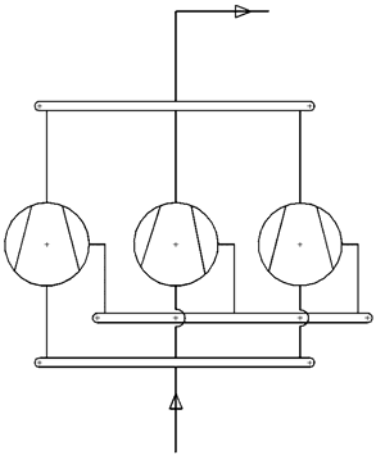
SOME METHODS OF OIL LEVEL CONTROL IN THE CRANCKCASE OF COMPRESSORS CONNECTED IN PARALLEL

State of the art

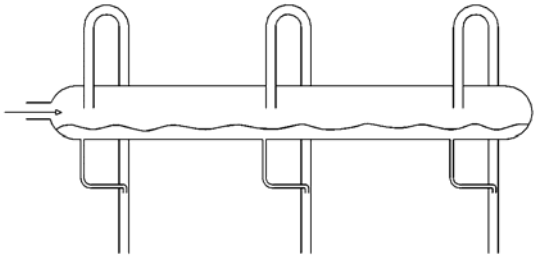
Methods currently used are the following:

- direct parallel of compressors crankcases (A)
- balanced return from low pressure accumulator (B)
- oil separator, oil accumulator and single oil level controller on each compressor (C1)
- oil separator with integrated oil accumulator and level controller on each compressor (C2)

Many variants are possible, based on the type of controller used, on which side of the circuit oil separation occurs, on methods used for oil level detection. Sometimes more than one method is used in the same refrigeration unit.



A)



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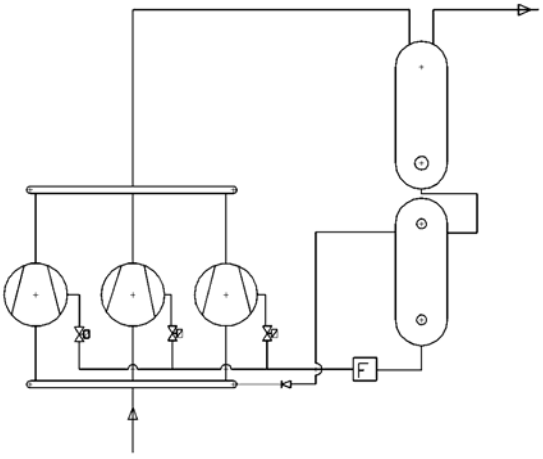
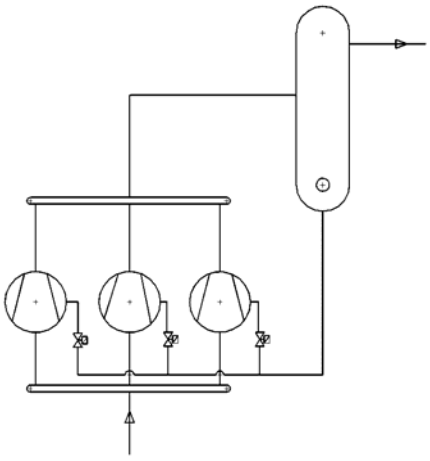


C1)



C2)

In the following description is reported the analysis of possibilities offered by sensors and controllers used for oil distribution among different compressors in parallel.

Methods description

Direct parallel of compressors crankcases (A)

Direct parallel of compressors crankcase is the easiest method. It consists in equalizing both liquid level and steam pressure by connecting the various crankcases with a big pipe. In alternative you can use a separate direct parallel for liquid and steam, even if this method presents more construction difficulties.
Direct parallel of compressors crankcase has some defect:

a) The only available oil is the one which is contained in the compressors, so, in the case of big installations, the oil level in crankcases could easily be too low. Generally the only direct parallel of crankcases is not enough to insure the correct functioning. An available oil reserve is necessary. It could be both the accumulator and the reserve, when they are present.
b) The oil level is not steady in the time and is not the same in all the compressors, especially for splash compressors. This is due to different pressure values in the various compressors crankcases.

In the practice, the direct parallel of compressors crankcases is always used together with another method, like for example:

- Oil separator for each compressor with crankcase discharge, or only one common separator with accumulator or direct parallel discharge.
- Aspiration oil separation and balanced return.

The main defect of this method is that you have to connect all the compressors with at least one additional accumulator, so that you have to preview taps and junctions.
At the end a good direct parallel compressors crankcases, respectful of all installation rules, has high costs, so that it is not as convenient as at first it could seem.

Balanced return from low pressure accumulator (B)

This method is based on the fact, that, basically, when crankcase oil level increases, also increases oil carriage, than if you assure a good and uniform distribution of the refrigerant among the compressors, the oil level remain steady. Obviously it is only a medium tendency and you have no security the oil level is in each moment and in each compressor the correct one. If you choose this method is would be good that you protect the system against low oil level functioning, overall in the case that compressors have no other security device against functioning without lubricating, as for example the compressors without oil pump (scroll compressors or small alternative compressors).

High pressure oil separator (C1 e C2)

It is the most used method, mainly because it is pretty easy to assemble a refrigeration installation and be sure that oil distribution will be correct. This is an active system, different from the other over mentioned. In addition an oil reserve is present in the system, and it can guarantee over a period good oil feeding to the compressors crankcases, also in the case of high oil carriage or big installation.

Oil separation in high or in low pressure side?

In order to be able to feed oil among more compressors in parallel it is necessary to collect the oil itself in one vessel, from which it is possible to bring it to the compressors where oil level is low. The most classic method is to separate oil in high pressure, using an oil separator.
Disadvantages of this method are:

- Cost of oil separator, considering that oil separator is a pressure vessel installed in the part of the circuit at the highest pressure.
- Separation efficiency is not complete, and a significant part of oil carried over by compressors is, in any case, sent in low pressure side of the circuit. For that reason it is necessary in any case to design piping network to allow oil return to compressors.
- A by-pass between high and low pressure side when separator valve opens, giving a decrease in efficiency. Beside that oil discharged is hot, and this gives an increase of temperature of the oil in crankcase.
- The system is critic in case of a leak defect in oil controller, specially in case of high pressure oil receiver.

The alternative to the previous method is the separation in low pressure.
Disadvantages:

- All the oil carried over by compressors is sent to low pressure side. When discharge rate is high or when piping network is large it is necessary to have a certain oil amount stored in low pressure side (in the header of in a different position), such as to allow to compressors to operate properly until an equilibrium condition is reached.
- There can be difficulties in the separation of oil from liquid refrigerant in suction.
- Oil could reduce heat transfer in evaporator, but for low oil percentage the practical effect cannot be noticed.

Separation of oil in low pressure should be avoided when using flooded evaporators, especially when oil is less dense than liquid refrigerant, as it would be impossible to drain the oil-rich layer from the bottom of the low pressure receiver.

Protection of compressors against insufficient oil level

Compressors with oil pump can be protected, in case of low oil level, with a differential pressure switch, cutting off in case the oil pressure is not sufficient to assure proper lubrication of moving parts.
This method doesn't protect completely the compressor. First of all it is necessary to introduce a delay in the protection to allow start up of compressor.
Another weak point is that a high pressure drop could mean also an obstruction of lubrication ducts. This latter problem can be prevented filtering the oil, to avoid obstruction.
To avoid the compressor to operate without oil in the sump for the all delay period of differential pressure switch, a possible solution can be the use of an oil level sensor. This can be done using electronic devices, both in case they are used also for the positive control of oil level and in case a different method is used (balanced distribution or parallel header, i.e.).

Protection of compressors against liquid return

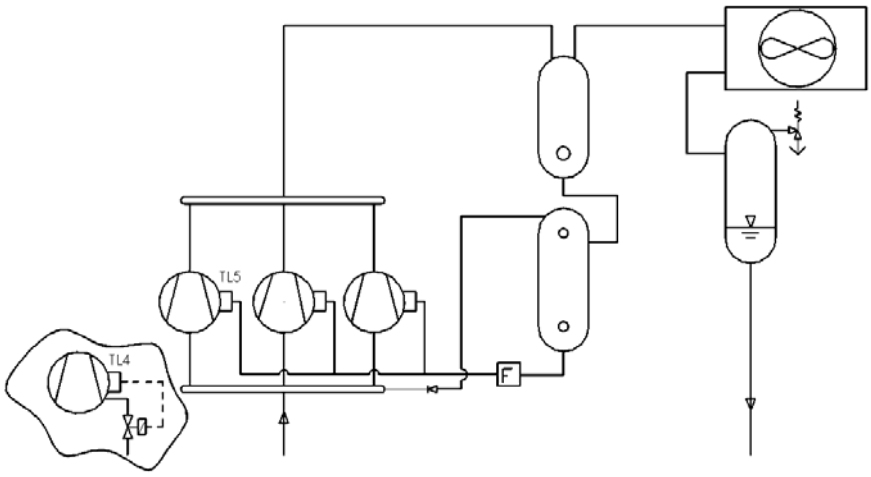
In addition to the problem of oil distribution, we can find in the refrigeration installation, the problem of liquid refrigerant return to the compressors. The aspiration collector must be developed to avoid direct aspiration of liquid refrigerants.
Also the oil pipe return developing must take this problem in consideration, and then you must use particular pipe configuration.

METHODS OF OIL DISTRIBUTION

1. <u>High pressure separator + oil reservoir + level controller on each compressor</u>

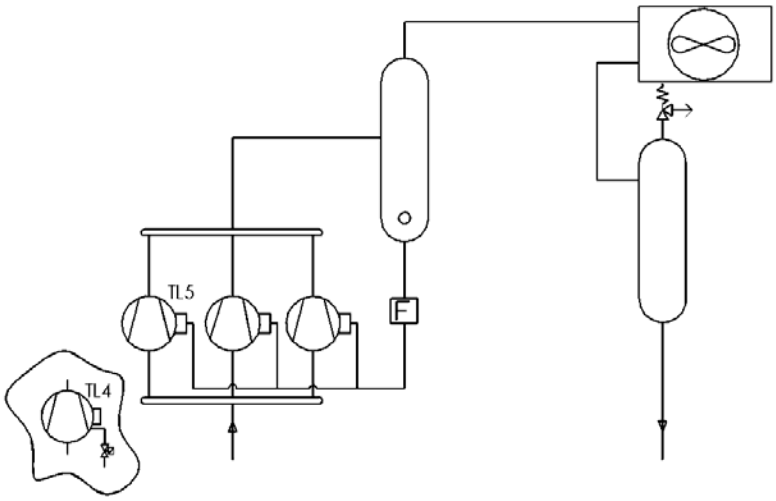
The drawing shows a possible connection way. It reproduces with electronic oil regulators what has been done over many years with floats.
This is the most used method in big refrigeration centrals made of few pieces, as it doesn't need any laboratory test.

Variants:
- Magnetic 2-way valve installed in the controller and driven from itself.
- Electronic oil level control with external solenoid.



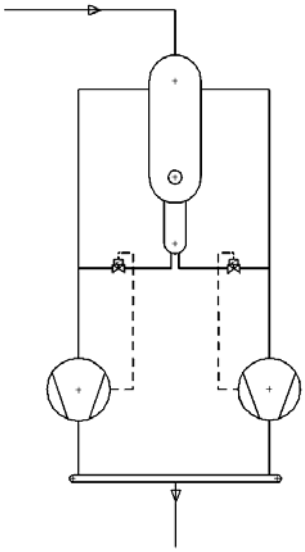
Another possible variant is the following, already mentioned.

2. <u>Separator with oil reservoir integrated+ level controller on each compressor</u>



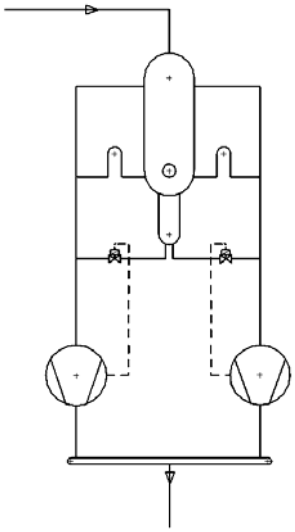
In that case it is imperative to use a magnetic 2-way valve, given the high difference of pressure existing between high pressure and low pressure side.
Also in this case electronic oil level controller can have integrated or external solenoid.

3. Separator in low pressure side and active control of oil level in compressor crankcase



For such application it is possible to use controllers which drive an external solenoid, considering that it is necessary to size the 2-way magnetic valves for a pressure drop compatible with operating conditions of circuit.

4. Separator in low pressure with balanced distribution of oil + active control of oil level in compressor crankcase



This method is equivalent to the previous one, and same considerations apply. Also in this case it is suggested to install an oil level sensor to stop the compressors, especially if it is a splash lubrication type.
In order to have a proper oil distribution different methods are possible. In the sketch is presented one of the possible solutions.
Also in this application it is possible to use controllers which drive an external solenoid.

5. Low pressure oil separator with balanced distribution and safety and alarm control

This method is certainly the simplest, even if it doesn't offer all the functionalities.
The present method is a low cost improvement of what is often used today. It is quite common to use splash lubricated compressors, being in that case impossible to use a oil pressure differential switch, and so letting the compressor without any kind of protection in case of insufficient oil lubrication. This method allows the protection of the compressor in case of low oil level in crankcase. The recommended sensor type is the simplest one, without advanced function, with integrated relay.

Liquid presence detection during aspiration

Electro optical sensors have a very interesting feature: it is possible to have measurement of the liquid temperature together with the level measurement.
It is then possible to have both a crankcase oil temperature measurement and implement advanced security features.
For example, referring to the over mentioned configurations of points 3 and 4, you can install a sensor in the aspiration collector low side, where oil is collected.
You can then detect a low oil level and have an alarm, but also detect the aspiration liquid return. This permits you for example to close the valves that bring oil to the compressors.
You can detect liquid return to the compressors when temperature on low side of the aspiration separator is near to the saturation one.