Compressors Used in OIL & GAS Industry

- Emphasis on Centrifugal compressor

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Gas Compressor

1 – Compressor in Natural gas production & transport
2 – Types and Principles
3 - Centrifugal Compressor Selection process
4 – Compressor Components
5 – Latest developments
What does a Compressor do

- Reduce volume of gas
- Increase pressure of gas
- Control pressure in process
GAS FROM RESERVOIR TO LAND
TYPICAL OIL PLATFORM
COMPRESSOR ON KOLLSNESS

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2 TYPES AND PRINCIPLE

- Compressor Type
- Centrifugal - principle
Compressor Types

- Axial - large flow, low pressure
- Centrifugal - large to medium flow, high pressure
- Helical Screw - low flow, low pressure
- Reciprocating - medium to low flow, high pressure
- Offshore North Sea - large flow, high pressure
Axial Compressor
Reciprocating Compressor
Helical Screw Compressor
Basic Principles

- Centrifugal Action
- A Centrifugal Stage
- Energy Conversion
Centrifugal Action
Centrifugal Action

Exit Path

Velocity Relationship
Centrifugal Action

- Cover
- Blades
- Disk

Low Velocity, Low Pressure Gas Inlet

High Velocity, Higher Pressure Gas Outlet
Impellers
DIFFUSOR

From impellers gas flows in to diffuser

Diffuser converts kinetic energy to pressure energy
How A Centrifugal Works

- **Impeller**
  - Increases Velocity
  - Increases Static Pressure

- **Diffuser**
  - Reduces Velocity
  - Increases Static Pressure

- **Guide Vanes**
- **Return Channel**
- **Return Bend**
- **Centrifugal Stage**
ONE COMPRESSOR TRAIN

- IMPELLER
  - Transfer energy
    - pressure and speed

- DIFFUSOR
  - Converts kinetic energy to pressure
3 – Centrifugal Compressor Selection process
Selection Process

- Inputs required for centrifugal compressor selection
  - Typically Know:
  - Ts inlet
  - Ps inlet
  - Pd outlet
  - Flow (Q)
  - gas composition
  - Driver type (Gas Turbine, Steam Turbine, Motor)

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Selection Process

- Selection Process
  - Aerodynamic Selection and Optimization
    - Impeller Requirements (including Stress)
  - Mechanical Design
    - Coupling size
    - Bearing and Seal sizes
  - Rotordynamic Design
    - Could reselect coupling, bearings, seals
**Polytropic Work (Head)**

**HEAD REQUIRED** is the energy in foot pounds required to compress and deliver one pound of a given fluid from one energy level to another.

![Diagram showing pressure and energy levels for polytropic work.](image-url)

Energy – FT-LBS  (HEAD REQUIRED)
Basic Thermodynamic Equations

\[
\text{Head} = \left( \left( \frac{P_d}{P_s} \right)^m - 1 \right) \times R \times T_s \times Z_{\text{avg}}
\]

\[
m = \left[ \frac{(k - 1)}{k} \right] \eta
\]

z = compressibility

R = Universal Gas Constant

(1545.3/Mw)

Mw = Mole Weight

k = Isentropic Exponent \((C_p/C_v)\)

\(C_p\) = Specific Heat at constant pressure

\(C_v\) = Specific Heat at constant volume

Redlich Kwong equation used to calculate compressibility \((z)\)

The Redlich-Kwong Equation

\[
P = \frac{RT}{V - b} - \frac{a(T)}{V(V + b)}
\]
Some Rotor dynamic terminology:

Concepts used in Rotor Dynamics:
- Basic principles of vibrations
- Knowledge of how a fluid film bearing works
- Influence of bearings on the dynamics of the machine
- Influence of labyrinth and damper seals on the dynamics of the machine
Some Rotor dynamic terminology:

- **Rotor**: rotating element consisting of shaft, impellers/disks, shrunk-on components like sleeves, balance piston, etc.

- **Bearings**: Journal bearings support the rotor in the lateral direction. (Thrust bearings support the axial load of the rotor while in operation.)
Some Rotor dynamic terminology (Contd.):

- **Natural frequency**: Frequency at which the system vibrates. The frequency of vibration of a system (e.g. rotor-bearing system) with damping is called the damped natural frequency.
  - Ring of a bell or a tuning fork.

- **Critical speed**: Is a natural frequency with an ‘active enough’ response that the natural frequency should be designed around. (more on this later)

- **Stability**: The stability of a system is defined as the “reaction” to any external perturbation. (more on this later)
Some Rotor dynamic terminology (Contd.):
Compressor Control

Recycle Valve

Recycle Increases Suction Flow
4 – Centrifugal Compressor components
Rotor Assembly

- Impellers
- Balance Piston
- Drive Coupling Mount
- Shaft
- Bearing Journals
- Impeller Spacers
- Thrust Rotor
- Seal Area

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Centrifugal Flowpaths

Straight-Through or Series Flow

Balance Piston
Centrifugal Flowpaths

Series Flow with Sidestreams

Balance Piston
Centrifugal Flowpaths

Compound Flow

Balance Piston

Compound Flow
Centrifugal Flowpaths

Parallel or Double Flow

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Centrifugal Flowpaths

Back to Back Flow with No Cooler
Centrifugal Flowpaths

Back to Back Flow with a Cooler
KOMPRESSOR ACCESSORIES
- COMPONENTS

- Compressor
- Lube oil system
- Gasseal system – gas or oil
- Gear and Couplings
- Driver - el. motor, gasturbine, steam turbine
- Foundation skid
- Process- anti-surge valve, scrubber and cooler
- Instrumentation and control system
- 3 point support BASEPLATE
  (with central box beam)

- REMOVABLE LIFTING LUG
- A.V.M (anti vibration mount)
- DRIP PAN CONNECTION
5 – Centrifugal Compressor latest developments
Latest Developments

- Compact integral Motor driven compressor
**Latest Developments**

- Compact integral Motor driven compressor
  - High speed Electrical motors
  - No gearbox
  - Magnetic bearings that eliminate need for oil lubrication
  - Reduced footprint
  - digital controls instead of analog controls
  - Emission-free design
Latest Developments

Integrated Compression System (ICS)

Conventional compressor module design for off-shore installation

DATUM I Compressor package
Thank You