In a rotary-type compressor for a refrigeration plant, a lubricating oil cooling system which utilizes a portion of the condensed refrigerant as coolant for the oil and feeds back the refrigerant to the compressor at a point where the pressure levels of the compressor and the returning refrigerant are substantially equal.

12 Claims, 7 Drawing Figures
ROTARY COMPRESSOR WITH OIL COOLING

BACKGROUND OF THE INVENTION

Cooling the lubricating oil for a refrigeration compressor by means of water, air, or brine has been known, but each of these media creates difficult problems. Water-cooling, for example, demands an adequate supply of reasonably good quality water; air coolers tend to be large and expensive; and cooling by brine makes heavy demands on the material in the cooler.

SUMMARY OF THE INVENTION

This invention is based on the use of the compressed and condensed refrigerant fluid of the refrigeration plant for cooling the lubricating oil. Cooling is effected by means of a heat-exchanger, which may be designed either with separate paths for the two fluids or in the form of a mixing chamber cooler, in which the two fluids are mixed directly, and which may be supplemented by a device for subsequent fluid separation. The refrigerant, completely or partially evaporated in the oil cooling process and possibly mixed with more or less of the cooled oil is fed back to the compressor.

It would seem most obvious to return the used refrigerant to the suction side of the compressor. This, however, would cause a capacity loss in the refrigeration plant corresponding to the amount spent refrigerant to be fed back.

Another possibility is to provide a pump for compressing and feeding back the used refrigerant to the high-pressure side of the plant. The introduction of an extra pump component, however, even if small in relation to the compressor, requires extra service and increases the risk of breakdowns occurring in the refrigeration plant.

This invention proposes, therefore, to utilize the inherent design of the rotary compressor, which may be, for example, a screw compressor, sliding van compressor, or the like. Such a compressor has a continuous and uniform pressure rise through its working compartment, and this feature is utilized in the invention by feeding the refrigerant used in oil cooling back to the compression chamber at a point where the pressure levels of the compression chamber and of the returning refrigerant are substantially equal. In this way, the power requirement of the compressor increases slightly, but the capacity remains unchanged. It should be noted that this invention concerns compressors of relatively large capacity, and that the power for cooling the oil is small in comparison with the total capacity of the compressor. A small increase in the power requirement of the compressor will, therefore, do no harm, provided that the rated power of the compressor motor has sufficient margin. A reduction of the resultant power of the compressor, on the other hand, could be undesirable.

While the principle of feeding back refrigerant to a pressure level between the inlet and outlet sides of a compressor is known and has been disclosed in U.S. Pat. No. 3,568,466, it has not been applied to cooling the lubricating oil.

The primary object of the invention, therefore, is to provide a lubricating oil cooling system for refrigeration compressors of the rotary type using the refrigerant as a cooling medium and returning the spent refrigerant to a pressure level in the compressor substantially equal to the pressure of the refrigerant being fed back. The principle embodied in the invention permits a wide variety of different versions of the oil cooling system, as will be described hereinafter with reference to the accompanying drawings, and will be defined by the accompanying claims.

DRAWINGS

FIG. 1 shows diagrammatically an oil cooling system for a refrigeration compressor of the rotary type in which the oil cooler is a heat exchanger;

FIG. 2 shows diagrammatically an oil cooling system in which the oil cooler is a mixing chamber;

FIG. 3 is a diagrammatic showing of the mixing chamber of FIG. 2 in greater detail and with possible variations;

FIG. 4 diagrammatically discloses a combined oil separator and oil cooler;

FIGS. 5 and 6 show diagrammatically two modifications of a combined oil separator/oil cooler; and

FIG. 7 shows diagrammatically a modified form of the mixing chamber of FIG. 3.

DESCRIPTION OF THE EMBODIMENTS

According to FIG. 1, refrigerant is sucked through tube 1 from the low-pressure side of the refrigeration unit to the compressor 2, where it is compressed and conducted to an oil separator 3 through tube 16. Oil separator 3 may be combined with oil container 4 of the oil system. From oil separator 3 the refrigerant is led further to the condenser 5 of the refrigeration unit, where it is cooled, condensed and conducted further to a receiver (not shown), if any, or to the low-pressure side through tube 6. One side of the oil cooler 7 is coupled to the liquid side of the refrigeration unit through tube 8 from the liquid tube 6. One side of the oil cooler 7 is coupled to the liquid side of the refrigeration unit through tube 8 from the liquid tube 6 shown in FIG. 1, or directly to condenser 5 or to the receiver. The amount of refrigerant supplied is controlled by a control valve 9 in tube 8.

Hot oil from oil container 4 is led to oil cooler 7 through tube 18. By absorbing heat from the hot oil in oil cooler 7 (here shown as a heat exchanger), the refrigerant is vaporized and is then supplied to the working compartment of compressor 2 through tube 11 to a port 10 located in compressor 2 in such a way that the pressure at this point is higher than the low pressure of the refrigeration unit and lower than its high pressure. By reintroducing the refrigerant at this location in compressor 2, no capacity loss is encountered, at the expense of a very small power increase of compressor 2. Depending on how port 10 is positioned, this increased power requirement can be minimized. The cooled oil may be supplied to compressor 2 by its own pressure.

A control device 12 may be introduced in tube 11 between oil cooler 7 and compressor 2, with the help of which the oil temperature can be controlled by adjusting the outlet pressure of the refrigerant. Also, a pump 13 may be provided to pump the oil to compressor 2 through oil cooler 7.

FIG. 1 also shows that oil tube 14, connecting oil cooler 7 and compressor 2, may be branched so that oil for injection into the working compartment of compressor 2 is conducted into port 10 of compressor 2 to-
3,820,350

3
gather with the refrigerant through regulating valve 15.

Regulating valve 9 in refrigerant inlet tube 8 to oil cooler 7 is controlled by thermosensitive members 17 or 17'. Thermosensitive member 17 is inserted in refrigerant outlet tube 11 from oil cooler 7. In this way, the cooled oil in tube 14 will be maintained at a fairly constant temperature. Alternately, a thermosensitive member 17' may be placed in outlet tube 16 from compressor 2, the regulating valve 9 thus being controlled by the outlet temperature of compressor 2.

FIG. 1 also shows that an oil pump 13 may be inserted in oil outlet tube 18 from oil container 4, in this way ensuring sufficient oil pressure in tube 14, as well as in the bearing of compressor 2 and other points of lubrication.

It is evident that components 1-6 and 16 constitute the conventional elements of a rotary type refrigeration compressor, whereas parts 7-11, plus 14, 18, and 17 or 17' comprise the framework of the oil cooling system of this invention, and, as mentioned, control device 9 may be regulated by one of the thermosensitive members 17 or 17'. Elements 12, 13, and 15, on the other hand, are selectively supplementary parts which may be employed according to the needs of a given situation.

FIG. 2 describes another version of an oil cooling system in accordance with this invention, wherein oil cooler 7' is shown as a mixing chamber for direct cooling of the oil by admixing it with refrigerant from condenser 2. Reference characters for the same parts are identical with those of FIG. 1, and it is clear that the arrangement of components in this embodiment is the same as that of FIG. 1.

FIG. 3 shows mixing chamber 7' of FIG. 2 in some detail, as well as some variants in the system. Refrigerant tube 8 with its regulating valve 9 and oil tube 18 are both connected to cooler mixing chamber 7' at inner chamber 20 within a cylindrical baffle 19, outside of which there is an oil chamber 21. Above chambers 20 and 21 a scum-removing layer 22 may be placed, which in its simplest form consists of a net or coarse filter of metal wire or the like.

The refrigerant which enters the central chamber 20 together with the hot oil will vaporize, and the gaseous refrigerant which may be intermingled with some oil foam, is led by tube 11 through regulating valve 12 to intake 10 on compressor 2. The oil fro oil chamber 21 goes through tube 14 to compressor 2. Tube 14 may be divided into two parts as shown, one of which leads to an extra intake 10' on compressor 2, whereas the other part of tube 14 leads to bearings and other points of lubrication on compressor 2, possibly through oil pump 13'. It is also possible to conduct part of the oil from tube 14 to refrigerant tube 11 as shown by the dashed branch tube carrying regulating valve 15, and thus this portion of oil would be brought to intake 10 along with the refrigerant.

FIG. 4 shows a variant of FIGS. 1 and 2 where oil cooler 7 or 7' is built into oil container 4 in oil separator 3. The more detailed constructions of combined oil separator/cooler are shown in FIGS. 5 and 6, FIG. 5 corresponding to the heat exchanger of FIG. 1, and FIG. 6 corresponding to the mixing chamber 7' of FIG. 2.

In FIG. 5 the oil cooler 7 comprises tube bundles 23, 24 introduced between vertical extensions of inlet tube 8 and outlet tube 11. Tube bundles 23, 24 are surrounded by a casing 26, inside which a baffle 25 is fixed, to the center of which outlet tube 14 for the oil is connected. In this way, the oil, which drips down from oil separator 3 into oil container 4, will follow the path marked by arrows through cooling casing 26; that is, through the bottom of casing 26 parallel to tube 14, and thereafter upward and outward, around the edges of baffle 25 and inward through tube bundle 24 to the center of baffle 25, where the oil leaves cooler 7 through outlet tube 14.

FIG. 6 shows an oil cooler 7' according to the mixing principle of FIG. 2. At the bottom of oil separator 3, oil container 4 is defined by a baffle 27. Condensed refrigerant is conducted to the bottom of oil container 4 through tube 8 and regulating valve 9, which is here controlled by a temperature sensitive element 17 on oil outlet tube 14. Oil from compressor 2 is separated in oil separator 3 and runs through it, optionally through a scum-removing filter 22' corresponding to scum remover 22 of FIG. 3. The vaporized refrigerant from oil container 4 moves upward and can either be brought back to intake 10 on compressor 2 through tube 11, or can be mixed with the hot refrigerant in separator 3 and from there proceed to condenser 5.

FIG. 7 shows a further variant of mixing chamber 7" of FIG. 2. An extra mixing chamber 28 has been added to the side of mixing chamber 7". Refrigerant tube 8 and oil tube 18 are connected to side wiring chamber 28, from which the mixture of oil and refrigerant enters the main mixing chamber 7", in which a scum-remover 22" in the form of a coarse metal wire filter has been mounted. Oil outlet tube 14 is connected to the bottom of mixing chamber 7", while refrigerant outlet 11 is connected to the top.

According to FIGS. 2, 3, 6 and 7, through tubes 11 and 14, oil and refrigerant, respectively, and various mixtures of these two fluids, may be supplied to compressor 2 at suitable locations. It is clear that the different elements for controlling and regulating the various flows may be used or omitted according to the specific needs of any individual situation. In this way, the invention foresees many different possibilities for combination in the refrigeration system without departing from its scope. In addition, it should be noted that the principles of this invention may be applied to multi-stage compressors of different kinds, the refrigerant from oil cooler 7 or 7' being fed back to the compressor between any pair of these stages.

What is claimed:

1. In a refrigeration compressor (2) of the rotary type, in which oil for lubrication of the compressor and refrigerant together leave the outlet side of the compressor and are brought to an oil separator (3) from which the refrigerant flows to a condenser (5), an oil cooling system which comprises:

an oil cooler (7), to which the oil flows from the oil separator; and

the compressor being provided with an intermediate intake port (10) between its inlet and outlet sides (1, 16 respectively),

wherein a portion of the condensed refrigerant is supplied to said oil cooler for cooling the oil, from whence this portion of refrigerant is fed back to the compressor through said intake which is positioned at a pressure level of the compressor which sub-
stantially corresponds to the pressure of the refrigerant leaving said oil cooler.

2. Oil cooling system according to claim 1, wherein the refrigerant is supplied to said oil cooler (7) through a regulating valve (9).

3. Oil cooling system as defined in claim 2, wherein said regulating valve (9) is controlled by the temperature on the outlet side (11, 14) of said oil cooler (7, 7') respectively.

4. Oil cooling system according to claim 2, in which said regulating valve (9) is controlled by the temperature on the outlet side (16) of the compressor.

5. Oil cooling system as described in claim 1, further comprising a constant pressure valve (12) for the refrigerant operatively connected between said oil cooler (7) and said intake (10) on the compressor.

6. Oil cooling system according to claim 1, wherein said oil cooler (7) forms the bottom portion (4) of the oil separator (3).

7. Oil cooling system according to claim 1, wherein said oil cooler (7) is a heat exchanger through which the oil and the refrigerant flow separately.

8. Oil cooling system as defined by claim 7, wherein the oil and the refrigerant are returned to the compressor (2) separately.

9. Oil cooling system according to claim 7, wherein part of the cooled oil from said oil cooler (7) may be diverted through a branch line valve (15) and returned to the compressor (2) together with the refrigerant through said compressor intake (10).

10. Oil cooling system according to claim 1, wherein said oil cooler (7') is a mixing chamber where oil and refrigerant are mixed for cooling the oil before both fluids are returned to the compressor (2).

11. Oil cooling system according to claim 10, wherein said oil cooler mixing chamber (7') comprises a part of the oil separator (3) on its inlet side, separate outlet means (11, 14 respectively) for oil and refrigerant being provided on the oil separator.

12. Oil cooling system according to claim 11, wherein part of the cooled oil is supplied to a second intake port (70') situated between the inlet and outlet sides (1, 16 respectively) of the compressor (2).
UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,820,350                                      Dated       June 28, 1974

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It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

[30] Foreign Application Priority Data

December 22, 1971        Sweden.........16463/1971

Signed and sealed this 17th day of September 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.                        C. MARSHALL DANN
Attesting Officer                      Commissioner of Patents