Tikrit University

College of Petroleum Processes Engineering

Department of Petroleum and Gas Refining Engineering

Gas Technology

Forth Class

Lecture 17

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Liquefied Natural Gas Transportation & Storage

Natural Gas Compression

- Compression is used in all aspects of the natural gas industry, including gas lift, reinjection of gas for pressure maintenance, gas gathering, gas processing operations (circulation of gas through the process or system), transmission and distribution systems, and reducing the gas volume for shipment by tankers or for storage.
- The benefits of operating at higher pressures include the ability to transmit larger volumes of gas through a given size of pipeline, lower transmission losses due to friction, and the capability to transmit gas over long distances without additional boosting stations. In gas transmission, two basic types of compressors are used:
  - ❖ Reciprocating compressors are usually driven by either electric motors or gas engines
  - ❖ Centrifugal compressors use gas turbines or electric motors as drivers.

RECIPROCATING COMPRESSORS

- A reciprocating compressor is a positive displacement machine in which the compressing and displacing element is a piston moving linearly within a cylinder. The reciprocating compressor uses automatic spring-loaded valves that open when the proper differential pressure exists across the valve. Figure 1 describes the action of a reciprocating compressor using a theoretical pressure–volume (PV) diagram.
- Reciprocating compressors are widely utilized in the gas processing industries because they are flexible in throughput and discharge pressure range.
- Reciprocating compressors are classified as either “high speed” or “slow speed.” Typically, high-speed compressors operate at speeds of 900 to 1200 rpm and slow-speed units at speeds of 200 to 600 rpm.

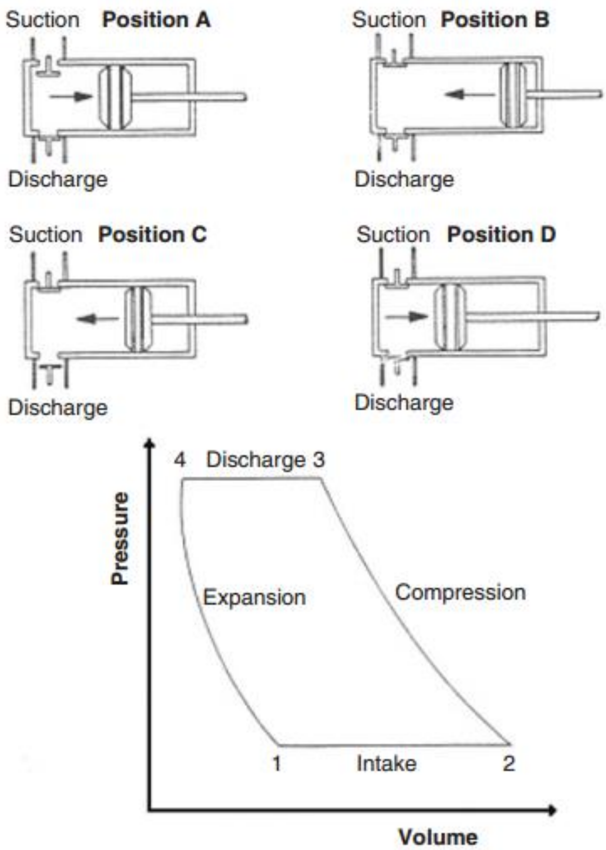

Figure 1: **Reciprocating compressor compression cycle.**

CENTRIFUGAL COMPRESSORS

- Centrifugal compressors are used in a wide variety of applications in chemical plants, refineries, onshore and offshore gas lift and gas injection applications, gas gathering, and in the transmission of natural gas. Centrifugal compressors can be used for outlet pressures as high as 10,000 psia.
- Centrifugal compressors are usually either turbine or electric motor driven. Typical operating speeds for centrifugal compressors in gas transmission applications are about 14,000 rpm for 5000-hp units and 8000 rpm for 20,000-hp units.

COMPARISON BETWEEN COMPRESSORS

Advantages of a reciprocating compressor over a centrifugal machine include

- Ideal for low volume flow and high-pressure ratios
- High efficiency at high-pressure ratios
- Relatively low capital cost in small units (less than 3000 hp)
- Less sensitive to changes in composition and density

Advantages of a centrifugal compressor over a reciprocating machine include

- Ideal for high volume flow and low head
- Simple construction with only one moving part
- High efficiency over normal operating range
- Low maintenance cost and high availability
- Greater volume capacity per unit of plot area
- No vibrations and pulsations generated

COMPRESSOR SELECTION

The design philosophy for choosing a compressor should include the following considerations.

- Good efficiency over a wide range of operating conditions
- Maximum flexibility of configuration
- Low maintenance cost
- Low life cycle cost
- Acceptable capital cost
- High availability

However, additional requirements and features will depend on each project and on specific experiences of the pipeline operator. In fact, compressor selection consists of the purchaser defining the operating parameters for which the machine will be designed. The “process design parameters” that specify a selection are as follows.

- Flow rate
- Gas composition
- Inlet pressure and temperature
- Outlet pressure
- Train arrangement
  a. For centrifugal compressors: series, parallel, multiple bodies, multiple sections, intercooling, etc.
  b. For reciprocating compressors: number of cylinders, cooling, and flow control strategy
- Number of units

COMPRESSION RATIO

The compression ratio (CR) is the ratio of absolute discharge pressure to the absolute suction pressure. Mathematically

$$CR = \frac{p_2}{p_1} \quad \text{...(1)}$$

By definition, the compression ratio is always greater than one. If there are "*n*" stages of compression and the compression ratio is equal on each stage, then the compression ratio per stage is given by

$$CR_{stage} = \left(\frac{p_2}{p_1}\right)^{1/n} \quad \text{.......................................(2)}$$

If the compression ratio is not equal on each stage, then Equation (1) should be applied to each stage.

The term compression ratio can be applied to a single stage of compression and multistage compression. When applied to a single compressor or a single stage of compression, it is defined as the stage or unit compression ratio; when applied to a multistage compressor it is defined as the overall compression ratio. The compression ratio for typical gas pipeline compressors is rather low (usually below 2), except for stations that feed into pipelines. These low-pressure ratios can be covered in a single compression stage for reciprocating compressor and in a single body (with one or two impellers) in a centrifugal compressor.

SALES GAS TRANSMISSION

DESIGN CONSIDERATIONS OF SALES GAS PIPELINES

The typical design of a gas transmission pipeline involves a compromise among the pipe diameter, compressor station spacing, fuel usage, and maximum operating pressure. Each of these variables influences the overall construction and operating cost to some degree, hence an optimized design improves the economics of the construction and operation of the system and the competitiveness of the project.

- ### Line Sizing Criteria

The pipe size generally is based on the acceptable pressure drop, compression ratio, and allowable gas velocities. Acceptable pressure drop in gas transmission pipelines must be one that minimizes the size of the required facilities and operating expenses such as the pipe itself, the installed compression power, the size and number of compressors, and fuel consumption. In fact, a large pressure drop between stations will result in a large compression ratio and might introduce poor compressor station performance.

- ### Compressor Station Spacing

In long-distance gas transmission systems with a number of operating compressors, there is a definite need to optimize the spacing between compressor stations. Compressor station spacing is fundamentally a matter of balancing capital and operating costs at conditions, which represent the planned operating conditions of the transmission system.

- ## Compression Power

The next step in the design of a pipeline system is to calculate the maximum power required at the stations and set the design point(s). Typically, a new pipeline system will grow from a low flow condition to the maximum over a period of several years, and the decisions on compressors and drivers have to take these changing conditions into account