A recent development is the thermoelectric refrigeration as described in Fig. 1.11. But its COP is so poor that it cannot be exploited commercially. Temperatures approaching absolute zero have been obtained by adiabatic demagnetization, as described in Fig. 1.12, on a limited scale in laboratories.

Revision Exercises

2.1 (a) A refrigerator has working temperatures in the evaporator and condenser coils of –30 and 35°C respectively. What is the maximum possible COP of the refrigerator?

(b) If the actual refrigerator has a refrigerating efficiency of 0.75, calculate the refrigerating effect in kW and TR per kW of power input.

2.2 A reversed Carnot cycle has a COP for cooling of 4. Determine the temperature ratio T_k/T_o.

If the power consumption of the cycle is 7.5 kW, determine the refrigerating capacity of the machine in *TR*.

If the cycle is used as a heat pump with the same ratio of temperatures, determine its COP for heating and the quantity of heat pumped.

2.3 A Carnot refrigerator operates with Refrigerant 134a as a refrigerant condensing at 50°C and evaporating at –15°C.

Find its COP using the Carnot expression as well as the properties of R134a. Also determine the power consumption per ton of refrigeration.

2.4 The overall volume compression ratio of a reversed Carnot cycle working with air as a refrigerant is 10. The temperature limits of the cycle are 40°C and 0°C.

Determine:

(i) the pressure, volume and temperature at each point of the cycle,

(ii) the work done in the cycle,

(iii) the refrigerating effect, and

(iv) the COP of the cycle.

2.5 An air conditioning system is operating in an ambient of 45°C. The room temperature is maintained at 25°C. Determine the power consumption of the system per ton of refrigeration if it is,

(a) air-cooled as in a window-type air conditioner;

(b) water-cooled as in a central air conditioning plant.

The cooling water from cooling tower is available at 30°C. Assume suitable operating temperatures. Actual COP of the system is only 50% of the COP of the reversible cycle.

2.6 Determine the power consumption of a domestic refrigerator if its refrigerating capacity is $\frac{1}{8}$ TR. It is operating in an ambient of 40°C. Temperature in the freezer must be maintained at –15°C. COP of the system is half the Carnot COP. Assume suitable condensing and evaporating temperatures.

3

Vapour Compression System

3.1 MODIFICATIONS IN REVERSED CARNOT CYCLE WITH VAPOUR AS A REFRIGERANT

The reversed Carnot cycle with vapour as a refrigerant can be used as a practical cycle with minor modifications. The isothermal processes of heat rejection and heat absorption, accompanying condensation and evaporation respectively, are nearly perfect processes and easily achievable in practice. The isentropic compression and expansion processes, however, have certain limitations which are discussed below and are, therefore, suitably modified.

3.1.1 Dry Versus Wet Compression

The compression process as shown in Fig. 3.1 involves the compression of wet-refrigerant vapour at 1′ to dry-saturated vapour at 2′. It is called *wet compression*. With a reciprocating compressor, wet compression is not found suitable due to the following reasons:

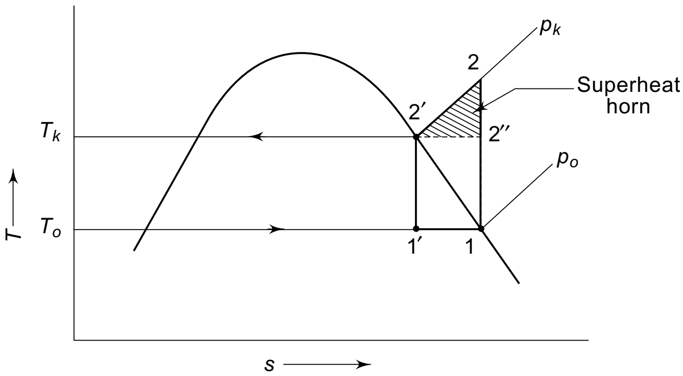

Fig. 3.1 Dry and wet compression processes

(i) First, the liquid refrigerant may be trapped in the head of the cylinder and may damage the compressor valves and the cylinder itself. Even though the state