I

Name _____

Roll No. _____ Year 20____20____

Exam Seat No. _____

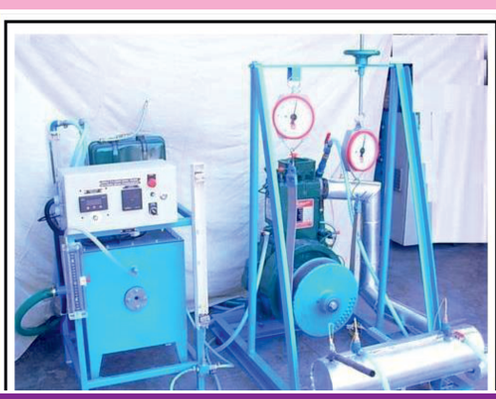
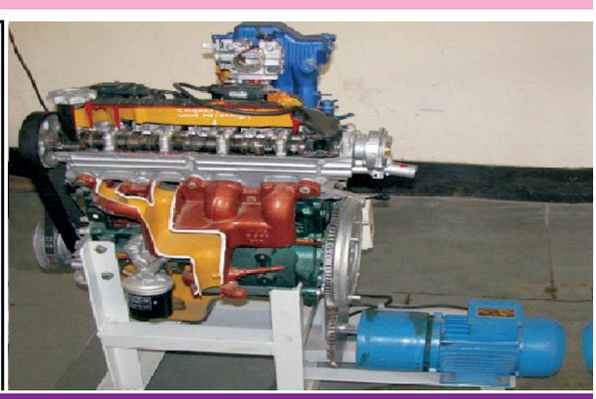
MECHANICAL GROUP | SEMESTER - V | DIPLOMA IN ENGINEERING AND TECHNOLOGY

A LABORATORY MANUAL

FOR

POWER ENGINEERING AND REFRIGERATION

(22562)

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION, MUMBAI
(Autonomous) (ISO 9001 : 2015) (ISO / IEC 27001 : 2013)

VISION

To ensure that the Diploma level Technical Education constantly matches the latest requirements of technology and industry and includes the all-round personal development of students including social concerns and to become globally competitive, technology led organization.

MISSION

To provide high quality technical and managerial manpower, information and consultancy services to the industry and community to enable the industry and community to face the changing technological and environmental challenges.

QUALITY POLICY

We, at MSBTE are committed to offer the best in class academic services to the students and institutes to enhance the delight of industry and society. This will be achieved through continual improvement in management practices adopted in the process of curriculum design, development, implementation, evaluation and monitoring system along with adequate faculty development programmes.

CORE VALUES

MSBTE believes in the followings:

- Education industry produces live products.
- Market requirements do not wait for curriculum changes.
- Question paper is the reflector of academic standards of educational organization.
- Well designed curriculum needs effective implementation too.
- Competency based curriculum is the backbone of need based program.
- Technical skills do need support of life skills.
- Best teachers are the national assets.
- Effective teaching learning process is impossible without learning resources.

A Practical Manual

for

Power Engineering and Refrigeration

(22562)

Semester – V

(ME)

Maharashtra State
Board of Technical Education, Mumbai
(Autonomous) (ISO:9001:2015) (ISO/IEC 27001:2013)

Maharashtra State Board of Technical Education,
(Autonomous) (ISO:9001:2015) (ISO/IEC 27001 : 2013)
4th Floor, Government Polytechnic Building, 49, Kherwadi,
Bandra (East), Mumbai - 400051.
(Printed on May,2019)

Maharashtra State
Board of Technical Education

Certificate

This is to certify that Mr. / Ms …….
Roll No……of Fifth Semester of Diploma in ……of Institute ……..
(Code ----------) has completed the term work satisfactorily in course **Power Engineering and Refrigeration (22562)** for the academic year 20…….to 20…..... as prescribed in the curriculum.

Place ……. Enrollment No……
Date:…..... Exam Seat No . …….....

Course Teacher **Head of the Department** **Principal**

Seal of the Institute

Preface

The primary focus of any engineering laboratory/ field work in the technical education system is to develop the much needed industry relevant competencies and skills. With this in view, MSBTE embarked on this innovative 'I' Scheme curricula for engineering diploma programmes with outcome-base education as the focus and accordingly, relatively large amount of time is allotted for the practical work. This displays the great importance of laboratory work making each teacher; instructor and student to realize that every minute of the laboratory time need to be effectively utilized to develop these outcomes, rather than doing other mundane activities. Therefore, for the successful implementation of this outcome-based curriculum, every practical has been designed to serve as a ***'vehicle'*** to develop this industry identified competency in every student. The practical skills are difficult to develop through 'chalk and duster' activity in the classroom situation. Accordingly, the 'I' scheme laboratory manual development team designed the practical to ***focus*** on the ***outcomes***, rather than the traditional age old practice of conducting practical to 'verify the theory' (which may become a byproduct along the way).

This laboratory manual is designed to help all stakeholders, especially the students, teachers and instructors to develop in the student the pre-determined outcomes. It is expected from each student that at least a day in advance, they have to thoroughly read through the concerned practical procedure that they will do the next day and understand the minimum theoretical background associated with the practical. Every practical in this manual begins by identifying the competency, industry relevant skills, course outcomes and practical outcomes which serve as a key focal point for doing the practical. The students will then become aware about the skills they will achieve through procedure shown there and necessary precautions to be taken, which will help them to apply in solving real-world problems in their professional life.

This manual also provides guidelines to teachers and instructors to effectively facilitate student-centered lab activities through each practical exercise by arranging and managing necessary resources in order that the students follow the procedures and precautions systematically ensuring the achievement of outcomes in the students.

Power producing and absorbing devices are essentials for mechanical engineering. It is necessary for mechanical engineering technologists to analyze working and plot the performance of devices like internal combustion engines, air compressors, gas turbines so that he will be able to operate them effectively in an industrial situation. This knowledge is also useful in selecting suitable prime mover for given application and to maintain and test the same. This course also gives basic exposure of refrigeration and air-conditioning equipment which play a vital role in maintaining controlled atmosphere in different domestic and industrial applications. A separate elective course on Refrigeration and Air-conditioning is also available in sixth semester for in-depth knowledge of the course.

Although all care has been taken to check for mistakes in this laboratory manual, yet it is impossible to claim perfection especially as this is the first edition. Any such errors and suggestions for improvement can be brought to our notice and are highly welcome.

Programme Outcomes (POs) to be achieved through Practical of this Course:

Following POs and PSO are expected to be achieved through the practicals of the (Power Engineering and Refrigeration) course.

PO 1. **Basic knowledge :** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based mechanical engineering problems

PO 2. **Discipline knowledge:** Apply mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

PO 3. **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based mechanical engineering problems.

PO 4. **Engineering tools:** Apply relevant mechanical technologies and tools with an understanding of the limitations

PO 5. **The engineer and society:** Assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to practice in field of mechanical engineering.

PO 6. **Environment and sustainability:** Apply mechanical engineering solutions also for sustainable development practices in societal and environmental contexts.

PO 7. **Ethics:** Apply ethical principles for commitment to professional ethics, responsibilities and norms of the practice also in the field of mechanical engineering

PO 8. **Individual and team work:** Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PO 9. **Communication:** Communicate effectively in oral and written form.

PO 10. **Life-long learning:** Engage in independent and life-long learning activities in the context of technological changes also in the mechanical engineering and allied industry.

Program Specific Outcomes (PSOs)

PSO 1: Modern Software Usage: Use latest mechanical related software for simple design, drafting, manufacturing, maintenance and documentation of mechanical components and processes.

PSO 2: Maintenance and selection of machines, equipment, instruments: Maintain and select appropriate machine, equipment and instrument in field of Mechanical Engineering.

PSO 3: Manage Mechanical Process: Manage the mechanical process by selection and scheduling right type of machinery, equipment, substrates, quality control techniques, operational parameters and software for a particular mechanical process or job for economy of operations.

List of Industry Relevant Skills

The following industry relevant skills of the competency Use P**ower Engineering and Refrigeration** are expected to be developed in you by undertaking the practical of this laboratory manual.

1. Identify different components of I.C Engine
2. Test the performance of I C Engine
3. Test the performance of Air compressor
4. Test the performance of Vapour Compression system
5. Maintain Refrigeration and air conditioning system

Practical- Course Outcome matrix

Course Outcomes (COs)

a. Identify different components of I C engines and its auxiliaries.
b. Test the performance of I C Engine.
c. Maintain reciprocating air compressors.
d. Identify different components of gas turbines and jet engines.
e. Test the performance of refrigeration and air-conditioning systems

S. No.	Practical Outcome	CO a.	CO b.	CO c.	CO d.	CO e.
1.	Assemble/Dismantle single cylinder IC Engine. (Part-I) *	√	-	-	-	-
2.	Assemble/Dismantle single cylinder IC Engine. (Part-II) *	√	-	-	-	-
3.	Assemble/Dismantle multi cylinder IC Engine. (Part-I)	√	-	-	-	-
4.	Assemble/Dismantle multi cylinder IC Engine. (Part-II)	√	-	-	-	-
5.	Assemble/Dismantle inline/rotary fuel injection pump in a diesel engine.	√	-	-	-	-
6.	Perform test on the given IC Engine to prepare heat balance sheet and plot performance characteristics. (Part-I) *	-	√	-	-	-
7.	Perform test on the given IC Engine to prepare heat balance sheet and plot performance characteristics. (Part-II) *	-	√	-	-	-
8.	Perform Morse Test on the given IC Engine.	-	√	-	-	-
9.	Use exhaust gas analyzer to measurement and analyze pollutants in the given IC engine.	-	√	-	-	-
10.	Perform diagnosis test on given IC engine using Engine Control Unit *	-	√	-	-	-
11.	Perform test on the given two-stage reciprocating air compressor to find volumetric and isothermal efficiency. (Part-I) *	-	-	√	-	-

12.	Perform test on the given two-stage reciprocating air compressor to find volumetric and isothermal efficiency. (Part-II) *	-	-	√	-	-	
13.	Assemble/Dismantle of Gas turbine model.	-	-	-	√	-	
14.	Perform test on vapor compression refrigeration cycle test rig to find COP *	-	-	-	-	√	
15.	Trace the refrigerant flow of domestic refrigerator and measure temperatures at critical points for different settings of thermostat.	-	-	-	-	√	
16.	Assemble/Dismantle various components of domestic refrigerator.	-	-	-	-	√	
17.	Assemble/Dismantle various components of Water Cooler and Window/Split air conditioning units.	-	-	-	-	√	

Guidelines to Teachers

1. ***Teacher need to ensure that a dated log book*** for the whole semester, apart from the laboratory manual is maintained by every student which s/he has to ***submit for assessment to the teacher*** in the next practical session.
2. There will be two sheets of blank pages after every practical for the student to report other matters (if any), which is not mentioned in the printed practicals.
3. For difficult practicals if required, teacher could provide the demonstration of the practical emphasizing of the skills which the student should achieve.
4. Teachers should give opportunity to students for hands-on after the demonstration.
5. Assess the skill achievement of the students and COs of each unit.
6. One or two questions ought to be added in each practical for different batches. For this teachers can maintain various practical related question banks for each course.
7. If some repetitive information like data sheet, use of software tools etc. has to be provided for effective attainment of practical outcomes, they can be incorporated in Appendix.
8. For effective implementation and attainment of practical outcomes, teacher ought to ensure that in the beginning itself of each practical, students must read through the complete write-up of that practical sheet.
9. During practical, ensure that each student gets chance and takes active part in taking observations/ readings and performing practical.
10. Teacher ought to assess the performance of students continuously according to the MSBTE guidelines

Instructions for Students

1. For incidental writing on the day of each practical session every student should maintain a ***dated log book*** for the whole semester, apart from this laboratory manual which s/he has to ***submit for assessment to the teacher*** in the next practical session.
2. For effective implementation and attainment of practical outcomes, in the beginning it self of each practical, students need to read through the complete write-up including the practical related questions and assessment scheme of that practical sheet.
3. Student ought to refer the data books, IS codes, Safety norms, Technical Manuals, etc.
4. Student should not hesitate to ask any difficulties they face during the conduct of practical.

Content Page

List of Practical and Progressive Assessment Sheet

12.	Perform test on the given two-stage reciprocating air compressor to find volumetric and isothermal efficiency. (Part-II)						
13.	Assemble/Dismantle Gas turbine model.	76					
14.	Perform test on vapor compression refrigeration cycle test rig to find COP	82					
15.	Trace the refrigerant flow of domestic refrigerator and measure temperatures at critical points for different settings of thermostat.	93					
16.	Assemble/Dismantle various components of domestic refrigerator.	101					
17.	Assemble/Dismantle various components of Water Cooler and Window/Split air conditioning units.	118					
Total							

Note: To be transferred to Proforma of CIAAN-2017.

A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.

Practical No.1and 2: Assemble/Dismantle single cylinder IC Engine. (Part-I and II)

I Practical Significance

Internal combustion engine is a device in which combustion occurs inside the engine cylinder. I.C. engine works in four strokes –suction, compression, expansion and exhaust. If four stokes takes place in one cylinder then it is called as Single cylinder I.C. engine. Dismantling is the process of removing all the engine parts to know various sub-assemblies of engine, identify the parts and their location in the sub-assemblies and inspect parts to know their physical and functional condition. Dismantling of I.C. Engine is a feature of preventive as well as breakdown maintenance. After dismantling or repair, all the parts are put back together. This is called engine assembly (reassembly). Engine assembly mainly consists of three major sub-assemblies' like cylinder and related parts, piston and related parts and valve mechanism components.

II Relevant Program Outcomes (POs)

PO1- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic Engineering to solve the broad-based Mechanical Engineering problems.
PO2-**Discipline knowledge**: Apply Mechanical engineering knowledge to solve broad- based mechanical engineering related problems.
PO3- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical Engineering problems.
PO4-**Engineering tools:** Apply relevant Mechanical technologies and tools with an understanding of the limitations.
PO8- **Individual and team work:** Function effectively as a leader and team member in diverse/ multidisciplinary teams.

III Competency and Skills

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences**:**

- **Maintain power engineering and refrigeration devices.**

IV Relevant Course Outcome(s)

- Identify different components of I C engines and its auxiliaries

V Practical Outcome

- Assemble/Dismantle single cylinder IC Engine.

VI Relative Affective Domain-

- Follow safety practices.
- Practice good housekeeping.
- Maintain tools and equipment.
- Follow ethical Practices.

VII Minimum Theoretical Background

1. Know the construction and working of I.C. Engine.
2. Identify recommended tools.
3. Identify various subassemblies of I.C. Engine.
4. Identify accessories of I.C. Engine.

VIII Experimental setup

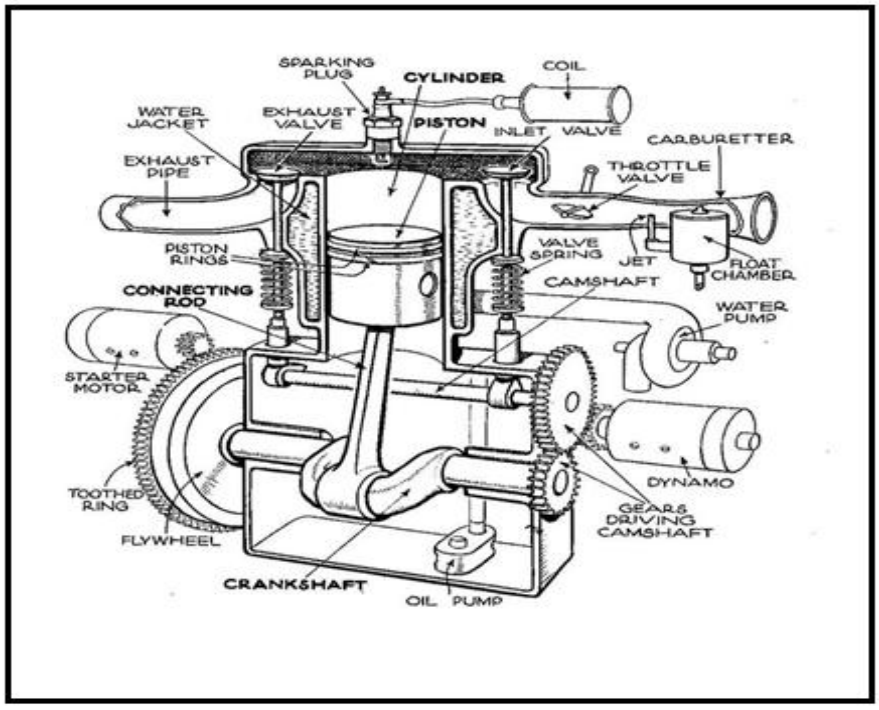


Figure No.1 Single Cylinder Diesel Engine(In section)

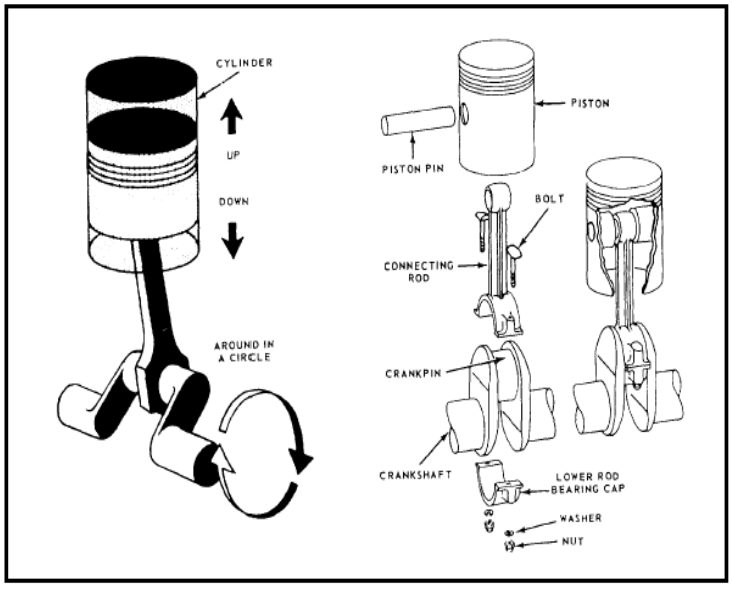


Figure No 2 Piston sub-assembly (exploded view)

Figure No 3 Tool Box

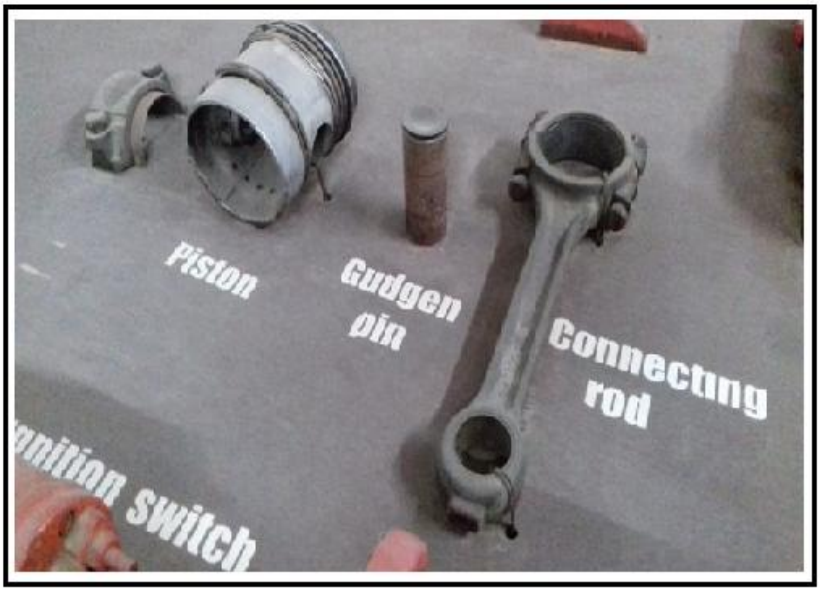


Figure No 4 Piston sub-assembly

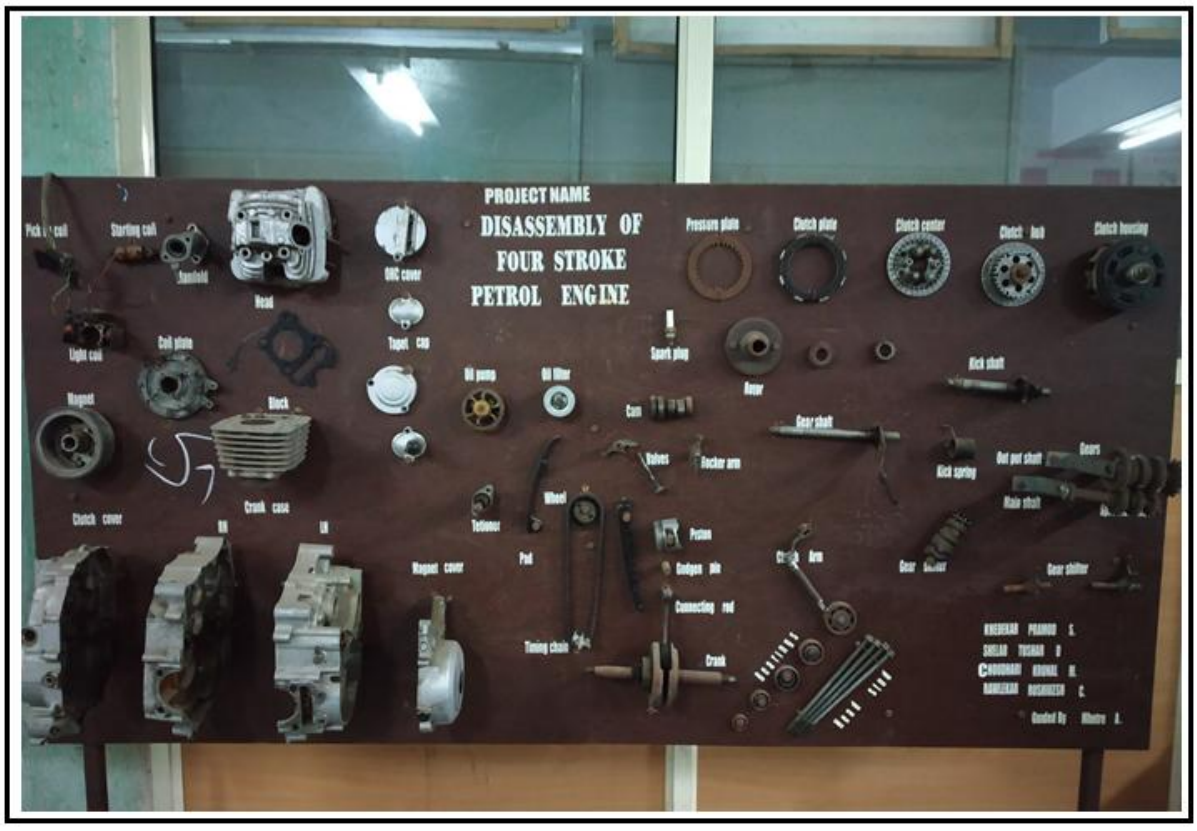


Figure No 5 Dismantling of 4-stroke single cylinder petrol engine

Figure No 6 Pitting of Piston

IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Tool box	Adjustable wrench – 10/250 mm	1
		Plier – 8”/200mm	
		Piston ring remover	
		Ball peen Hammer – 500 gm, claw hammer- 1/4 LB	
		Allen key set – 1.5 to 10 inch	
		Screw driver set – 5 pieces	
		Open end jaw spanner set- 6-7 to 30-32	
		Round / box spanner set - 6-7 to 30-32	
		Rachet set – 10mm to 32 mm	

X Precautions to be Followed

1. Avoid improper handling of I.C. Engine.
2. Use special and recommended tools for assembly and dismantling of I.C. Engine.
3. Use clean work bench for assembly and dismantling of I.C. Engine.

XI Procedure

1. Select the proper tools and equipment.
2. Apply recommended tools to remove engine accessories and components of I.C. engine.
3. Identify the various subassemblies and accessories of the Engine.
4. Examine all the components carefully
5. Observe their physical and functional conditions

XII Resources Used - (Use only Euro4 comply Engine)

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					
4.					
5.					
6					
7					
8					

XIII Actual Procedure Followed with Tools required

A. Dismantling of cylinder head and block

.....
.....
.....
.....

B. Dismantling of piston sub - assembly

.....
.....
.....
.....

C. Dismantling of valve mechanism

.....
.....
.....
.....

D. Dismantling of accessories

.....
.....
.....
.....

E. Assembly of cylinder head and block

.....
.....
.....
.....

F. Assembly of piston sub - assembly

.....
.....
.....
.....

G. Assembly of valve mechanism

.....
.....

.....

.....

H. Assembly of accessories

.....

.....

.....

.....

XIV Precautions Followed

.....

.....

.....

.....

XV Observations and Calculations

Sr. No.	Particulars	Remark
1	Bore diameter	
2	Piston diameter	
3	Number of strokes	
4	Length of stroke	
5	Names of damaged and badly worn components	a.
		b.
		c.
6	No. of oil rings	
7	No. of compression rings	

Sr. No.	Name of Component	Remark (Functions/Observations/Specifications)
1	Cylinder head	
2	Poppet valves/ports	
3	Valve springs	
4	Cam shaft	
5	Head gasket	
6	Cylinder block	
7	Piston	

8	Piston rings	
9	Gudgeon pin	
10	Connecting rod	
11	Crank shaft	

XVI Results

.....
.....
.....
.....

XVII Interpretation of Results

.....
.....
.....
.....

XVIII Conclusions

.....
.....
.....
.....

XIX Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Draw a neat labeled sketch of piston.
2. Enlist the name of gasket material used in cylinder head.

[Space for Answer]

.....
.....
.....
.....
.....
.....
.....
.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

XX References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=vvqiioLIXtU&list=PLET1GQlHfInNMkHFDGaj7OLKhnzyRmQuV
2. https://www.youtube.com/watch?v=uJivC7452gE
3. https://www.youtube.com/watch?v=Pu7g3uIG6Zo

XXI Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**40%**
1	Handling of the tools in tool kit	20%
2	Identification of I.C. Engine components	20%
Product Related (15 Marks)		60%
3	Interpretation of components of I.C. Engine	20%
4	Conclusions	20%
5	Practical related questions	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1. ……
2. ……
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No.3 and 4: Assemble and Dismantle Multi-Cylinder IC Engine. (Part-I and II)

I Practical Significance

A multi-cylinder engine is a reciprocating internal combustion engine with multiple cylinders. It can be either a 2-stroke or 4-stroke engine and can be either Diesel or petrol engine. Multi-cylinder engines offer a number of advantages over single cylinder engines, chiefly with their ability to neutralize imbalances by having corresponding mechanisms moving in opposing directions during the operation of the engine. Dismantling and reassembly of Multi-cylinder is similar to that of Single cylinder I.C. Engine.

II Relevant Program Outcomes (POs)

PO1-**Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic Engineering to solve the broad-based Mechanical Engineering problems.

PO2-**Discipline knowledge:** Apply Mechanical engineering knowledge to solve broad- based mechanical engineering related problems.

PO3- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical Engineering problems.

PO4-**Engineering tools:** Apply relevant Mechanical technologies and tools with an understanding of the limitations.

PO8-**Individual and team work:** Function effectively as a leader and team member in diverse/ Multidisciplinary teams.

III Competency and Skills

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Maintain power engineering and refrigeration devices.**

IV Relevant Course Outcome(s)

- Identify different components of I C engines and its auxiliaries

V Practical Outcome

- **Assemble/Dismantle Multi cylinder IC Engine. (Part-I&II)**

VI Relative Affective Domain-

- Follow safety practices.
- Practice good housekeeping.
- Maintain tools and equipment.
- Follow ethical Practices.

VII Minimum Theoretical Background

1. Identify various subassemblies of I.C. Engine.
2. Identify recommended tools.

3. Distinguish accessories of I.C. Engine.
4. Know the procedure of dismantling and assembly.

VIII Experimental setup

Figure No 1 Four cylinder engine with holder

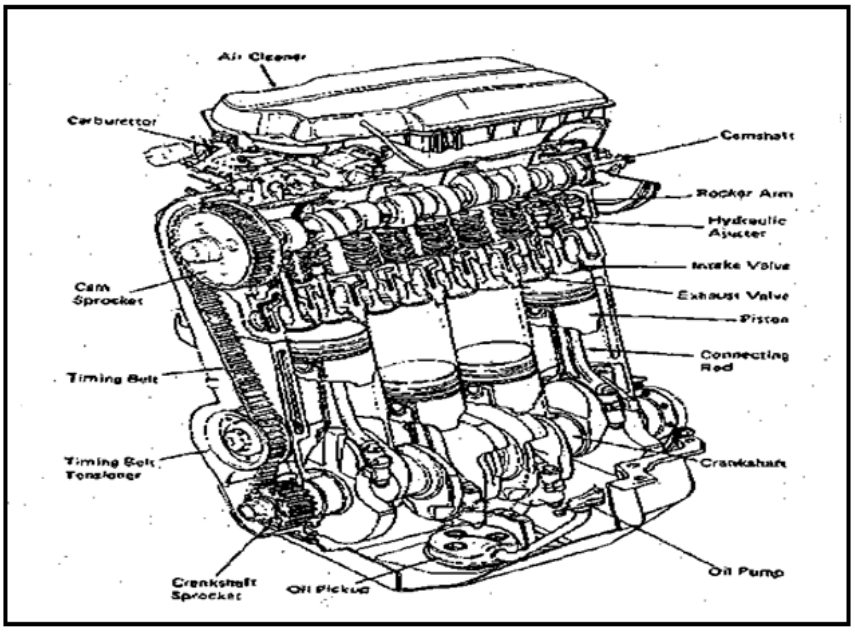


Figure No 2 Schematic view of Four cylinder engine (In section)

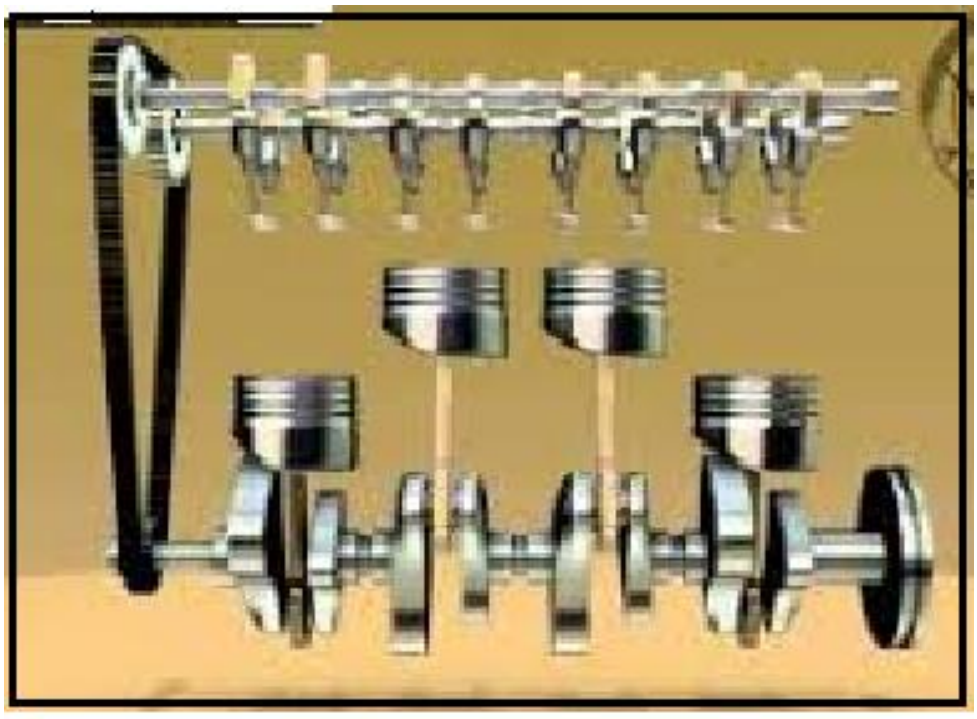


Figure No 3 Four cylinder engine (In section)

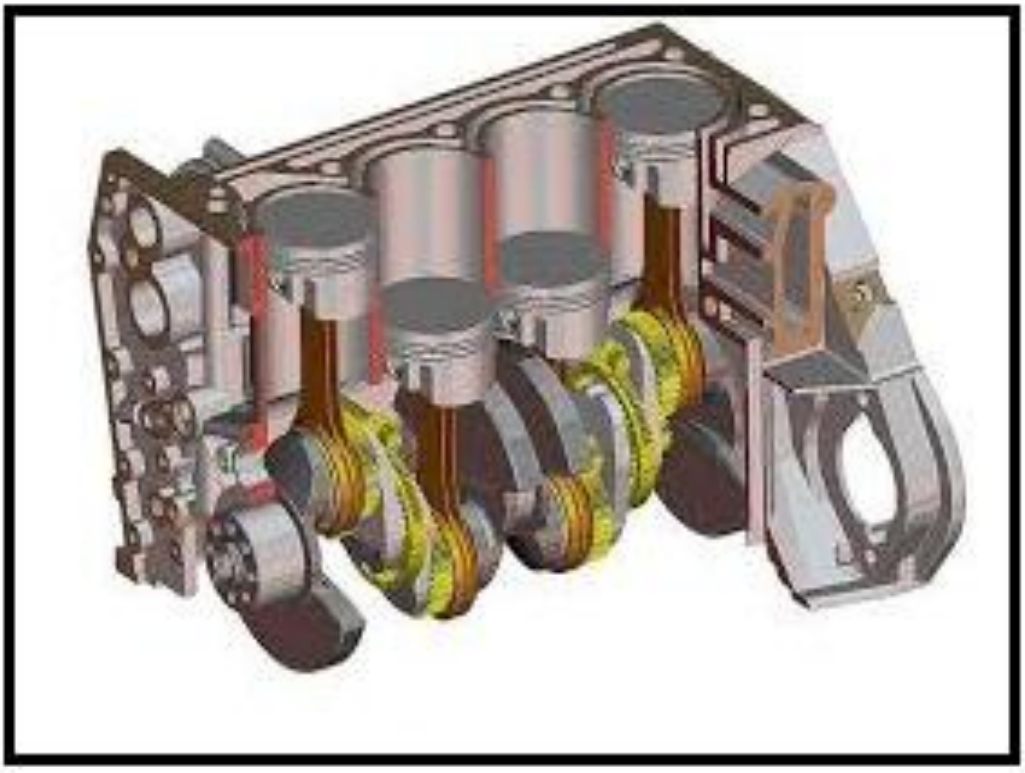


Figure No 4 Four cylinder engine (In section-Pictorial view)

IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Tool kit box	Adjustable wrench – 10/250 mm	1
		Plier – 8”/200mm	
		Piston ring remover	
		Ball peen Hammer – 500 gm, claw hammer- 1/4 LB	
		Allen key set – 1.5 to 10 inch	
		Screw driver set – 5 pieces	
		Open end jaw spanner set- 6-7 to 30-32	
		Round / box spanner set - 6-7 to 30-32	
		Rachet set – 10mm to 32 mm	

X Precautions to be Followed

1. Avoid improper handling of I.C. Engine**.**
2. Use special and recommended tools for assembly and dismantling of I.C. Engine.
3. Use clean work bench for assembly and dismantling of I.C. Engine.

XI Procedure

1. Select the proper tools and equipment.
2. Apply recommended tools to remove engine accessories and components of I.C. engine.
3. Identify the various subassemblies and accessories of the Engine.
4. Examine all the components carefully and observe their physical and functional conditions for dismantling and assembly of I.C. Engine.

XVII Resources Used (Use only Euro4 comply Engine**)**

S. No.	Name of Resource	Broad Specifications		Qty.	Remarks (If any)
		Make	Details		
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					

XII Actual Procedure Followed with Tools required.

A. Dismantling of cylinder head and block

.....
.....
.....
.....

B. Dismantling of piston sub - assembly

.....
.....
.....
.....

C. Dismantling of valve mechanism

.....
.....
.....
.....

D. Dismantling of accessories

.....
.....
.....
.....

E. Assembly of cylinder head and block

.....
.....
.....
.....

F. Assembly of piston sub - assembly

.....
.....
.....
.....

G. Assembly of valve mechanism

.....
.....
.....

H. Assembly of accessories

.....
.....
.....
.....

XIII Precautions Followed

.....
.....
.....
.....

XIV Observations and Calculations

Sr. No.	Particulars	Remark
1	Bore diameter	
2	Piston diameter	
3	Number of strokes	
4	Names of damaged and badly worn components	
5	Type and quantity of oil required	
6	No. of oil rings	
7	No. of compression rings	

Sr. No.	Name of Component	Function
1	Cylinder head	
2	Poppet valves	
3	Valve springs	
4	Cam shaft	
5	Head gasket	
6	Cylinder block	
7	Cylinder liner	

8	Piston	
9	Piston rings	
10	Gudgeon pin	
11	Connecting rod	
12	Journal bearing	
13	Crank pin bearing	
14	Crank shaft	
15	Oil pan	

XV Results

.....

.....

.....

.....

XVI Interpretation of Results

.....

.....

.....

.....

XVII Conclusions

.....

.....

.....

.....

XVIII Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions
so as to ensure the achievement of identified CO.

1. Draw a sketch of connecting rod of an Engine
2. Name the different components of valve mechanism of an I.C. Engine

[Space for Answer]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

XIX References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=lR6ku_g_eNI
2. https://www.youtube.com/watch?v=BXQ27pU3_7E
3. https://www.youtube.com/watch?v=fTAUq6G9apg

XX Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**40%**
1	Handling of the tools in tool kit	20%
2	Identification of I.C. Engine components	20%
Product Related (15 Marks)		**60%**
3	Interpretation of components of I.C. Engine	20%
4	Conclusions	20%
5	Practical related questions	20%
	Total	**100 %**

Names of Student Team Members

1. ……
2. ……
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No.5 : Assemble and Dismantle Inline/Rotary Fuel Injection Pump In A Diesel Engine.

I Practical Significance

Fuel injection pump is required to deliver accurately metered quantity of fuel under high pressure at the correct instant to the injector. Inline fuel pump- The eccentric on the camshaft causes constant linear movement of the pushers - the plungers, by the action of the pushers, push the fuel in the direction of the retention valve - the pressure is high enough to open the retention valve and the fuel is conducted by pipes to the injectors - the amount of fuel is controlled by the gear rack -The gear rack causes rotation movement to the plunger that is function of the accelerator pedal Rotary fuel pump -Send fuel to plungers - Time duration in close position of electro-valve determines the injection flow Send fuel to injectors - The plungers are pressed by cam -Fuel high pressure generated - Distributor rotates to injector flow position.

II Relevant Program Outcomes (POs)

PO1- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic Engineering to solve the broad-based Mechanical Engineering problems.
PO2-**Discipline knowledge**: Apply Mechanical engineering knowledge to solve broad- based mechanical engineering related problems.
PO3- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical Engineering problems.
PO4-**Engineering tools:** Apply relevant Mechanical technologies and tools with an understanding of the limitations.
PO8-**Individual and team work:** Function effectively as a leader and team member in diverse/ multi-disciplinary teams

III Competency and Skills

The aim of this course is to help the student to attain the following industry identified Competency through various teaching learning experiences**:**

- **Maintain power engineering and refrigeration devices.**

IV Relevant Course Outcome(s)

- Identify different components of I C engines and its auxiliaries

V Practical Outcome

- Assemble/Dismantle inline/rotary fuel injection pump in a diesel engine.

VI Relative Affective Domain-

- Follow safety practices.
- Practice good housekeeping.
- Maintain tools and equipment.
- Follow ethical Practices.

VII Minimum Theoretical Background

1. Know the construction and working of Fuel pump.
2. Identify recommended tools.
3. Identify various sub-assemblies of Fuel pump

VIII Experimental setup

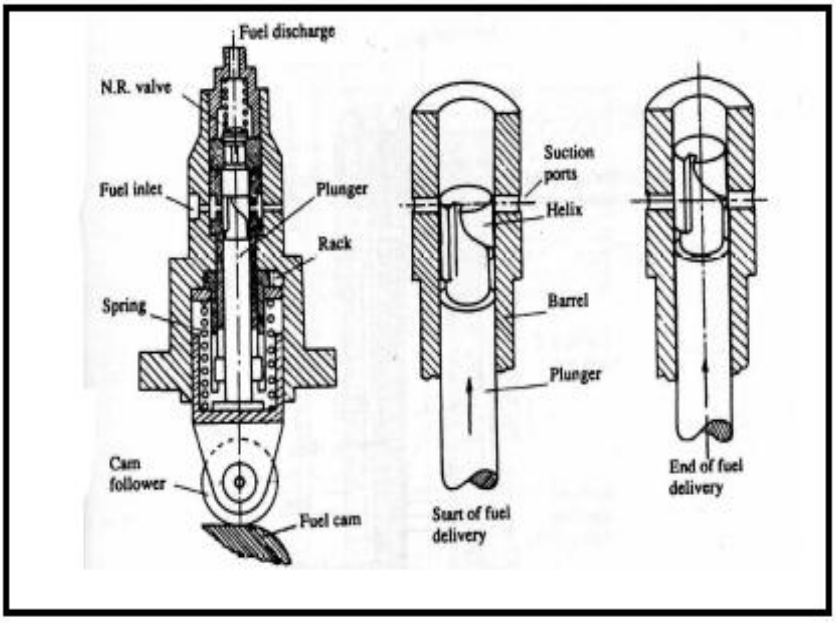


Figure 1 Fuel pump in section

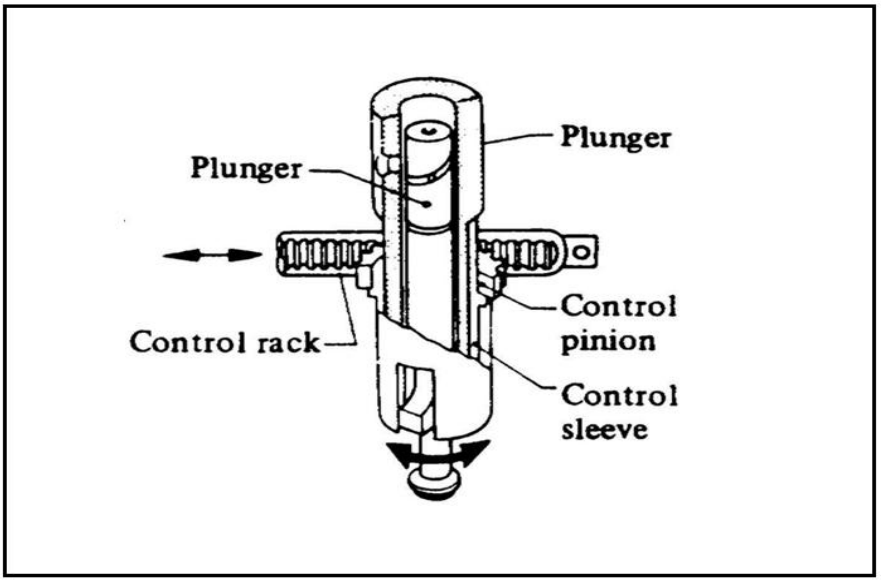


Figure 2 Fuel pump elements

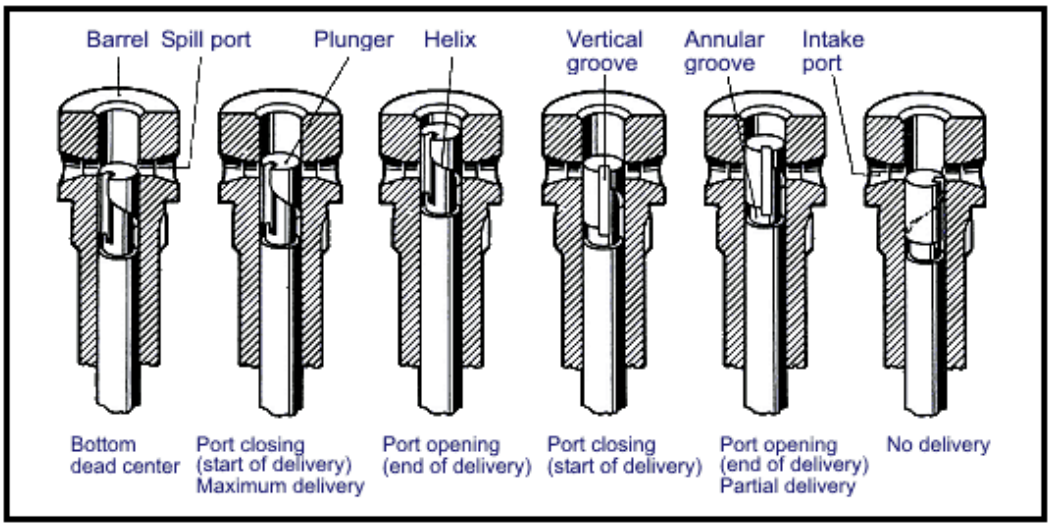


Figure 3 Fuel pump elements (Cut-section-port)

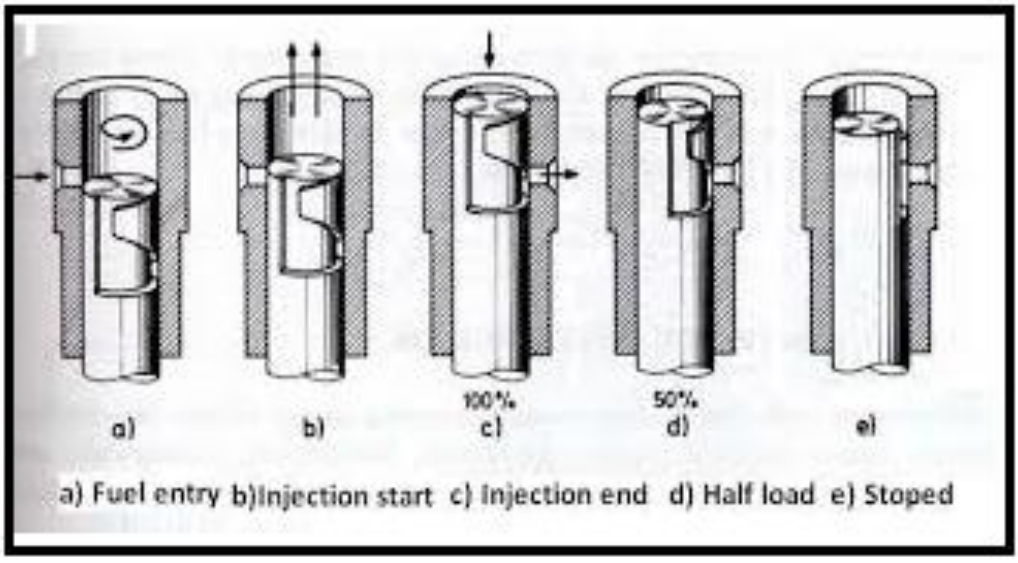


Figure 4 Fuel pump elements (Cut-section-load)

Figure 5 Inline Fuel pump

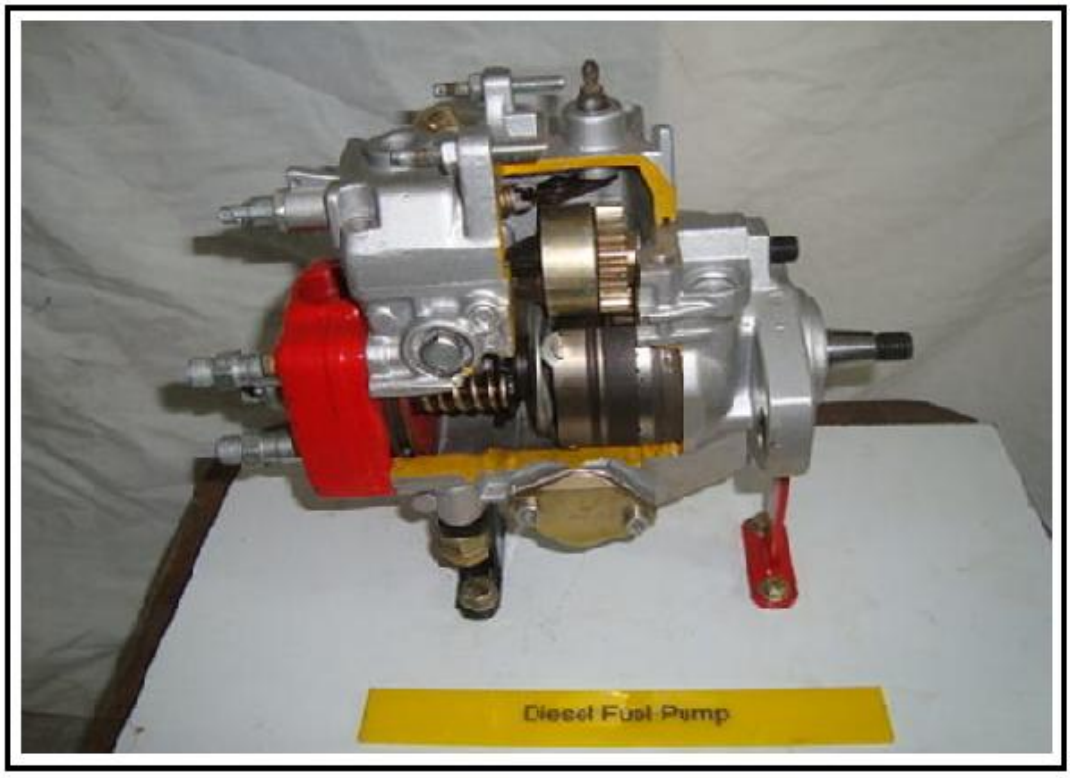


Figure 6 Rotary Fuel pump

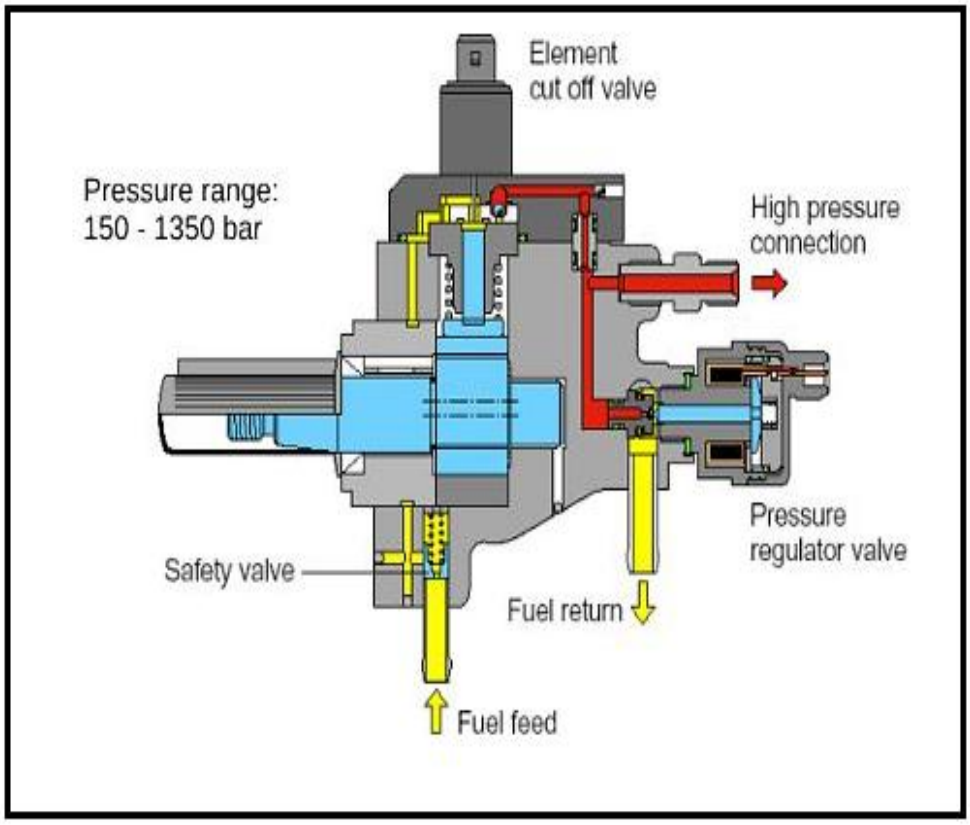


Figure 7 Rotary Fuel pump (cut - section)

IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Tool box	Adjustable wrench – 10/250 mm	1
		Plier – 8”/200mm	
		Allen key set – 1.5 to 10 inch	
		Screw driver set – 5 pieces	
		Open end jaw spanner set- 6-7 to 30-32	
		Round / box spanner set - 6-7 to 30-32	
		Rachet set – 10mm to 32 mm	

X Precautions to be Followed

1. Avoid improper handling of Fuel pump.
2. Use special and recommended tools for assembly and dismantling of Fuel pump
3. Use clean work bench for assembly and dismantling of Fuel pump.

XI Procedure

A) Dismantling of fuel injection pump:

Note: Teacher shall allot assembling of fuel injection pump and writing of steps involved in it as students activity.

1. Remove delivery valve holder.
2. Take out delivery valve spring and delivery valve.
3. Remove lock ring from lower side of pump.
4. Remove plunger return spring by removing plunger foot lock.
5. Remove plunger from barrel. Keep it in tray. Do not allow plunger to come in contact with moisture otherwise it may corrode the plunger barrel.
6. Remove the gear quadrant and spring plate.
7. Remove the control-rack from the housing of pump.
8. Remove barrel fixing screw and remove the barrel from the housing of pump.

XII Resources Used

Sr. No	Name of Resource	Broad Specifications		Qty	Remark (If any)
		Make	Details		
1					
2					
3					
4					
5					

XIII Actual Procedure Followed with Tools required

Dismantling of Fuel pump

.....
.....
.....
.....

Assembly of Fuel pump

.....
.....
.....
.....

XIV Observations and Calculations

Sr. no	Name of unit	Function	Tools used to dismantle
01	Plunger and barrel sub-assembly		
02	Delivery valve sub-assembly		
03	Housing sub-assembly		
		'	

XV Results

.....
.....
.....
.....

XVI Interpretation of Results

.....
.....
.....
.....

XVII Conclusions

.....
.....
.....
.....

XVIII Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Interpret if delivery valve spring is weak in fuel injection pump.
2. Conclude the injection pump plunger positions according to its motion.

[Space for Answer]

.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....

.....

.....

.....

.....

.....

XIX References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=IjXnbFVJKRY
2. https://www.youtube.com/watch?v=091xsWZ2wHY
3. https://www.youtube.com/watch?v=vp7fE-e0hQs
4. https://www.youtube.com/watch?v=iYFfMWh_nP8
5. https://www.youtube.com/watch?v=HVIE36oIR1s

XX Assessment Scheme

	Performance Indicators	Weightage
	Process Related (10 Marks)	**40%**
1	Handling of the tool kit tools	20%
2	Identification of Fuel pump components	20%
	Product Related (15 Marks)	60%
3	Interpretation of components of Fuel pump	20%
4	Conclusions	20%
5	Practical related questions	20%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. ……
2. ……
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No.6 and 7 : Perform Test On The Given I.C. Engine to Prepare Heat Balance Sheet and Plot Performance Characteristics.

I Practical Significance

Testing of an I.C. Engine is a process in which the engine is tested for various parameters for efficient performance.

The purpose of testing an I.C. Engine is

a. To determine the information which cannot be obtained by calculations.

b. To confirm validity of the data used in engine design.

c. To satisfy the customer regarding the performance of the engine.

There are three types of test carried out for I.C. Engine.

a. Commercial test b. Thermodynamic test c. PUC test

Heat balance sheet is an account of heat supplied to the engine and heat utilized in various ways by the engine. Thermodynamic test is carried out for the purpose of comparing actual results with the theoretical or ideal performance.

II Relevant Program Outcomes (POs)

PO1- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic Engineering to solve the broad-based Mechanical Engineering problems.

PO2-**Discipline knowledge**: Apply Mechanical engineering knowledge to solve broad- based mechanical engineering related problems.

PO3- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical Engineering problems.

PO4-**Engineering tools:** Apply relevant Mechanical technologies and tools with an understanding of the limitations.

PO8- **Individual and team work:** Function effectively as a leader and team member in diverse/ multidisciplinary teams.

III Competency and Skills

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences**:**

- **Maintain power engineering and refrigeration devices.**

IV Relevant Course Outcome(s)

- Test the performance of I C Engine.

V Practical Outcome

Perform test on the given I.C. Engine to prepare heat balance sheet and plot performance characteristics.

VI Relative Affective Domain-

- Follow safety practices.
- Practice good housekeeping.
- Work as a leader/a team member.
- Follow ethical Practices.

VII Minimum Theoretical Background

1. Identify parameters of I.C. Engine for Testing.
2. Know the procedure of Heat Balance Sheet.
3. Estimate Heat Balance Sheet.

VIII Experimental setup

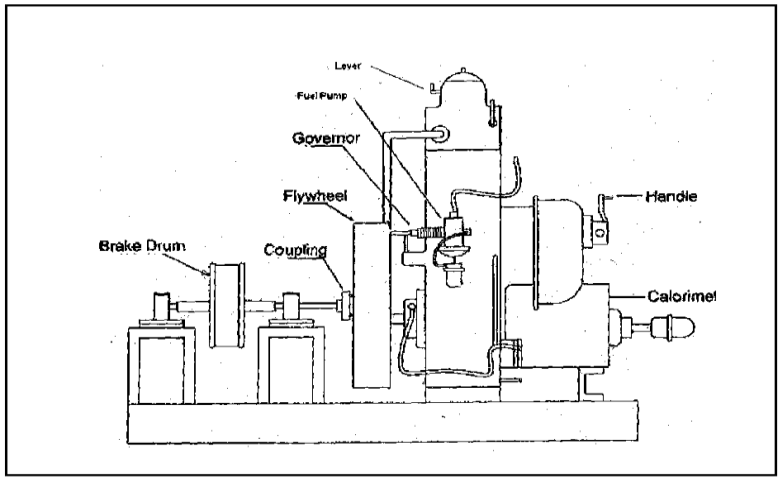


Figure No 1 Schematic diagram of Diesel engine test rig with rope brake dynamometer

Figure No 2 Diesel Engine Test Rig With Rope Brake Dynamometer

IX Resources Required

Sr. No	Name of Resource	Suggested Broad Specification	Quantity
1	Engine	Type – Single cylinder	1
		Bore - 0.875 m	
		Stroke – 0.017 m	
		Power developed- 7 HP	
		Torque -7.46 N-m At 1500 rpm	
2	Rope brake dynamometer OR	Diameter of rope brake drum, D = 0.3 m	1
		Diameter of Rope, d = 0.015 m	
3	Hydraulic dynamometer OR	Dynamometer constant, K = 2000	1
4	Eddy current dynamometer	Dynamometer constant, K = 200	
5	Orifice specification	Diameter of Orifice(d_0) = 0.014 m	1
		Coefficient of discharge for orifice, C_d = 0.65	
6	Tachometer	Standard (Range-1000 to5000 rpm)	1
7	Calorimeter	Type –Exhaust gas calorimeter	1
8	Fuel gauge	Burette of 50 ml	1
9	Temperature gauge/Thermocouple	RTD	1
10	Water manometer	Glass U tube manometer	1
11	Glass /Fiber Jar	Capacity - 1 lit.	1

Note: Specifications mentioned are for reference only.

X Precautions to be Followed

1. Avoid improper handling of I.C. Engine.
2. Operate the I.C. Engine as per given procedure.
3. Before starting the engine, oil level in sump and jacket cooling water supply must be checked.
4. Never stop the engine on load and never use decompression lever for stopping.
5. Do not tamper with any of engine setting, like governor, fuel injector.

XI Procedure

1. Fill up sufficient diesel in diesel tank.
2. Check oil level in the engine. It should be up to the top edge of the flat portion provided over the oil dipstick. If oil level is reduced, add up clean

SAE-40 oil to the crankcase by opening the valve cover at the top of the engine. Replace the cover after filling the oil.

3. Fill up water in Manometer up to half of the manometer height.
4. Start the water supply and see that water is flowing though engine jacket, brake drum and exhaust gas calorimeter.
5. If diesel tank was empty before filling the diesel, remove air bubbles in fuel pipe, by opening the vent screw provided at the right side, top of the fuel pump.
6. Adjust the load on the dynamometer to zero, by releasing the loading screw, so that there is no tension in the rope.
7. Start the engine. For starting, lift up decompression lever, at the side of the valve cover. Put the handle over the starting shaft and rotate the shaft. As engine picks up sufficient speed, drop the decompression lever. The engine will start. Remove the handle immediately. Allow the engine to get stabilized.
8. As engine picks up its rated speed, start water to the brake drum.
9. If required, adjust the fuel supply in order to bring the engine to the desired test speed at which trials to be conducted (further, all the readings are to be taken at this test speed).
10. Open burette filling cock, take sufficient diesel in burette and close the cock.
11. Now, turn selector cock to 'BURETTE' position and note down time required to consume certain amount of fuel <10 ml or 20 ml etc.) with the help of fuel gauge and stop watch i.e. 't' second.
12. Note down engine speed with tachometer.
13. Take manometer reading $\mathbf{h_1}$and $\mathbf{h_2}$. '
14. Measure quantity of jacket cooling water **(m_{wc})** in lit/min. and its inlet temperature **(t_1°C)** and outlet temperature **(t_2°C**) across the engine jacket.
15. Measure engine room temperature **(t_r°C).**
16. i) Measure temperature of exhaust gases from the engine (**$t_1{}^0$C**)
    ii) If exhaust gas calorimeter is used, then measure,
    (a) Quantity of. water supplied to the exhaust gas calorimeter (**m_{cc}**) in lit/min.
    (b) Temperature of water inlet to calorimeter **(t_{c1}°C)**
    (c) Temperature of water outlet from the calorimeter **(t_{c2}°C)**
    (d) Temperature of exhaust gas entering the calorimeter **(t_{g1}°C)**
    (e) Temperature of exhaust gas leaving the calorimeter **(t_{g2}°C)**
17. All the readings taken in step nos. 10 to 16 are for zero load, Note these readings in the Observation table in the column of zero load.
18. Calculate full brake load capacity of the engine.
19. Apply certain load (say $1/4^{th}$ of full load) on the dynamometer. In case of constant speed governor, engine will attain the test speed. In case of variable speed governor, adjust the fuel supply to bring the engine to test speed at which test is to be conducted. Note this load in the observation table and take all readings as in step nos. 10 to 16. Note these readings in the observation table in the column for this load. .

20. Repeat the same procedure for different loads (say $^1/_2{}^{th}$ of full load, $^3/_4{}^{th}$ of full load and full load).
21. Determine Frictional Power (F.P.) as follows -
22. On graph paper mark X and Y axis. On X axis take Brake Power (BP) in KW to some scale. On Y axis take mass of fuel consumed in Kg / min **(m_f)** to some scale. Mark the points showing X and Y co-ordinates i.e. respective BP and $m_f$on graph. Draw straight line passing through maximum no. of points on graph, as shown in the following figure. The plot is known as Willam's Line.
23. Distance OA represents FP to some scale. As the trial is conducted at constant speed, FP is assumed to be same for all loads. Enter FP obtained as above, in the tabular form of calculation (5.0) in the Sr. No. 11 for all loads.
24. Prepare heat balance sheet on minute and percentage basis for any one brake load other than zero.

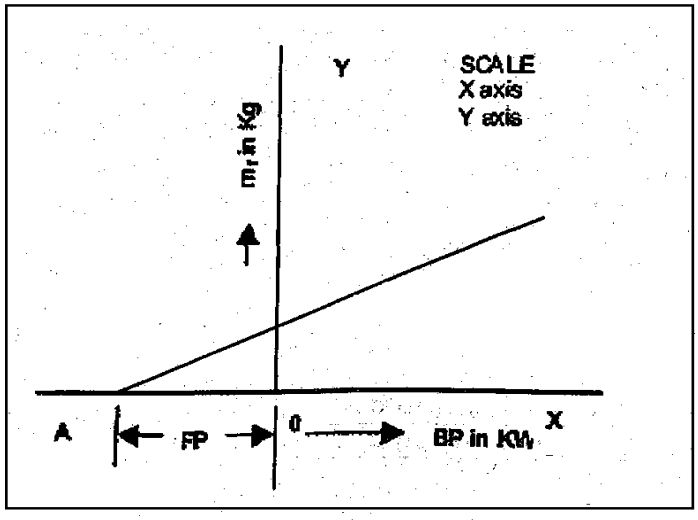


Figure No 3 William's Straight Line method

XII. Resources Used

Sr. No	Name of Resource	Broad Specifications		Qty	Remarks (If any)
		Make	Details		
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					

XII Actual Procedure Followed

Please note: If the engine test rig available in laboratory is different from the test rig given in the manual, then there will be change in layout diagram, stepwise procedure, observation table and calculations. The teachers are advised to make the necessary changes and guide the students accordingly

.....
.....
.....
.....

XIII Precautions Followed

.....
.....
.....
.....

XIV Observations and Calculations

Sr. No.	Load condition Particulars		Zero load	1 /4th load	Half Load	3/4th Load	Full Load
1	Weight (W) in kg						
2	Spring balance reading (S) in kg (in case of rope brake dynamometer)						
3	Speed **(N)** in rpm						
4	Time taken to consume specific quantity (10ml, 20 ml as suitable of fuel (t) in sec			-			
5	Cooling water inlet temp, (t.,) in °C						
6	Cooling water outlet temp. (t_2) in °C						
7	Quantity of jacket cooling water (m_{wc}) in lit/min						
8	Exhaust gas temp. (t_q) in °C						
9	Engine room temp. (t_r) in °C						
10	Water manometer reading h_w	$^{h}1$ cm					
		$^{h}2$ cm					
11	Quantity of water supplied to exhaust gas calorimeter (m_{cc}) in lit / min						

12	Temp, of water inlet from calorimeter (t_{c1}) in °C					
13	Temp, of water outlet from calorimeter (t_{c2}) in °C					
14	Temp, of exhaustgases entering calorimeter (t_{g1}) in °C					
15	Temp, of exhaust gases leaving calorimeter (t_{g2}) in °C					

Calculations:

Calculation table for Efficiencies and Heat balance Sheet

Sr No.	**Particulars**		**Load condition Formulae**	**Zero load**	**1/4th load**	**Half Load**	**3/4th Load**	**Full Load**
1	Weight (W) in N		(W in kg x 9.81)					
2	Spring balance reading (S) in N (in case of rope brake dynamometer)		(S in kg x 9.81)					
3	Speed (N) in rpm							
4	Brake Power (BP) in kW	For rope brake dynamometer	$\frac{2(w-s)\pi r_e N}{60x1000}$					
		For hydraulic dynamometer	$\frac{WxN}{K}$					
		For Eddy Current dynamometer	----------					
5	Quantity of fuel consumed (m_{fc}) in lit/sec		$\frac{\text{Sp. Quantity of fuel(ml)}}{1000 \times t}$					
6	Mass of Fuel Consumed (m_f) in kg/min		(m_{fc} x sp. gr. of fuel) x 60					
7	Mass of jacket cooling water (m_w) in kg/min		(m_{wc} x sp. gr. of water)					
8	Manometer difference or water head (m_w) in meters		$\frac{(h_2-h_1)}{100}$					

9	Frictional Power (FP) in kW	Refer step no. 21 for determination of FP					
10	Indicated Power (IP) in kW	(BP + FP)					
11	Mechanical Efficiency η_{Mech} in (%)	(BP / IP) x 100					
'12	Mass of water supplied to exhaust gas calorimeter (m_c) in kg/min	(m_{cc} x sp. gr. of water)					

Calculations for heat balance sheet

Prepare heat balance sheet on minute and percentage basis for any one brake load other than zero.

For load on engine = ... N

1. **Heat Supplied**

H_f = Heat supplied by combustion of fuel = (m_f) X **CV**

= …… X ……..

= .....kJ / min

2. **Heat Expenditure**

i. **Heat equivalent to brake power (H_{BP})**

Brake power, BP ={ [2π (W-S) r_e N / 60] x 1000 }KW

=……

BP = …… kW or kJ/s

H_{BP} = Heat equivalent to brake power = BP x 60

= ……. X 60

=……kJ / min

ii. **Heat carried away by Jacket cooling water (Hcw)**

H_{cw}= Heat carried away by Jacket cooling water

= (m_w) x C_{pw} x $(t_2 – t_1)$

= (……)x 4.187 X (……– ... .. ….)

H_{cw}= …… kJ/min .

iii. **Heat carried away by exhaust gases (H_g)**By two methods,

a) By using Air box,

First determine the mass of exhaust gas as follows

$m_a = p_a x Q$ = ……. equation (i)

Density of air is calculated from general gas equation as follows:

We know, PV = RT

Where, P = Atmospheric Pressure = 1.01325 bar

= 1.01325 x 10^s N/m^2

R = Characteristic constant for air - 0.287 kJ/kg K .

T = Absolute temperature of air = $(t_r + 273)°K$

$P \times (1 / p_a) = RT$

$p_a = P / RT$

p_a = ……Kg/m^3

Now quantity of air supplied is calculated as

$Q = C_d \times a_0 \times \sqrt{2gh_a}$ m^3/s

a_0= area of orifice =$\pi / 4 \times (d_0)^2$

= $\pi / 4 \times (\ldots\ldots\ldots\ldots)^2$

= …… m^2

Here, h_a = air head in meter = $(p_w h_w / p_a)$

= [(1000 x……)/(.....)]m of air

= …… m of air.

Q = . ……. x.....,.x $\sqrt{2x9.81 \text{ x}..... .m^3/s}$

Q =…… m^3/sec

Thus, mass of air supplied in kg/s from equation (i) is

m_a=Pa x Q =

= ……. Kg/sec

mass of air supplied in kg/min

m_a = mass of air supplied in kg/sec X 60

= …….. kg/min

Thus, mass of exhaust gases in kg/min

= mass of air consumed in kg/min + mass of fuel consumed in kg/min

$m_g = m_a + m_f$

m_g=……+ …….. .

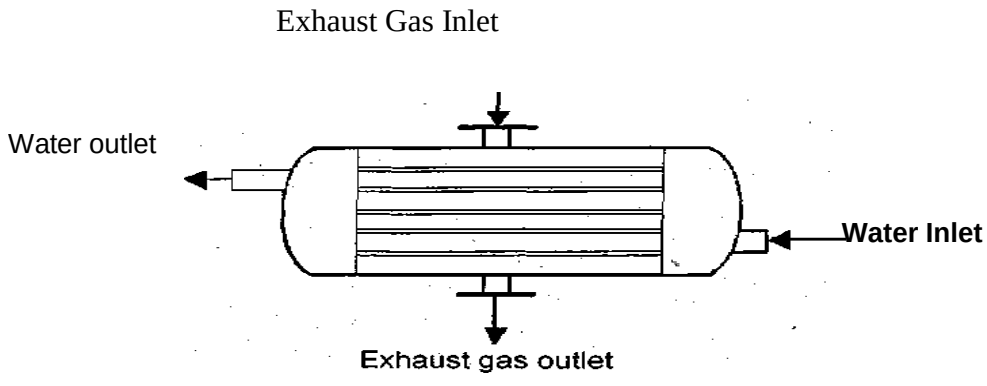
m_g = ……kg/min

Hence

Heat carried .away by exhaust gases = m_g x C_{pg} x (t_f - t_r)

Hg = …….. kJ/min

b) **By using Exhaust gas Calorimeter**



Writing the heat balance for calorimeter as -

Heat rejected by exhaust gases in the calorimeter = heat gained by the water in the calorimeter

Now, Total heat carried away by exhaust gases =

$H_g = m_g \times C_{pg} \times (t_{g1} - t_{g2}) = [m_c \times C_{pw} \times (t_{c2} - t_{c1})]$

$m_g \times C_{pg} = [m_c \times C_{pw} \times (t_{c2} - t_{c1})] / (t_{g1} - t_{g2})$

Now, total heat carried away by exhaust gases $= H_g = m_g \times C_{pg} \times (t_g - t_r)$

$= \{ [m_c \times C_{pw} \times (t_{c2} - t_{c1})] / (t_{g1} - t_{g2}) \} \times (t_g - t_r)$

Hg = ……. kJ / min

iv) Heat unaccounted (Heat Lost due to radiation, pumping losses, errors of observation etc.) by difference

H_u= (Heat supplied by combustion of fuel**)** - [(Heat equivalent of BP) + (Heat lost to jacket cooling water) + (Heat lost to exhaust gases)]

$= \mathbf{H_f - [H_{BP} + H_{cw} + H_g]}$

$\mathbf{H_u}$ =……..... kJ/min

XV Results

Heat balance sheet for .... N brake load

HEAT CREDIT			HEAT DEBIT		
Heat supplied	**kJ/min**	%	**Heat Expenditure**	**kJ/min**	%
Heat supplied by combustion of fuel (H_f)		100	a) Heat equivalent to BP (H_{BP})		
			b) Heat lost to jacket cooling water (H_{cw})		
			c) Heat lost to exhaust gases '(Hg)		
			b) Heat unaccounted (H_u)		
Total		**100**			**100**

XVI Interpretation of Results

.....
.....
.....
.....

XVII Conclusions

.....
.....

.....

.....

XVIII Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

.

1. Compare the ignition temperature of diesel fuel and petrol fuel.
2. Identify costly engine of same capacity of petrol or diesel engine. Justify.
3. Draw performance characteristics based on calculations.

[Space for Answer]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

XIX References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=wr5JsovSX_o
2. https://www.youtube.com/watch?v=HAFR9fVknso
3. https://www.youtube.com/watch?v=uOYslENZlnc

XX Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**40%**
1	Ability to start, stop and operate the engine	20%
2	Ability to apply desired load on engine	20%
Product Related (15 Marks)		60%
3	Calculate Heat balance sheet of I.C. Engine	20%
4	Conclusions	20%
5	Practical related questions	20%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. …….
2. …….
3. …….

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No. 8: Perform Morse Test on the given IC Engine.

I Practical Significance

A Morse Test is a test conducted to determine the power developed in each cylinder in multi cylinder I.C. Engine. Then the power of the individual cylinders are determined by cutting- off the power supply to the spark plug of the cylinder under test for petrol engine and fuel supply of the cylinder in diesel engine. Morse Test is used to calculate Indicated power of Multi cylinder high speed engine.

II Relevant Program Outcomes (POs)

PO1- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic Engineering to solve the broad-based Mechanical Engineering problems.
PO2-**Discipline knowledge**: Apply Mechanical engineering knowledge to solve broad- based mechanical engineering related problems.
PO3- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical Engineering problems.
PO8- **Individual and team work:** Function effectively as a leader and team member in diverse/ multidisciplinary teams.

III Competency and Skills

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences**:**

- **Maintain power engineering and refrigeration devices.**

IV Relevant Course Outcome(s)

- Test the performance of I C Engine.

V Practical Outcome

- Perform Morse Test on the given I.C. Engine.

VI Relative Affective Domain-

- Follow safety practices.
- Practice good housekeeping.
- Work as a leader / a team member.
- Follow ethical Practices.

VII Minimum Theoretical Background

1.Know the procedure of Morse Test.
2.Identify performance parameters of Morse Test.
3.Determine the brake load in order to bring the engine to desired speed, while cutting- off individual cylinders.

VIII Experimental setup

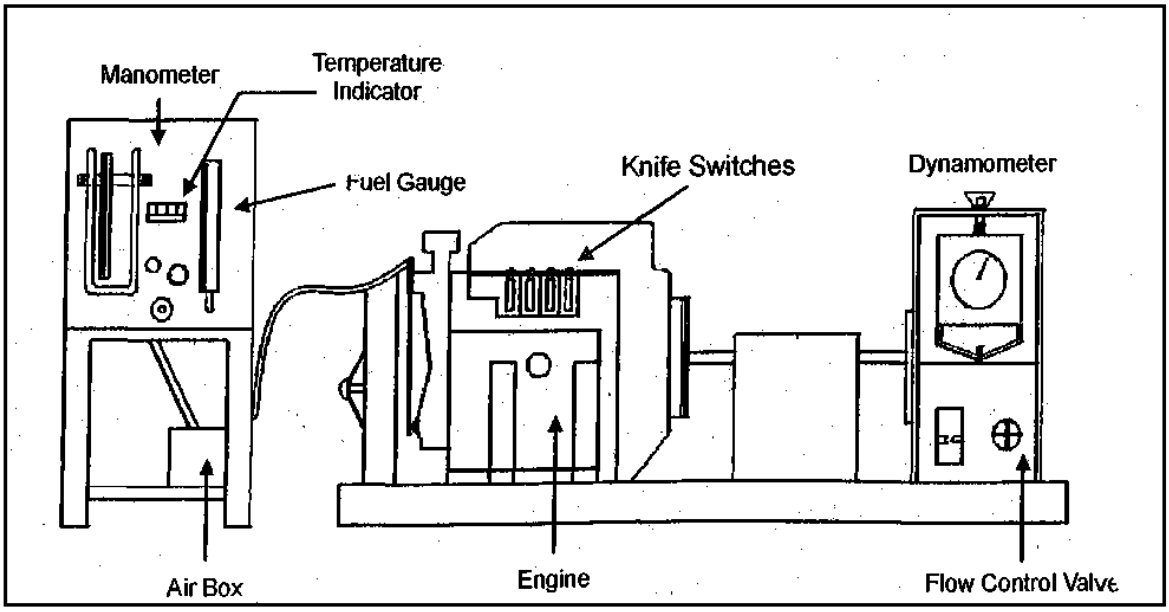


Figure No 1 Four stroke four cylinder petrol engine test rig with hydraulic dynamometer

Figure No 2 Four stroke Four cylinder Petrol engine Morse Test rig

IX Resources Required

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Engine	Type – Multi- cylinder (3 or 4) Four Stroke petrol/Diesel Engine	1
		Bore - 0.080 m	
		Stroke – 0.110 m	
		Power developed- 3.75 KW	
2	Rope brake Dynamometer OR	Diameter of rope brake drum, D = 0.3 m	1
		Diameter of Rope, d = 0.015 m	
3	Hydraulic dynamometer OR	Dynamometer constant, K = 2000	1
4	Eddy current dynamometer	Dynamometer constant, K = 200	1

Note: Specifications mentioned are for reference only.

X Precautions to be Followed

1. Fill up sufficient fuel in the fuel tank.
2. Check oil level in the engine with the help of dipstick provided and ensure level is appropriate.
3. Ensure battery water level is proper.
4. Jacket cooling water supply is appropriate.
5. Do not disturb any of the engine settings

XI Procedure

1. Insert the key in the ignition switch and start the engine. Allow it to get stabilized warmed up.
2. Adjust the fuel supply and the load on the dynamometer to bring the engine to the required speed at which test is conducted. This is test speed-N.
3 Note the speed with tachometer.
4 Note the load applied on engine from dynamometer load dial.
5. The speed and load measured in step no.**6** and 7 are for all cylinders developing power. Note readings in the observation table.
6. Now put off first knife switch to cut off ignition of cylinder 1. Speed of engine will reduce. Adjust the load on the dynamometer to bring the engine to the test speed N rpm. Allow it to get stabilized. Note this load in the observation table.
7. Reconnect ignition to cylinder 1. All cylinders are now developing power. Allow the engine to run on all cylinders for a short time.

8. Cut off cylinder No. 2 adjust the load on the dynamometer to bring the engine to the test speed. allow it to get stabilized. Note this load in the observation table.
9. Similarly, cut off remaining cylinders one by one. Adjust the load on the dynamometer to bring the engine to the test speed. Note this load in the observation table.
10. Complete observation table and calculations in the tabular form.

XII Resources Used

Sr. No	Name of Resource	Broad Specifications		Qty	Remarks (If any)
		Make	Details		
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					

XIII Actual Procedure Followed

.....

.....

.....

.....

XIV Observations and Calculations:

Test speed of the engine, N =…… rpm

(It will be constant for all sets of readings)

Readings for Brake power calculation

Sr. No.	Particulars $_n$ Cylinder off	Nil	**1**st	**2**nd	**3**rd	4th
1	Load (W) kg					
2	Load in N (W x 9.81)	W=	W_1=	W_2=	W_3=	W_4 =

Sr. No	Particulars	Formulae	Quantity
1	Brake Power of engine with ail cylinders Working (B)	WN / K	..... KW
2	Brake Power of engine when first cylinder cut-off (B_1)	W_1N / K	..... KW
3	Brake Power of engine when second cylinder cut-off (B_2)	W_2N / K	..... KW
4	Brake Power of engine when third cylinder cut-off (B_3)	W_3N / K	..... KW
5	Brake Power of engine when fourth cylinder cut-off (B_4)	W_4N / K	..... KW

- **Calculations for indicated power:**

IP of 1st Cylinder

I_1= B - B_1= ..... - .....

= ... ... *KW*

IP of 2nd Cylinder

I_2= B - B_2= ..... - .....

= …… KW

IP of 3rd Cylinder

I_3 = B - B_3= ..... - .....

= ……KW

IP of 4th Cylinder

I_4 = B –B_4 = ... - .....

= …… KW

IP of all cylinders or engine, I =I_1+ l_2 + l_3 + l_4

= …… + …… + …… …. . + ……

= …..... KW

Frictional power of the engine,

FP = I – B = ... -.....

= .....…… KW

Mechanical Efficiency of Engine,

η_{Mech}= (BP of all Cylinders) / (IP of all Cylinders)

= B/I x100

= ---------- x 100

= ----------

XV Results

.....
.....
.....
.....

XVI Interpretation of Results

.....
.....
.....
.....

XVII Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Identify which engine is more efficient diesel and petrol engine of same capacity,
2. Interpret Indian standard specification for testing for I.C. engines.

[Space for Answer]

.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....

.....

.....

.....

.....

.....

.....

.....

XVIII References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=lR6ku_g_eNI
2. https://www.youtube.com/watch?v=BXQ27pU3_7E
3. https://www.youtube.com/watch?v=fTAUq6G9apg

XX Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**40%**
1	Ability to start,stop and operate the engine	20%
2	Ability to apply desired load on engine	20%
Product Related (15 Marks)		**60%**
3	Calculate Mechanical efficiency of I.C. Engine	20%
4	Conclusions	20%
5	Practical related questions	20%
	Total (25 Marks)	**100 %**

Names of Student Team Members

1. ……..
2. …….
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No.9 : Use Exhaust Gas Analyzer for Measurement And Analysis of Pollutants In The Given IC Engine.

I Practical Significance

Improved transportation and an improved economy made the automobile one of the most important invention in past few decades. But besides that one more challenge for our developed sector is facing that is generation of emissions, which is bi–product of fuels. Emission from automobiles produce adverse effect on human being as well as on our environment, so to check and regulate the emission from automobiles a device like Exhaust gas analyzer/ Pollution Under Control (PUC) testing was introduced. With the help of these equipment's, automobile sector has certified their vehicles for emission and health check-up which is valid for 6 months, this checking is mandatory for all vehicles by Government of India. These regulation norms are known as Bharat stage which is followed by Euro norms.

II Relevant Program Outcomes (POs)

PO1-**Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic Engineering to solve the broad-based Mechanical Engineering problems.

PO2-**Discipline knowledge:** Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

PO3- **Experiments and practice**: Plan to perform experiments and practices to use the results to solve broad-based Mechanical Engineering problems.

PO4-**Engineering tools:** Apply relevant Mechanical technologies and tools with an understanding of the limitations.

PO5-**The engineer and society:** Assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to practice in field of Mechanical engineering.

PO7 - **Ethics:** Apply ethical principles for commitment to professional ethics, responsibilities and norms of the practice also in the field of Mechanical engineering.

PO8-**Individual and team work:** Function effectively as a leader and team member in diverse/Multi-disciplinary teams.

III Competency and Skills

- This practical is expected to develop the following skills for the industry identified competency through various teaching learning experiences.
  'Maintain power engineering and refrigeration devices.'

IV Relevant Course Outcome(s)

- Test the performance of I C Engine.

V Practical Outcome

- Use exhaust gas analyzer to measurement and analyze pollutants in the given IC engine.

VI Relative Affective Domain-

- Follow safety practices.
- Practice good housekeeping.
- Practice energy conservation.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.

VII Minimum Theoretical Background

1. Know the purpose of PUC test
2. Know the emission norms in India
3. Apply the procedure of Exhaust gas analyzer

VIII Experimental setup

Figure No 1 Layout of Exhaust Gas Analyzer

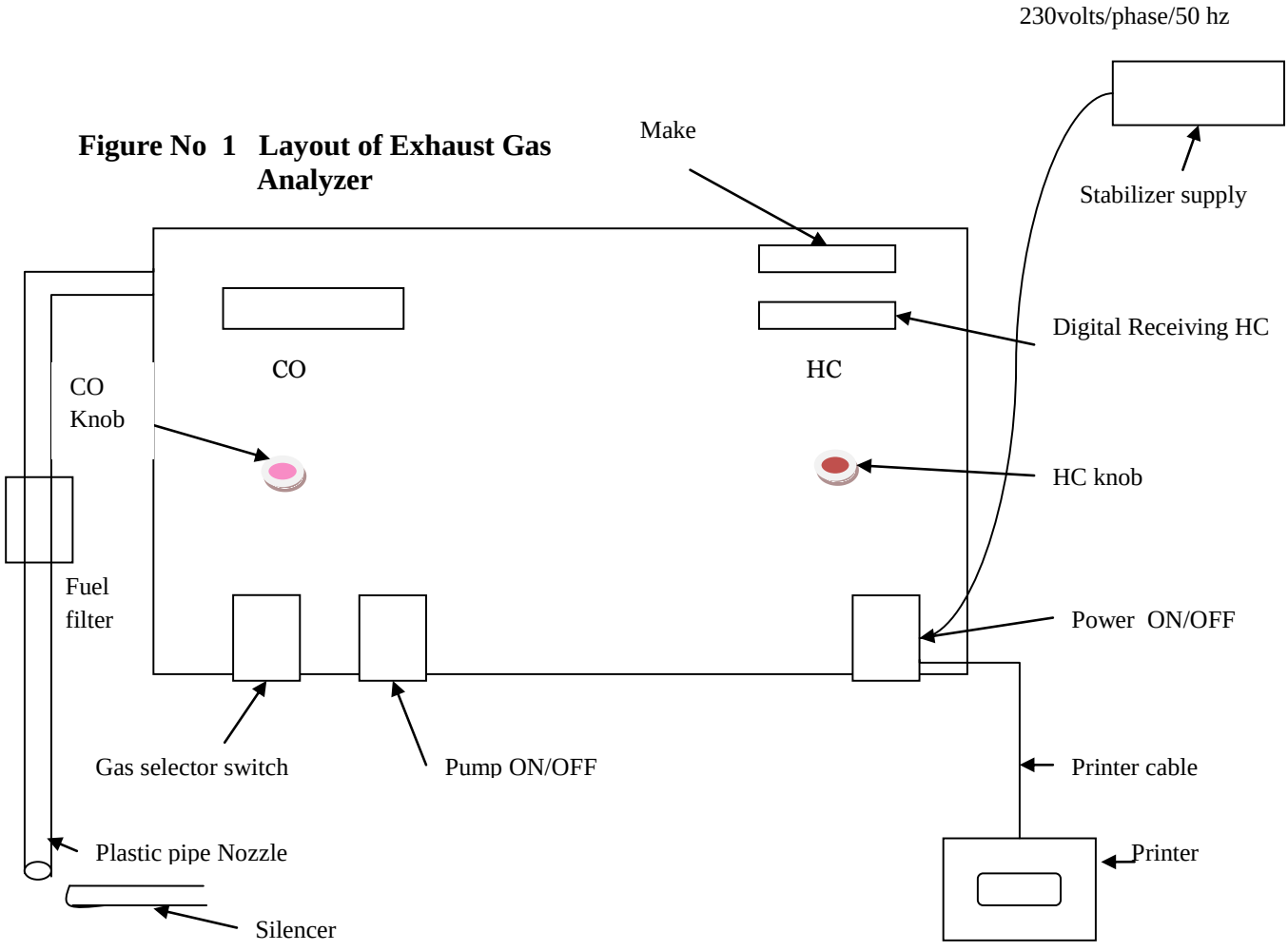


Figure No 2 A Typical Exhaust Gas Analyzer

Figure No 3 Dwell- tachometer

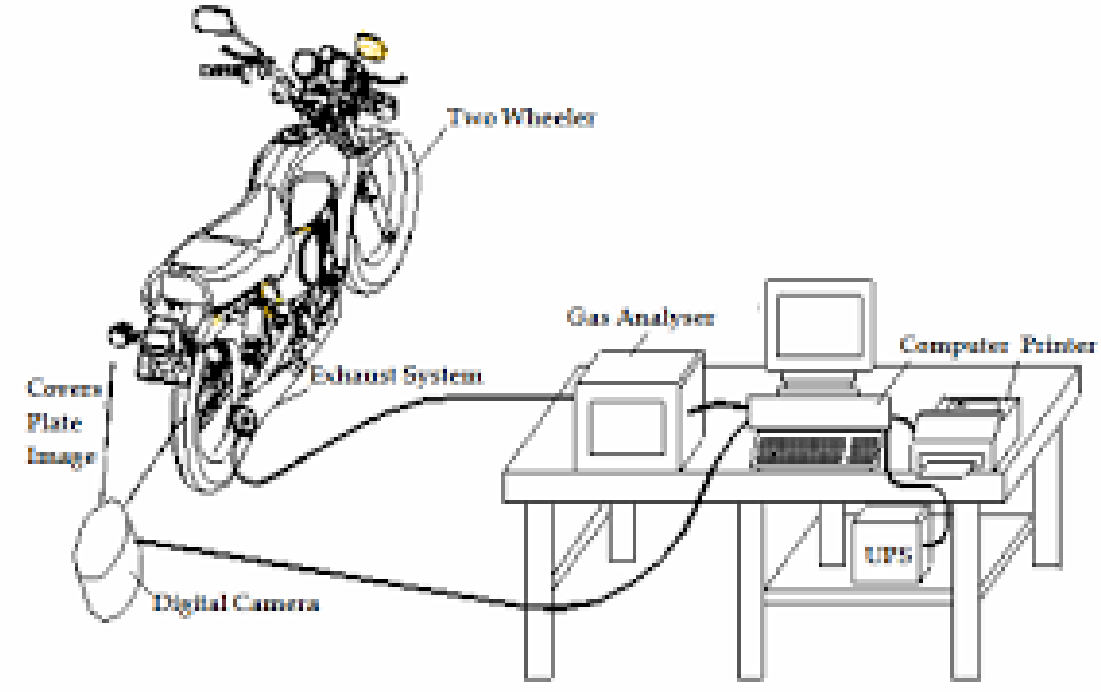


Figure No 4 Computerized PUC Testing for two wheeler

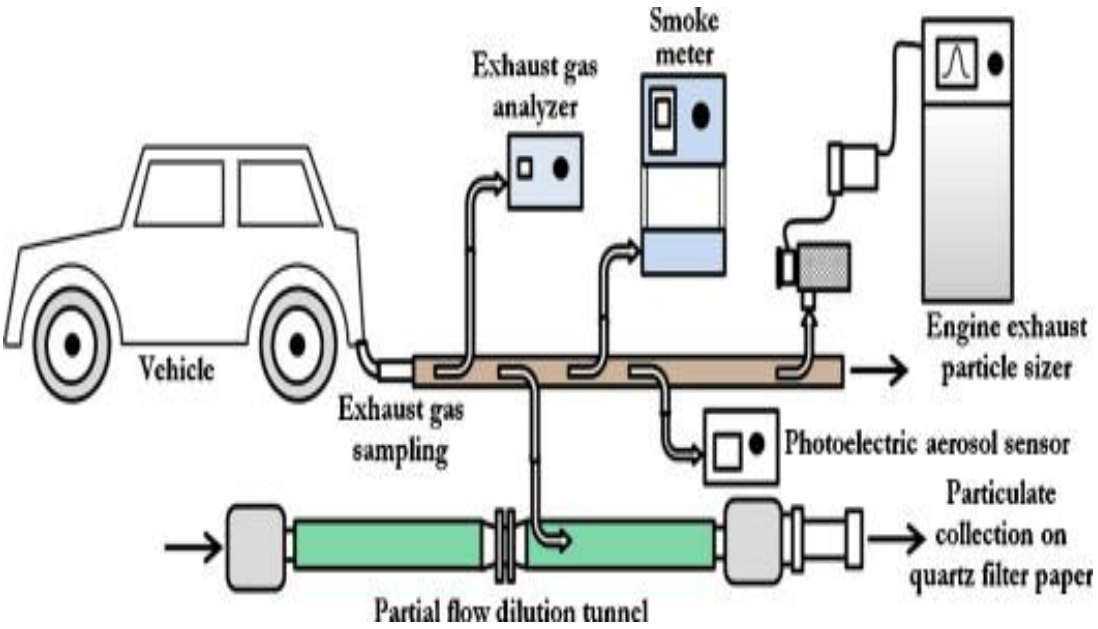


Figure No 5 Emission health check-up for four wheeler

Figure No 6- PUC Slip

Figure No 7 Health Check Slip

Check Slip

IDLING EMISSION STANDARDS

Sr No	Vehicle Type	Co%	HC(n-hexane equivalent ppm)	Non-methane Hydro Carbon (NMHC)	Reactive Hydrocarbon (RHC)
1.	2 & 3-Wheelers (2/4-Stroke) (vehicles manufactured on and before 31 march 2000)	4.5	9,000	0.3 times HC	0.6 times HC
2.	2 & 3-Wheelers (2/4-Stroke) (vehicles manufactured on and after 31 march 2000)	3.5	6,000		
3.	2 & 3-Wheelers (4-Stroke) (vehicles manufactured on and after 31 march 2000)	3.5	4,500		
4.	Bharat Stage II compliant 4 wheelers	0.5	750		
5.	4 Wheelers Other than Bharat Stage II Compliant	3	1,500		

Authorisation number & Address
T.O. AUTHORISATION
MH-12/191-2003
DUSTAN PUC CENTER
Petrol Pump Hadapsar Pune-28

Note : Holding a valid PUC Certificate does not give immunity from checking a vehicle for pollution and levy of fine thereafter during the validity period of PUC Certificate in case of excessive emission.

Signature of person authorised to conduct the test

Figure No 8 Typical test /health certificate provided after PUC testing

IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Exhaust gas Analyzer	For CO(%)-Range 0-10	1
		For HC (ppm)- Range 0-10000	
		RPM-Range 0-9000	
2	Dwell- tachometer (RPM)	RPM-Range 0-10000	1
3	Vehicle to be tested	As per available	1

Note-Specifications mentioned are reference only

X Precautions to be Followed

1. Avoid improper handling of Exhaust gas Analyzer
2. Select proper knob and selector switch
3. Provide proper warming period

XI Procedure

Note - The procedure may differ from machine to machine. Students shall refer the manufacturer's catalogue prior to the procedure.

1. Connect the power supply cable and exhaust gas probe to the exhaust gas Analyzer/ PUC machine
2. Allow analyzer to warm up for 15 min
3. After warming up, calibration is automatically carried out and analyzer is ready for measurement.
4. Start the engine and let it warm up at its idling speed.
5. Insert exhaust gas probe /nozzle into the exhaust muffler/silencer. Wait for few minutes.
6. Set CO and HC value to zero by using the knob.

7. Switch on the pump. Operate the gas selector switch and put it to CO and HC mode.
8. Note the reading of CO and HC or take print out.
9. Switch off the pump and remove the pipe from the exhaust muffler of the vehicle.Take additional readings at higher speeds by adjusting air screw in the carburetor or by accelerator.

XII Resources Used

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity	Remarks (If any)
1	Exhaust gas Analyzer	Make-	1	
		Model No.-		
		For CO(%)-		
		For HC (ppm)-		
		RPM-		
2	Dwell- tachometer (RPM)	RPM-	1	
3	Vehicle to be tested	Make -	1	
		Model-		
		Registration no.-		

XIII Actual Procedure Followed

.....
.....
.....
.....

XIV Precautions Followed

.....
.....
.....
.....

XV Observations and Calculations

Sr. No.	Engine Speed	CO(%)	HC(ppm)
1	Idling =		
2	Cruising speed =		
3	High Power =		

Note: For car, during test, measure the engine speed by the use of dwell-tachometer.

XVI Results

.....
.....
.....
.....

XVII Interpretation of Results

.....
.....
.....
.....

XVIII Conclusions

.....
.....
.....
.....

XIX Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Illustrate the Bharat Stage standard norms.
2. State the necessity of exhaust gas analyzer for vehicle.

[Space for Answer]

.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....

.....

.....

.....

.....

.....

.....

XX References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=W6dIsC_eGBI
2. https://www.youtube.com/watch?v=sGoW1OotFSc
3. https://www.youtube.com/watch?v=hpIxrWtxAJQ
4. https://www.youtube.com/watch?v=W9oVMzo5zgk

XXI Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**40%**
1	Handling of the measuring Instruments	20%
2	Compare final readings at different speed	20%
Product Related (15 Marks)		**60%**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1. ……..
2. …….
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No.10 : Perform Diagnosis Test On Given IC Engine Using Engine Control Unit

I Practical Significance

ENGINE CONTROL UNIT or ECU is the brain of engine that controls all the functioning of the engine by means of electronic control unit. The ECU is used to operate the engine by using input sensors and output components/actuators to control all engine functions since it is also work as management technique of engine and it serves several functions which includes regulating and maintaining the amount of fuel and air in the fuel injection part and helps in increasing horsepower of the engine.

On-Board Diagnostics -II (OBD II) is quickly, easily and safely 'HACK' your car, to run better and faster perform advanced fault/health diagnostics and most of all save money and time on repairs and maintenance.

Here are the most common symptoms of a bad ECU:

- Engine Light stays on after resetting.
- Car was jump started on reverse polarity.
- Engine turning off for no reason.
- Water Damage or Fire Damage on the ECU.
- Apparent loss of spark.
- Apparent loss of injection pulse or fuel pump.
- Intermittent starting problems.
- Overheating ECU.
- Engine performance issues.

II Relevant Program Outcomes (POs)

PO1- Basic knowledge: Apply knowledge of basic mathematics, sciences and basic Engineering to solve the broad-based Mechanical Engineering problems.

PO2-Discipline knowledge: Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

PO3- Experiments and practice: Plan to perform experiments and practices to use the results to solve broad-based Mechanical Engineering problems.

PO4-Engineering tools: Apply relevant Mechanical technologies and tools with an understanding of the limitations

PO8- Individual and team work: Function effectively as a leader and team member in diverse/ multidisciplinary teams

PO10- Life-long learning: Engage in independent and life-long learning activities in the context of technological changes also in the Mechanical engineering and allied industry.

III Competency and Skills

- This practical is expected to develop the following skills for the industry identified competency
  'Maintain power engineering and refrigeration devices.'

IV Relevant Course Outcome(s)

- Test the performance of I C Engine

V Practical Outcome

- Perform diagnosis test on given IC engine using Engine Control Unit

VI Relative Affective Domain-

- Follow safety practices.
- Practice good housekeeping.
- Practice energy conservation.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.

VII Minimum Theoretical Background

1. Know ECU, sensors, actuators.
2. Identify the notation code on dash board and monitor of Computer
3. Inspect the health remedies for the vehicle problem

VIII Experimental setup

Figure Importance of ECU

Fig 2 Diagnostic car with OBD

Figure 3 OBD slot arrangement near clutch pedal

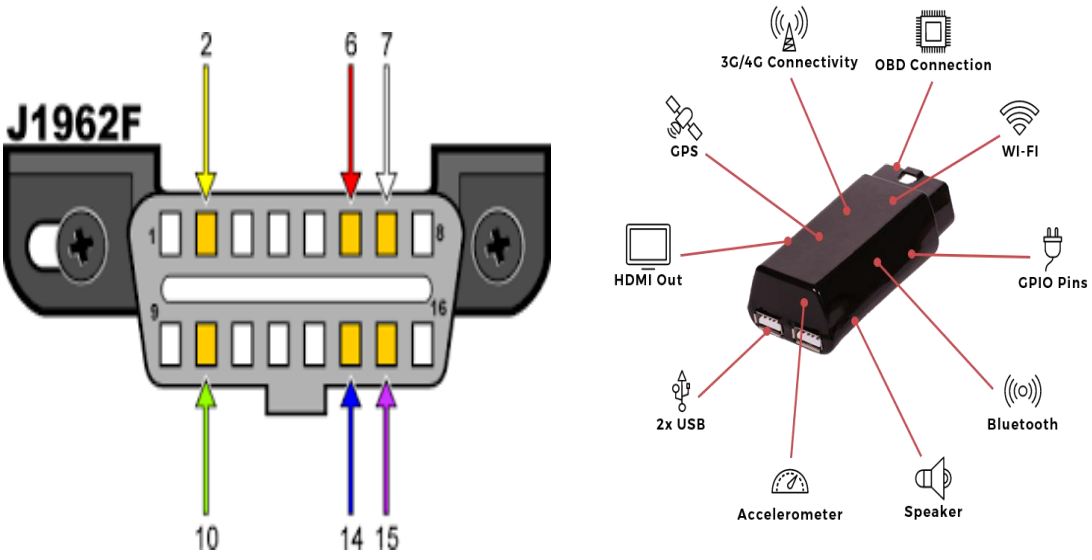


Figure 4 OBD II

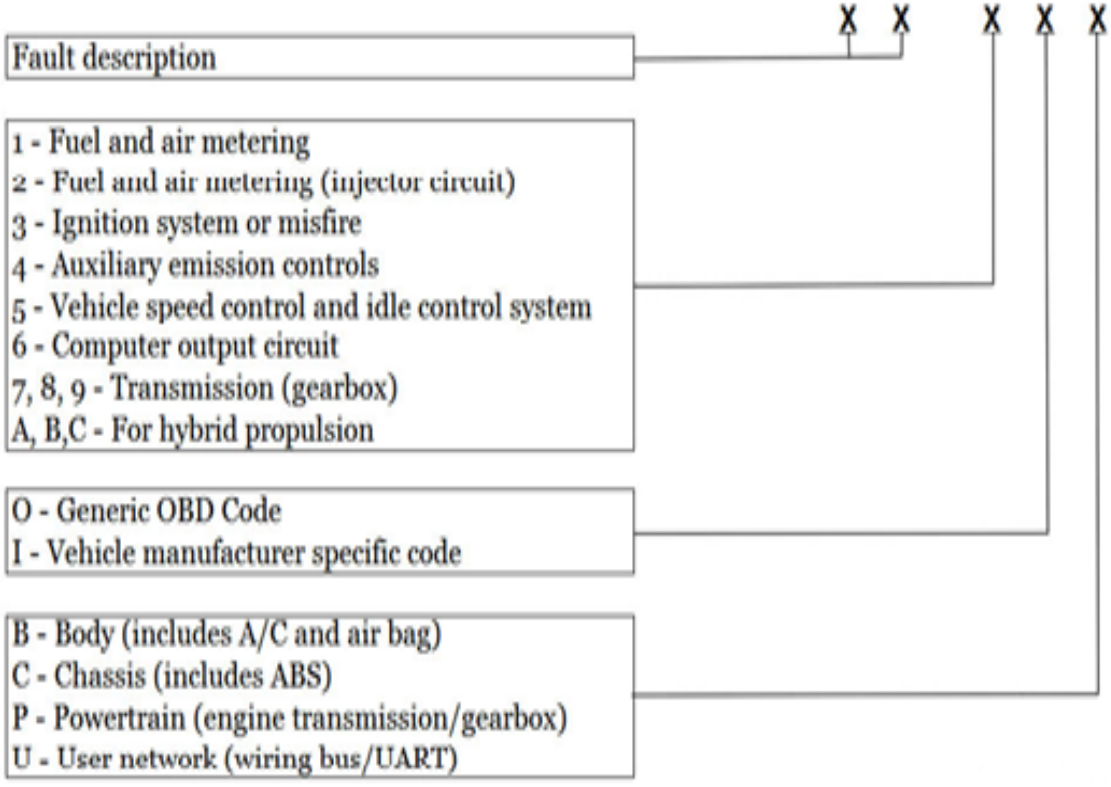


Figure 5 OBD-II diagnostics trouble code

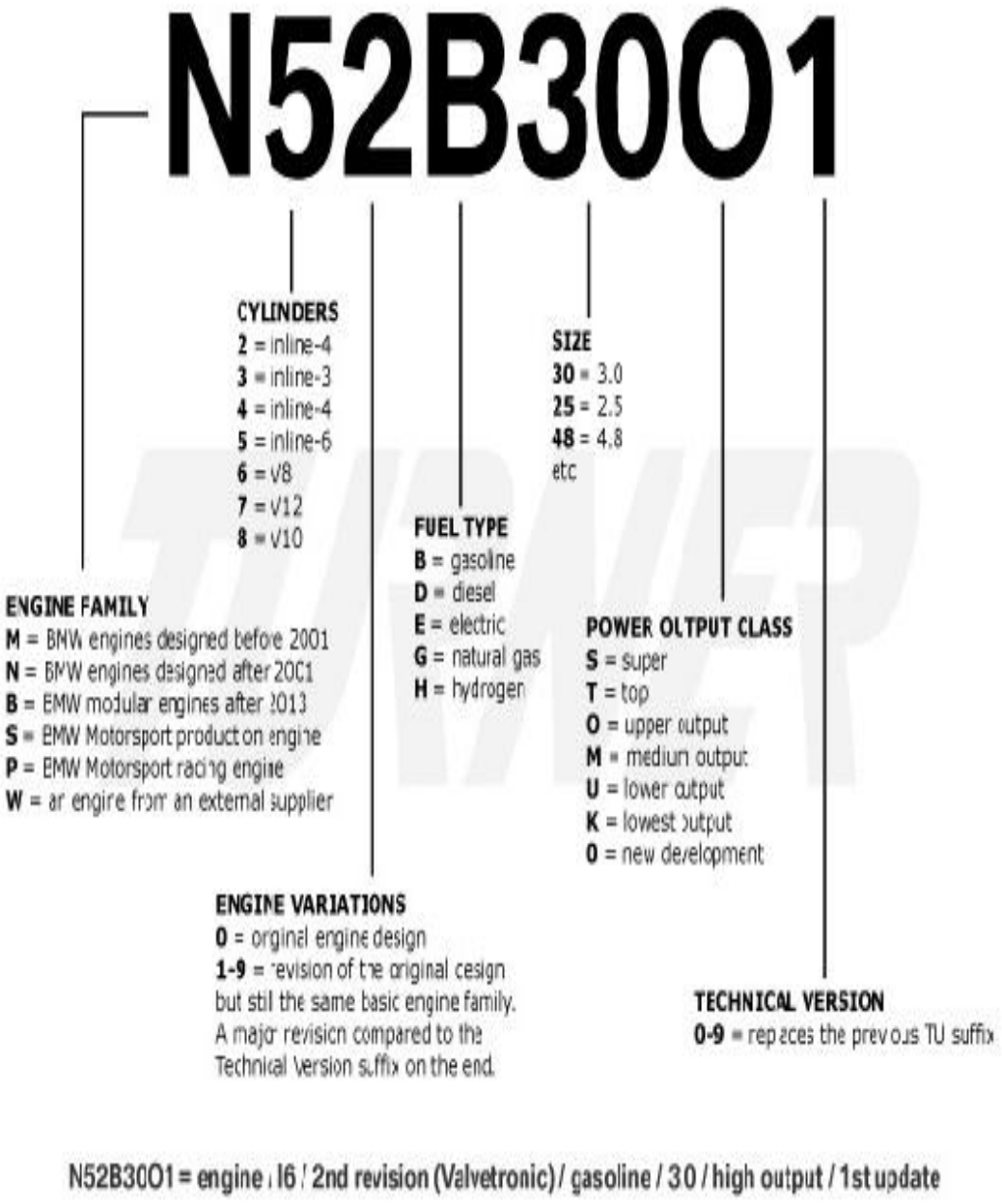


Figure 6 OBD-II diagnostics trouble code (BMW)

Figure 7 ECU/OBD II through mobile phone

DIFFERENCE BETWEEN GENERIC AND MANUFACTURER SPECIFIC

CODE TYPE	EXPLANATION
Generic (normally P0xxx)	The definition for the code is defined in the EOBD/OBD-II standard and will be the same for all manufacturers
Manufacturer-specific (normally P1xxx)	Where manufacturers feel that a code is not available within the generic list, they can add their own codes The definition for these are set by the manufacturer

Your Mechanic

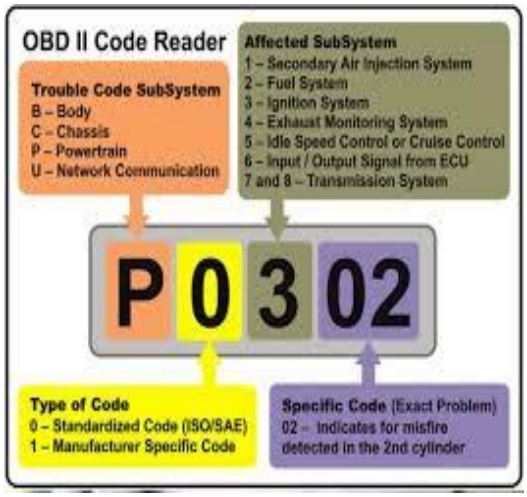


Figure 8 OBD II code reader

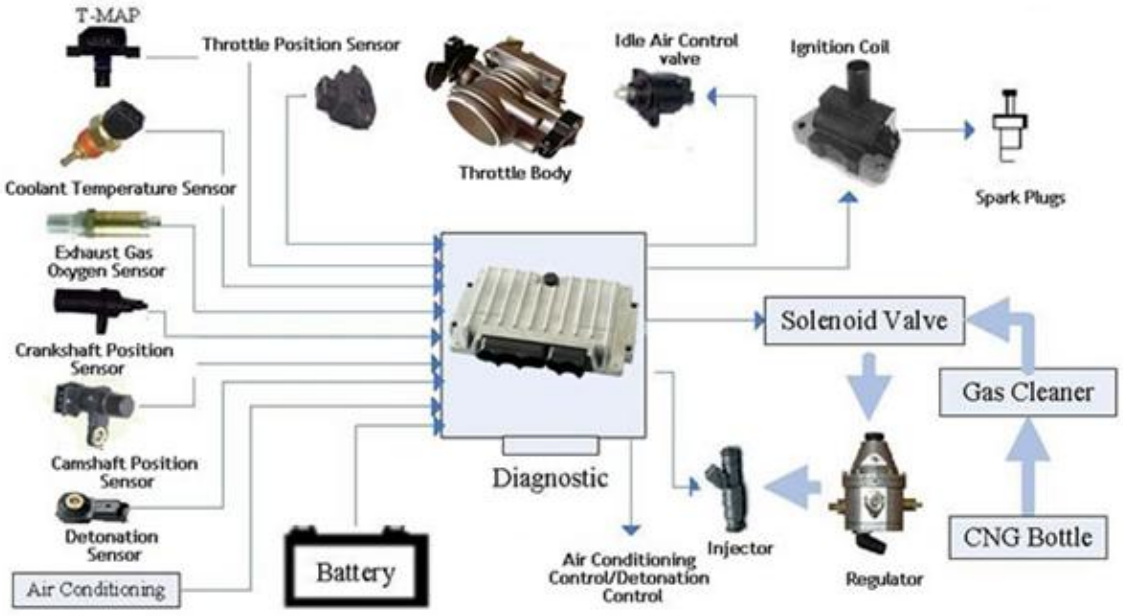


Figure 9 Engine Control Unit (ECU)

IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1.	ECU	Available in the vehicle	1
2.	OBD II car diagnostic tool	Grade II	1
3.	Visit to official diagnostic station of Nexa /Maruti / ECU operating service station	Industrial visit	1
4.	Sensor and Actuator car/bike	Available in the vehicle	1

X Precautions to be Followed

1. Avoid improper handling of ECU/OBD II
2. Check connection is proper or not.
3. The diagnostic code may differ from car to car. Students shall refer the manufacturer's catalogue prior to the procedure.
4. History of problem stored in ECU is clear after maintenance of the problem

XI Procedure

1. OBD II is placed in the slot just above clutch pedal in the car.
2. Turn the ignition knob, you don't need to turn on engine
3. Ensure that headlights are shut down.
4. Turn on Bluetooth on your mobile and find OBD II
5. Pair with OBD II pass is 1234 or 0000
6. Go to Torque App
7. For trial purpose Torque pro App can also be downloaded through internet
8. When blue car icon appears that means you are connected
9. Now tap to scan the faults or press menu for more options
10. Requesting for fault codes

11. Reading fault code
12. Fault code responses
13. If there is no fault codes stored in ECU , then your car diagnostic is OK
14. If there are fault codes observed in ECU , go for fault log manager and clear it there .
15. By typing fault code provided by ECU, solution can be obtained through online.
16. Once the testing is done, turn off the ignition and remove the OBD II from the slot.

(For more reference refer https://www.youtube.com/watch?v=JIa0nsrQXI0)

XII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					
4.					
5.					

XIII Actual Procedure Followed

.....
.....
.....
.....

XIV Precautions Followed

.....
.....
.....
.....

XV Observations and Calculations

S N	Problem code	Faults diagnose in car	Remedies on problem
	Generic Fault		
1			
2			
	Specific Fault		
1			
2			

XVI Results

.....
.....
.....
.....

XVII Interpretation of Results

.....
.....
.....
.....

XVIII Conclusions

.....
.....
.....
.....

XIX Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Enlist the sensors used with ECU for diagnosis test of vehicle.
2. Enlist the common faults in vehicle with their code and remedies

[Space for Answer]

.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....

.....

.....

.....

.....

.....

.....

.....

.....

XX References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=_lAqQ7uXQTY
2. https://www.youtube.com/watch?v=49SjHjnnVn4
3. https://www.youtube.com/watch?v=U8j1mOPSDHM
4. https://www.youtube.com/watch?v=JIa0nsrQXI0

XXI Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**40%**
1	Handling of the Instruments	20%
2	Diagnostic faults	20%
Product Related (15 Marks)		60%
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1. ……..
2. …….
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No.11 and 12: Perform Test On The Given Two-Stage Reciprocating Air Compressor To Find Volumetric And Isothermal Efficiency

I Practical Significance

The air compressor is a machine which uses a drive motor to power the device, which sucks in successive volumes of air from the atmosphere, compresses (squeezes) each volume of air in the limited space to increase the pressure, resulting in a smaller amount, and then transfers the air high pressure in the receiver tank. This high pressure air is removed from the receiving tank for the electrical equipment. When certain amount of constant discharge of air is displaced, then it is called as a positive displacement air compressor

Performance of reciprocating compressor is improved by multi-staging. Here number of staging represents number of cylinder. Two stage reciprocating air compressor consist of two cylinders. One is called low-pressure cylinder and another is called high-pressure cylinder. When piston in a low-pressure cylinder is at its outer dead center (ODC) the weight of air inside a cylinder is zero (neglecting clearance volume), as piston moves towards inner dead center (IDC) pressure falls below atmospheric pressure & suction valves open due to a pressure difference.

Air compressors have many uses, including: supplying high-pressure clean air to fill gas cylinders, supplying moderate-pressure clean air to a submerged surface supplied diver, supplying moderate-pressure clean air for driving some office and school building pneumatic HVAC control system valves, supplying a large amount of moderate-pressure air to power pneumatic tools, such as jackhammers, filling high pressure air tanks (HPA), for filling tires, and to produce large volumes of moderate-pressure air for large-scale industrial processes (such as oxidation for petroleum coking or cement plant bag house purge systems)

II Relevant Program Outcomes (POs)

PO1- Basic knowledge: Apply knowledge of basic mathematics, sciences and basic Engineering to solve the broad-based Mechanical Engineering problems.

PO2-Discipline knowledge: Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

PO3- Experiments and practice: Plan to perform experiments and practices to use the results to solve broad-based Mechanical Engineering problems.

PO8-Individual and team work: Function effectively as a leader and team member in diverse/ multidisciplinary teams.

III Competency and Skills

This practical is expected to develop the following skills for the industry identified competency

'Maintain power engineering and refrigeration devices '

IV Relevant Course Outcome(s)

- Maintain reciprocating air compressors.

V Practical Outcome

- Perform test on the given two-stage reciprocating air compressor to find volumetric and isothermal efficiency

VI Relative Affective Domain-

- Follow safety practices.
- Practice good housekeeping.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.

VII Minimum Theoretical Background

1. Know the working of two stage air compressor
2. Identify the different parts of two stage reciprocating air compressor
3. Know the efficiencies of compressor

VIII Experimental setup

Figure No 1 Pressure Gauge

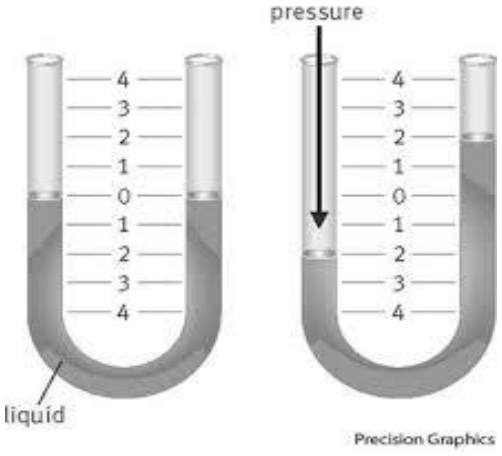


Figure No 2 Manometer

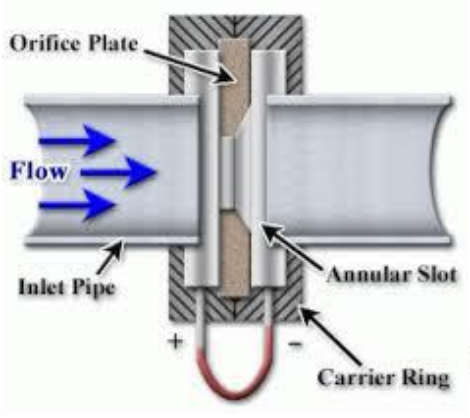


Figure No 3 Orifice plate **Figure No 4 Thermocouple(K Type)**

Figure No 4 Digital Temperature indicator **Figure No 5 Tachometer**

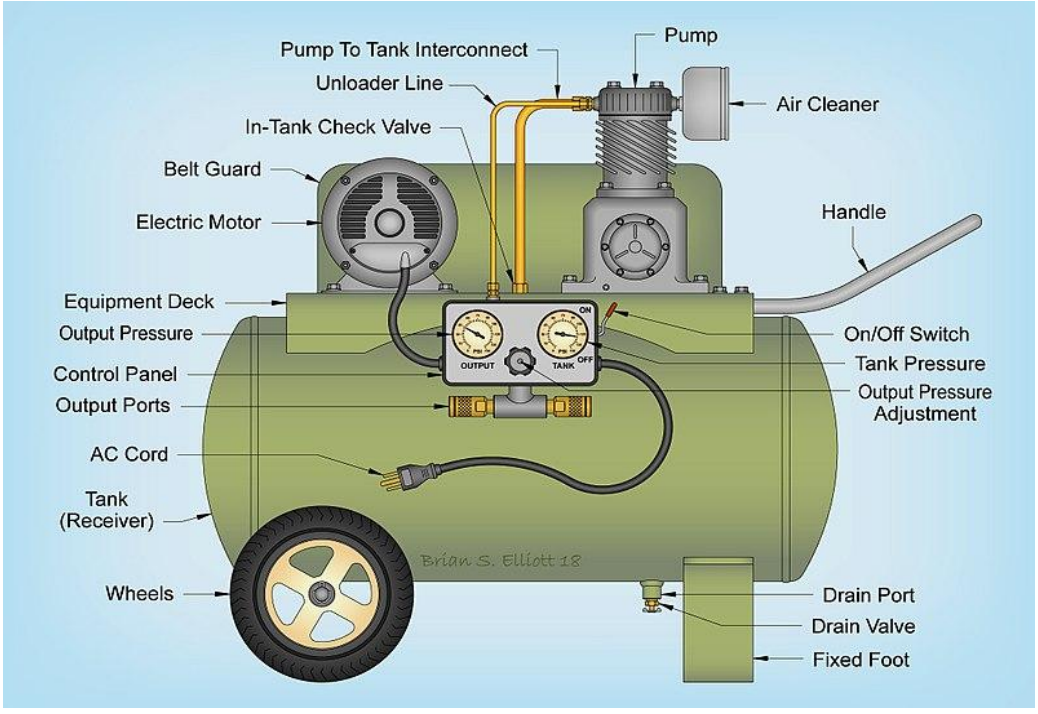


Figure No 6 Technical Illustration of a single-stage manual air compressor

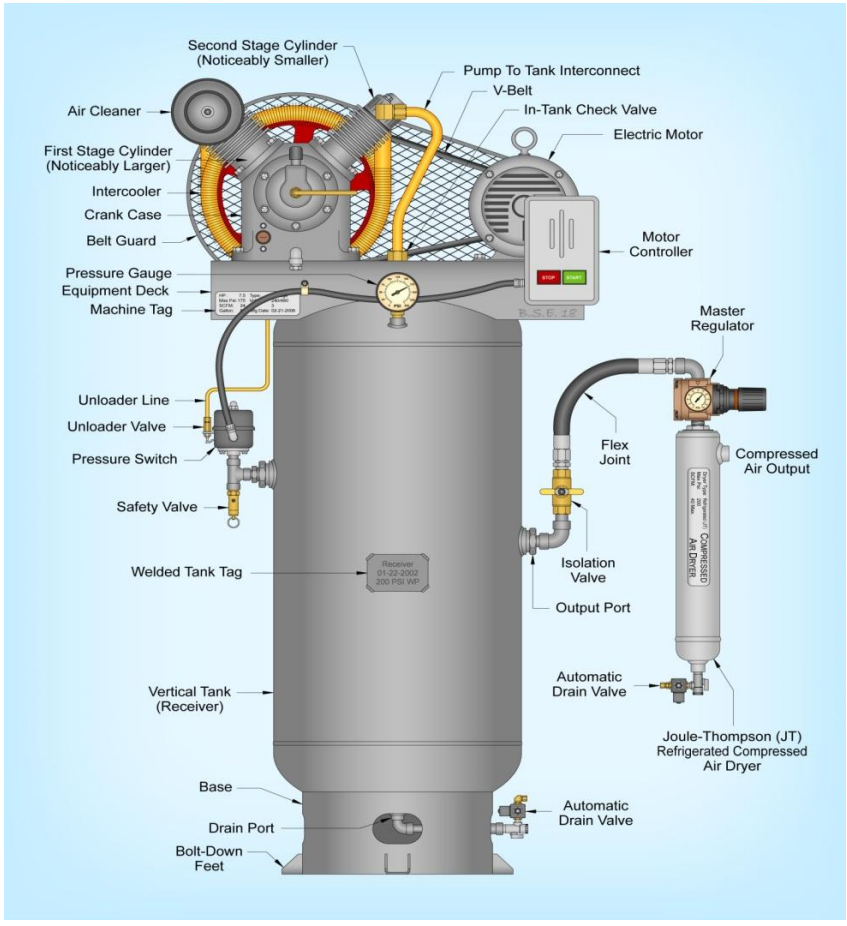


Figure no 7 Technical Illustration of a two-stage air compressor with vertical storage tank

Figure No 8 Typical experimental set up of two stage Reciprocating air compressor test rig

IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification		Quantity
1	Two stage single acting reciprocating air compressor	Pressure Gauge	Range from 0-10Kg/cm^2	1
		Water Manometer	U-shaped glass tube	
		Air box	-----	
		Orifice plate	Diameter size from 6-30mm	
		Air receiver tank	------	
		Thermometer/Thermocouple	Mercury in glass type/ Type K	
		Digital Temperature indicator	Pt100RTDs Milli volt And 4-20 range current	
		Tachometer	Speed up to 1000 rpm	
2	Motor	Speed upto 1200rpm		1

Note: These specifications are for reference only.

X Precautions to be Followed

1. Avoid improper handling of Two stage air compressor.
2. Maintain the proper level of lubricating oil up to red mark
3. Checking for oil and air leaks.

XI Procedure

1. Fill the manometer with water up to half level.
2. Keep delivery valve and manometer cock on suction line in closed position.
3. Start the compressor and open the manometer cock. Then, let the air pressure build-up in the tank. .
4. Maintain pressure of air inside the tank constant, by adjusting delivery valve. Note this delivery pressure reading by pressure gauge mounted on tank.
5. With this constant delivery pressure, measure motor speed using tachometer and note it down.
6. With the same delivery pressure, note down water manometer reading, intake pressure, intermediate pressure, delivery pressure, intake temperature, temperatures before and after intercooler and delivery temperature.

XII Resources Used

Sr. No.	Name of Resource	Suggested Broad Specification		Quantity
1	Two stage single acting reciprocating air compressor	Pressure Gauge		1
		Water Manometer		
		Air box		
		Orifice plate		
		Air receiver tank		
		Thermometer/Thermocouple		
		Digital Temperature indicator		
		Tachometer		
2	Motor	Speed		1

XIII Actual Procedure Followed

.....

.....

.....

.....

XIV Precautions Followed

.....

.....

.....

.....

XV Observations and Calculations

Sr. No.	Particulars	Notations	Unit	Reading
1	Intake Pressure (gauge)	$P_{1(\text{gauge})}$	Kg / cm^2	
	Intake Pressure (absolute) $P_{1(abs)}=P_{(atm)}+P_{1(gauge)}$ =(……)+(……X 0.9806)	P_1	bar	

2	Intercooler/Intermediate pressure (gauge)	$P_{2(\text{gauge})}$	Kg / cm^2	
	Intermediate Pressure (absolute) $P_{2(abs)}=P_{(atm)}+P_{2(gauge)}$ =(……)+(……X 0.9806)	P_2	bar	
3	Delivery pressure (gauge)	$P_{3(\text{gauge})}$	Kg / cm^2	
	Delivery pressure (absolute) $P_{3(abs)}=P_{(atm)}+P_{3(gauge)}$ =(……)+(……X 0.9806)	P_3	bar	
4	Intake temperature	t_1	^0c	
		$T_1 = t_1 + 273$	^0K	
5	Temperature before intercooler	t_2	^0c	
		$T_2 = t_2 + 273$	^0K	
6	Temperature after intercooler	$t_{2'}$	^0c	
		$T_{2'} = t_{2'} + 273$	^0K	
7	Delivery temperature	t_3	^0c	
		$T_3 = t_3 + 273$	^0K	
8	Motor speed	N_1	rpm	
9	Manometer reading	h_1	mm	
		h_2	mm	

.

A. Calculations for Volumetric Efficiency

1. Compressor Speed

   As belt drive is used, $D_1 x N_1 = D_2 x N_2$

   Compressor Speed, $N_2 = D_1 x N_1 / D_2$ = …… rpm

   = …… rpm

Note: If compressor is directly coupled to motor, speed of motor is the speed of compressor.

2. Density of air

   Using characteristic gas equation,

   $P_1 x V_1 = m_a x R_a x T_1$.

   Where, m_a = mass of air

   R_a = Characteristic gas constant = 287 J/kg

   $m_a = P_1 x V_1 / (R_a x T_1)$

Now, density of air = $\rho_a = m_a / V_1 = P_1 / [R_a x T_1]$,

where P_1 is in N/m^2.

$= P_1 / [R_a x (t_1 + 273)]$

ρ_a=…….. kg/m^3

3. Water manometric head

$h_w = h_1 – h_2$= .....

h_w =..... mm of water

h_w = …….m of water

4. Air ahead causing the flow of air

$h_a = h_w x \rho w / \rho_a$ Where,ρ_w = Density of water = 1000 kg/m^3

Therefore, h_a=(..... .. .. x 1000) / (.....)

= ..... m of air

5. Actual volume of free air delivered

Area of Orifice, $a = (\pi/4)d^2 = (\pi/4)$ x (..... . .....)^2

a = ...m^2

Actual volume of free air delivered, $V_a = C_d$ x a x $\sqrt{2gha}$ m^3/s

V_a= ……m^3/s

6.Mass of air supplied $m_a = \rho_a$ x V_a

m_a= ….. kg/s.

7. Theoretical volume of air delivered

Volume of low pressure cylinder = $V_{LP} = (\pi/4) D_{LP}^2$ x L_1 m^3 / cycle

= (π/4) x (..... ...)^2

x(…….)

V_{LP} = ... m^3/cycle

Theoretical volume of air delivered at intake condition

$v_{th} = V_{Lp}$ x N_2 / 60 m^3 / s

V_{th} = ……...... m^3/s.

8. Volumetric efficiency

Volumetric efficiency =

(Actual volume of free air delivered) / (Theoretical volume of air Delivered)

$\eta_{vol.} = (V_a / V_{th}) \times 100$

= (………………../ ……………………) X 100

η_{vol} = ...

B. Calculations for Isothermal efficiency

1. Index of compression

Compression follows the polytropic process i.e. $PV^n = C$

a) Value of compression index 'n' for 1st stage compression –

We know for compression process 1-2,

$T_1 / T_2 = (P_1/P_2)^{(n-1/n)}$

=……………………………………

n = …………..

Value of compression index 'n' for 2nd stage compression –

We know for compression process 2'-3

$T_2'/T_3 = (P_2/P_3)^{(n-1/n)}$

=……………………..

n **=**

Actual work done

a) Work done in compressing air in low pressure (L.P.) cylinder is

$W_{LP} = (n / n-1) \times \{P_1V_1 [(P_2 / p_1)^{(n-1/n)} - 1]\}$ J /s

$= (n/n-1) \times \{m_aR_aT_1 [(P_2/P_1)^{(n-1/n)} -1]\}$ J / s

=……………………………………………………..J / s

a) Work done in compressing air in high pressure (H.P.) cylinder

$W_{HP} = (n/n-1) \times \{P_2V_2.[(P_3/ P_2)]^{(n-1/n)} -1\}$ J/s

$= (n/n-1) \times \{m_aR_aT_2'[(P_3/P_2)]^{n-1/n)} -1\}$ J/s

=…………………………………………………………J/S

1. **Actual work done or indicated work ;**

$W_{ind:} = w_{LP} + W_{Hp}$

$W_{ind:}$=……..**J/S**

2. Isothermal Work

$W_{iso} = P_1V_1[\log_e(P_3/P_1)]$

$=m_aR_aT_1[(P_3/P_1)]J/s$

W_{jso} = ... J / s or W

=..... ....kW.

3. Isothermal efficiency

η_{lso} = (Isothermal work / Indicated work) x 100

= (……./……) x 100

=…….....

XVI Results

1. Volumetric Efficiency of this air Compressor =...…….. %.
2. Isothermal Efficiency of this air Compressor =…… %.

XVII Interpretation of Results

.....
.....
.....
.....

XVIII Conclusions

.....
.....
.....
.....

XIX Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Illustrate the factors which limit the delivery pressure in reciprocating compressor.
2. Categorize the factors that influence the performance of compressor.

[Space for Answer]

.....

.....

.....

.....

.....

XX References / Suggestions for Further Reading

1. www.youtube.com/watch?v=rtrOcFq6QSs
2. www.youtube.com/watch?v=bJluUxA7aaY
3. www.youtube.com/watch?v=doDVrnV69CM
4. www.youtube.com/watch?v=rtrOcFq6QSs
5. www.youtube.com/watch?v=bJluUxA7aaY
6. www.youtube.com/watch?v=doDVrnV69CM

XXI Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**40%**
1	Handling of the measuring Instruments	20%
2	Calculation of final readings	20%
Product Related (15 Marks)		**60%**
3	Interpretation of result	20%
4	Conclusions	20%
5	Practical related questions	20%
Total (25 Marks)		100 %

Names of Student Team Members

1. ……..
2. …….
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No.13 : Assemble/Dismantle Of Gas Turbine Model.

I Practical Significance

A gas turbine, also called a combustion turbine, is a type of continuous combustion, internal combustion engine. There are three main components: An upstream rotating gas compressor; a downstream turbine on the same shaft; a combustion chamber or area, called a combustor, in between them.

A jet propulsion is the system of gas turbine plant which produces a high velocity jet of hot gases to propel the vehicles. Jet propulsion systems are classified into two types -.jet engines and rocket engines. Jet engines include turbojet engine, turbo-prop engine and ram jet engine. Rocket engines include liquid propellant rocket engine and Solid propellant rocket engine

II Relevant Program Outcomes (POs)

PO1- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic Engineering to solve the broad-based Mechanical Engineering problems.
PO2-**Discipline knowledge**: Apply Mechanical engineering knowledge to solve broad- based mechanical engineering related problems.
PO3- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical Engineering problems.

III Competency and Skills

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences**:**

- **Maintain power engineering and refrigeration devices.**

IV Relevant Course Outcome(s)

- Identify different components of gas turbines and jet engines.

V Practical Outcome

- Assemble/Dismantle of Gas turbine model.

VI Relative Affective Domain-

- Follow safety practices.
- Practice good housekeeping.
- Maintain tools and equipment.
- Follow ethical Practices.

VII Minimum Theoretical Background

1. Know the construction and working of Gas Turbine Model
2. Identify recommended tools.
3. Identify various sub-assemblies of Gas Turbine Model

VIII Experimental setup

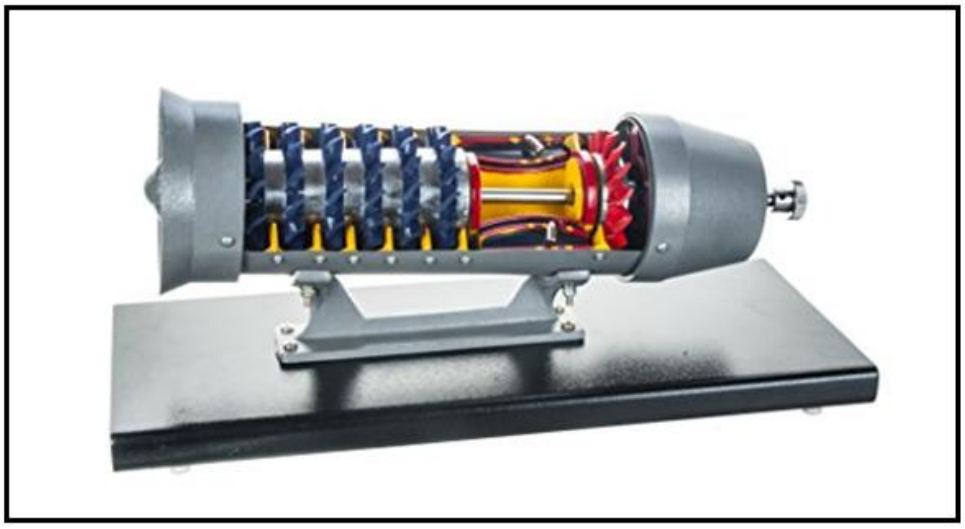


Figure No 1 A typical cut section model of Turbo jet engine

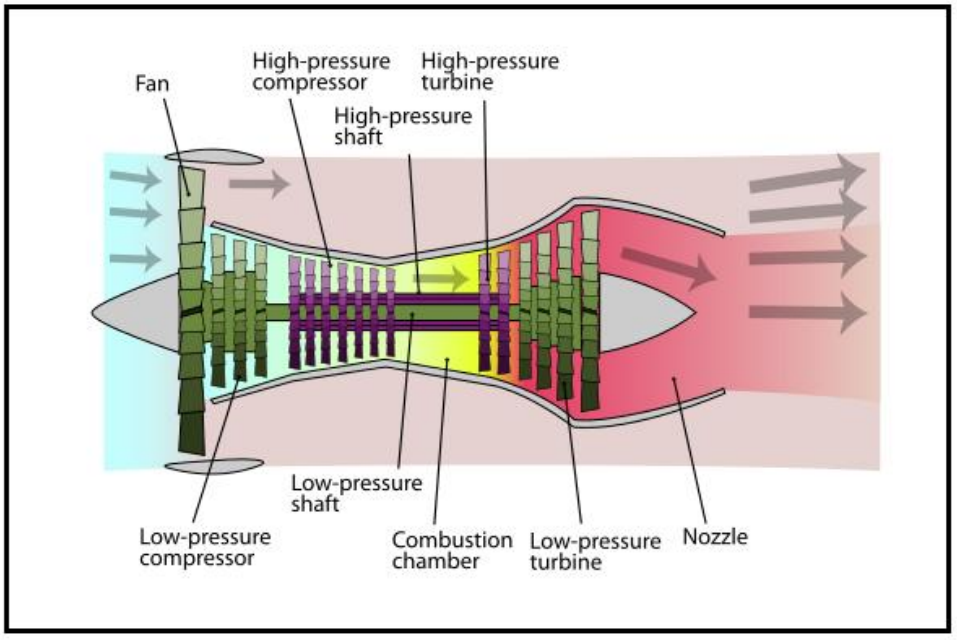


Figure No 2 Schematic diagram of Turbo jet Engine

IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Tool box	Adjustable wrench – 10/250 mm	1
		Plier – 8"/200mm	
		Allen key set – 1.5 to 10 inch	
		Screw driver set – 5 pieces	
		Open end jaw spanner set- 6-7 to 30-32	
		Round / box spanner set - 6-7 to 30-32	
		Ratchet set – 10mm to 32 mm	

X Precautions to be Followed

1. Avoid improper handling of Gas Turbine model.
2. Use special and recommended tools for assembly and dismantling of Gas Turbine model
3. Use clean work bench for assembly and dismantling of Gas Turbine model.

XI Procedure

1. Select the proper tools and equipment.
2. Apply recommended tools to remove components of Fuel.
3. Identify the various subassemblies of the Gas Turbine model.
4. Examine all the components carefully.
5. Observe their physical and functional conditions.

XII Resources Used

Sr. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					
4.					
5.					

XIII Actual Procedure Followed

Dismantling of Gas Turbine model

.....

.....

.....

.....

Assembly of Gas Turbine model

.....

.....

.....

.....

XIV Observations and Calculations

Sr. no	Name of unit	Function	Tools used to dismantle	Parts in sub-assembly
01	Compressor sub-assembly			
02	Turbine sub-assembly			
03	Combustion chamber sub-assembly			

XV Results

.....
.....
.....
.....

XVI Interpretation of Results

.....
.....
.....
.....

XVII Conclusions

.....
.....

.....

.....

XVIII Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Interpret jet propulsion system which can travel through the vacuum.
2. Draw the jet engine in which compressor and turbine is absent.

[Space for Answer]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

XX References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=zcWkEKNvqCA
2. https://www.youtube.com/watch?v=KjiUUJdPGX0
3. https://www.youtube.com/watch?v=oYpG0HDcFsA
4. https://www.youtube.com/watch?v=XdQkt_Mtpd8

XXI Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**40%**
1	Handling of the tool kit tools	20%
2	Identification of Gas Turbine components	20%
Product Related (15 Marks)		**60%**
3	Interpretation of components of Gas turbine model	20%
4	Conclusions	20%
5	Practical related questions	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1. ……..
2. …….
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No.14: Perform Test On Vapor Compression Refrigeration Cycle Test Rig To Find COP.

I Practical Significance

Vapor Compression Refrigeration cycle consisting of hermetically sealed compressor, condenser, expansion devices and evaporator. The working medium called as Refrigerant used in vapor form to obtain the cooling effect. Refrigerating effect is the amount of cooling produced by the system. This cooling is obtained at the expense of some form of energy. Vapor-compression refrigeration or vapor-compression refrigeration system (VCRS), in which the refrigerant undergoes phase changes, is one of the many refrigeration cycles and is the most widely used method for air-conditioning of buildings and automobiles. Coefficient of performance is the ratio of refrigerating effect to the compressor work.

II Relevant Program Outcomes (POs)

PO1- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic Engineering to solve the broad-based Mechanical Engineering problems.

PO2-**Discipline knowledge**: Apply Mechanical engineering knowledge to solve broad- based mechanical engineering related problems.

PO3- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical Engineering problems.

PO8- **Individual and team work:** Function effectively as a leader and team member in diverse/ multidisciplinary teams.

III Competency and Skills

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences**:**

- **Maintain power engineering and refrigeration devices.**

IV Relevant Course Outcome(s)

- Test the performance of refrigeration and air-conditioning systems.

V Practical Outcome

- Perform Test on vapor compression refrigeration cycle test rig to find COP.

VI Relative Affective Domain-

- Follow safety practices.
- Practice good housekeeping.
- Work as a leader / a team member.
- Follow ethical Practices.

VII Minimum Theoretical Background

1. Know the working of Vapour compression refrigeration system.
2. Identify and know the function of each component of vapor compression refrigeration system.
3. Calculate refrigerating effect, compressor work and C.O.P.

VIII Experimental setup

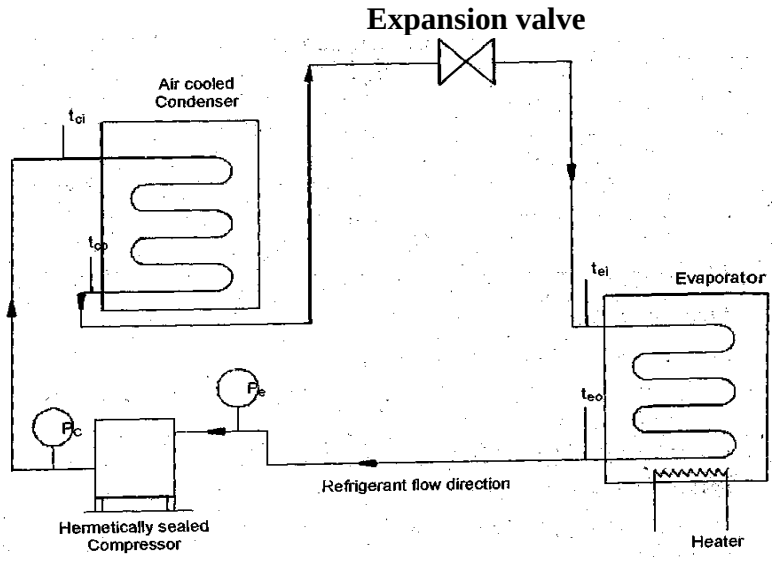


Figure 1 Line Diagram of vapor compression refrigeration Test Rig

Figure 2 Vapor compression refrigeration Test rig

IX Resources Required

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Refrigerant used	R-134 a	1
2	Compressor	Type – Hermetically sealed	1
3	Condenser:	Forced Air Cooled	1
4	Expansion device	Capillary Tube/Thermostatic Valve	1
5	Evaporator	Coil type	1
6	Devices used for measurement	Pressure gauge	1
		Temperature Indicator	1
7	Electric Energy	As per standard	1
8	Energy meter	For Heater = $N_{h,}$ as per standard	1
		For compressor = Nc , as per standard	

X Precautions to be followed

1. Never operate the unit, keeping the condenser fan switched off.
2. Do not operate the unit if voltmeter on the panel reads less or more voltage than specified.

XI Procedure

1. Refer the manual supplied by the manufacturer and identify different components and controls of refrigeration test rig.
2. Select capillary tube or thermostatic expansion valve (TEV) by using manually operated shut-off valves.
3. Fill three fourth of evaporator tank with water.
4. Switch on the condenser fan and after two minutes switch on the compressor.
5. Watch the thermometer reading of the water in the evaporator, it will go on reducing.
6. As the temperature of the Water reaches around 20°C switch on the heater unit.
7. Adjust the dimmer stat of heater such that temperature of water does not further fall.
8. Run-the unit till steady state is reached i.e. temperature of water remains constant.
9. Read the condenser & evaporator pressure gauges & enter in observation table.
10. Note the temperature reading on digital temperature indicator by turning the knob.
11. Measure the time taken for 10 revolutions of energy meter disc of the compressor and heater (i.e. T_c & T_h). (In case of electronic energy meter, measure the time taken for 10 pulses)
12. Switch- off the unit in the following order - heater, compressor and condenser fan.

XII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					

XIII Actual Procedure Followed

.....

.....

.....

.....

XIV Observations and Calculations:

Sr. No.	Description	Symbol	Unit	Reading
1	Evaporator pressure	P_e	bar	
2	Condenser pressure	P_c	bar	
3	Evaporator Inlet Temperature	t_{ei}	^0C	
4	Evaporator Outlet Temperature	t_{eo}	^0C	
5	Condenser Inlet Temperature	t_{ci}	^0C	
6	Condenser Outlet Temperature	t_{co}	^0C	
7	Time for 10 revolutions of pulses of energy meter of compressor	T_c	sec	
8	Time for 10 revolutions of pulses of energy meter of Heater	T_h	sec	

a. Carnot COP :

Read from refrigerant property table and fill the following table for the calculation Carnot COP

Sr. No	Description
1	T_L= Saturation temperature corresponding to Pe= …….. + 273 = …….. K
2	T_H= Saturation temperature corresponding to Pc = + 273 = …… K

Carnot COP = $T_L / (T_H - T_L)$ = ……..

b. Theoretical COP -

Plot the cycle on P-h chart for the refrigerant used and fill the table given below for calculation of theoretical COP

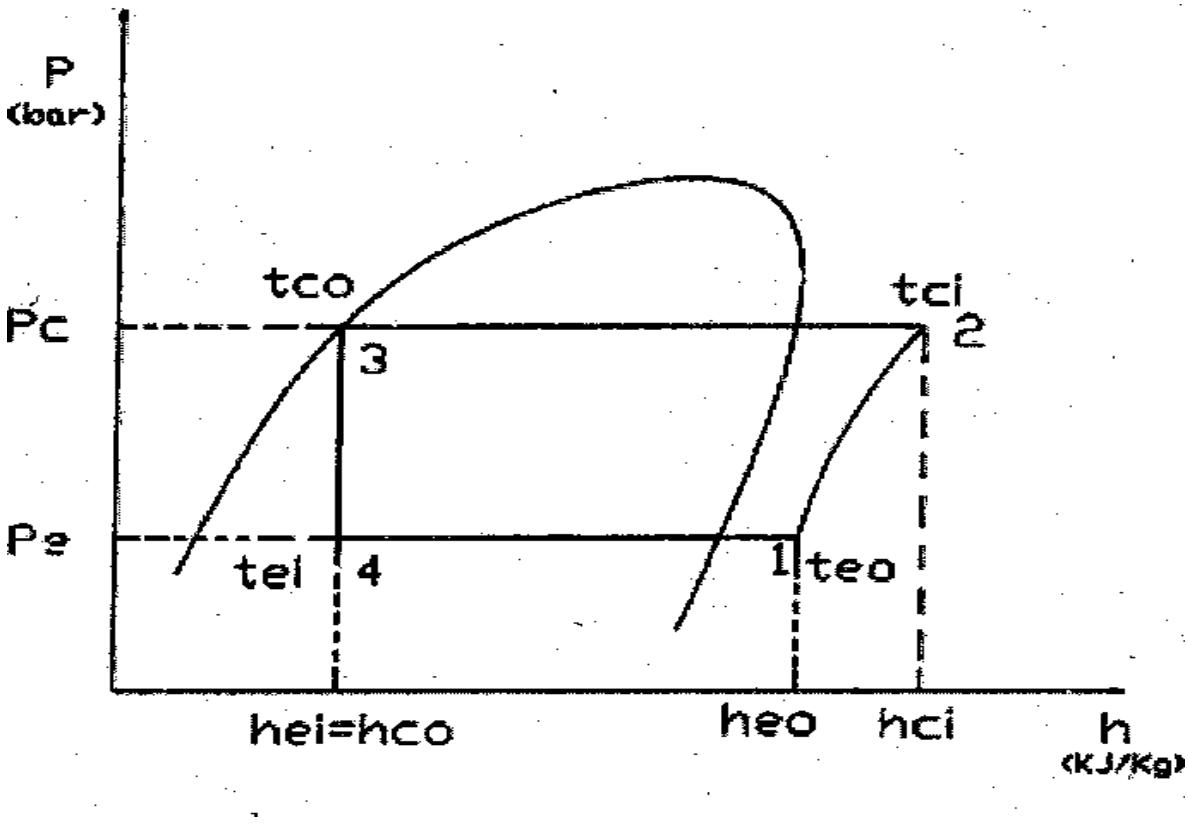


Figure 3 P-H Diagram for VCR cycle

(**Note**: Students shall draw refrigeration cycle on P-h diagram over a separate paper, if the refrigerant conditions at various state points different than those shown in the above diagram)

Sr. No.	Description	Symbol	Reading in kJ / kg
1	Enthalpy at evaporator inlet	h_{ei}	
2	Enthalpy at evaporator outlet	h_{eo}	
3	Enthalpy at condenser inlet	h_{ci}	
4	Enthalpy at condenser outlet	h_{co}	

Theoretical COP

= (Theoretical Refrigerating Effect) / (Theoretical Compressor Work)

= $(h_{eo}-h_{ei})$ /$(h_{ci}-h_{eo})$

= (..... - .....) / (..... - .....)

= ……

Actual COP = (Actual Refrigerating Effect) / (Actual work supplied to compressor)

Here, actual Refrigerating Effect = Heat produced by heater

RE = $(10 / N_h)$ x $(3600 / T_h)$kW

= …… kW

Or if heater is not used

RE = $\{M_w * C_{pw} * (T_2 - T_1)\}$ / time required for cooling from initial to final water temperature

Where T_1 = Initial temperature of water

T_2 = Final temperature of water

M_w = mass of water in evaporator

Actual energy supplied to compressor

$$W = (10 / N_c) \times (3600 / T_h) \quad kW$$

Actual COP = RE / W =…… KW

Results:

- Carnot COP = ...

  Theoretical COP = …….
- Actual COP = ……

XVI Interpretation of Results

.....
.....
.....
.....

XVII Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

.

1. Compare actual COP and theoretical COP of VCR cycle .
2. Illustrate the cooling medium used in hermetically sealed compressor.

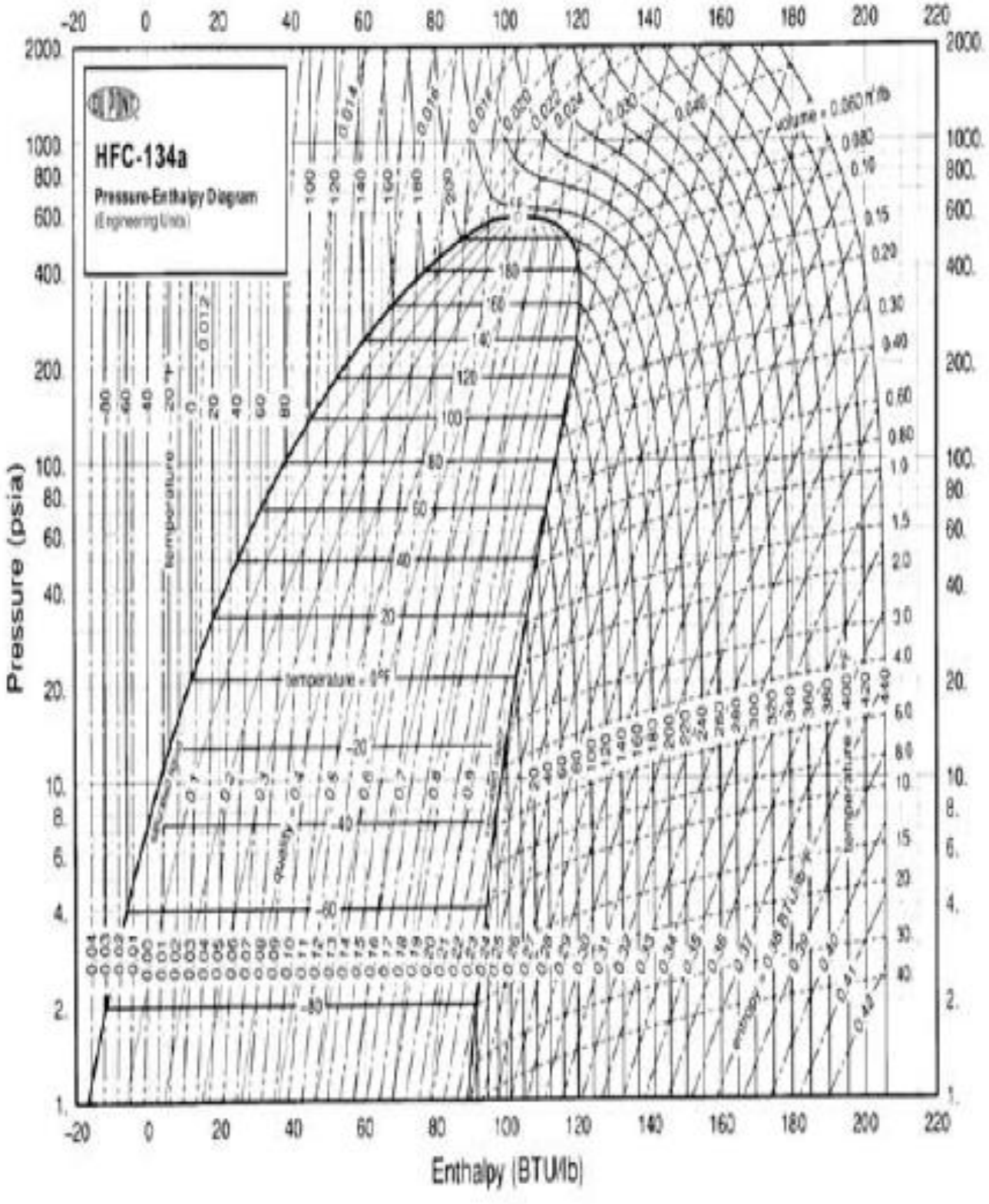


Figure 4 P-H chart of HFC-134a Refrigerent

[Space for P-H Chart]
(Student should paste P-H chart of respective Refrigerant)

[Space for Answer]

.....

.....

.....

.....

.....

.....

.....

.....

XX References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=F8kPHK2atR4
2. https://www.youtube.com/watch?v=v36FiXcxt0k
3. https://www.youtube.com/watch?v=dRuK7RBuqog

XX Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**40%**
1	Ability to operate refrigeration test rig	20%
2	Ability to measure pressure & temperature at salient points of the system	20%
Product Related (15 Marks)		**60%**
3	Ability to use P-h Chart and property table of refrigerant	20%
4	Conclusions	20%
5	Practical related questions	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1. ……..
2. …….
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No.15 : Trace The Refrigerant Flow Of Domestic Refrigerator And Measure Temperatures At Critical Points For Different Settings Of Thermostat.

I Practical Significance

Domestic (also household refrigerator), an appliance that is used for the short-term preservation of food products in the home by means of refrigeration. A domestic refrigerator is a metal cabinet with a built-in hermetically sealed refrigerating unit When the hot gas in the coils of the condenser meets the cooler air temperature of the kitchen, it becomes a liquid. Now in liquid form at high pressure, the refrigerant cools down as it flows through the expansion valve into the evaporator coils inside the freezer and the fridge. This process of conversion is in cyclic form known as Vapour Compression Cycle (VCC). Modern refrigerators usually use a refrigerant called HFC-134a (1,1,1,2-Tetra- fluoro- ethane), which does not deplete the ozone layer, instead of Freon. The fundamental reason for having a refrigerator is to keep food cold. Cold temperatures help food stay fresh longer. The basic idea behind refrigeration is to slow down the activity of bacteria (which all food contains) so that it takes longer for the bacteria to spoil the food. A refrigerator does not cool items by lowering their original temperatures; instead, an evaporating gas called a refrigerant draws heat away, leaving the surrounding area much colder. Refrigerators and air conditioners both work on the principle of cooling through evaporation. Thermostat is a component which senses the temperature of a physical system and performs actions so that the system's temperature is maintained near a desired set point. A thermostat operates as a "closed loop" control device, as it seeks to reduce the error between the desired and measured temperatures. Sometimes a thermostat combines both the sensing and control action elements of a controlled system, such as in an automotive thermostat.

II Relevant Program Outcomes (POs)

PO1- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic Engineering to solve the broad-based Mechanical Engineering problems.

PO2-**Discipline knowledge**: Apply Mechanical engineering knowledge to solve broad- based mechanical engineering related problems.

PO3- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical Engineering problems.

PO5-**The engineer and society:** Assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to practice in field of Mechanical engineering.

PO6-**Environment and sustainability:** Apply Mechanical engineering solutions also for sustainable development practices in societal and environmental contexts.

PO8- **Individual and team work:** Function effectively as a leader and team member in diverse/ multidisciplinary teams.

III Competency and Skills

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences**:**

- **Maintain power engineering and refrigeration devices.**

IV Relevant Course Outcome(s)

- Test the performance of refrigeration and air-conditioning systems.

V Practical Outcome

Trace the refrigerant flow of domestic refrigerator and measure temperatures at critical points for different settings of thermostat.

VI Relative Affective Domain-

- Follow safety practices.
- Practice good housekeeping.
- Maintain tools and equipment.
- Follow ethical Practices.

VII Minimum Theoretical Background

1. Know the construction and working of refrigeration system.
2. Identify various subassemblies of refrigeration and refrigeration system.
3. Identify accessories of refrigeration and refrigeration system.
4. Know the Vapour Compression Cycle (VCC) on P-H and T-S diagram
5. Identify the parts of VCC
6. Know the thermodynamic analysis of domestic refrigerator

VIII Experimental setup

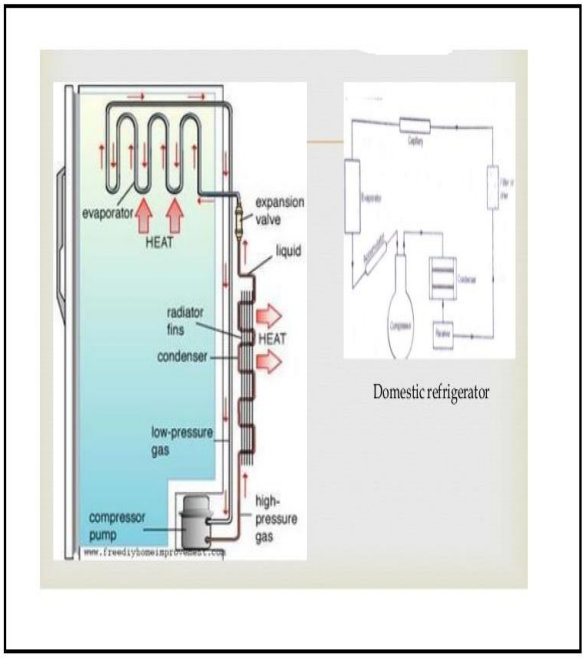


Figure No 1 Domestic refrigerator

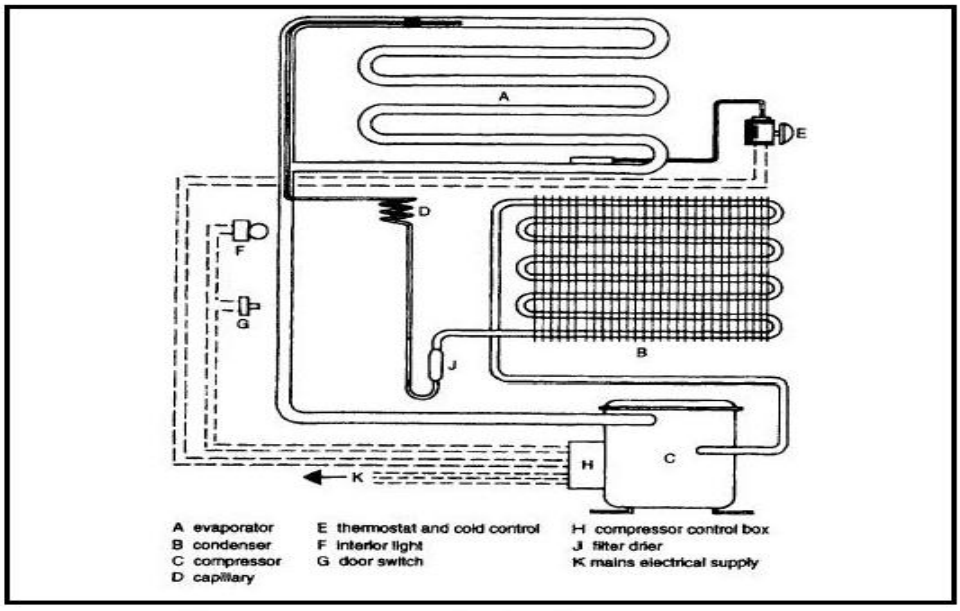


Figure No 2 Line diagram of Domestic refrigerator

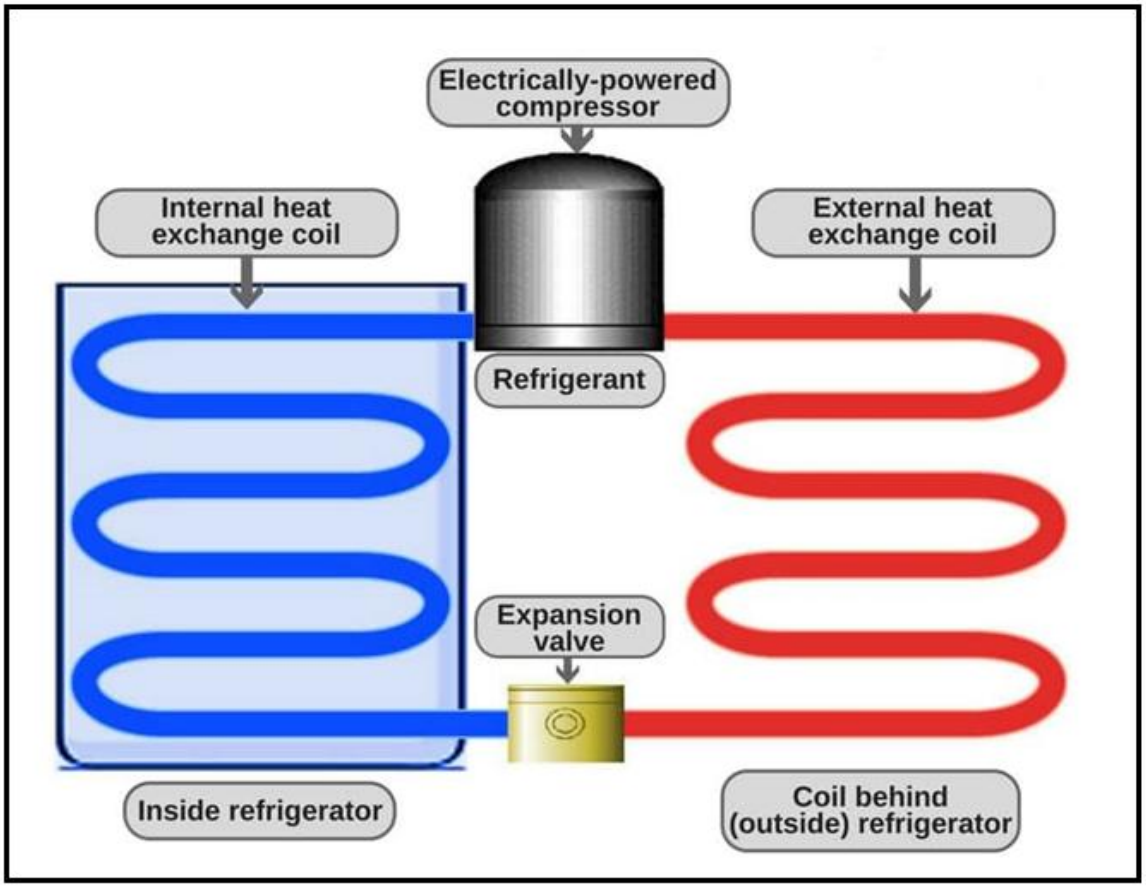


Figure No 3 Simple VCC diagram

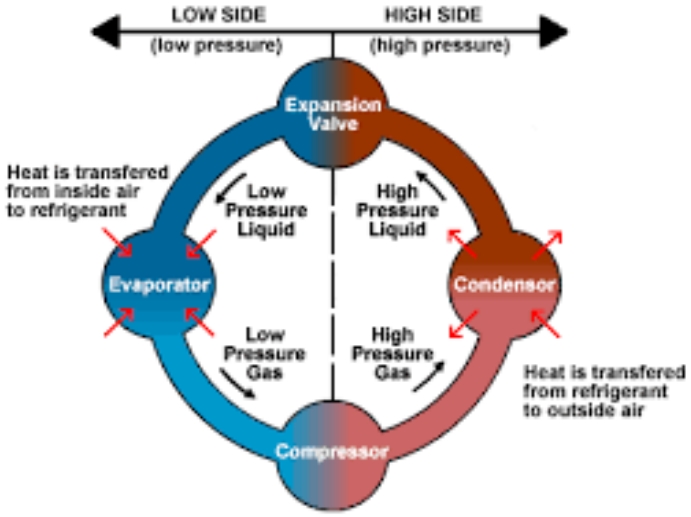


Figure No 4 Pressure variation in VCC

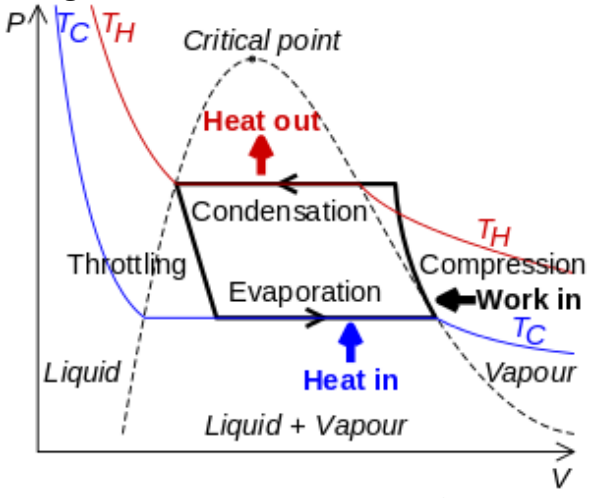


Figure No 5 P-V diagram of VCC

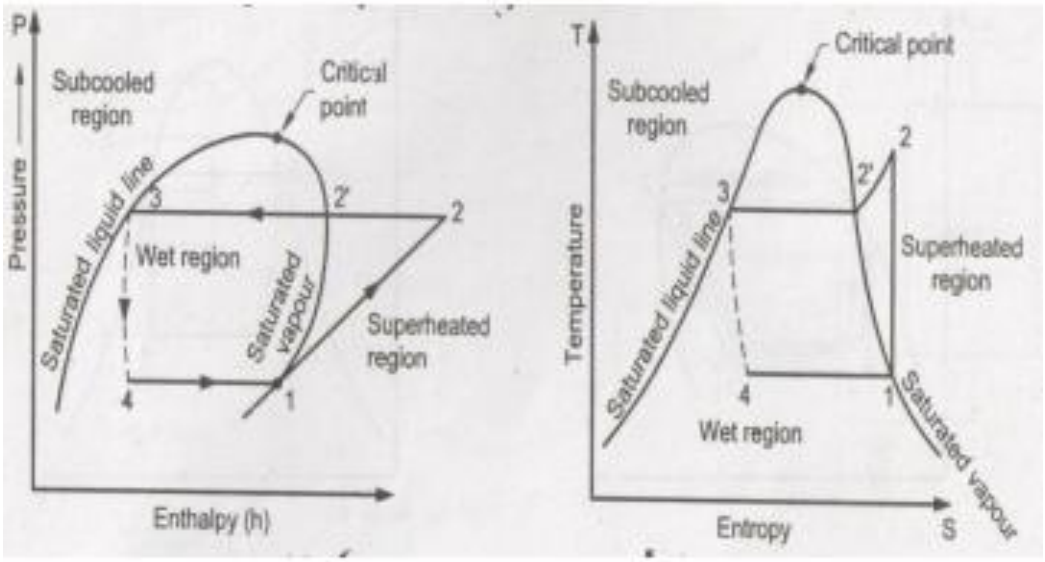


Figure No 6 P-H and T-S diagram of VCC

IX Resources Required

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Domestic Refrigerator	Capacity – 165 lit.	1
		Refrigerant –R 134a	
2	Thermocouple	RTD	4

X Precautions to be Followed

1. Ensure that refrigerator is connected to with proper electric power supply.
2. Ensure that refrigerator door is tightly closed.
3. Inspect that there is proper distance between refrigerator and wall.
4 Avoid improper handling of domestic refrigerator.

XI Procedure

1. Identify and locate the components.
2. Locate the refrigerant tubes connecting different parts and trace the path of refrigerant.
3. Observe and trace the path of refrigerant.
4. Mark temperature at critical points for different setting of thermostat by thermocouple.

XII Resources Used

Sr. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					

XIII Actual Procedure Followed

.....
.....
.....
.....
.....
.....
.....

XIV Observations and Calculations

Sr. No.	Description	Symbol	Unit	Thermo stat setting 1	Thermo stat setting 2
1	Evaporator Inlet Temperature	t_{ei}	^0C		
2	Evaporator Outlet Temperature	t_{eo}	^0C		
3	Condenser Inlet Temperature	t_{ci}	^0C		
4	Condenser Outlet Temperature	t_{co}	^0C		

Sr. No.	Particulars	Remark (Functions /Type)
1	Compressor	
2	Condenser	
3	Evaporator	
4	Thermostat valve	
5	Expansion valve	

XV Results

.....
.....
.....
.....

XVI Interpretation of Results

.....
.....
.....
.....

XVII Conclusions

.....
.....
.....
.....

XVIII Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Detect the location of sensing bulb of thermostatic switch.
2. Draw the expansion device used in domestic refrigerator.

[Space for Answer]

.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....

.....

.....

.....

.....

.....

.....

.....

.....

XX References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=h5wQoA15OnQ
2. https://www.youtube.com/watch?v=L5jQqmaFKOE
3. https://www.youtube.com/watch?v=TPabv9iDENc

XX Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**40%**
1	Draw line diagram of domestic refrigerator	20%
2	Identify the path of refrigerant	20%
Product Related (15 Marks)		**60%**
3	Interpretation of result at different thermostat settings	20%
4	Conclusions	20%
5	Practical related questions	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1. ……..
2. …….
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No.16: Assemble/Dismantle Various Components Of Domestic Refrigerator

I Practical Significance

Domestic. (also household refrigerator), an appliance that is used for the short-term preservation of food products in the home by means of refrigeration. A domestic refrigerator is a metal cabinet with a built-in hermetically sealed refrigerating unit When the hot gas in the coils of the condenser meets the cooler air temperature of the kitchen, it becomes a liquid. Now in liquid form at high pressure, the refrigerant cools down as it flows through the expansion valve into the evaporator coils inside the freezer and the fridge.

Modern refrigerators usually use a refrigerant called HFC-134a (1,1,1,2-Tetrafluoroethane), which does not deplete the ozone layer, instead of Freon.

II Relevant Program Outcomes (POs)

PO1- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic Engineering to solve the broad-based Mechanical Engineering problems.

PO2-**Discipline knowledge**: Apply Mechanical engineering knowledge to solve broad- based mechanical engineering related problems.

PO3- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical Engineering problems.

PO5-**The engineer and society:** Assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to practice in field of Mechanical engineering.

PO8- **Individual and team work:** Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PO10-**Life-long learning:** Engage in independent and life-long learning activities in the context of technological changes also in the Mechanical engineering and allied industry.

III Competency and Skills

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences**:**

- **Maintain power engineering and refrigeration devices.**

IV Relevant Course Outcome(s)

- Test the performance of refrigeration and air-conditioning systems.
- **Practical Outcome**
- Assemble/Dismantle various components of domestic refrigerator.

V Relative Affective Domain-

- Follow safety practices.
- Practice good housekeeping.
- Maintain tools and equipment.

- Follow ethical Practices.

VI Minimum Theoretical Background

- Know the construction and working of refrigeration system.
- Identify various subassemblies of refrigeration system.
- Identify accessories of refrigeration system.

VII Experimental setup

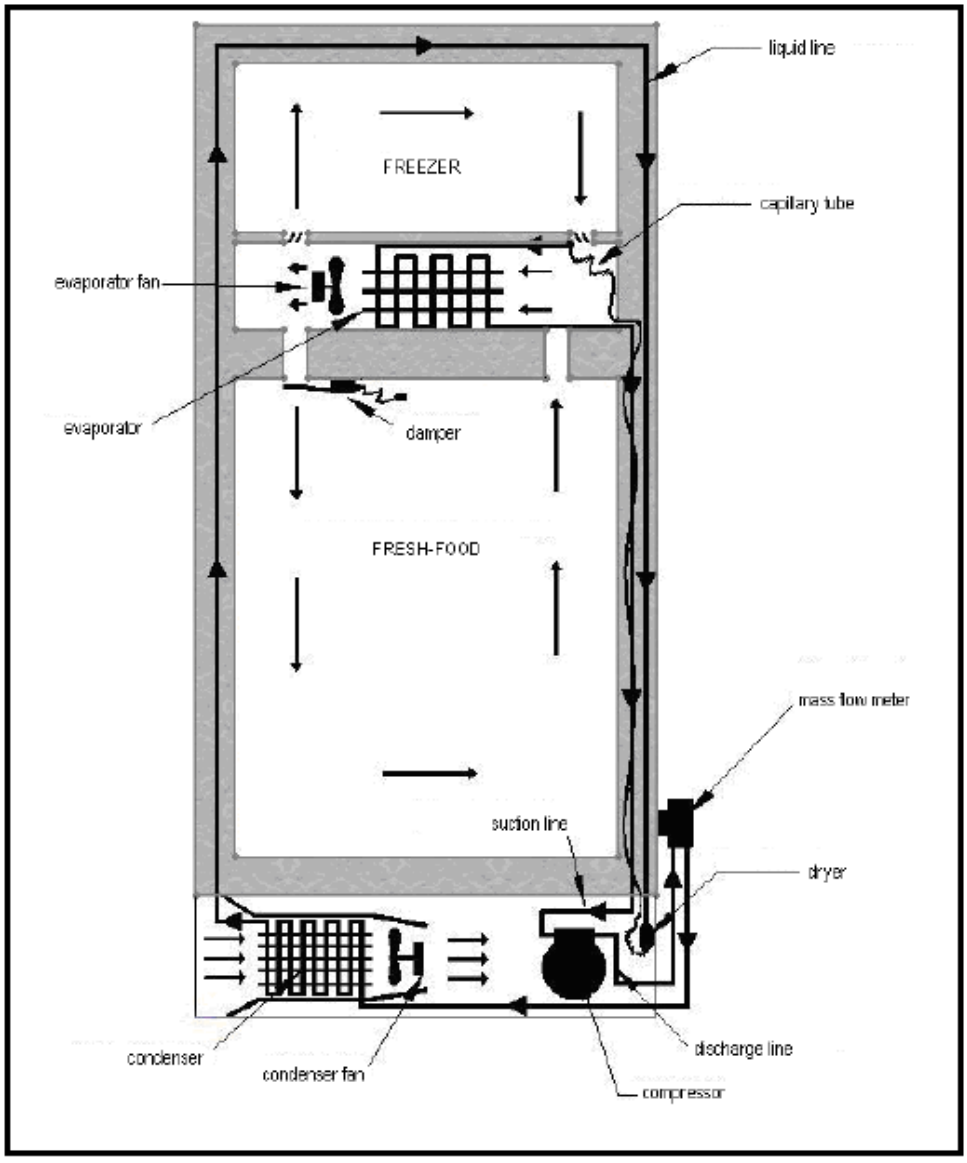


Figure No. 1 Schematic diagram of Domestic Refrigerator

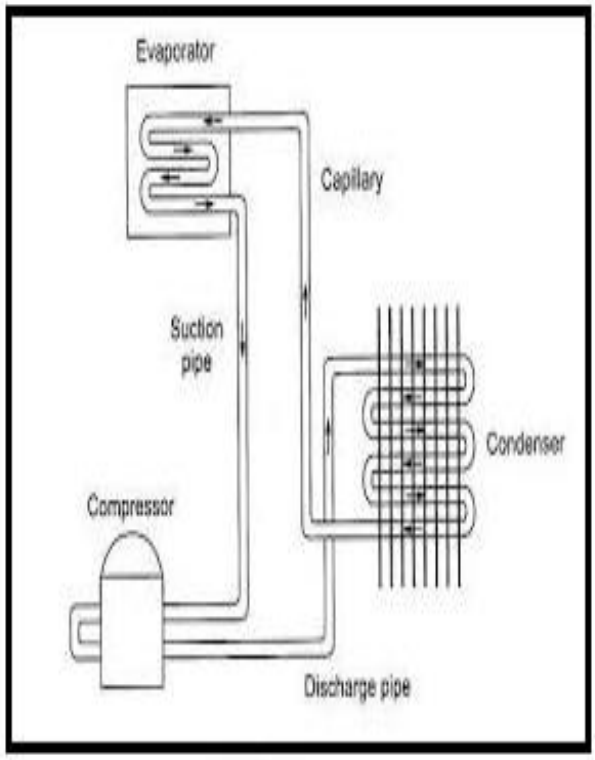


Figure No. 2 Refrigerator flow diagram

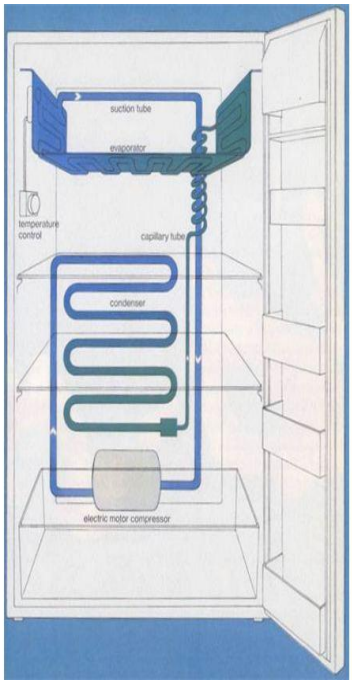


Figure No. 3 Domestic Refrigeration

Spanner

Side cutter

Hammer

Drilling machine

Cordless screwdriver

Piercing Pliers

Figure No. 4 Tools for Domestic Refrigerator

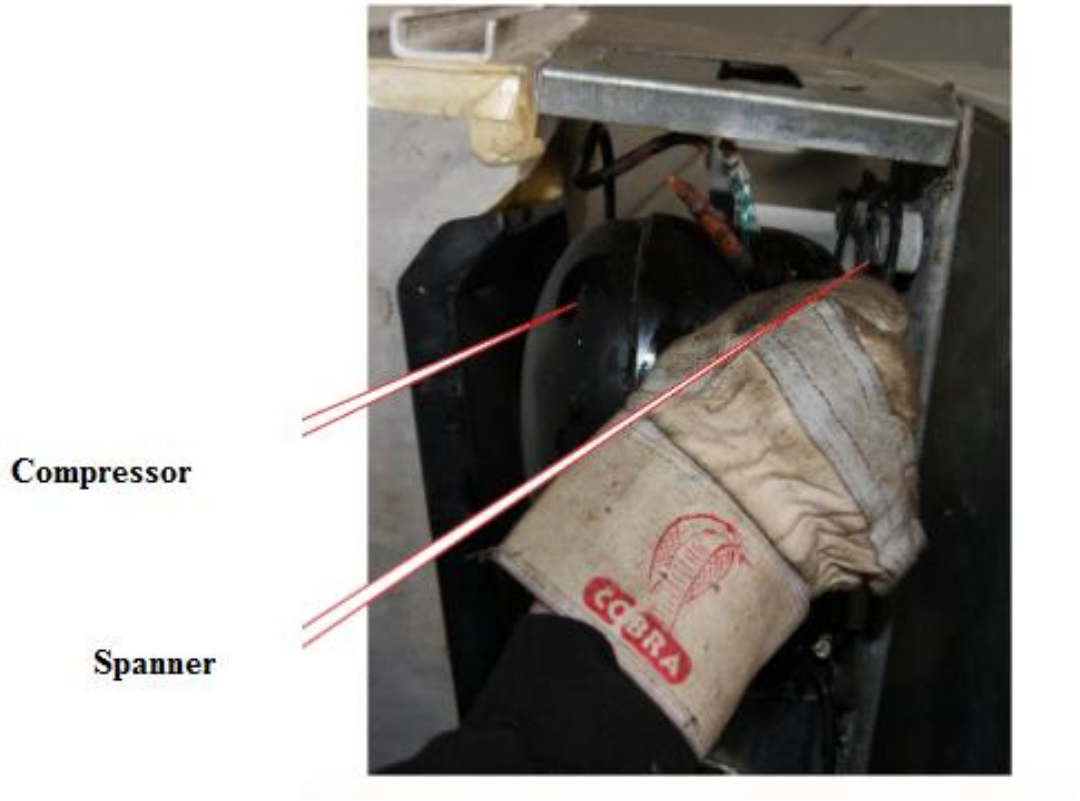


Figure No. 5 Compressor dismantling

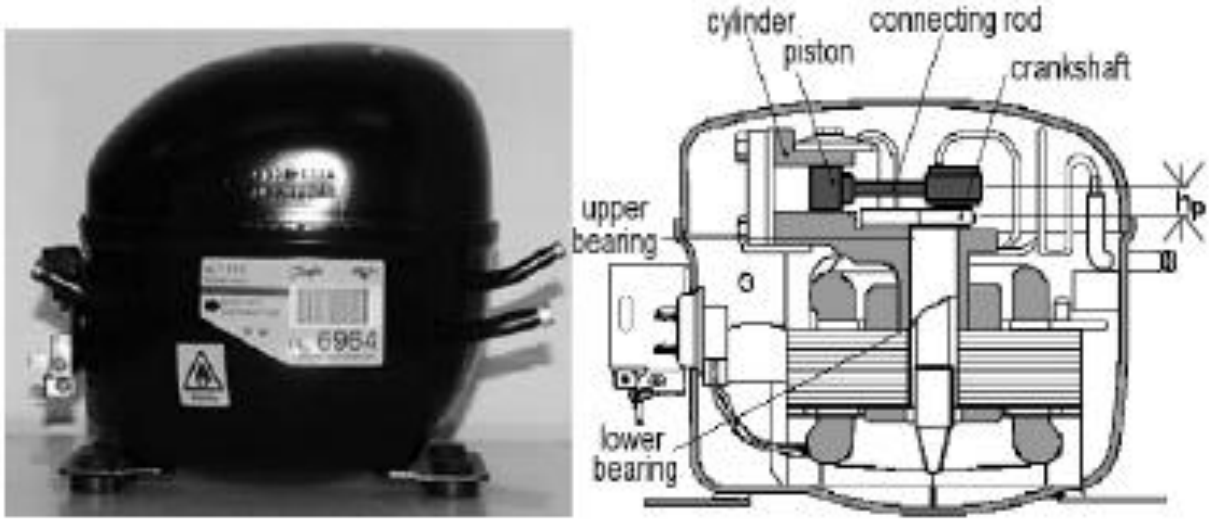


Figure No. 6 Hermetically sealed compressor

Figure No. 7 Disassembly of Hermetically sealed rotary compressor

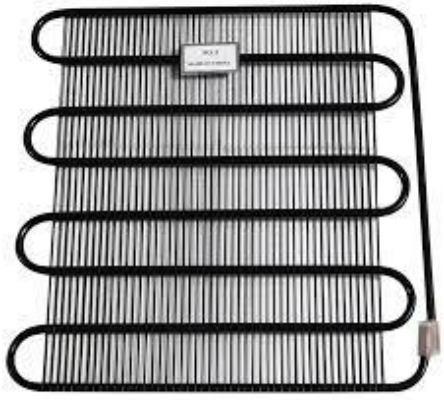


Figure No. 8 Condenser

Figure No. 9 Capillary Tube

Figure No. 10 Evaporator

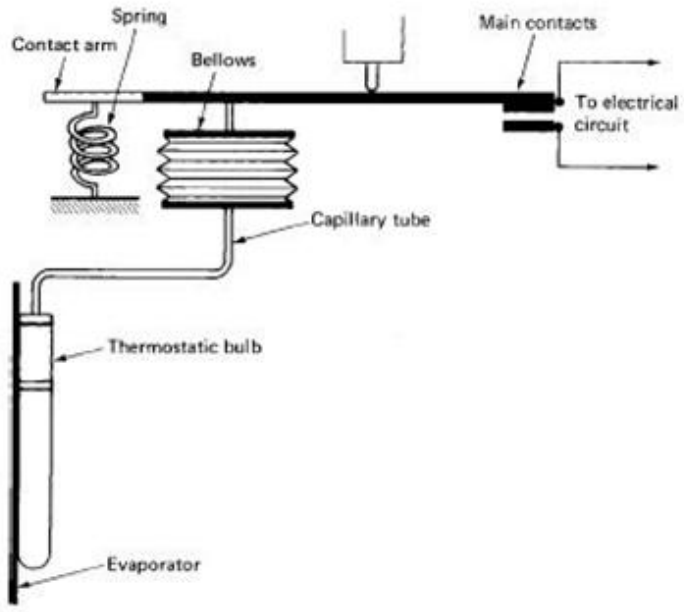


Figure No.11 Bellows type Thermostatic Switch

Figure No.12 Thermostat

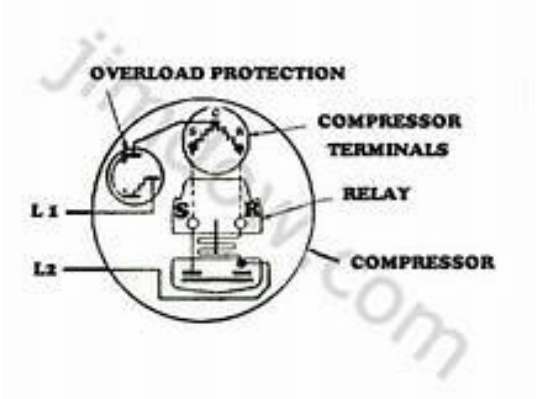


Figure No.13 Over load Protector

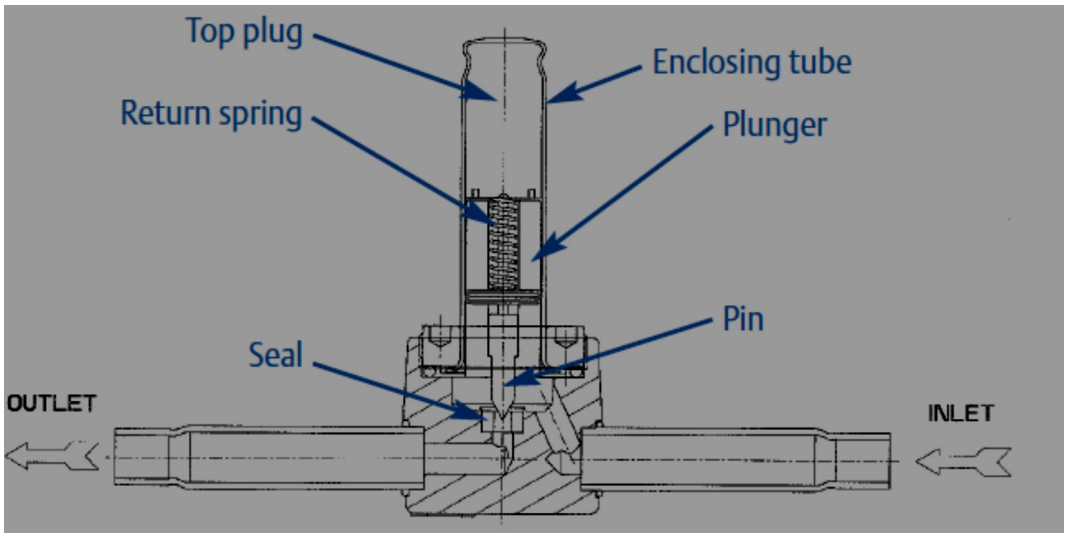


Figure No 14 Direct Acting Solenoid Valve

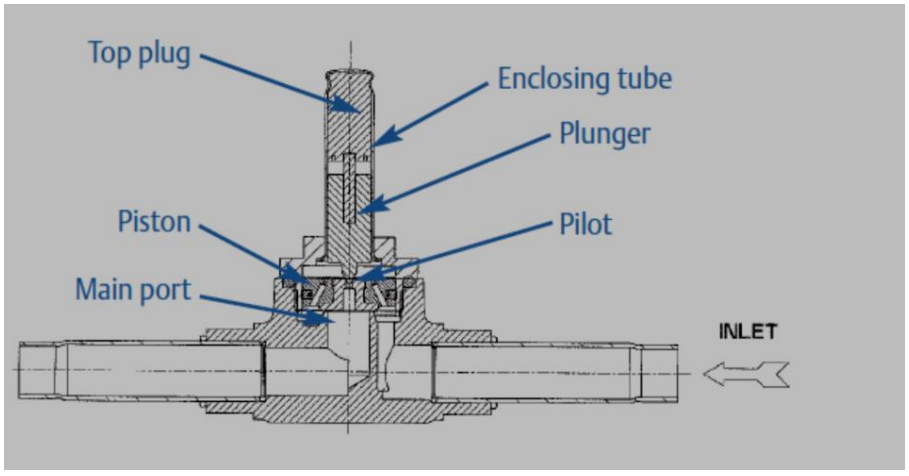


Figure No 15 Pilot operated Solenoid Valve

Figure No. 16 Actual Cut-section of household refrigerator representing PUF insulating back panel, condenser coil.

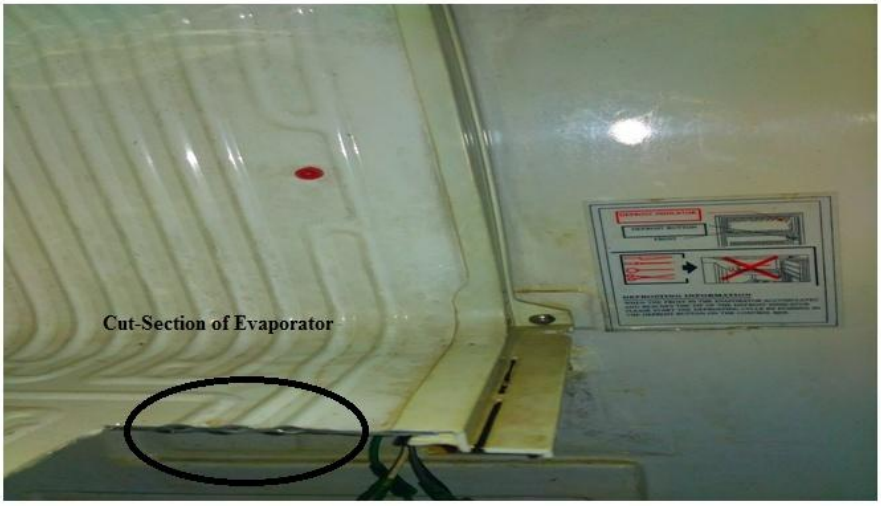


Figure No. 17 Actual Cut-section of household refrigerator representing Evaporator

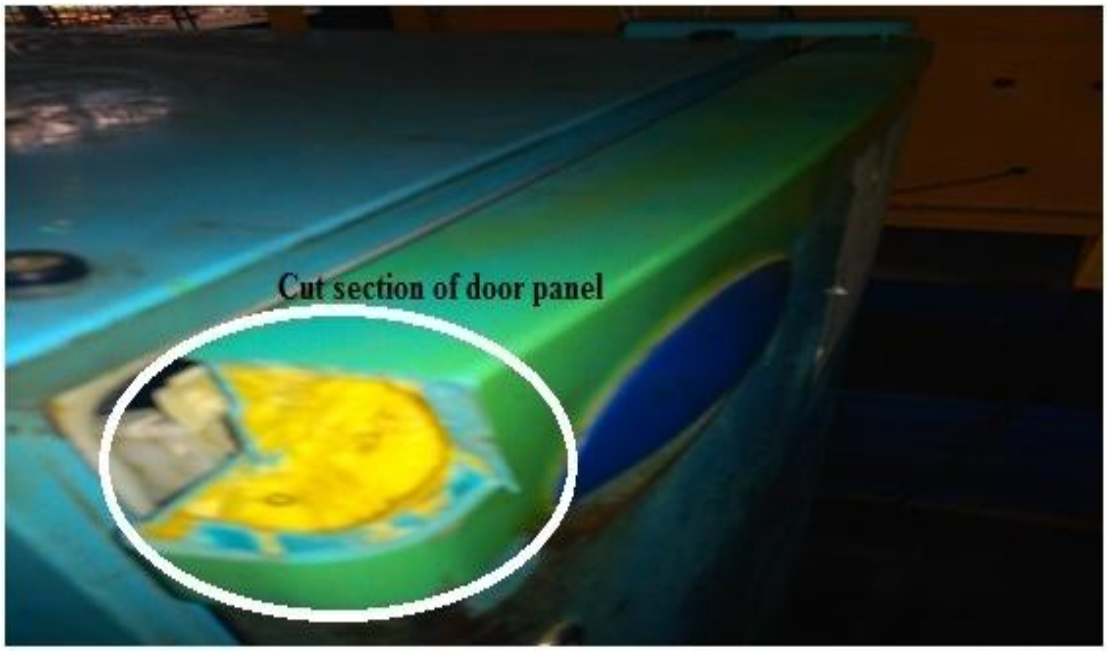


Figure No. 18 Actual Cut-section of household refrigerator representing PUF insulating door panel

VIII Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Old cut section of household refrigerator	165 litre	1
2	HVAC Tool Box	Failing tool	1
		Spanner	
		Piercing Pliers	
		Hammer	
		Side cutter	
		Cordless screw driver	
		Drilling machine	
		Rounding tool	
3	Industrial Visit	Visit to Refrigeration and air conditioner service stations	1

Note : Above Resource table is for reference only

IX Precautions to be Followed

1. Avoid improper handling of refrigeration and air conditioning system.
2. Use special and recommended tools for refrigeration and air conditioning system.

3. Use clean work bench for assembly and dismantling of refrigeration and air conditioning system.
4. Do not release Refrigerants (harmful substances) into the atmosphere
5. Unplug the domestic refrigerator before dismantling

X Procedure

1. Visually inspect unit
2. Removal of loose parts of storage container of domestic refrigerator.
3. Inspect electrical wiring and components
4. Cut all visible protruding parts and store them separately
5. Remove the capacitor from the refrigerator
6. Unscrew the compressor manually with a spanner
7. Dismantling of compressor done by Cut the compressor using an angle grinder
8. Further dismantling of compressor is done on clean bench
9. Observe the Cut unit of the Compressor
10. Observe the Cut unit of the Condenser
11. Observe the Expansion unit
12. Observe the Cut unit of the Evaporator
13. Observe the Thermostatic switch
14. Observe the drier
15. Observe the OLP
16. Observe the cabinet with PUF insulation

XI Resources Used

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Old cut section of household refrigerator		
2	HVAC Tool Box		
3	Industrial Visit		

XII Actual Procedure Followed

.....

.....

.....

.....

XIII Precautions Followed

.....
.....
.....
.....

XIV Observations and Calculations

Sr. No.	Particulars	Remark
1	Compressor	Capacity -
		Make-
		Type-
2	Condenser	Capacity -
		Type-
		No. of coils-
3	Expansion valve	Name-
		Type-
		Type-
		No. of coils-
		Type-
4	Drier	Type-
5	OLP (Over Load Protector)	Capacity(volt)-
		Capacity(current)-
		Construction-
		Type-

Observations

Draw Compressor, Condenser, Expansion, Evaporator and Thermostatic switch you observed

[Space for Diagram]

[Space for Diagram]

XV Results

.....
.....
.....
.....

XVI Interpretation of Results

.....
.....
.....
.....

XVII Conclusions

.....
.....
.....
.....

XVIII Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Enlist the common faults in refrigerator
2. Enlist the components of domestic refrigerator with their material
3. Enlist different Safety systems in Refrigeration system

[Space for Answer]

.....

.....

.....

.....

.....

.....

.....

.....

XIX References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=Y8sViu2zFnI
2. https://www.youtube.com/watch?v=0Ko23CLI_J0
3. https://www.youtube.com/watch?v=P72zJ6DrEpg
4. www.youtube.com/watch?v=nA-XbfxqgRo
5. www.youtube.com/watch?v=shFGqflIHtc
6. www.youtube.com/watch?v=GAUFvx_ac2Q

XX Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**40 %**
1	Handling of the tool kit tools	20%
2	Identification of Refrigeration and air conditioning components	20%
Product Related (15 Marks)		**60%**
3	Interpretation of Refrigeration and air conditioning components	20%
4	Conclusions	20%
5	Practical related questions	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1. ……..
2. …….
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No.17 : Assemble / Dismantle Various Components Of Water Cooler And Window / Split Air Conditioning Units.

I Practical Significance

Window air conditioning unit is a factory assembled air conditioning unit. Casing of the unit is divided into indoor portion and outdoor portion. Indoor portion which faces the room consists of evaporator, blower, filter and control unit. Outdoor portion consists of compressor, condenser and its fan. The main components of a water cooler and window/split air conditioning units are the compressor, the condenser, the expansion valve and the evaporator. In summer due to hot climate ,the quench of thrust is not satisfied by normal water. Since water cooler are developed. According to their line of performance, they are broadly classified as storage type and Instantaneous type. According to various climate zone ,the comfort zone is not available without any external mode of comfort. The most popular comfort zone provided by air conditioning system(A.C.) which is broadly classified as window /split A.C. A.C. not only provide comfort zone ,but also it purifies air, maintain humidity and temperature. All the above devices are also work on heart of refrigeration system ,that is Vapour Compression Cycle (VCC)

II Relevant Program Outcomes (POs)

PO1- **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic Engineering to solve the broad-based Mechanical Engineering problems.

PO2-**Discipline knowledge**: Apply Mechanical engineering knowledge to solve broad- based mechanical engineering related problems.

PO3- **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical Engineering problems.

PO4-**Engineering tools:** Apply relevant Mechanical technologies and tools with an understanding of the limitations.

PO5-**The engineer and society:** Assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to practice in field of Mechanical engineering.

PO6-**Environment and sustainability:** Apply Mechanical engineering solutions also for sustainable development practices in societal and environmental contexts.

PO7-**Ethics:** Apply ethical principles for commitment to professional ethics, responsibilities and norms of the practice also in the field of Mechanical engineering.

PO10-Life-long learning: Engage in independent and life-long learning activities in the context of technological changes also in the Mechanical engineering and allied industry.

III Competency and Skills

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences**:**

- **Maintain power engineering and refrigeration devices.**

IV Relevant Course Outcome(s)

- Test the performance of refrigeration and air-conditioning systems.

V Practical Outcome

- Assemble/Dismantle various components of Water Cooler and Window/Split air conditioning units.

VI Relative Affective Domain-

- Follow safety practices.
- Practice good housekeeping.
- Maintain tools and equipment.
- Follow ethical Practices.

VII Minimum Theoretical Background

- Know the construction and working of refrigeration system.
- Identify various subassemblies of refrigeration system.
- Identify various sub-assemblies of water cooler and window/split air conditioning units
- Identify recommended tools.
- Know the procedure of dismantling and assembly.

VIII Experimental setup

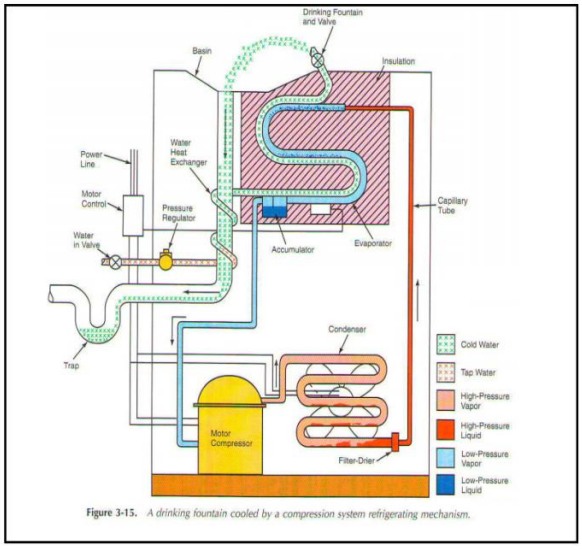


Figure No.1 Schematic diagram of Water cooler

Figure No.2 Water Cooler

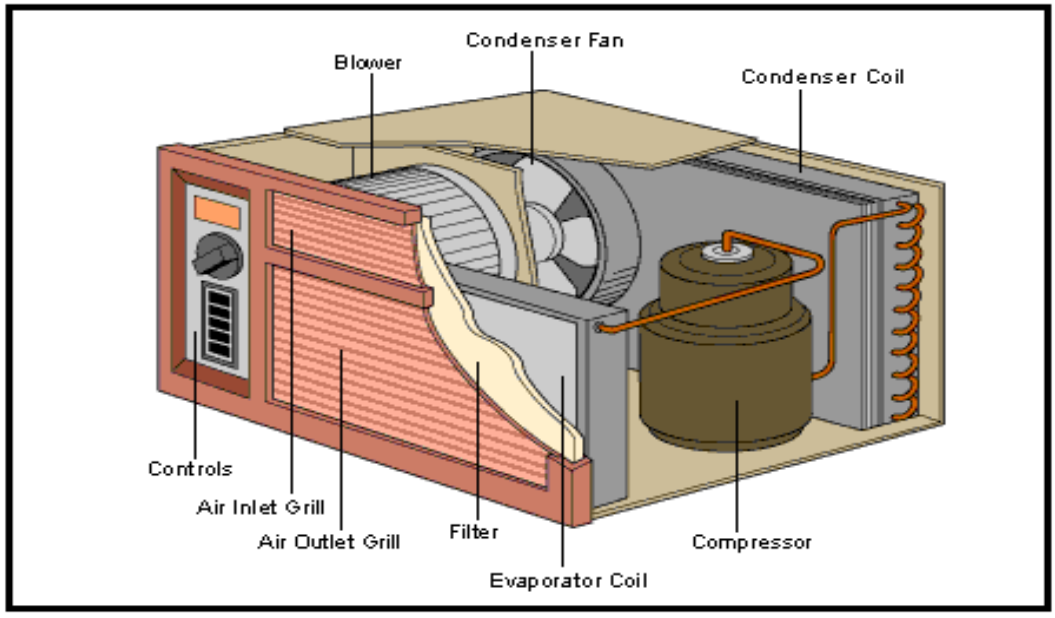


Figure No.3 Window air conditioner unit

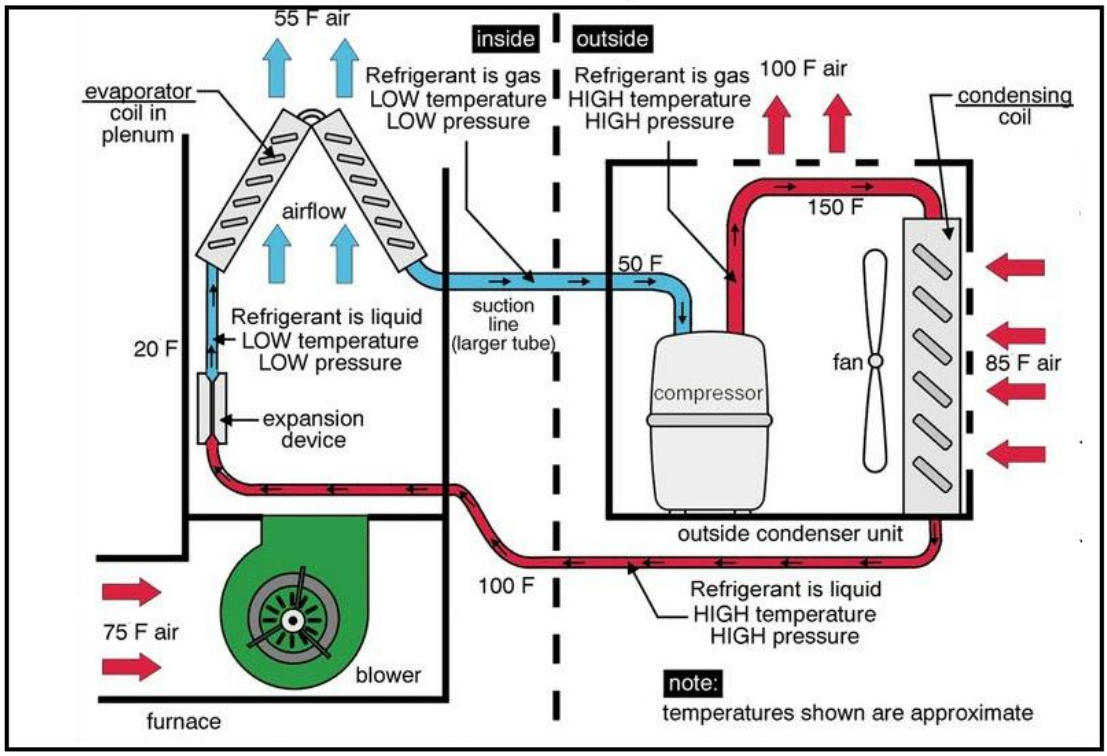


Figure No.4 Schematic diagram of Window air conditioner

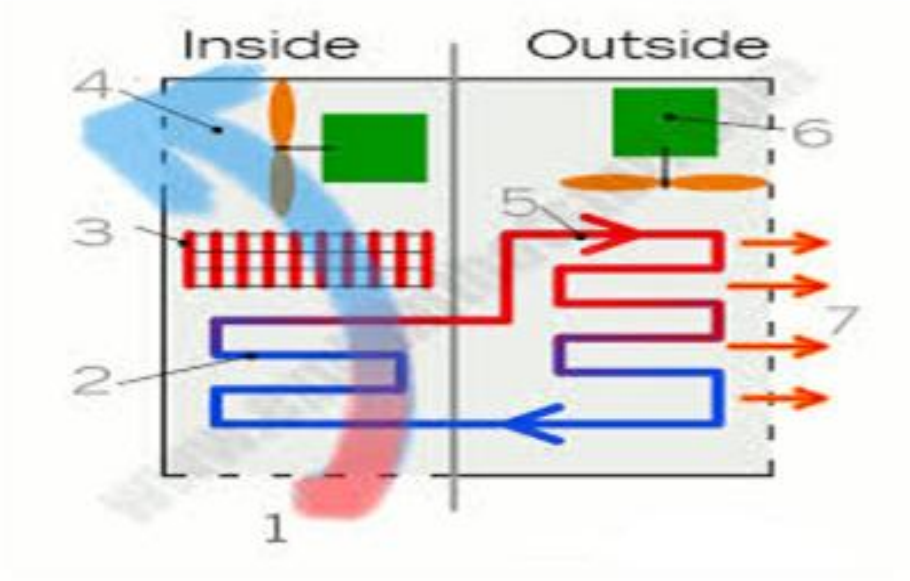


Figure No.5 Diagram of Window air conditioner

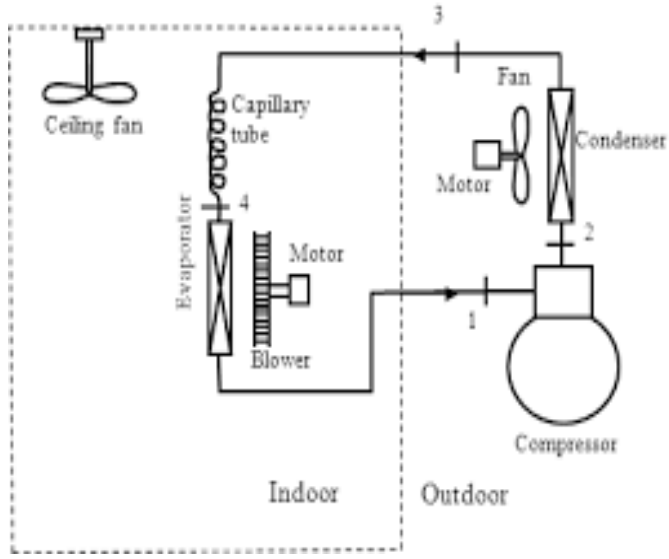


Figure No.6 Circuit Diagram of Window air conditioner

IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Old cut section of Water Cooler **or** Window/Split air conditioning	As per standard	1
2	HVAC Tool Box	Flaring tool	1
		Spanner	
		Piercing Pliers	
		Hammer	
		Side cutter	
		Cordless screw driver	
		Drilling machine	
		Rounding tool	
3	Industrial Visit	Visit to Water Cooler Or air conditioner service stations	1

X Precautions to be Followed

1. Avoid improper handling of refrigeration and air conditioning system.
2. Use special and recommended tools for refrigeration and air conditioning system.
3. Use clean work bench for assembly and dismantling of refrigeration and air conditioning system.
4. Do not release Refrigerants (harmful substances) into the atmosphere
5. Unplug the water cooler and window/split air conditioning units before dismantling

6. Avoid improper handling of water cooler and window/split air conditioning units
7. Use special and recommended tools for assembly and dismantling of water cooler and window/split air conditioning units
8. Ensure that water cooler and window/split air conditioning units is connected with proper electric power supply.

XI Procedure

1. Visually inspect unit
2. Removal of loose parts of storage container of your system
3. Inspect electrical wiring and components
4. Cut all visible protruding parts and store them separately
5. Remove the capacitor from the refrigerator
6. Unscrew the compressor manually with a spanner
7. Further dismantling of compressor is done on clean bench
8. Observe the Cut unit of the Compressor
9. Observe the Cut unit of the Condenser
10. Observe the Expansion unit
11. Observe the Cut unit of the Evaporator
12. Observe the Thermostatic switch
13. Observe the drier
14. Observe the OLP
15. Observe the cabinet with PUF insulation
16. Observe the Blower
17. Observe the Fan motor

XII Resources Used

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Old cut section of Water Cooler **or** Window/Split air conditioning		
2	HVAC Tool Box		

XIII Actual Procedure Followed

.....
.....
.....
.....

XIV Precautions Followed

.....
.....
.....
.....

XV Observations and Calculations

Sr. No.	Particulars	Remark
1	Compressor	Capacity -
		Make-
		Type-
2	Condenser	Capacity -
		Type-
		No. of coils-
3	Expansion valve	Name-
		Type-
4	Evaporator	Make-
		Type-
		No. of coils-
5	Thermostatic switch	Type -
6	Drier	Type -
7	OLP	Capacity(volt)-
		Capacity(current)-

8	Blower	Type-
9	Fan Motor	Capacity -
		Type-
10	Cabinet	Inside Panel -
		Outside Panel -
		Insulation -

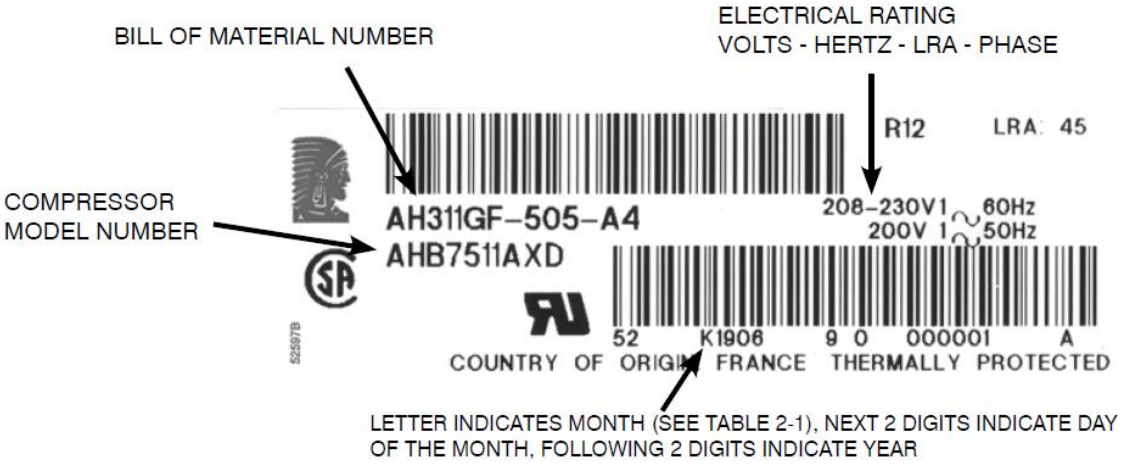


Figure No.7- Label on Compressor

[Space for student observation of Label on Compressor]

XVI Results

.....

.....

.....

.....

XVII Interpretation of Results

.....

.....

.....

.....

XVIII Conclusions

.....

.....

.....

.....

XIX Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Compare split air conditioning unit with window air conditioner unit on the basis of cost, noise produced, space occupied and electric power consumption.
2. Collect the names of Indian manufacturers of window air conditioners alongwith their range of capacity in TR.

[Space for Answer]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

XX References / Suggestions for Further Reading

1. https://www.youtube.com/watch?v=qBbND6UcjOs
2. https://www.youtube.com/watch?v=NzCj_BPKv0U
3. https://www.youtube.com/watch?v=cDl90FQo-I8

XX Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**40%**
1	Handling of the tool kit tools	20%
2	Identification of water cooler and air conditioning components	20%
Product Related (15 Marks)		**60%**
3	Interpretation of water cooler and air conditioning components	20%
4	Conclusions	20%
5	Practical related questions	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1. ……..
2. …….
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

List Of Laboratory Manuals Developed by MSBTE

First Semester:

1	Fundamentals of ICT	22001
2	English	22101
3	English Work Book	22101
4	Basic Science (Chemistry)	22102
5	Basic Science (Physics)	22102

Second Semester:

1	Bussiness Communication Using Computers	22009
2	Computer Peripherals & Hardware Maintenace	22013
3	Web Page Design with HTML	22014
4	Applied Science (Chemistry)	22202
5	Applied Science (Physics)	22202
6	Applied Machines	22203
7	Basic Surveying	22205
8	Applied Science (Chemistry)	22211
9	Applied Science (Physics)	22211
10	Fundamental of Electrical Engineering	22212
11	Elements of Electronics	22213
12	Elements of Electrical Engineering	22215
13	Basic Electronics	22216
14	'C' programming Language	22218
15	Basic Electronics	22225
16	Programming in "C"	22226
17	Fundamentals of Chemical Engineering	22231

Third Semester:

1	Applied Multimedia Techniques	22024
2	Advanced Serveying	22301
3	Highway Engineering	22302
4	Mechanics of Structures	22303
5	Building Construction	22304
6	Concrete Technology	22305
7	Strength Of Materials	22306
8	Automobile Engines	22308
9	Automobile Transmission System	22309
10	Mechanical Operations	22313
11	Technology Of Inorganic Chemicals	22314
12	Object Oriented Programming Using C++	22316
13	Data Structure Using 'C'	22317
14	Computer Graphics	22318
15	Database Management System	22319
16	Digital Techniques	22320
17	Principles Of Database	22321
18	Digital Techniques & Microprocessor	22323
19	Electrical Circuits	22324
20	Electrical & Electronic Measurment	22325
21	Fundamental Of Power Electronics	22326
22	Electrical Materials & Wiring Practice	22328
23	Applied Electronics	22329
24	Electrical Circuits & Networks	22330
25	Electronic Measurments & Instrumentation	22333
26	Principles Of Electronics Communication	22334
27	Thermal Engineering	22337
28	Engineering Matrology	22342
29	Mechanical Engineering Materials	22343
30	Theory Of Machines	22344

Fourth Semester:

1	Hydraulics	22401
2	Geo Technical Engineering	22404
3	Chemical Process Instrumentation & Control	22407
4	Fluid Flow Operation	22409
5	Technology Of Organic Chemicals	22410
6	Java Programming	22412
7	GUI Application Development Using VB.net	22034
8	Microprocessor	22415
9	Database Managment	22416
10	Electric Motors And Transformers	22418
11	Industrial Measurements	22420
12	Digital Electronics And Microcontroller Applications	22421
13	Linear Integrated Circuits	22423
14	Microcontroller & Applications	22426
15	Basic Power Electronics	22427
16	Digital Communication Systems	22428
17	Mechanical Engineering Measurments	22443
18	Fluid Mechanics and Machinery	22445
19	Fundamentals Of Mechatronics	22048

Fifth Semester:

1	Design of Steel and RCC Structures	22502
2	Public Health Engineering	22504
3	Heat Transfer Operation	22510
4	Environmental Technology	22511
5	Operating Systems	22516
6	Advanced Java Programming	22517
7	Software Testing	22518
8	Control Systems and PLC's	22531
9	Embedded Systems	22532
10	Mobile and Wireless Communication	22533
11	Industrial Machines	22523
12	Switchgear and Protection	22524
13	Energy Conservation and Audit	22525
14	Power Engineering and Refrigeration	22562
15	Solid Modeling and Additive Manufacturing	22053
16	Guidelines & Assessment Manual for Micro Projects & Industrial Training	22057

Sixth Semester:

1	Solid Modeling	17063
2	Highway Engineering	17602
3	Contracts & Accounts	17603
4	Design of R.C.C. Structures	17604
5	Industrial Fluid Power	17608
6	Design of Machine Elements	17610
7	Automotive Electrical and Electronic Systems	17617
8	Vehicle Systems Maintenance	17618
9	Software Testing	17624
10	Advanced Java Programming	17625
11	Mobile Computing	17632
12	System Programing	17634
13	Testing & Maintenance of Electrical Equipments	17637
14	Power Electronics	17638
15	Illumination Engineering	17639
16	Power System Operation & Control	17643
17	Environmental Technology	17646
18	Mass Transfer Operation	17648
19	Advanced Communication System	17656
20	Mobile Communication	17657
21	Embedded System	17658
22	Process Control System	17663
23	Industrial Automation	17664
24	Industrial Drives	17667
25	Video Engineering	17668
26	Optical Fiber & Mobile Communication	17669
27	Therapeutic Equipment	17671
28	Intensive Care Equipment	17672
29	Medical Imaging Equipment	17673

Pharmacy Lab Manual

First Year:

1	Pharmaceutics - I	0805
2	Pharmaceutical Chemistry - I	0806
3	Pharmacognosy	0807
4	Biochemistry and Clinical Pathology	0808
5	Human Anatomy and Physiology	0809

Second Year:

1	Pharmaceutics - II	0811
2	Pharmaceutical Chemistry - II	0812
3	Pharmacology & Toxicology	0813
4	Hospital and Clinical Pharmacy	0816

HEAD OFFICE

Secretary,
Maharashtra State Board of Technical Education
49, Kherwadi, Bandra (East), Mumbai - 400 051
Maharashtra (INDIA)
Tel: (022)26471255 (5 -lines)
Fax: 022 - 26473980
Email: -secretary@msbte.com
Web -www.msbte.org.in

REGIONAL OFFICES:

MUMBAI

Deputy Secretary (T),
Mumbai Sub-region,
2nd Floor, Govt. Polytechnic Building,
49, Kherwadi, Bandra (East)
Mumbai - 400 051
Phone: 022-26473253 / 54
Fax: 022-26478795
Email: rbtemumbai@msbte.com

PUNE

Deputy Secretary (T),
M.S. Board of Technical Education,
Regional Office,
412-E, Bahirat Patil Chowk,
Shivaji Nagar, Pune
Phone: 020-25656994 / 25660319
Fax: 020-25656994
Email: rbtepn@msbte.com

NAGPUR

Deputy Secretary (T),
M.S. Board of Technical Education
Regional Office,
Mangalwari Bazar, Sadar, Nagpur - 440 001
Phone: 0712-2564836 / 2562223
Fax: 0712-2560350
Email: rbteng@msbte.com

AURANGABAD

Deputy Secretary (T),
M.S. Board of Technical Education,
Regional Office,
Osmanpura, Aurangabad -431 001.
Phone: 0240-2334025 / 2331273
Fax: 0240-2349669
Email: rbteau@msbte.com