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CHAPTER 44

COMPONENT BALANCING IN REFRIGERATION SYSTEMS

Performance Diagrams, Effects of Pressure Drop, Effect of Other Variable Factors, Trouble Diagnosis, System Performance

ONE of the principal aspects of the design of a refrigeration system, either in factory-built units or in field-assembled systems, is the selection of the components, such as the compressor, condenser, evaporator, refrigerant flow control device, fan, motor, and controls.

Some components can be selected individually, based entirely on definable operating requirements, and without regard to interaction with other components in the system. However, most components must be selected so that when they are operated together as a system, the net result is as required.

In general, more than one combination of components will meet the performance requirements of the system. Examination of several such combinations must be made to determine which is best suited to the particular application for which the system is being designed.

PERFORMANCE DIAGRAMS

A simplified evaporator-compressor-condenser combination for an air-cooled direct expansion system will illustrate the methods used to determine the system performance.

The capacity of each of the components can be defined in terms of certain variables. Some of these variables are internal to the system, such as refrigerant temperatures in the evaporator and condenser. Others are external, such as the air flow quantity and air temperatures entering the condenser and evaporator.

Determination of the performance of the three components operating together as a system involves the elimination of the internal variables by the process of simultaneously solving three equations, each equation expressing the performance of one of the components. Since these equations can become very complex, an equivalent graphical method is often simpler. This graphical method offers the further advantage that the pictorial representation makes it readily possible to visualize the relative importance of the major variables. Thus, the designer is able to make quick estimates of the effects of modifications in the performance characteristics of each component.

The development of the graphical method is illustrated by Figs. 1 to 6.

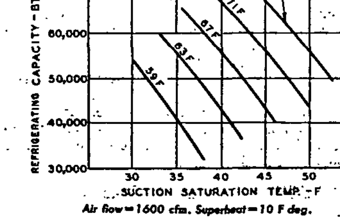
Fig. 1 shows the total capacity of the evaporator plotted against the saturation temperature of the refrigerant for several air inlet wet-bulb temperatures and with a constant air flow.

Fig. 2 shows the performance of the compressor plotted against the suction saturation temperature and condensing temperature, at the same suction inlet superheat as that for which the evaporator performance is expressed in Fig. 1. Part A of Fig. 2 shows the amount of heat that must be removed by the condenser to condense the refrigerant and subcool it 10 F deg. Part B of Fig. 2 shows the corresponding refrigerating capacity of the refrigerant circulated by the compressor, based on the stated superheat and sub-cooling.

Fig. 3 shows the capacity of the condenser to transfer heat from the refrigerant to the condenser cooling air, as a function of condensing temperature and condenser entering air temperature, with the same sub-cooling of refrigerant as used in Fig. 2.

Since condensing temperature is common to the compressor and condenser, Figs. 2 and 3 are plotted against this variable to permit easier superposition of the two separate performance diagrams. In Fig. 4, the diagram of Fig. 3 has been superposed on the diagram of Part A of Fig. 2. The intersections of the lines of constant entering air temperature with the lines of constant evaporator temperature indicate the condensing temperatures that will result from operation of this particular compressor and condenser as a combination. The lines of constant condenser entering-air temperature can be plotted on Part B of Fig. 4 by transferring each point of intersection in the upper portion vertically downward to the corresponding evaporator temperature line on Part B of Fig. 4.

Part B of Fig. 4 is then re-plotted on Fig. 1, using the common variable of evaporator temperature, resulting in the diagram shown in Fig. 5. It is now possible to determine the refrigerating capacity of the system for a given combination of evaporator and condenser entering-air temperatures, the two external variables.



Air flow = 1600 cfm. Superheat = 10 F deg.

Fig. 1.... Evaporator Performance Diagram

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