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Comparison of the High Side vs

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COMPARISON OF THE HIGH SIDE VS. LOW SIDE SCROLL COMPRESSOR DESIGN

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ABSTRACT

High and low side scroll design features, functional operation, and requirements are examined. The advantages and disadvantages of each approach are also discussed.

INTRODUCTION

Three generical different types of gas distribution systems are used in scroll compressors.

1. Low side configurations in which the chamber above the fixed scroll is at discharge pressure and the rest of the housing cavity is at suction pressure.

2. High side configurations in which the whole housing is at discharge pressure and the suction enters directly into the scroll suction chamber.

3. A partition configuration which is a combination of suction and discharge housing pressure chambers.

This paper will discuss both high and low side design concepts.

High or low side considerations are a key determinant of scroll compressor design. This choice will determine many aspects of the rest of the configuration. The selection of high side or low side will influence how the forces are generated which urge the scroll set together during the compression process. The low side design must counteract the forces pushing the scroll set apart; whereas the high side design must resist the forces pushing the scrolls together.

DESIGN FUNCTION

The working fluid flows through the typical low side configuration as follows [see Figure I]: The suction gas passes through the housing and into the chamber around the compressor mechanism and motor, filling this cavity with low pressure gas at suction conditions. The gas is then drawn into the suction inlet of the scroll set and compressed between the wraps, after which it passes through the discharge port and is expelled into the top chamber of the housing above the fixed scroll. This chamber is connected in turn to the discharge tube through which gas exits the housing and passes into the system.

The typical high side design flow path is as follows [see Figure II]: The inlet to the housing is connected to the suction cavity of the scroll set. Suction gas at suction temperature and pressure enters the scrolls and is compressed in the process of reaching the center of the scroll set, after which, it flows through the discharge passage and into the top of the housing. Discharge gas flows over the top of the fixed scroll and into passages between the fixed scroll, main bearing, and housing into the housing chamber between the main bearing and motor. The gas exits the housing through the discharge tube. The oil flows past the stator and into the oil sump after separating out of the discharge gas.

DESIGN FEATURES

The design of a scroll compressor requires consideration be given to the following topics:

1. The forces created by the compression process must be controlled so as to hold the scrolls together without generating large power losses.
2. The supply of oil to the scroll set must be controlled in order to keep excess oil from circulating through the system. Excess oil in the system will lower system operating efficiency.
3. The mating scroll surfaces must fit together in such a way that they minimize gas leakage.
4. The discharge gas temperature must be closely monitored to protect the scroll set.
5. Suction gas heating should be minimized for optimum volumetric efficiency.
6. Controlling compressor sound, suction, and discharge pressure pulses.
7. Control of liquid slugging and flooding.
8. Scroll set fits and finish control for short wear-in times.
9. Motor and overload selection.
10. Control of overturning moment.
11. Axial compliance.
12. Radial compliance.
13. Control of shutdown reverse rotation.

DESIGN REQUIREMENTS

Low Side Design:

1. The forces generated by the gas in the scroll pockets will be greater than the pressure forces urging the scroll set together, due to the fact the gas surrounding the orbiting scroll is at suction pressure, thus the orbiting scroll and fixed scroll will be pushed apart. The force tending to separate the scrolls is overcome by a low clearance thrust bearing mounted on the back of the orbiting scroll. Alternatively, an intermediate pressure between suction and discharge pressure is applied to the back of the fixed or orbiting scroll to produce a positive sealing force capable of pushing the scroll set together. The magnitude of the force pushing the scrolls together is controlled by the diameter of the support surface and pressure level thereon.

2. The supply of oil into the scroll set must be minimal, since any excess oil in the scroll set will be dumped directly into the system, thereby reducing the system operating efficiency. This is accomplished by keeping the suction inlet well away from the oil sump or bearing oil vents.

3. The geometry of the scroll set mating surfaces must be held very tight to minimize leakage. CNC machines are used to machine the scroll sets to extremely close tolerances.

4. The control of the discharge gas temperature is very important. If the temperature is excessive, the scroll set will fail. The low side design usually controls this temperature by using a sensor in the discharge chamber above the fixed scroll.

5. The heating of the suction gas in the housing before it enters the scroll set for compression will reduce the volumetric efficiency of the compressor. Typically, the low side design uses a semi-direct suction configuration to put part of the suction gas directly into the scroll set while allowing the remainder to flow over the motor and into the housing chamber.

6. The control of suction gas noise and suction pulsations are accomplished using the housing as a muffler.

7. Controlling the discharge gas pulse and sound are accomplished using the discharge volume of the housing chamber above the fixed scroll.

8. The presence of liquid refrigerant in the gas stream or sump of the housing in the low side scroll compressor is controlled by metering the liquid through the scroll set and using the motor to heat the liquid in the sump.

9. The wear-in time is controlled by holding extremely tight tolerances and super finishes in the scroll set. The wear-in time will be proportionate to how successfully these goals are achieved.

10. The motor/overload selection is the same as any other low side compressor.

11. The overturning moment caused by the distance between the line of action of the forces acting in the orbiting scroll bearing and those generated in the wraps give rise to tilt in the orbiting scroll. The low side design controls this using a thrust bearing on the back of the orbiting scroll.

12. Axial compliance is achieved by either the orbiting scroll or the fixed scroll being free to move in the axial direction.

13. Radial compliance is achieved by the use of a swing or sliding link.

14. When operation ceases, a reverse rotation of the scroll set occurs. This is controlled by putting a check valve in the discharge line or over the discharge port.

High Side-Design:

1. The gas enveloping the scroll set is at discharge pressure. As a result, the orbiting scroll will be pushed toward the fixed scroll. The magnitude of the force pushing the scroll set together is controlled by the diameter of a seal on the back of the orbiting scroll which separates the back of the orbiting scroll into suction and discharge pressure regions.

2. The supply of the oil to the scroll set can be large since the housing acts as an oil separator to remove the oil from the discharge gas before it exits the housing and passes into the system.

3. The geometry of the scroll set mating surfaces must be tightly controlled, however, the oil can be used to fill any leak paths resulting from imperfect machining.

4. The control of the discharge gas temperature is very important. If the temperature is excessive, the scroll set will fail. The high side design controls this temperature by using the motor overload protector since it is in the discharge chamber of the housing.

5. The heating of the suction gas in the housing before it enters the scroll set for compression will reduce the volumetric efficiency of the compressor. The high side design uses direct suction, thereby minimizing the suction gas heating.

6. The control of suction gas noise and pulsations is accomplished by using the suction cavity in the scroll set.

7. Discharge gas noise and pulsations are controlled by using the housing as a muffler.

8. The presence of liquid refrigerant in the gas stream or sump of the housing is controlled by metering the liquid through the scroll set and using the motor to heat the liquid in the sump.

9. Wear-in time is controlled by holding tight tolerances and maintaining good finishes in the scroll set. The oil is used to control the leakage losses while wear-in is occurring. The wear-in time will be proportionate to how successfully this is accomplished.

10. The motor is in the discharge gas, therefore, the motor/overload selection is more difficult.

11. The overturning moment caused by the distance between the line of action of the forces acting in the orbiting scroll bearing and those generated in the wraps give rise to tilt in the orbiting scroll. The high side design controls this, using the oil between the flange of the orbiting scroll and the main bearing.

12. Axial compliance is achieved by allowing the orbiting scroll to float axially between the seal pad and the fixed scroll.

13. Radial compliance is achieved using a swing link mechanism.

14. When operation ceases, a reverse rotation of the scroll set occurs. This is controlled by putting a check valve over the discharge port.

ADVANTAGES

Low Side:

1. Large housing chamber used as suction muffler.
2. Simple motor/overload application.
3. Good overturning moment control.
4. Simple radial compliance.

High Side:

1. Simple pressure force control design.
2. No intermediate pressure holes for leak paths.
3. Simple machining.
4. No problem associated with passing large quantities of oil through the scroll set.
5. Oil used to seal leak paths between the scrolls as they wear-in.
6. Extra sensor not required to monitor discharge temperature.
7. Minimal suction gas heating.
8. Large volume available in housing to act as a discharge muffler.
9. The scroll set meters the liquid passing through the compressor during slugging, thereby minimizing bearing oil film dilution caused by liquid refrigerant.
10. Use of the oil provides a simple means of controlling overturning moment.
11. Simple axial compliance mechanism.
12. Simple radial compliance mechanism.
13. Simple check valve design.

DISADVANTAGES

Low Side:

1. Complex thrust bearing design.
2. Extra high to low leak from intermediate pressure holes.
3. Difficult intermediate pressure hole machining.
4. Minimal oil in scroll to reducing gas leakage.

5. Exact scroll set machining for minimal leak paths.

6. Extra discharge gas temperature sensor.

7. Suction gas heating reduces volumetric efficiency.

8. Small discharge muffler volume.

9. During slugging, liquid migrates to the oil sump and floods the bearings which are heavily loaded.

10. The fits and finishes of the scroll set must be extremely tight and smooth since oil can not be used to help reduce the power losses while wear-in is occurring.

11. Complex axial compliance mechanism.

12. Check valve in discharge line is more complex than the port valve.

High Side:

1. Small cavity for suction muffling.

2. Difficult motor/overload application.

3. Housing design is more stringent to meet the U.L. pressure test requirements.

LOW SIDE DESIGN

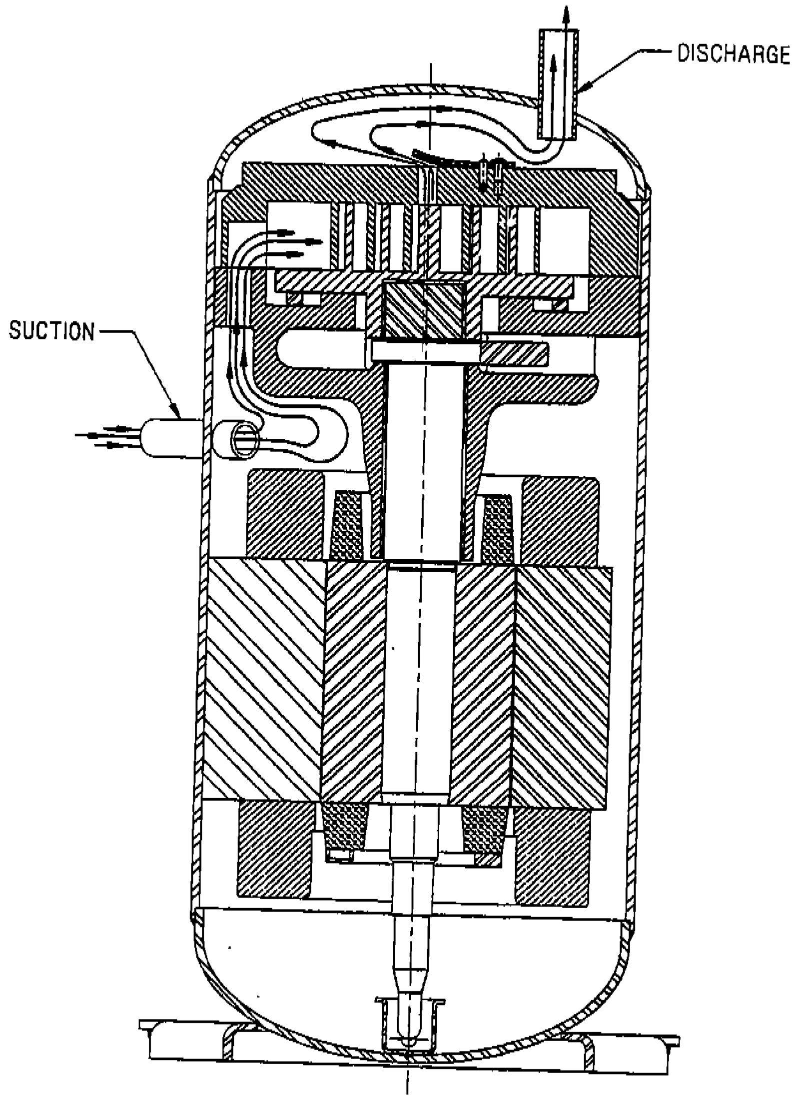

FIGURE I

HIGH SIDE DESIGN

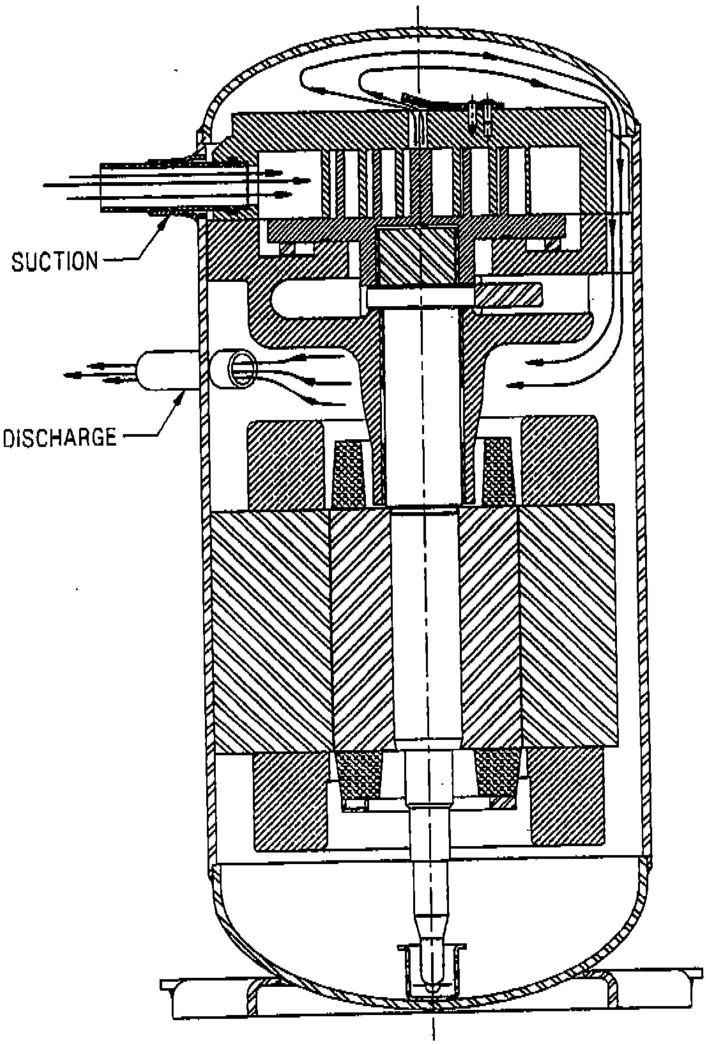

FIGURE II