Gas Power Cycles

4.0 Introduction:

An important application of thermodynamics is the analysis of power cycles through which the energy absorbed as heat can be continuously converted into mechanical work. A thermodynamic analysis of the heat engine cycles provides valuable information regarding the design of new cycles or for improving the existing cycles.

Classification of Cycles:

The purpose of a thermodynamic cycle is either to produce power, or to produce refrigeration/pumping of heat. Therefore, the cycles are broadly classified as follows:

(a) Heat engine or power cycles.
(b) Refrigeration/heat pump cycles.

Any thermodynamic cycle is essentially a closed cycle in which, the working substance undergoes a series of processes and is always brought back to the initial state. However, some of the power cycles operate on open cycle. It means that the working substance is taken into the unit from the atmosphere at one end and is discharged into the atmosphere after undergoing a series of processes at the other end. The following are illustrations of heat engines operating on open cycle:

(i) Petrol and diesel engines in which the air and fuel are taken into the engine from a fuel tank and products of combustion are exhausted into the atmosphere.
(ii) Steam locomotives in which the water is taken in the boiler from a tank and steam is exhausted into the atmosphere.

Essentially, such devices do not form a cycle. However, they can be analyzed by adding an imaginary processes to bring the state of the working substance, thus completing a cyclic. Note that the terms closed cycle and open cycle used here do not mean closed system cycle and open system cycle. In fact, the processes both in closed and open cycles could either be closed or open system processes.

Different types of working fluids are employed in the power plants. The nature of the working fluids can be classified into two groups: vapours and gases. The power cycles are accordingly classified into two groups as:

(1) Vapour power cycles in which the working fluid undergoes a phase change during the cyclic process.

(2) Gas power cycles in which the working fluid does not undergo any phase change.

In the thermodynamic analysis of power cycles, our chief interest lies in estimating the energy conversion efficiency or the thermal efficiency. The thermal efficiency of a heat engine is defined as the ratio of the network delivered to the energy absorbed as heat.

Analysis of Cycles:

In air standard analysis, air is considered as the working medium. The analysis is carried out with the following assumptions.

Assumptions:

(i) The working substance consists of a fixed mass of air and behaves as a perfect gas. The closed system is considered which under goes a cycle process. Therefore, there are no intake or exhaust process.

(ii) The combustion process is replaced by an equivalent heat addition process form an external source. Thus there is no change in the chemical equilibrium of the working fluid and also composition.

(iii) There is no exhaust process; this is replaced by an equivalent heat rejection process.

(iv) Compression and expansion processes in the cycle are considered as reversible adiabatic process.

(v) The specific heats C_p and C_v of air do not vary with temperature.