COURSE CODE: *MCE 503*

COURSE TITLE: *Refrigeration & Air-Conditioning II*

NUMBER OF UNITS: *3 Units*

COURSE DURATION: *Three hours per week*

COURSE DETAILS:

Course Coordinator: **Engr. Dr. Bukola Olalekan Bolaji** *B.Eng., M.Eng., PhD*
Email: bolajibo@unaab.edu.ng, bobbolaji2007@yahoo.com
Office Location: **HOD MCE's Office, COLENG**
Other Lecturers: **None**

COURSE CONTENT:

Fundamental of vapour compression refrigeration. Analysis of refrigeration cycles. Heat pumps. Refrigerants and their properties. Absorption refrigeration. Principles of air-conditioning with emphasis on thermodynamic processes involving air-water-vapour mixture. Production of atmospheric and thermal-environments for human activity. Principles of cooling, freezing and storing of perishable products.

COURSE REQUIREMENTS:

This is an elective course for 500 level students in the Department of Mechanical Engineering. In view of this, students who registered for this course are expected to participate in all the course activities and have minimum of 75% attendance to be able to write the final examination.

READING LIST:

1. Bolaji BO. Refrigerants and stratospheric ozone: past, present and future. In: Okoko E, Adekunle VAJ (Eds), Environmental Sustainability and Conservation in Nigeria. Jubilee, Akure, Nigeria, 2005, pp. 231-239.
2. Bolaji BO. Experimental analysis of reciprocating compressor performance with eco-friendly refrigerants. Proc. IMechE, Part A: Journal of Power and Energy 2010;224:781-786.
3. Dincer I. Refrigeration Systems and Applications. England: John Wiley and Sons, Ltd., 2003.
4. Dossat RJ, Horan TJ. Principles of Refrigeration, Prentice-Hall International Inc., New Jersey, USA, 2002.
5. ASHRAE, Refrigeration Handbook. Atlanta: American Society of Heating, Refrigeration and Air-Conditioning Engineers. Atlanta, GA: ASHRAE, Inc., 1998.
6. ASHRAE. Thermophysical Properties of Refrigerants. Atlanta, GA: ASHRAE Fundamental, Inc., 2001; pp. 20:1-67.

LECTURE NOTES

1.0 ELEMENTS AND DESIGN OF REFRIGERATION SYSTEMS

Refrigeration is the cooling effect of the process of extracting heat from a lower temperature heat source, a substance or cooling medium, and transferring it to a higher temperature sink, probably atmospheric air and surface water to maintain the temperature of the heat source below that of the surroundings. Therefore, *Refrigeration is defined as the branch of science that deals with the process of reducing and maintaining the temperature of a space or material below the temperature of the surroundings*.

1.1 VAPOUR COMPRESSION REFRIGERATION

The vapour compression cycle is the most widely used refrigeration cycle in practice. In this cycle, a compressor compresses the refrigerant to a higher pressure and temperature from an evaporated vapour at low pressure from an evaporated vapour at low pressure and temperature. The compressed refrigerant is condensed into liquid form by releasing the latent heat of condensation to the condenser water. Liquid refrigerant is then throttled to a low-pressure, low temperature vapour, producing the refrigeration effect during evaporation. Vapour compression is often called mechanical refrigeration, that is, refrigeration by mechanical compression.

1.2 CARNOT REFRIGERATION CYCLE

The Carnot cycle is one whose efficiency cannot be exceeded when operating between two given temperature. The Carnot heat engine receives energy at a high of temperature, converts a portion of the energy into work, and discharges the remainder to a heat sink a low level of temperature.

The Carnot refrigeration cycle performs the reverse effect of the heat engine, because it transfers energy from a low level of temperature to a high level of temperature. The diagram of the equipment and the temperature-entropy diagram of the refrigeration cycle are shown in Figs 1 and 2.

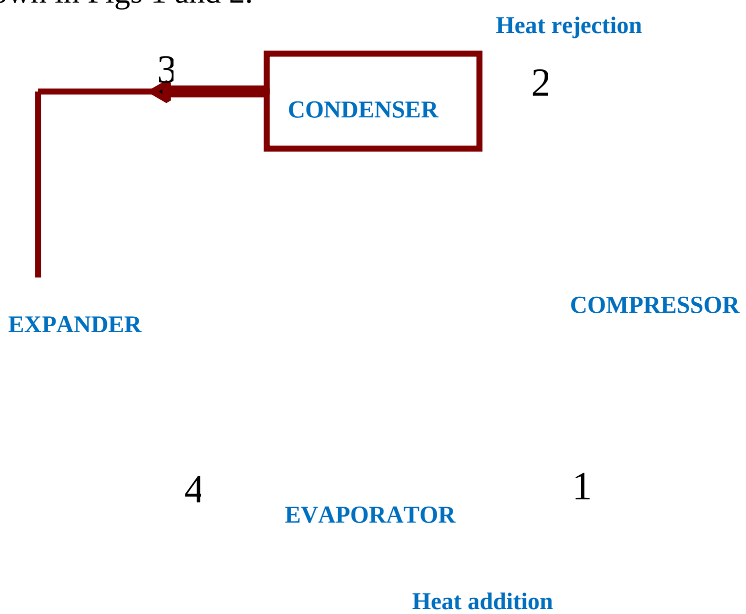

Fig. 1 Carnot Refrigeration cycle

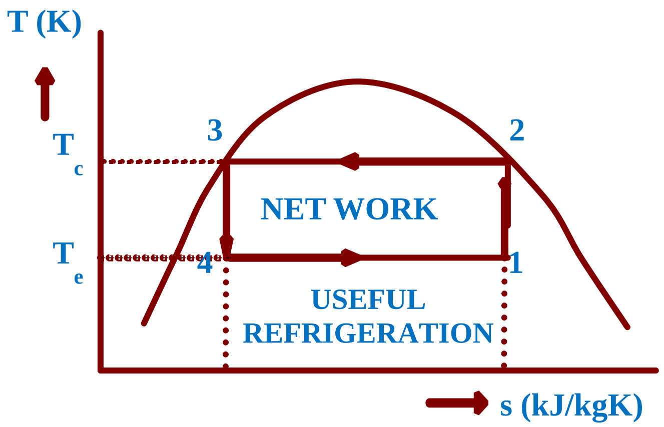

Fig. 2: T-s diagram of the Carnot refrigeration cycle

The processes which constitute the cycle are:
Process 1 - 2: Isontropic compression, $S_1 = S_2$
Process 2 – 3: Isothermal rejection of heat Tc= constant i.e. $T_2 = T_3$
Process 3 – 4: Isentropic expansion $S_3 = S_4$
Process 4 – 1: Isothermal addition of heat (heat absorption from the cold reservoir) at Te – constant i.e. $T_1 = T_4$
All processes in the Carnot cycle are thermo dynamical reversible. Processes 1-2 and 3-4 are consequently reversible adiabatic (isentropic).

The withdrawal of heat from the low temperature source in process 4-1 is the refrigeration step and is the entire purpose of the cycle. All the other processor in the cycle functions so that the low temperature energy can be discharged to some convenient high-temperature sink.

The Carnot cycle, consist of reversible which make its efficiency high than could be achieved in an actual cycle. Although Carnot cycle is an unattainable ideal cycle, it necessary to study the cycle because of the following reason:

(i) It serves a standard of comparison, and
(ii) It provides a convenient guide to the temperatures that should be maintained to achieve maximum effectiveness.

1.3 COEFFICIENT OF PERFORMANCE (COP)

The index of performance is not called efficiency, because that term is usually reserved for the ratio of output to input. The ratio of output to input would be misleading applied to a refrigeration system because the input in process 2-3 (Fig. 2) is usually wasted. The performance term in the refrigeration cycle is called the coefficient of performance, (COP), defined as