UPKAR'S

Objective Mechanical Engineering

[Railway & Other Engineering (Diploma) Competitive Exams.]

P. K. Mishra

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Objective

Mechanical Engineering

[For competitive selection examinations of Railway Service, Engineering (diploma) level, State Public Service Commissions, C.P.W.D., P.W.D., Coal India, Irrigation Departments and other equivalent services.]

By

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&

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PREFACE

Success in examinations depends on proper planning of studies and appropriate selection of study materials. The pattern of examinations has become tough. This is the reason why a right choice of study materials plays a very important role. This book cover thoroughly all the basics of the whole course as well as present to the examinee a wide spectrum of the multiple choice questions having a huge variety. The author has made a sincere attempt in this direction in the present book. Various unique features of the book are as under :

- A brief review of concepts at a glance covering all fundamentals and important conclusions is given at the start of every chapter.
- Chapters are classified under different units.
- Multiple choice questions in every chapter are arranged in a systematic and sequential way covering the whole text and spectrum of the chapter.
- Answers are provided at the end of every chapter.
- **Model Test Papers** covering the whole syllabus are also provided at the end of the book again with their answers. These papers will prove to be fit for examination and will provide a chance to students in assessing their level of preparation.

The present book is self-sufficient in all respects.

I am thankful to my wife Mrs. Rita Mishra who has put hard labour in reading the proofs thoroughly and pointing out errors and omissions. My sincere thanks are also due to publisher Mr. Mahendra Jain who gave me a chance to write this type of books. This edition is a nice form.

Although all attempts have been made to avoid errors and printing mistakes, yet omissions are a human weakness and, therefore, constructive suggestions, modifications and errors brought to my notice will be highly appreciated and incorporated in the next edition.

—Pramod Kumar Mishra

&

Kumar Sundram

CONTENTS

Mechanical Engineering

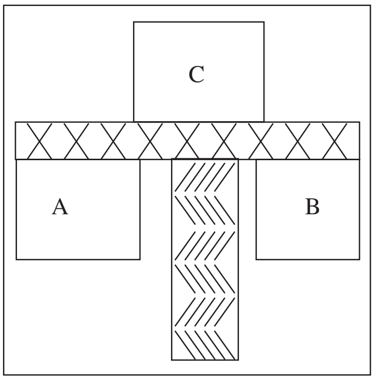
1 THERMODYNAMICS

Thermodynamics

The study of heat and its transformation to mechanical energy is called THERMODYNAMICS. It is the science that deals with the relations between heat, work and properties of systems. It is based on the law of conservation of energy and the fact that heat flows naturally from a hot body to a cold body and not the other way around.

Zeroth Law of Thermodynamics

This law states that "Two bodies or systems that are in thermal equilibrium with a third body are in thermal equilibrium with each other". Two bodies A and B are in thermal equilibrium if they are at the same temperature. One way to determine if two bodies A and B are in thermal equilibrium would be to make use of a third body C in thermal equilibrium by a thermometer. If the thermometer reads the same temperature for bodies A and B, then bodies A and B are in thermal equilibrium with each other.



First Law of Thermodynamics

When the law of energy is applied to thermal system then we call it the first law of thermodynamics. This law states that, "Whenever heat is added to a system, it transforms to an equal amount of some other form/forms of energy".

Clausius stated the first law or thermodynamics in the form as—

$$dH = dU + dW$$

Where dH = quantity of heat supplied or taken away from the system

dU = change in internal energy of the system

dW = External work done

The other form of first law is

$$dQ \propto dW$$

$$dQ = \frac{dW}{J}$$

$$\Rightarrow \quad \int dQ = \int \frac{dW}{J}$$

Second Law of Thermodynamics

Kelvin's Law—It is impossible by means of inanimate material agency to derive mechanical effect from any portion of the matter by cooling it below the temperature of the coldest of the surrounding objects.

Planck's Law—It is impossible to construct an engine which working in a complete cycle, will produce no effect other than the raising of a weight and the cooling of a heat reservoir.

Kelvin-Planck Law—It is impossible to construct an engine that operating in a cycle, will produce no effect other than the extraction of heat from a reservoir and the performance of an equivalent amount of work.

Clausius' Law—It is impossible for a self-acting machine, unaided by an external agency to convey heat from one body to another at a higher temperature or heat can't of itself pass from a colder to a warmer body.

Third Law of Thermodynamics

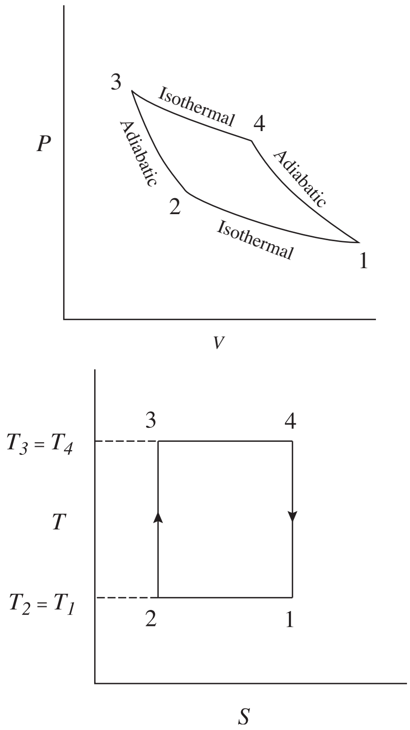
Third Law of thermodynamics states as follows :

"The entropy of perfect crystal at absolute zero temperature is zero". However, if the substance is not a perfect crystal like glass or solid solution, this entropy will have a finite value.

Power Cycle

(i) **Carnot Cycle**—In a Carnot cycle, the working substance is subjected to a cyclic operation consisting of two isothermal and two reversible adiabatic or isentropic operations.

$$\text{Efficiency } (\eta)_{\text{carnot}} = \frac{T_3 - T_1}{T_3}$$

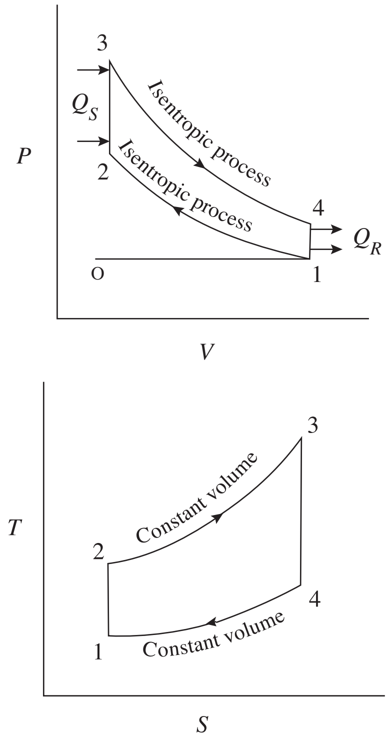


Carnot Cycle

(ii) **Otto Cycle**—The ideal otto cycle consists of two constant volume and two reversible adiabatic or isentropic processes. It is also known as constant volume cycle. This cycle is taken as a standard of comparison for internal combustion engines. These days, many gas, petrol and many of the oil engines run on this cycle.

$$\text{Efficiency } (\eta)_{\text{otto}} = 1 - \frac{T_4 - T_1}{T_3 - T_2}$$

$$(\eta)_{\text{otto}} = 1 - \frac{1}{r^{(\gamma - 1)}}$$

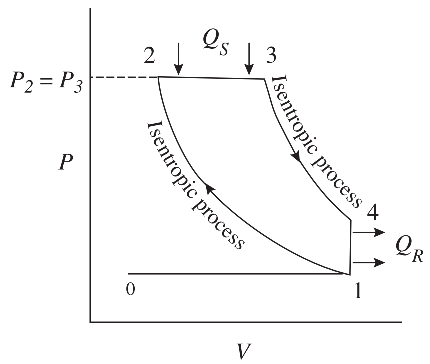


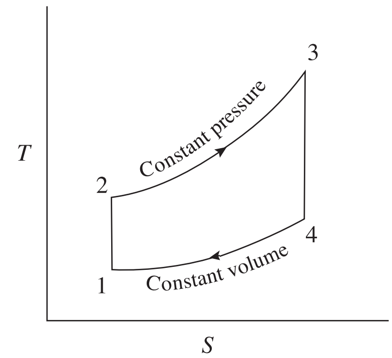
Otto Cycle

Hence the efficiency of otto cycle depends on compression ratio (r) only. In actual practice 'r' cannot be increased beyond a value of 7 or so.

(iii) **Diesel Cycle**—The ideal diesel cycle consists of two reversible adiabatic or isentropic, a constant pressure and a constant volume processes. This is an important cycle on which all the diesel engines work. It is also known as constant pressure cycle as heat is received at a constant pressure.

$$\text{Efficiency } (\eta)_{\text{Diesel}} = 1 - \frac{1}{\gamma}\left(\frac{T_4 - T_1}{T_3 - T_2}\right)$$





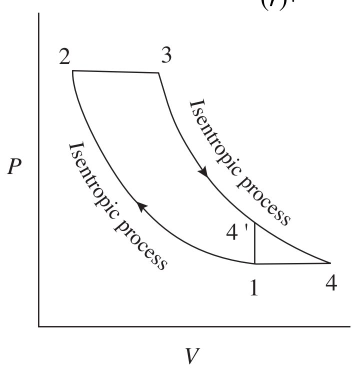
Diesel Cycle

(iv) **Joule's Cycle**—It consists of two constant pressure and two reversible adiabatic or isentropic processes. The efficiency of the Joule's cycle is lower than Carnot efficiency. The reversed Joule cycle is known as Bell Coleman cycle or Brayton cycle and is applied to refrigerators, where air is used as a refrigerant.

$$\text{Efficiency } (\eta)_{\text{Joule}} = 1 - \frac{T_4 - T_1}{T_3 - T_2}$$

Or

$$(\eta)_{\text{Joule}} = 1 - \frac{1}{(r)^{\gamma - 1}}$$



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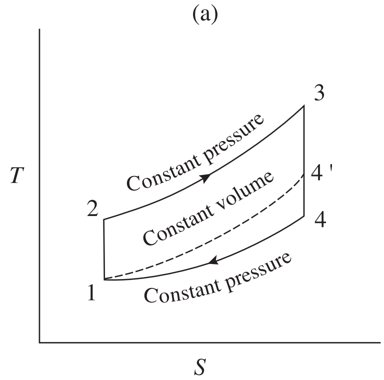
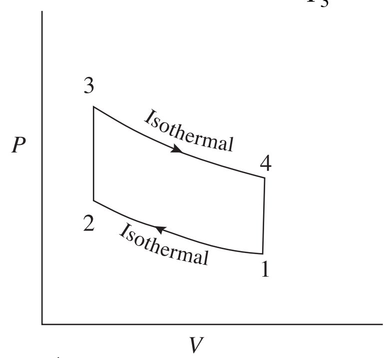


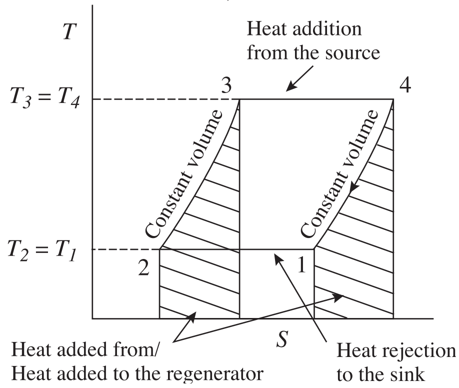
(b)

Brayton Cycle

(v) **Stirling Cycle**—It consists of two isothermal and two constant volume processes. The efficiency of Stirling cycle is same as that of Carnot cycle. This is due to the fact that the cycle is reversible, and all reversible cyclic have the same efficiency.

$$\text{Efficiency } (\eta)_{\text{Stirling}} = \frac{T_3 - T_1}{T_3}$$





Stirling Cycle

(vi) **Ericsson Cycle**—It consists of two isothermal and two constant pressure processes. It is made thermodynamically reversible by the action of a regenerator. This cycle is used these days in the manufacture of closed-cycle type gas turbines. The efficiency of the Carnot cycle is same as that of Carnot efficiency *i.e.,*

$$\text{Efficiency } (\eta)_{\text{Ericsson}} = \frac{T_3 - T_1}{T_3}$$