem is properly analyzed, correct solution designed, appropriate language constructs/ tools are applied	Assigned problem is properly analyzed & correct solution designed	Assigned problem is properly analyzed
AC3: Identification & Removal of errors/ bugs	Able to identify errors/ bugs and remove them	Able to identify errors/ bugs and remove them with little bit of guidance	Is dependent totally on someone for identification of errors/ bugs and their removal	Unable to understand the reason for errors/ bugs even after they are explicitly pointed out
AC4:Execution & Demonstration	All variants of input /output are tested, Solution is well demonstrated and implemented concept is clearly explained	All variants of input /output are not tested, However, solution is well demonstrated and implemented concept is clearly explained	Only few variants of input /output are tested, Solution is well demonstrated but implemented concept is not clearly explained	Solution is not well demonstrated and implemented concept is not clearly explained
AC5:Lab Record Assessment	All assigned problems are well recorded with objective, design constructs and solution along with Performance analysis using all variants of input and output	More than 70 % of the assigned problems are well recorded with objective, design contracts and solution along with Performance analysis is done with all variants of input and output	Less than 70 % of the assigned problems are well recorded with objective, design contracts and solution along with Performance analysis is done with all variants of input and output	Less than 40 % of the assigned problems are well recorded with objective, design contracts and solution along with Performance analysis is done with all variants of input and output

LAB EXPERIMENTS

EXPERIMENT NO. 1

AIM: To study fire tube boiler.

Apparatus: Model of Lancashire Boiler.

Theory

Boiler: - A steam boiler is a closed vessel in which steam is produced from water by combustion offuel.

Classification of Boiler:

Boilers are classified on the basis of following-

1. **According to contents in the Tube:**

   a) Fire tube boiler: In fire tube boilers, the flue gases pass through the tube and water surroundthem.

   b).Water tube boiler: In water tube boiler, water flows inside the tubes and the hot flue gases flowoutside the tubes.

2. **According to the pressure of steam:**

   a). Low pressure boiler: A boiler which generates steam at a pressure of below 80 bars is called lowpressure boiler. Examples-Cochran boiler, Lancashire boiler etc.

   b). High pressure boiler: A boiler which generates steam at a pressure higher than 80 bar is calledhigh pressure boiler. Example- Babcock and Wilcox boiler etc.

LANCASHIRE BOILER:

Lancashire is a stationary fire tube, internally fired, horizontal, naturalcirculation boiler. It is a commonly used in sugar – mills and textiles industries where along with the power steam and steam for the process work is also needed.

The specifications of Lancashire boiler are given below:

Diameter of the shell – 2 to 3 m.

Length of the shell – 7 to 9 m

Maximum working pressure – 16 bar

Steam capacity – 9000 kg/h

Efficiency – 50 to 70 %

Construction and Working:

Lancashire boiler consists of a cylindrical shell inside which two large tube are placed. The shell is constructed with several rings of cylindrical from and it is placed horizontally over a brick work which forms several channels for the flow of hot gasses. These two tubes are also constructed with several rings of cylindrical form. They pass from one end of the shell to other end all covered with water. The furnace is placed at the front end of the each tube and they are known as furnace tubes. The coal is introduced through the fire hole into the great. There is a low brick work fire bridge at the back of the gate to prevent the entry of the burning coal of ashes into interior of the furnace tubes. The combustions from the grate pass up to the back end of the furnace tube and then in downward direction. There after they move through the bottom channel or bottom flue upto the front end of the boiler where they are divided and pass upto the side flues.

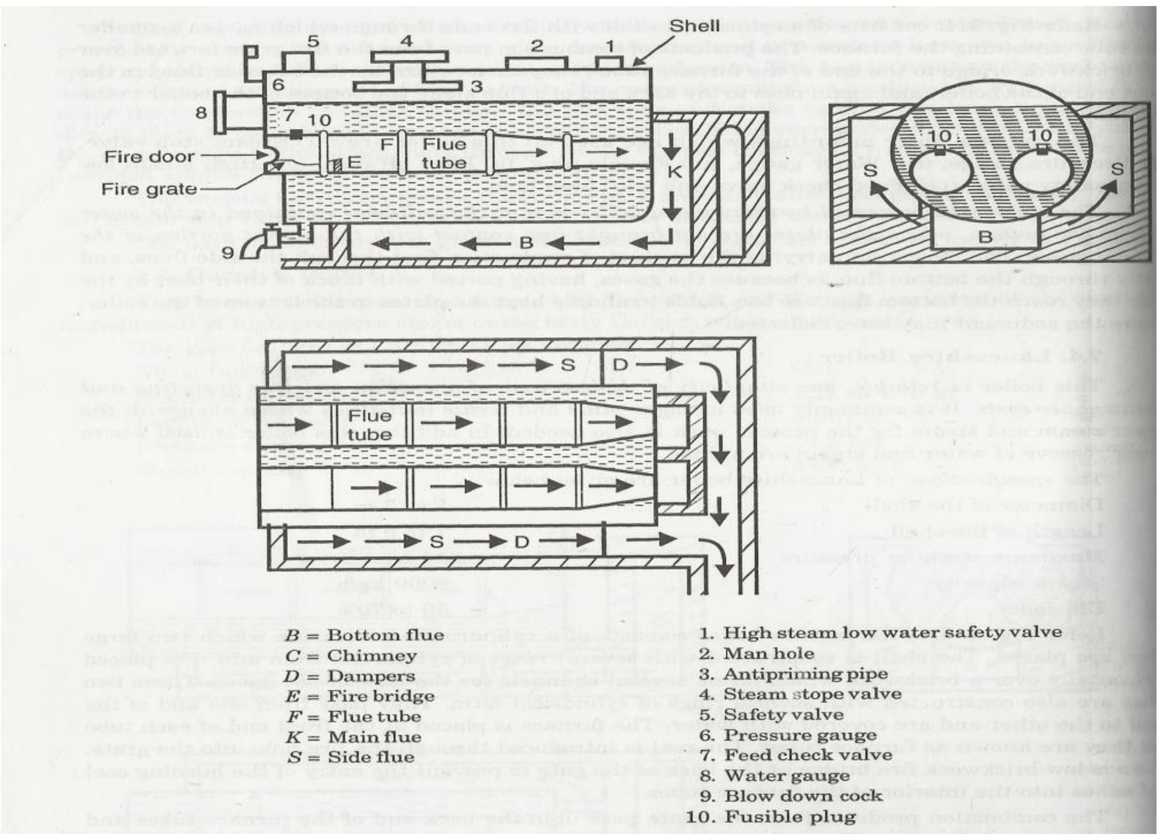


Figure: Lancashire Boiler

EXPERIMENT NO. 2

AIM: To study water tube boiler.

Apparatus: Model of Babcock Wilcox Boiler.

Theory

Boiler: - A steam boiler is a closed vessel in which steam is produced from water by combustion offuel.

Classification of Boiler:

Boilers are classified on the basis of following-

1. **According to contents in the Tube:**

   a) Fire tube boiler: In fire tube boilers, the flue gases pass through the tube and water surroundthem.

   b).Water tube boiler: In water tube boiler, water flows inside the tubes and the hot flue gases flowoutside the tubes.

2. **According to the pressure of steam:**

   a) Low pressure boiler: A boiler which generates steam at a pressure of below 80 bars is called lowpressure boiler. Examples-Cochran boiler, Lancashire boiler etc.
   b) High pressure boiler: A boiler which generates steam at a pressure higher than 80 bar is calledhigh pressure boiler. Example- Babcock and Wilcox boiler etc.

BABCOCK AND WILCOX BOILER:

Babcock and Wilcox boiler is a horizontal shell, multi tubular, water tube, externally fired, natural circulation boiler.

The specifications of Babcock and Wilcox boiler are given below:

Diameter of the drum-1.22 m to 1.83 m
Length of the drum- 6.096 to 9.144 m
Size of water tubes-7.62 to 10.16 cm
Size of super heater tube - 3.84 to 5.71cm
Working pressure - 100 bar
Steam Capacity - 40,000 kg/hr (Maximum)
Efficiency - 60-80%

Construction:

Figure shows the details of a Babcock and Wilcox water tube boiler. It consists of a drum mounted at the top and connected by upper header and down take header. A large number of water tubes connect the uptake and down take headers. The water tubes are inclined at an angle of 5to 15 degrees to promote water circulation. The heating surface of the unit is the outer surface of the tubes and half of the cylindrical surface of the water drum which is exposed to flue gases.

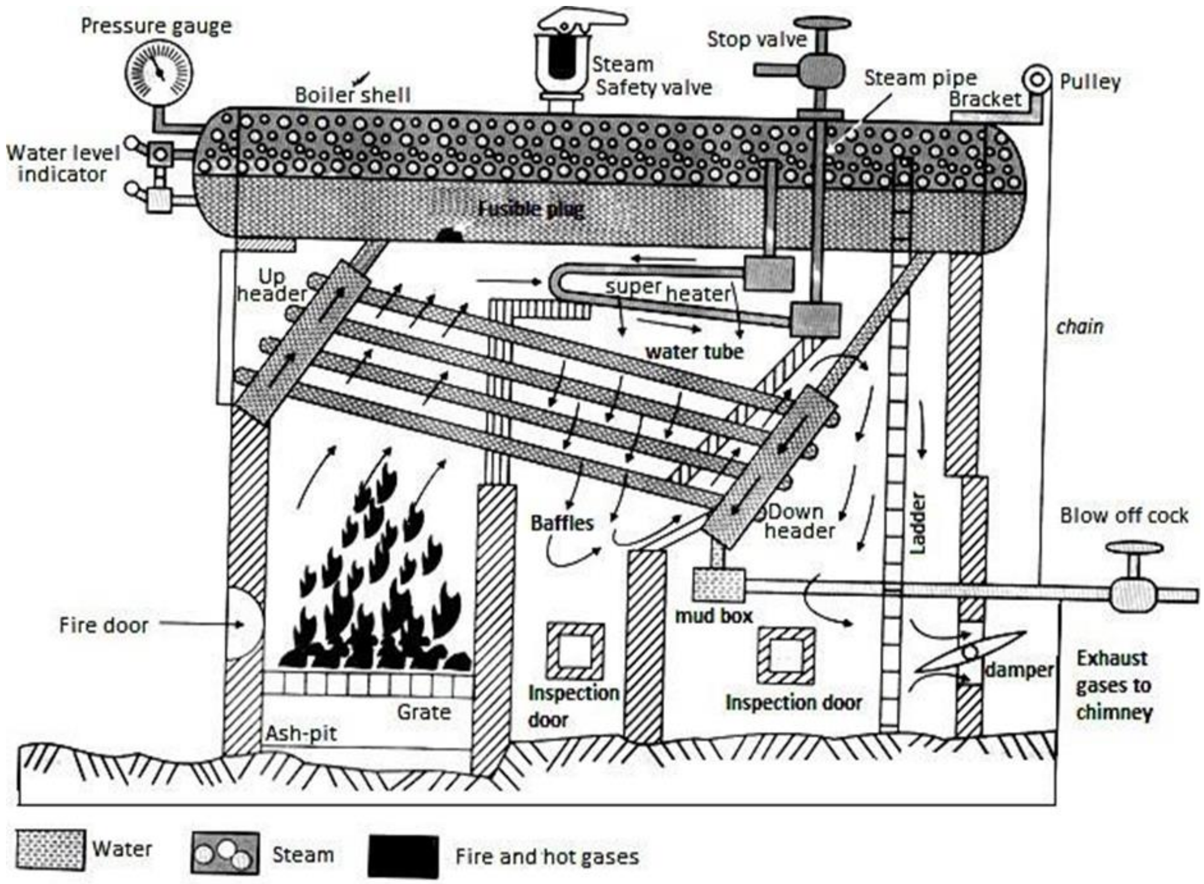
Below the uptake header the furnace of the boiler is arranged. The coal is fed to the chain grate stoker through the fire door. There is a bridge wall deflector which deflects the combustion gases upwards. Baffles are arranged across the water tubes to act as deflectors for the flue gases and to provide them with gas passes. Here, two baffles are arranged which provide three passes of the flue gases. A chimney is provided for the exit of the gases. A damper is placed at the inlet of the chimney to regulate the draught. There are superheating tubes for producing superheated steam. Connections are provided for other mounting and accessories.

Working:

The hot combustion gases produced by burning of fuel on the grater rise upwards and are deflected by the bridge wall deflector to pass over the front portion of water tubes and drum. By this way they complete the first pass. With the provision of baffles they are deflected downwards and complete the second pass. Again, with the provision of baffles they rise upwards and complete the third pass and finally come out through the chimney. During their travel they give heat to water andsteam is formed. The flow path of the combustion gases is shown by the arrows outside the tubes. The circulation of water in the boiler is due to natural circulation set-up by convective currents (dueto gravity). Feed water is supplied by a feed check valve.

The hottest water and stem rise from the tubes to the uptake header and then through the riser it enters the boiler drum. The steam vapours escape through the upper half of the drum. The cold water flows from the drum to the rear header and thus the cycle is completed.

To get superheated steam, the steam accumulated in the steam space is allowed to enter into the super heater tubes which are placed above the water tubes. The flue gases passing over the flue tubes produce superheated steam. The steam thus superheated is finally supplied to the user througha steam stop valve.


Pressure gauge
Steam
Safety valve
Stop valve
Steam pipe
Bracket
Pulley
Boiler shell
Water level
indicator
Fusible plug
Up
header
super heater
water tube
chain
Baffles
Down
header
Ladder
Blow off cock
Fire door
mud box
Inspection
door
Inspection door
damper
Exhaust
gases to
chimney
Grate
Ash-pit
Water
Steam
Fire and hot gases

EXPERIMENT NO. 3

AIM: To study four stroke petrol engine.

Apparatus: Model of cross-sectional view of four stroke petrol engine.

Theory:

The four stroke-cycles refers to its use in petrol engines, gas engines, light, oil engine and heavy oil engines in which the mixture of air fuel are drawn in the engine cylinder. Since ignition in these engines is due to a spark, therefore they are also called spark ignition engines.

Movement of the piston between TDC to BDC or BDC to TDC is referred to as one stroke. Hence, in 4-stroke engines piston moves between TDC and BDC four times.

Working principle of four stroke petrol engines:-

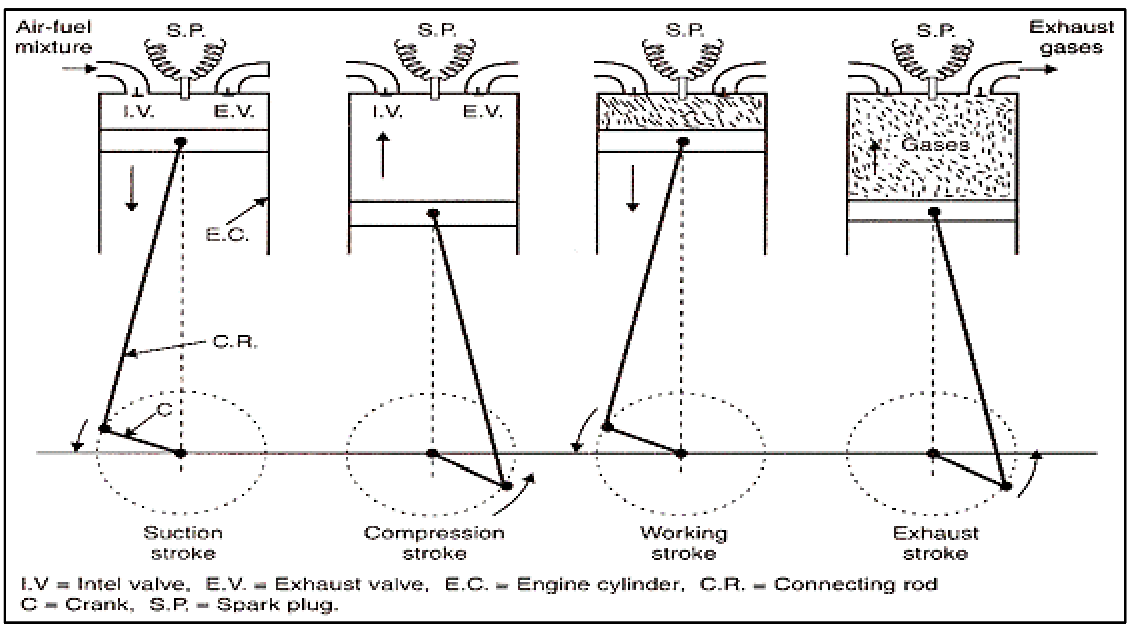
There are four strokes which are as follows:

i) Suction stroke

ii) Compression stroke

iii) Expansion or working or power stroke

iv) Exhaust stroke



SUCTION STROKE: In this Stroke the inlet valve opens and proportionate fuel-air mixture is sucked in the engine cylinder. Thus the piston moves from top dead centre

(T.D.C.) to bottom dead centre (B.D.C.). The exhaust valve remains closed throughout the stroke.

COMPRESSION STROKE: In this stroke both the inlet and exhaust valves remain closed during the stroke. The piston moves towards (T.D.C.) and compresses the enclosed fuel-air mixture drawn. Just before the end of this stroke the operating plug initiates a spark which ignites the mixture and combustion takes place at constant pressure.

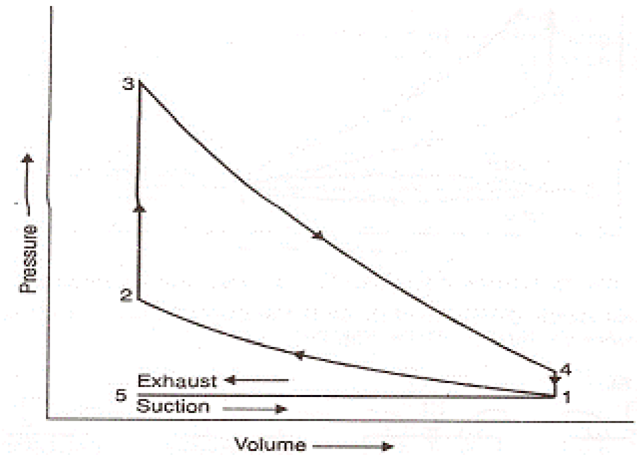


Figure: P-V Diagram of Petrol Engine Cycle

POWER STROKE OR EXPANSION STROKE: In this stroke both the valves remain closed during the start of this stroke but when the piston just reaches the B.D.C. the exhaust valve opens. When the mixture is ignited by the spark plug the hot gases are produced which drive or throw the piston from T.D.C. to B.D.C. and thus the work is obtained in this stroke.

EXHAUST STROKE: This is the last stroke of the cycle. Here the gases from which the work has been collected become useless after the completion of the expansion stroke and are made to escape through exhaust valve to the atmosphere. This removal of gas is accomplished during this stroke. The piston moves from B.D.C. to T.D.C. and the exhaust gases are driven out of the engine cylinder; this is also called **SCAVENGING**.

EXPERIMENT NO. 4

AIM: To study four stroke diesel engine.

Apparatus: Model of cross-sectional view of four stroke diesel engine.

Theory:

In diesel engines, air is drawn in the engine cylinder. Since ignition in these engines is due to a compression of air, therefore they are also called compression ignition engines.

Movement of the piston between TDC to BDC or BDC to TDC is referred to as one stroke. Hence, in 4-stroke engines piston moves between TDC and BDC four times.

Working principle of four stroke diesel engines:-

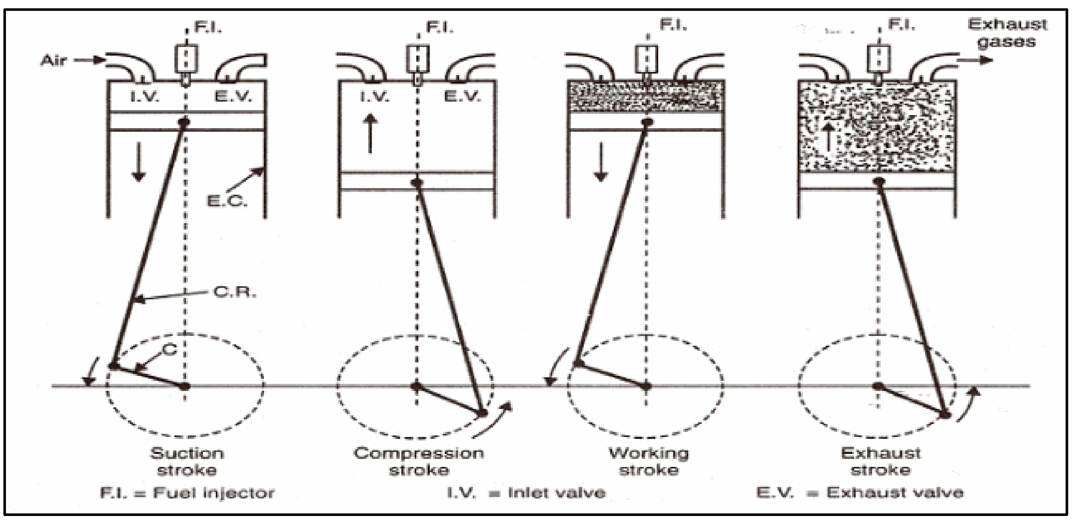
There are four strokes which are as follows:

i) Suction stroke

ii) Compression stroke

iii) Expansion or working or power stroke

iv) Exhaust stroke



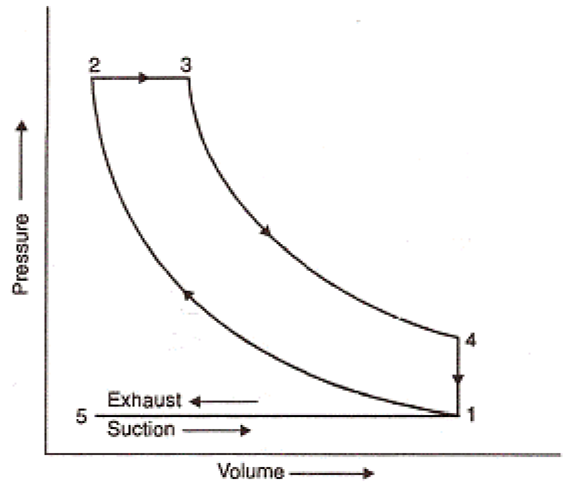


Figure: P-V Diagram of Diesel Engine Cycle

SUCTION STROKE: With the movement of the piston from T.D.C. to B.D.C. during this stroke, the inlet valve opens and the air at atmospheric pressure is drawn inside the engine cylinder; the exhaust valve however remains closed. This operation is represented by the line 5-1

COMPRESSION STROKE: The air drawn at atmospheric pressure during the suction stroke is compressed to high pressure and temperature as the piston moves from B.D.C. to T.D.C. Both the inlet and exhaust valves do not open during any part of this stroke. This operation is represented by 1-2

POWER STROKE OR EXPANSION STROKE: As the piston starts moving from T.D.C to B.D.C, the quantity of fuel is injected into the hot compressed air in fine sprays by the fuel injector and it (fuel) starts burning at constant pressure shown by the line 2-3.

At the point 3 fuel supply is cut off. The fuel is injected at the end of compression stroke but in actual practice the ignition of the fuel starts before the end of the compression stroke. The hot gases of the cylinder expand adiabatically to point 4. Thus doing work on the piston.

EXHAUST STROKE: The piston moves from the B.D.C. to T.D.C. and the exhaust gases escape to the atmosphere through the exhaust valve. When the piston reaches the T.D.C. the exhaust valve closes and the cycle is completed. This stroke is represented by the line 1-5.

EXPERIMENT NO. 5

AIM: To study two stroke petrol engine.

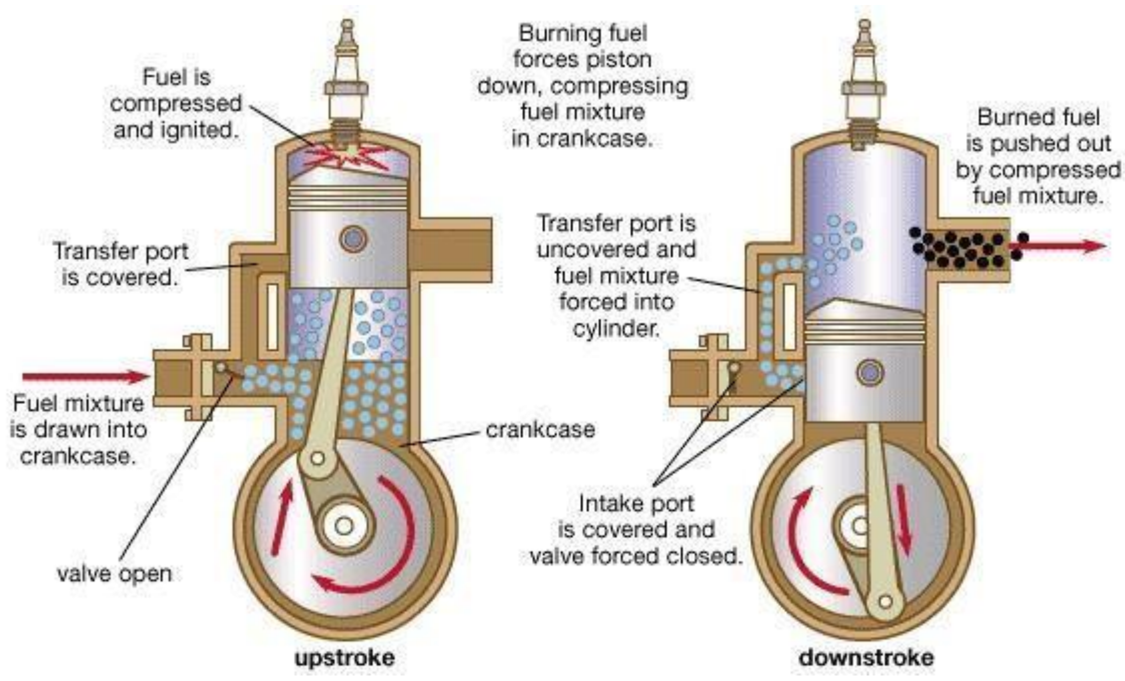
Apparatus: Model of cross-sectional view of two stroke petrol engine.

Theory:

The two stroke-cycles refers to its use in petrol engines, gas engines, light, oil engine and heavy oil engines in which the mixture of air fuel are drawn in the engine cylinder. Since ignition in these engines is due to a spark, therefore they are also called spark ignition engines.

Movement of the piston between TDC to BDC or BDC to TDC is referred to as one stroke. Hence, in 2-stroke engines piston moves two times between TDC and BDC.

In two stroke cycle engines, the whole sequence of events i.e., suction, compression, power and exhaust are completed in two strokes of the piston i.e. one revolution of the crankshaft. There is no valve in this type of engine. Gas movement takes place through holes called ports in the cylinder. The crankcase of the engine is air tight in which the crankshaft rotates.



There are two strokes in petrol engine:

1. **Upward stroke of the piston (Suction + Compression):**

   When the piston moves upward it covers two of the ports, the exhaust port and transfer port, which are normally almost opposite to each other. This traps the charge of air- fuel mixture drawn already in to the cylinder. Further upward movement of the piston compresses the charge and also uncovers the suction port. Now fresh mixture is drawn through this port into the crankcase. Just before the end of this stroke, the mixture in the cylinder is ignited by a spark plug (Fig 2 c &d). Thus, during this stroke both suction and compression events are completed.

2. **Downward stroke (Power + Exhaust):**

   Burning of the fuel rises the temperature and pressure of the gases which forces the piston to move down the cylinder. When the piston moves down, it closes the suction port, trapping the fresh charge drawn into the crankcase during the previous upward stroke. Further downward movement of the piston uncovers first the exhaust port and then the transfer port. Now fresh charge in the crankcase moves in to the cylinder through the transfer port driving out the burnt gases through the exhaust port. Special shaped piston crown deflect the incoming mixture up around the cylinder so that it can help in driving out the exhaust gases. During the downward stroke of the piston power and exhaust events are completed**.**

EXPERIMENT NO. 6

AIM: To study two stroke diesel engine.

Apparatus: Model of cross-sectional view of two stroke diesel engine.

Theory:

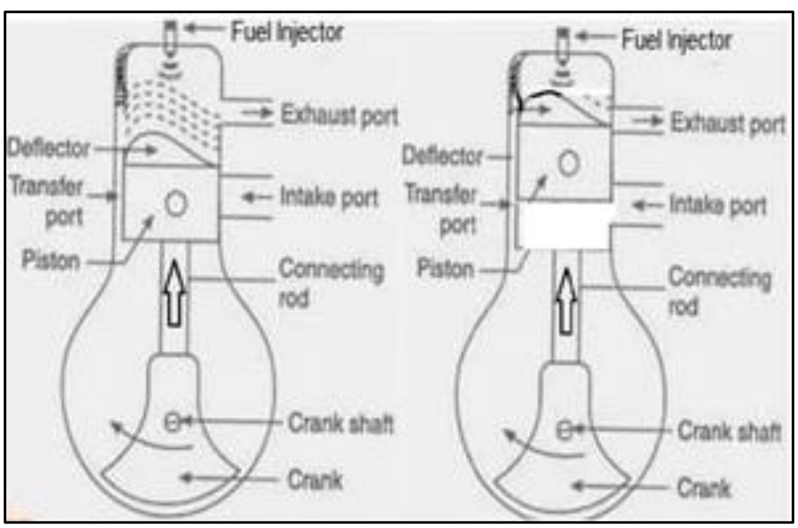
In diesel engines, air is drawn in the engine cylinder. Since ignition in these engines is due to a compression of air, therefore they are also called compression ignition engines.

Movement of the piston between TDC to BDC or BDC to TDC is referred to as one stroke. Hence, in 2-stroke engine piston moves twice between TDC and BDC.

In two stroke cycle engines, the whole sequence of events i.e., suction, compression, power and exhaust are completed in two strokes of the piston i.e. one revolution of the crankshaft. There is no valve in this type of engine. Gas movement takes place through holes called ports in the cylinder. The crankcase of the engine is air tight in which the crankshaft rotates.

WORKING PRINCIPLE OF DIESEL ENGINE:

The basic components of diesel engine are cylinder, piston, injector, valves, connecting rod and crankshaft. In diesel engines only air is drawn into the cylinder. The engine has high compression ratio hence the air in the cylinder attains very high temperature and pressure at the end of the compression stroke. At the end of the compression stroke, the fuel is sprayed into the cylinder in atomized form using injectors. Due to high temperature, the fuel gets ignited, begins to burn and produce lot of heat. Due to the heat the gases expand, move the piston downward and rotate the crank shaft. The torque available at the rotating crank shaft is used to do any mechanical work.



Special features of Diesel Engine:

1) Engine has high compression ratio ranging from 14:1 to 22:1.

2) During compression stroke, the engine attains high pressure ranging from 30 to 45 kg/cm2 and high temperature of about 500°C.

3) At the end of the compression stroke, fuel is injected into the cylinder through injectors (atomizers) at a very high pressure ranging from 120 to 200 kg/cm2.

4) Ignition takes place due to heat of compression only.

5) There is no external spark in diesel engine.

6) Diesel engine has better slogging or lugging ability i.e. it maintains higher torque for a longer duration of time at a lower speed.

EXPERIMENT NO. 7

AIM: To study gas turbine.

Apparatus: Model of gas turbine.

Theory:

This machine has a single-stage radial compressor and turbine, a recuperator, and foil bearings. A gas turbine, also called a combustion turbine, is a rotary engine that extracts energy from a flow of combustion gas.

Construction:

It has an upstream compressor coupled to a downstream turbine, and a combustion chamber in-between. (Gas turbine may also refer to just the turbine element.)

Working:

Energy is generated where air is mixed with fuel and ignited in the combustor. Combustion increases the temperature, velocity and volume of the gas flow. This is directed through a (nozzle) over the turbine's blades, spinning the turbine and powering the compressor. Energy is extracted in the form of shaft power, compressed air and thrust, in any combination, and used to power aircraft, trains, ships, generators, and even tanks.

Operation:

Gas turbines are described thermodynamically by the Brayton cycle, in which air is compressed isentropically, combustion occurs at constant pressure, and expansion over the turbine occurs isentropically back to the starting pressure.

In practice, friction and turbulence cause:

a) Non-Isentropic Compression - for a given overall pressure ratio, the compressor delivery temperature is higher than ideal.

b) Non-Isentropic Expansion - although the turbine temperature drop necessary to drive the compressor is unaffected, the associated pressure ratio is greater, which decreases the expansion available to provide useful work.

c) Pressure loss in the combustor - reduces the expansion available to provide useful work

As with all cyclic heat engines, higher combustion temperature means greater efficiency. The limiting factor is the ability of the steel, ceramic, or other materials that make up the engine to withstand heat and pressure. Considerable engineering goes into keeping the turbine parts cool. Most turbines also try to recover exhaust heat, which otherwise is wasted energy. Recuperators are heat exchangers that pass exhaust heat to the compressed air, prior to combustion. Combined cycle designs pass waste heat to steam turbine systems and combined heat and power (co-generation) uses waste heat for hot water production.

Features of Gas Turbine:

Simple cycle gas turbines in the power industry require smaller capital investment than combined cycle gas, coal or nuclear plants and can be designed to generate small or large amounts of power. The ability to be turned on and off within minutes, supplying power during peak demand. Hence, they are sometimes called peaking turbine units. Large simple cycle gas turbines may produce several hundred megawatts of power and approach 40 % thermal efficiency. They can be particularly efficient—up to 60 %—when waste heat from the gas turbine is recovered by a conventional steam turbine in a combined cycle configuration.

Industrial gas turbines range in size from truck-mounted mobile plants to enormous, complex systems. The power turbines in the largest industrial gas turbines operate at 3,000 or 3,600 rpm to match the AC power grid frequency and to avoid the need for a reduction gearbox. Such engines require a dedicated building.

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