



Overview of Compressor Technologies and their Analyses

Eckhard A. Groll
Professor of Mechanical Engineering
Purdue University
Ray W. Herrick Laboratories
West Lafayette, Indiana 47907, USA
Phone: 765-496-2201; Fax: 765-494-0787
E-mail: groll@purdue.edu

July 14-15, 2012

Short Course "Compressors 102"

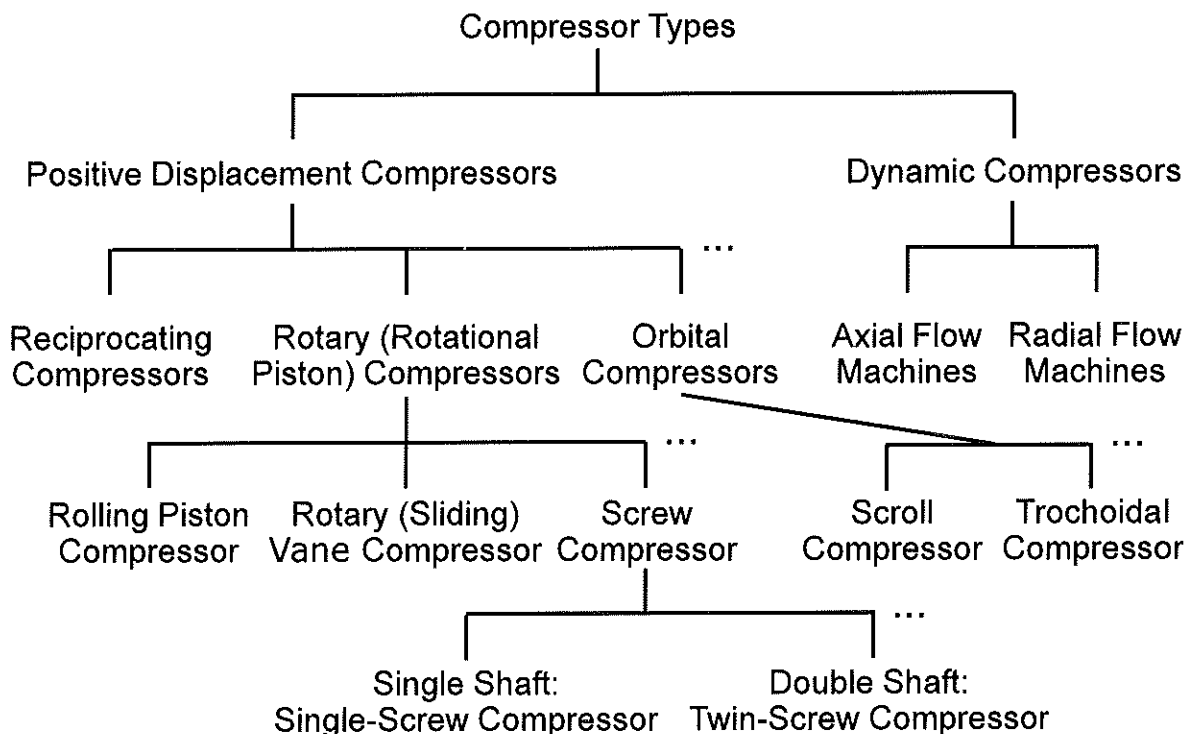
Lecture 1.1
© Eckhard A. Groll



-
- Review of Compressor Types
 - Compressor Characteristics
 - » Processes in compressors
 - » Description of compressor performance
 - Compressor Models
 - » Types of models
 - » Selecting the right compressor model
 - Advanced Compressor Models
 - Summary

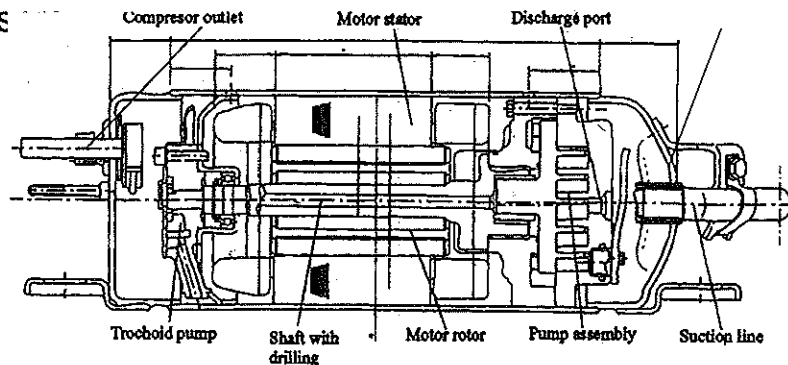


- "The compressor is the heart in a refrigeration system"!
 - » It is the only active main component, maintaining a flow of refrigerant
- "Compressors have a cooling capacity and a COP/EER"!
 - » Compressors by themselves do not have a cooling capacity or COP/EER
 - » However, compressors are often rated by cooling capacity and COP/EER based on assumed system state points
- The task of the compressor in a refrigeration system is to provide a mass flow rate of refrigerant from a low pressure level to a high pressure level





- Positive Displacement Compressors:
 - » Reciprocating Compressors
 - » Rotary Compressors:
 - Rolling Piston
 - Rotary (Sliding) Vane Compressor
 - » Scroll Compressors
 - » Screw Compress



July 14-15, 2012

Short Course "Compressors 102"

Lecture 1.7
© Eckhard A. Groll

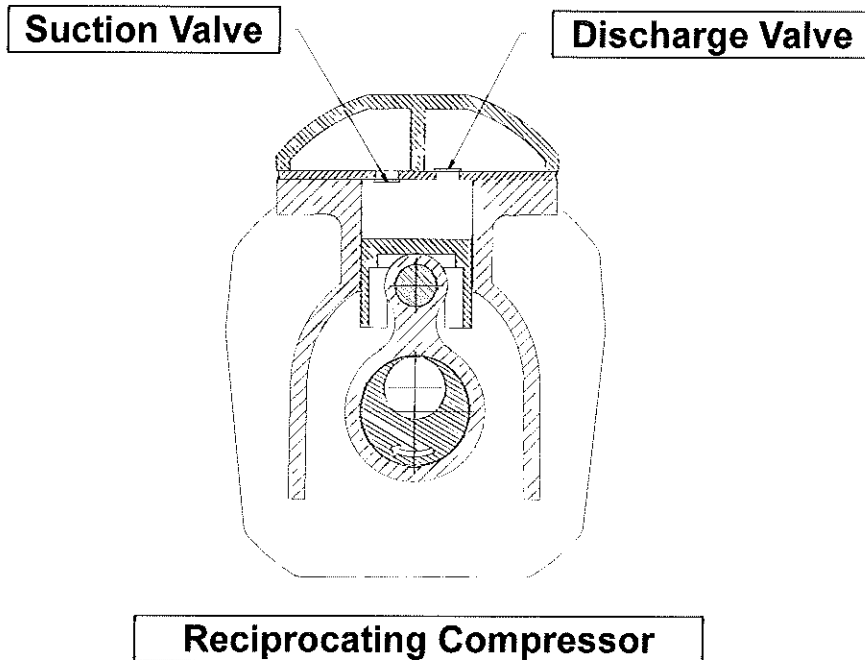


- Still most widely used compressor; simple to make, gives cost advantage
- Computer-aided design:
 - » Greatly increased performance and efficiency, with novel valve, port, and flow passage design
 - » Can expect further improvements with study of internal heat transfer.
- Parallel compressors are low-cost way to obtain multiple capacities and improved part load efficiency
- Common belief that other designs have inherently superior characteristics, e.g., reliability, volumetric efficiency, pressure oscillations, etc.
- Bottom line: Other types will continue to invade reciprocating market

July 14-15, 2012

Short Course "Compressors 102"

Lecture 1.8
© Eckhard A. Groll



July 14-15, 2012

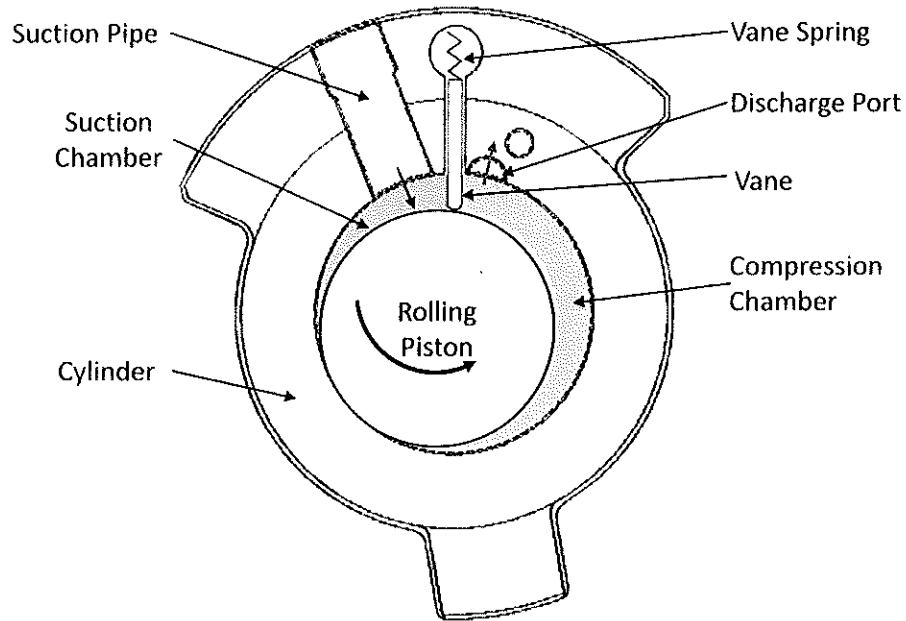
Short Course "Compressors 102"

Lecture 1.9
© Eckhard A. Groll



- Two types:
 - » Stationary (means non-rotating) vane, also called rolling piston compressor; more popular for domestic refrigerators and window air conditioners
 - » Rotating, sliding vane compressor; more popular some 20 years ago
- Advantages over reciprocating compressors:
 - » Smaller size for given capacity
 - » No suction valve means better reliability
 - » Better operation over larger speed range
- Limiting Factors:
 - » Wear has significant effect on performance
 - » Not reliable for field installations (needs clean environment)

REVIEW OF COMPRESSOR TYPES: Rolling Piston Compressors

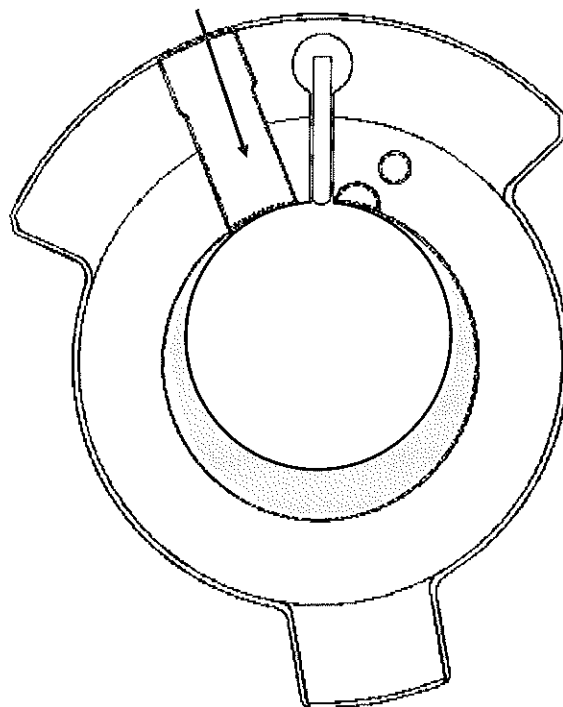


July 14-15, 2012

Short Course "Compressors 102"

Lecture 1.11
© Eckhard A. Groll

REVIEW OF COMPRESSOR TYPES: Rolling Piston Compressors

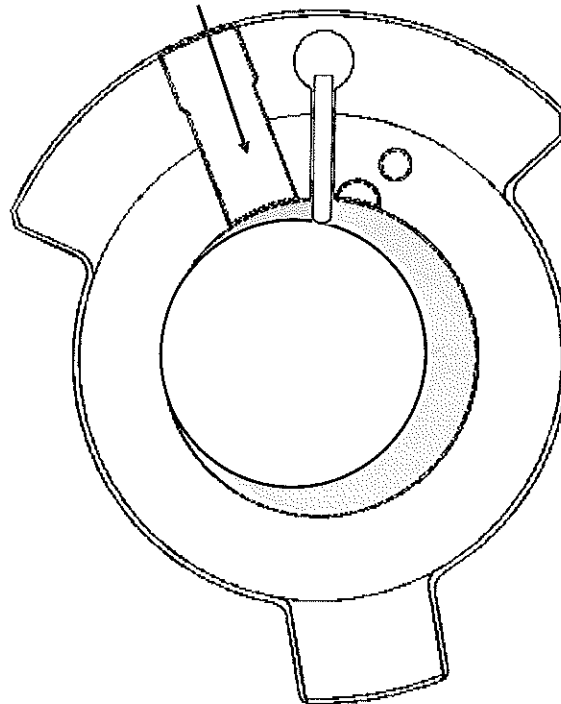


July 14-15, 2012

Short Course "Compressors 102"

Lecture 1.12
© Eckhard A. Groll

REVIEW OF COMPRESSOR TYPES: Rolling Piston Compressors

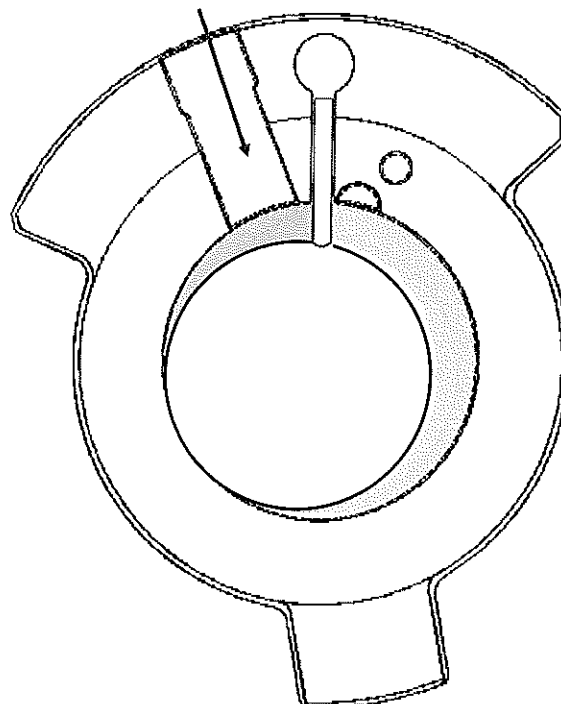


July 14-15, 2012

Short Course "Compressors 102"

Lecture 1.13
© Eckhard A. Groll

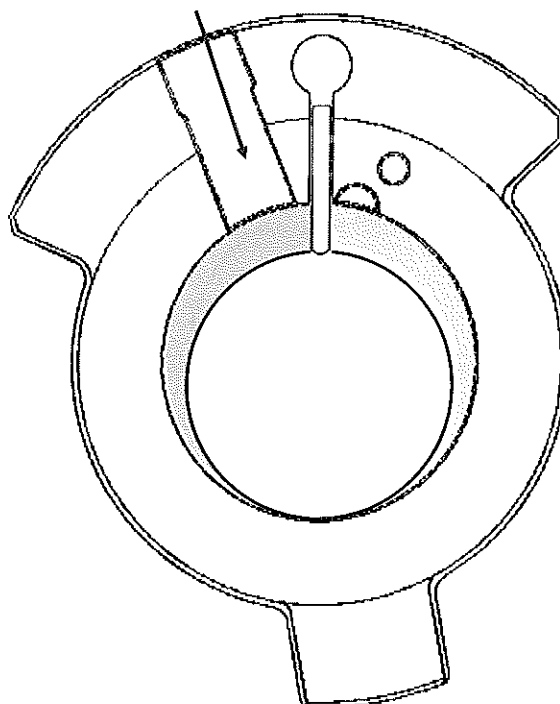
REVIEW OF COMPRESSOR TYPES: Rolling Piston Compressors



July 14-15, 2012

Short Course "Compressors 102"

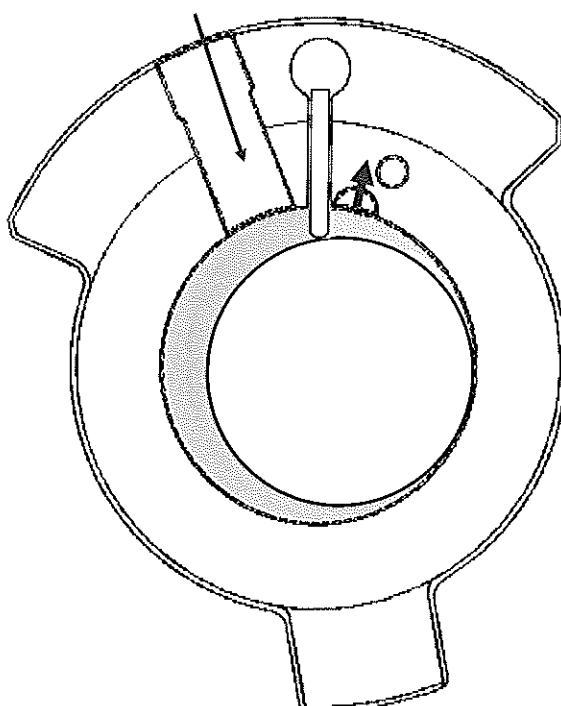
Lecture 1.14
© Eckhard A. Groll



July 14-15, 2012

Short Course "Compressors 102"

Lecture 1.15
© Eckhard A. Groll

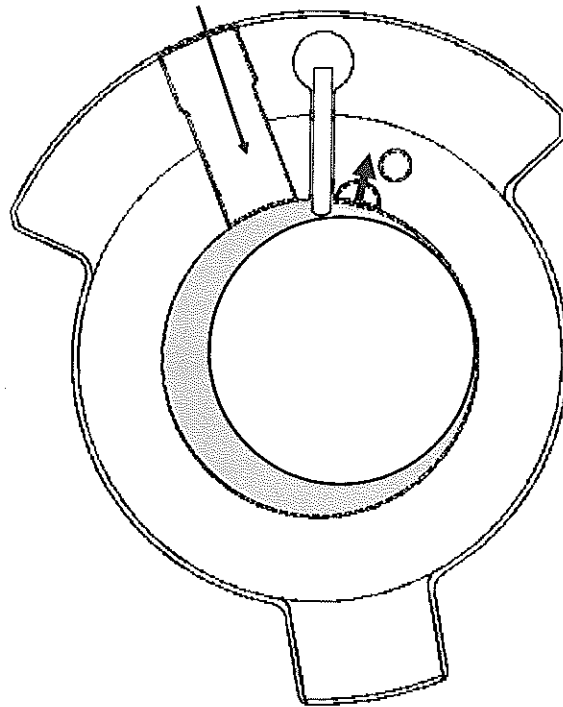


July 14-15, 2012

Short Course "Compressors 102"

Lecture 1.16
© Eckhard A. Groll

REVIEW OF COMPRESSOR TYPES: Rolling Piston Compressors

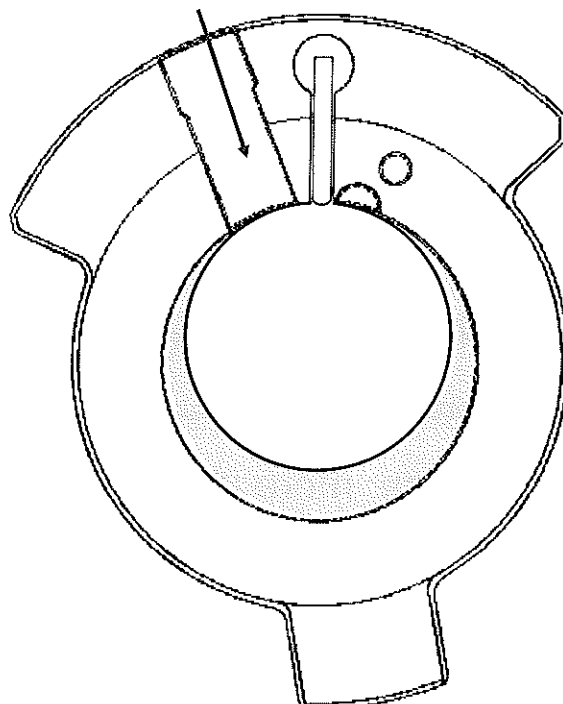


July 14-15, 2012

Short Course "Compressors 102"

Lecture 1.17
© Eckhard A. Groll

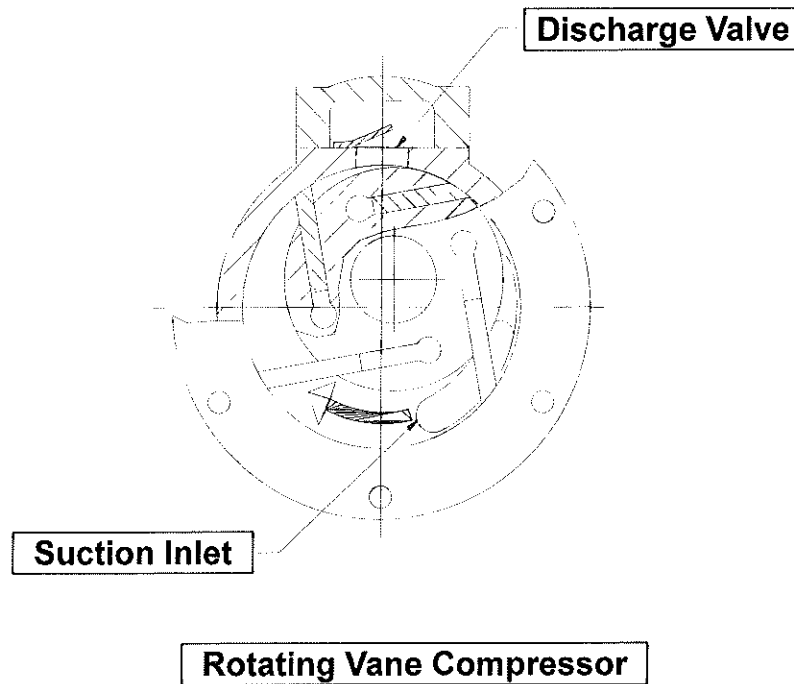
REVIEW OF COMPRESSOR TYPES: Rolling Piston Compressors



July 14-15, 2012

Short Course "Compressors 102"

Lecture 1.18
© Eckhard A. Groll



July 14-15, 2012

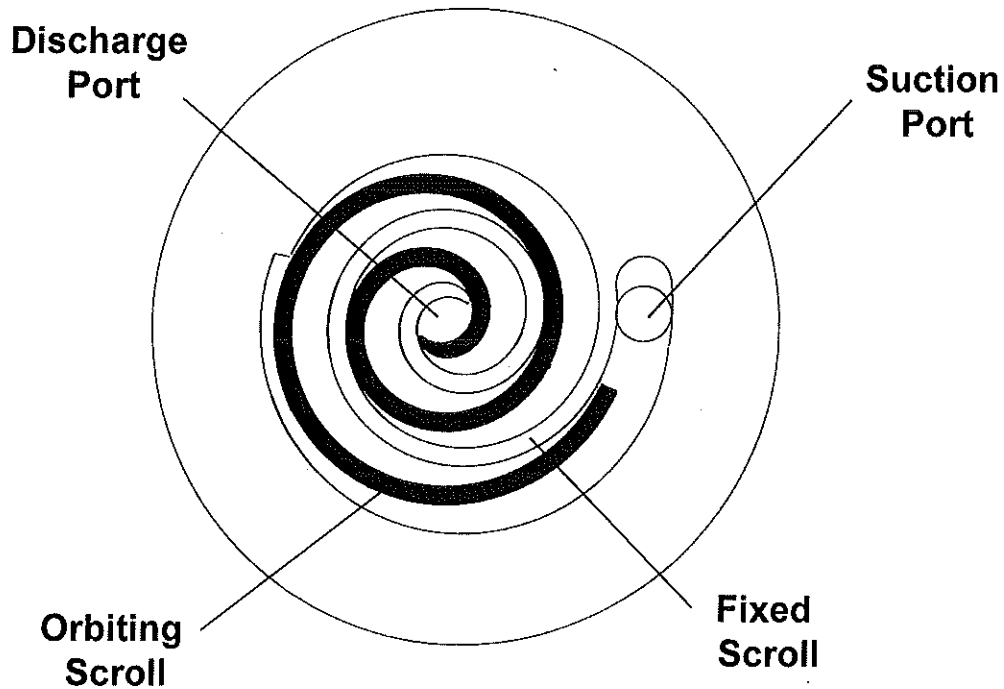
Short Course "Compressors 102"

Lecture 1.19
© Eckhard A. Groll



- Relatively complicated orbiting mechanism required, but many advantages
- No valves, better reliability
- No clearance volume effect, so volumetric efficiency is almost independent of pressure ratio
- Ideal for variable speed and capacity
- Better dynamic balance, more uniform shaft torque, less pressure oscillations, less noise and vibration

REVIEW OF COMPRESSOR TYPES: Scroll Compressors

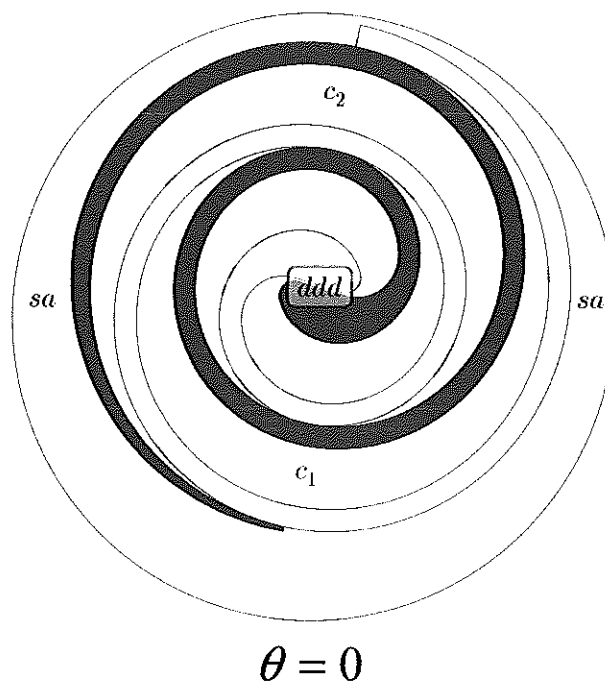


July 14-15, 2012

Short Course "Compressors 102"

Lecture 1.21
© Eckhard A. Groll

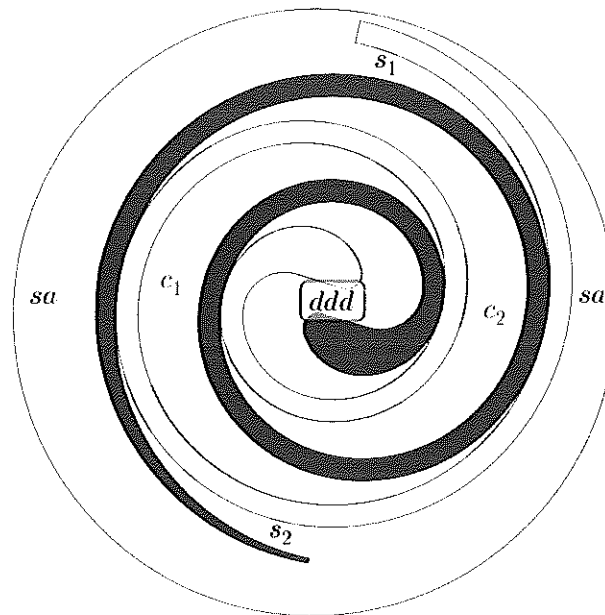
REVIEW OF COMPRESSOR TYPES: Scroll Compressors



July 14-15, 2012

Short Course "Compressors 102"

Lecture 1.22
© Eckhard A. Groll

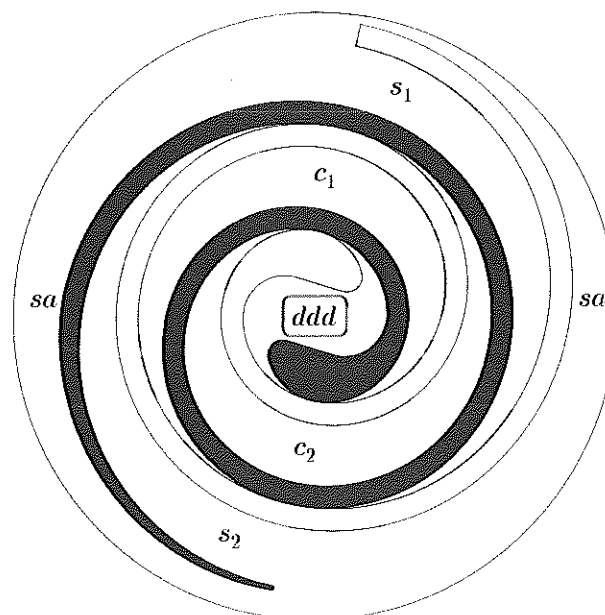


$$\theta = \pi / 2$$

July 14-15, 2012

Short Course "Compressors 102"

Lecture 1.23
© Eckhard A. Groll



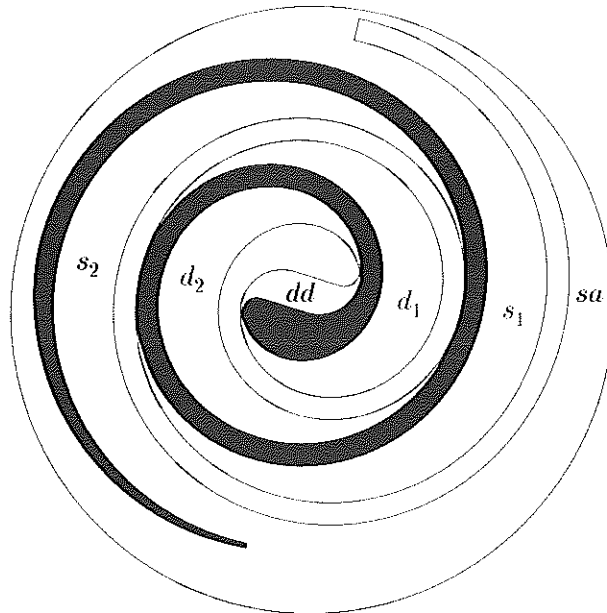
$$\theta = \pi$$

July 14-15, 2012

Short Course "Compressors 102"

Lecture 1.24
© Eckhard A. Groll

REVIEW OF COMPRESSOR TYPES: Scroll Compressors



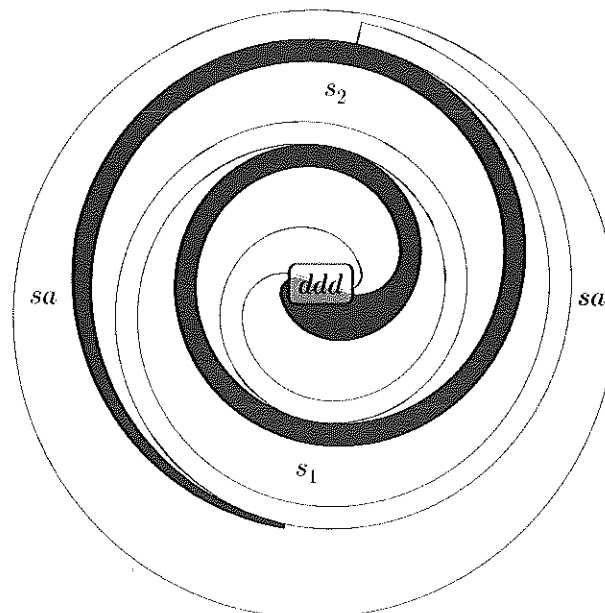
$$\theta = 3\pi / 2$$

July 14-15, 2012

Short Course "Compressors 102"

Lecture 1.25
© Eckhard A. Groll

REVIEW OF COMPRESSOR TYPES: Scroll Compressors



$$\theta = 2\pi$$

July 14-15, 2012

Short Course "Compressors 102"

Lecture 1.26
© Eckhard A. Groll



- Less space required for given capacity
- Suitable for higher pressure ratios such as needed for heat pump applications + *Commerc Refs -40*
- Compliant mechanisms makes ingesting liquid and dirt easy
- Digital machining made production possible
- Costs will drop with increased speed of production
- Current research to improve efficiency, oil management, and extend capacities and variable speed

*How long will machine stay in tolerance?
Each has to be CNC machined - too time consuming for small 1-Ton capacity*

July 14-15, 2012

Short Course "Compressors 102"

Lecture 1.27
© Eckhard A. Groll

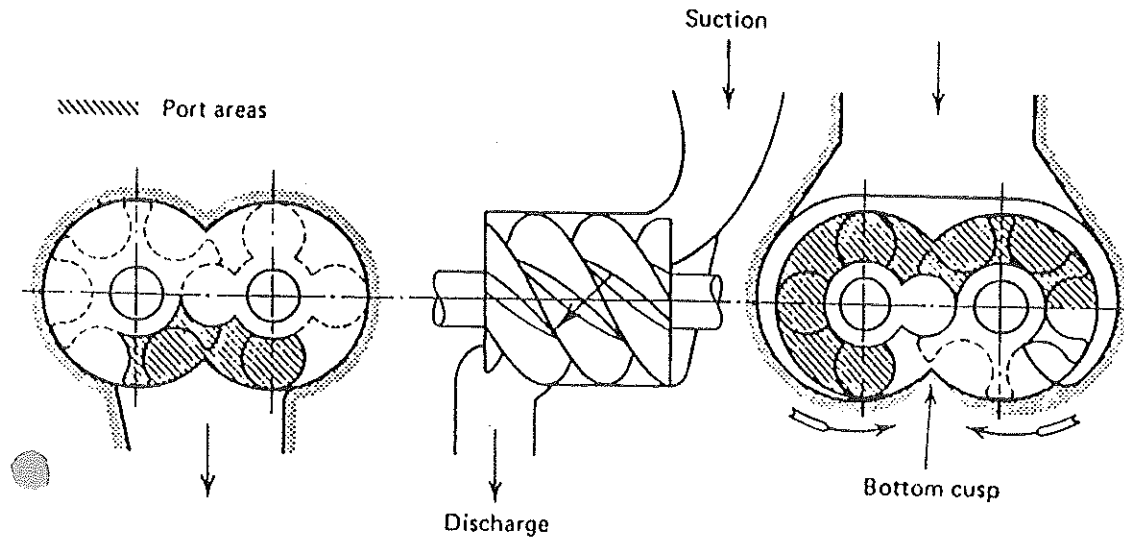


- Requires more oil (oil & liquid separator) used - oil separator required*
- Twin-screw Lysholm type appears to be more popular than single screw type
- Works well with speed control for capacity modulation
 - Low cost separators have been developed to control oil circulation, which can affect efficiency and superheat
 - Low cost semi-hermetic machines in the 30-100 ton range developed for R-22
 - Future work focuses on larger sizes, variable speed, and noise reduction
 - Improved rotor geometry is an area of work for improving efficiency and noise

July 14-15, 2012

Short Course "Compressors 102"

Lecture 1.28
© Eckhard A. Groll



July 14-15, 2012

Short Course "Compressors 102"

Lecture 1.29
© Eckhard A. Groll



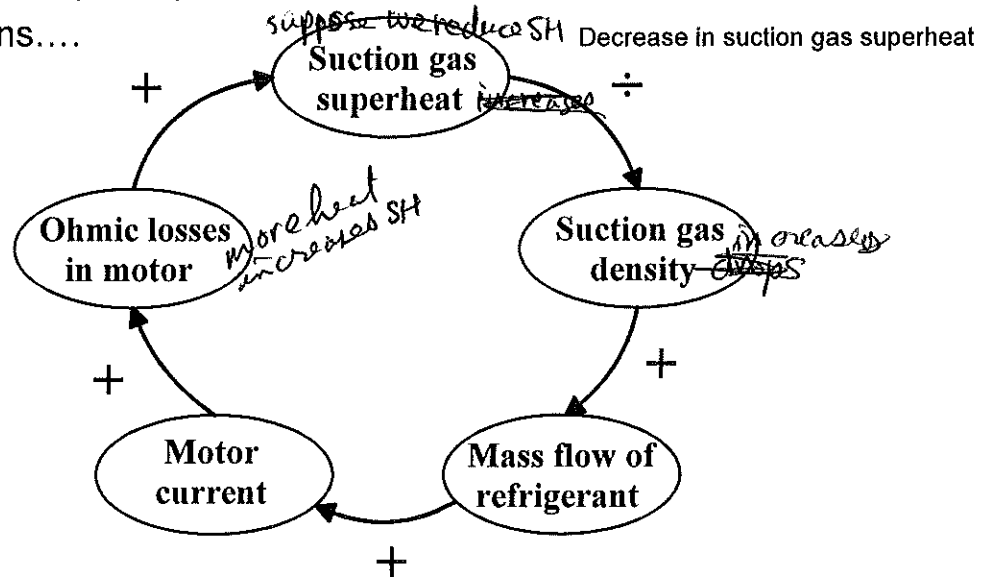
- Describing all processes in a refrigeration compressor involves many engineering disciplines:
 - » Thermodynamics
 - e.g.: Changes in refrigerant properties
 - » Fluid mechanics
 - e.g.: Flow of refrigerant in chambers and flow passages
 - » Solid mechanics
 - e.g.: Forces acting on valves and the resulting deformations
 - » Electrical engineering
 - e.g.: Conversion of electrical energy to mechanical energy in a motor
 - » Chemical engineering
 - e.g.: Unwanted decomposition of refrigerant and oil

INTERACTIONS BETWEEN PROCESSES



Interactions

- In compressors many different type of processes interact making it difficult to quantify the influence of changes in operating conditions....



PROCESS DYNAMICS



- Description of the thermal processes require time scales of [s] or [ks]. Thermodynamic processes related to the compression process require time scales of [ms] while other processes related to valve movement may require time scales of [μ s] or even [ns]

