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A Study on Various Compressors in Vapor Compression Refrigeration

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Abstract - *This paper aims to study various compressors, its working, advantages and limitations used in vapor compression refrigeration system. Also this paper investigates lubrication methods used in compressors.*

Key Words: Vapor compression refrigeration, Compressor, rotary compressor, reciprocating compressor, scroll compressor, lubrication.

1. INTRODUCTION

A compressor is the main and important part of any vapor compression refrigeration system and is considered as heart of the system

Functions

- to compress the refrigerant by raising the pressure and temperature
- to maintain pressure difference in the refrigeration system to maintain flow

1.1 Types of compressors

Before Compressors used in vapor compression refrigeration system can be broadly classified as follows

- reciprocating – rotary compressor
- sealed – semi sealed – open type compressor

2 Reciprocating compressor

A reciprocating compressor has cylinder and piston assembly which sucks – compress – delivers the refrigerant to the system. This type of compressors has wide application in industries and domestic operations.

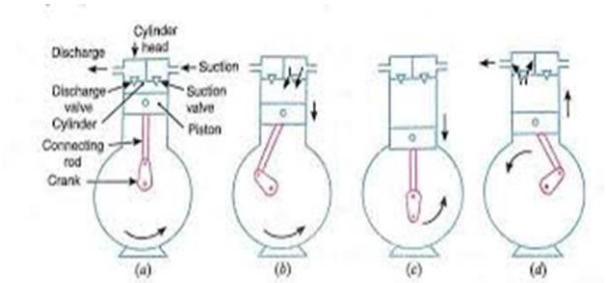
2.1 TYPES OF RECIPROCATING COMPRESSORS

- single acting reciprocating compressor
- double acting reciprocating compressor

Single acting reciprocating compressor

A single acting reciprocating compressor is shown in Fig-1 It consists of piston, cylinder, suction and delivery valves.

Fig-1



Working

1- When the piston moves down, the suction valve opens and the low temperature – low pressure vapor refrigerant enters compressor.

2- When the piston moves up, both the suction and exhaust valve closed

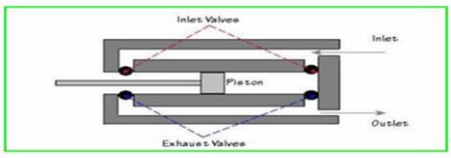
3- Pressure increases – temperature rises in the refrigerant vapor

4- High pressure – high temperature refrigerant vapor is delivered through delivery valve

Double acting reciprocating compressor

a double acting reciprocating compressor is shown in the Fig-2. It consists of piston, cylinder, two sets of suction and delivery valves on either side of the piston.

Fig-2



Working

When the piston moves from right side to left side inlet valve above piston opens and low pressure – low temperature refrigerant vapor enters – at the same

time, the suction and delivery port below piston is closed - the pressure – temperature of the refrigerant is raised and is discharged through the delivery port as high pressure – high temperature vapor and this cycle repeats. The supply of refrigerant is constant.

Comparison of single acting and double acting reciprocating compressor

Comparison of single and double acting compressor is shown in the following table-1

Table-1

single acting	double acting
One set of suction and delivery valves	Two set of suction and delivery valves
refrigerant is compressed above piston only	refrigerant is compressed above and below piston
the space below piston is connected to crank case directly	not so
refrigerant supply is not continuous	refrigerant supply is continuous

3. ROTARY COMPRESSOR

This type of compressor, compress the refrigerant with the help of rotating element, which may be vane, roller. Screw, spring.

3.1 TYPES OF ROTARY COMPRESSORS

The rotary compressors are classified as follows

- Centrifugal compressor
- Screw compressor
- Vane – roller compressor
- Scroll compressor

Centrifugal compressor

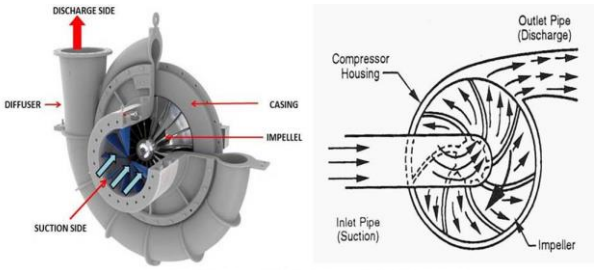
- Centrifugal compressor is a non-positive displacement compressor or simply dynamic compressor.
- This uses centrifugal force to compress the refrigerant.

Components:

- Motor- source of power to rotate impeller
- Impeller and diffuser - converts kinetic energy of refrigerant to pressure energy
- Casing – increases velocity and pressure
- Volute casing – further converts kinetic energy to pressure energy

The sketch of a centrifugal compressor is shown in Fig-3

Fig-3



CENTRIFUGAL COMPRESSOR

Working

- As the motor rotates, the impeller rotates
- Hence decrease in pressure at center – this suck low pressure and low temperature refrigerant vapor
- Due to the action of impeller , volute casing and diffuser – pressure and temperature of the refrigerant is increased and is discharged

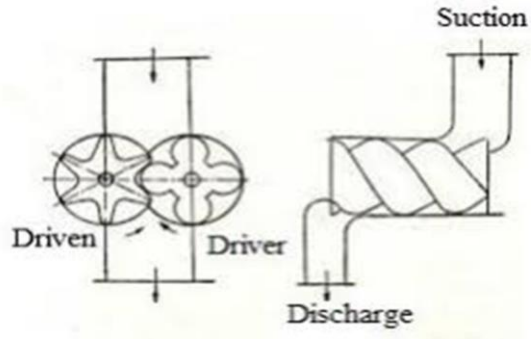
Screw compressor

These are positive displacement pumps

- Has 2 helically grooved rotors which are enclosed in a cylindrical housing
- The rotor which has lobes acts as driver and the one which has guides acts as follower.

The sketch of a screw compressor is shown in Fig-4

Fig-4



Working

- When the driver screw rotates, it creates pressure drop inside the cylindrical casing, hence the refrigerant enters the casing and gets compressed and delivered as high pressure- high temperature vapor through discharge.

Advantages and application

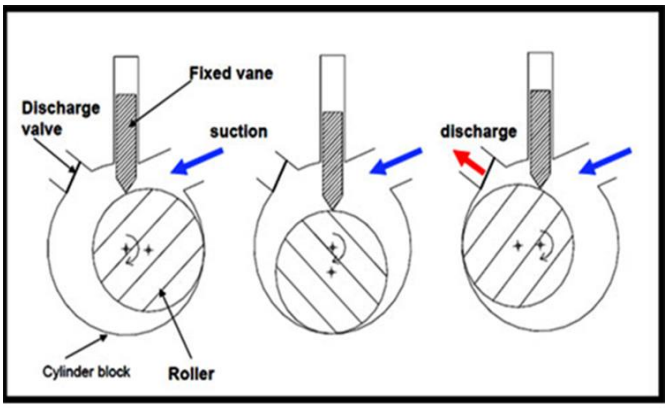
- efficient operation
- less wear and tear
- for large capacity operations no surging phenomenon

Vane- roller compressor

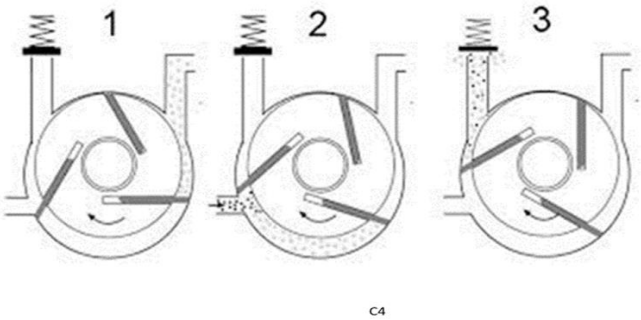
- This compressor consists of a roller, a spring-loaded fixed vane, motor and casing.
- this has suction port and discharge port

The sketch of this compressor is shown in Fig-5

Fig-5



C4



C4

Working

- The roller rotates along the inner surface of the cylinder block – in eccentric motion.
- The spring -loaded fixed vane separates suction and compression port.
- During one half of rotation of roller, and during maximum throw of roller, suction of low pressure – low temperature refrigerant vapor takes place and simultaneously compression / discharge of high pressure-high temperature refrigerant vapor takes place.
- This process repeats as cycle.

Advantages

- Simple in construction
- Smooth operation

Limitations

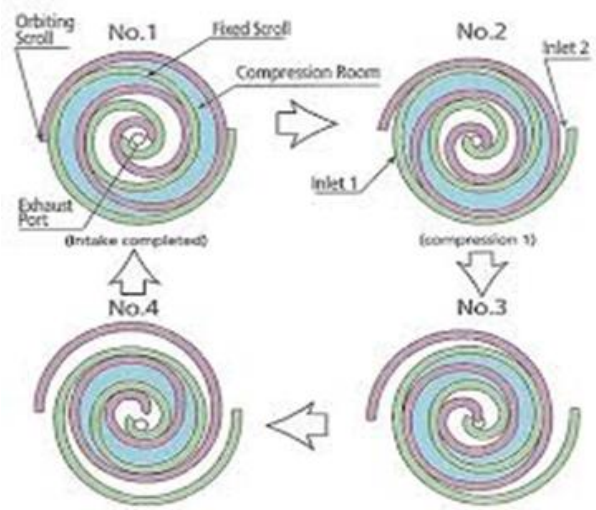
- For small capacities

Scroll compressor

- This uses scroll [a spring like arrangement] to compress the refrigerant
- This has fixed scroll and a rotating scroll
- The rotating scroll rotates eccentrically
- The free end od rotating scroll picks up the low pressure – low temperature refrigerant vapor from suction port
- Due to the eccentric rotational movement, the refrigerant is compressed and the pressure and temperature is raised and is let out through discharge port as high pressure – high temperature vapor

The sketch of scroll compressor is shown in Fig-6

Fig-6



4. COMPARISON OF RECIPROCATING AND ROTARY COMPRESSOR

The comparison of reciprocating and rotary compressor is shown in table-2

Table-2

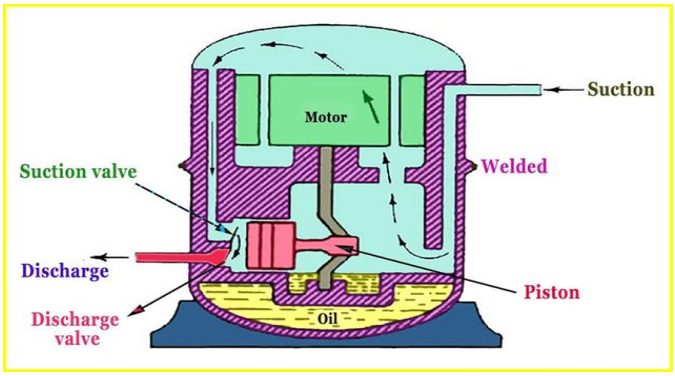
reciprocating compressor	rotary compressor
cylinder + piston exists	no piston and cylinder – only rotating parts
industrial + domestic application	domestic application
suction valve	check valve
multi cylinder option	no such options

5. SEALED COMPRESSOR

The sealed or hermetically sealed compressor has the following features and is shown in Fig-7

- compact
- compressor and motor mounted in same shaft
- motor directly drives compressor
- silent operation
- speed of compressor cannot be controlled
- service valves not required

Fig-7



Working

- in this compressor, the motor and compressor are mounted on same shaft
- both are enclosed in a casing
- casing is sealed
- only suction and delivery lines from compressor is visible
- all parts are concealed
- when the motor is on, the piston reciprocates and the process of suction [through suction valve] compression and delivery [through delivery valve] is carried on
- low pressure – low temperature refrigerant vapor enters compressor and high pressure – high temperature vapor leaves the compressor

Advantages and application

- quiet operation
- used commonly in domestic refrigerator

6. Comparison of sealed and open type compressors

The comparison of sealed and open type compressors are shown in the following table-3

Table-3

sealed compressor	open compressor
compact	occupies more space
compressor and motor mounted in same shaft	not in same shaft
motor directly drives compressor	drives through belt
silent operation	comparatively noisy

speed of compressor cannot be controlled	can be controlled
service valves not required	required

7. LUBRICATION

Lubrication for compressor is necessary for the following reasons

- to dissipate heat produced
- to reduce friction
- for smooth operation
- to extend life of moving components
- to improve efficiency of compressor
- to reduce noise

Types of lubrication

Splash lubrication – In this type, a small scoop like attachment is done at the lower end of connecting rod. when the piston reciprocates, this draws oil from the sump and splashes on components – hence lubrication is done.

Forced lubrication – In this type of lubrication is used for high capacity compressors. in this, oil is supplied with pressure – using a pump and is circulated. high degree of heat transfer is ensured. hence efficiency of compressor increases.

8. DESIGN CONSIDERATIONS OF CETRIFUGAL COMPRESSOR

- volume of refrigerant to be handled
- properties of refrigerant
- impeller diameter
- impeller width
- blade angle
- number of blades
- materials
- vane dimensions

9. CONCLUSIONS

This paper has investigated various types of compressors used in vapor compression refrigeration system, its working, advantages, limitation and applications along with design considerations and lubrication.

REFERENCES

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[2] Open source materials from internet.

BIOGRAPHIES

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