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CHAPTER 38

# COMPRESSORS

*RECIPROCATING: Performance, Features, Application; ROTARY: Performance, Features, Lubrication, Motor Selection, Large Rotary Type; CENTRIFUGAL: Cycle, Refrigerants, Compressor Types, System Components, Performance, Controls, Multiple Machine Operations, Selection*

THE compressor is one of the five essential parts of the compression refrigeration system, along with the condenser, the expansion valve (or its equivalent), the evaporator and the interconnecting piping. Since the compressor is the principal moving part, a knowledge of its construction and behavior is of fundamental importance.

This chapter discusses the design features and performance of refrigeration compressors. Reciprocating compressors are discussed in Part I, rotary in Part II, and centrifugal in Part III. Theoretical and actual compression cycles are treated in Chapter 1.

## PART I: RECIPROCATING COMPRESSORS

Most reciprocating compressors are single acting, using trunk-type pistons driven directly through a pin and connecting rod from the crankshaft. Double-acting compressors utilizing piston rods, crossheads, stuffing boxes, and oil injection are considered obsolete and are not covered in this chapter.

This section covers two classifications that include the majority of reciprocating refrigeration compressors, the halocarbon compressor and the ammonia compressor.

The most widely used is the halocarbon compressor, manufactured in three types of design, (1) open, (2) semi- or bolted hermetic, and (3) the welded shell hermetic.

Open-type compressors are those in which the shaft extends through the crankcase for an external drive.

Hermetic compressors are those in which the motor and compressor are contained within the same pressure vessel, with the motor shaft integral with the compressor crankshaft, and with the motor in contact with the refrigerant.

A semi-, (*bolted*), (*accessible*), or (*serviceable*) hermetic compressor is of bolted construction capable of field repair.

A welded shell, (sealed) hermetic compressor in which the motor-compressor is mounted inside a steel shell which in turn is sealed by welding.

Combinations of design features used are shown in Table 1:

### PERFORMANCE

The performance of a machine is an evaluation of the ability of the machine to accomplish its assigned task. Compressor performance is the result of a design compromise which must conform to certain physical limitations of the refrigerant, compressor, and motor, while attempting to provide:

1. The most refrigeration effect for the least power input.
2. The greatest trouble-free life expectancy.
3. The lowest cost.
4. A wide range of operating conditions.

Two useful measures of compressor performance are the capacity, which may be related to compressor displacement, and the performance factor.

Capacity is the refrigeration effect that can be accomplished by a compressor. It is equal to the difference in total enthalpy between the refrigerant liquid at a temperature corresponding to the pressure of the vapor leaving the compressor and the refrigerant vapor entering the compressor. It is usually measured in Btu per hour.

The performance factor for a hermetic compressor indicates combined operating efficiency of motor and compressor.

$$\text{Performance factor (hermetic)} = \frac{\text{Capacity, in Btuh}}{\text{Power input, in watts}}$$

The performance factor for an open compressor does not involve motor efficiency.

$$\text{Performance factor (open)} = \frac{\text{Power input, in Bhp}}{\text{Capacity, in tons}}$$

### The Ideal Compressor

The capacity of a compressor at a given operating condition is determined by the weight of gas it can compress in unit time. Ideally, the weight of gas compressed per unit time is equal to the density of the gas times the compressor displacement per unit time as shown in Equation 1:

$$w = 60ASnN\rho/1728 \quad (1)$$

*where*

$w$ = weight of gas compressed per unit of time, pounds of gas per hour.
$A$ = area of cylinder, square inches.
$S$ = stroke, inches.
$n$ = number of cylinders.
$N$ = compressor speed, revolutions per minute.
$\rho$ = density of gas entering compressor, pounds per cubic foot.

The ideal refrigeration cycle is discussed in Chapter 1, and the following quantities can be determined from the pressure—enthalpy diagram in Fig. 2 of Chapter 1:

$$\text{Refrigeration effect (Btu/lb)} = Q_R = (h_1 - h_4)$$

$$\text{Work of compressor (Btu/lb)} = Q_w = (h_2 - h_1)$$

Using $w$, the pounds of gas per hour, determined above:

$$\text{Ideal capacity (Btuh)} = wQ_R$$

$$\text{Ideal power input (Btuh)} = wQ_w$$

### Actual Compressor Performance

There are many deviations from the ideal cycle in a refrigeration compressor. These deviations are in the form of losses which are charged to the compressor and tend to reduce the capacity and raise the power input from those determined for an ideal compressor. The more important losses are considered here:

1. Pressure drop within the compressor due to the following restrictions:
   a. Suction and discharge shut-off valves.

The general responsibility for this chapter is assigned to TC 5.4, Reciprocating and Rotary Compressor Units; and TC 5.5, Centrifugal Machines.