Compressors

Standards and Codes

API STD 617

Centrifugal Compressors for Petroleum, Chemical, and Gas Industry Services

API STD 618

Reciprocating Compressors for Petroleum, Chemical, and Gas Industry Services

API STD 619

Rotary Compressors for Petroleum, Petrochemical, and Gas Industry Services

API STD 681

Liquid Ring Vacuum Compressors for Petroleum, Chemical

Compressors Classification

Kinetic

A – Centrifugal

B – Axial

Positive Displacement

C -Reciprocating

D -Rotary

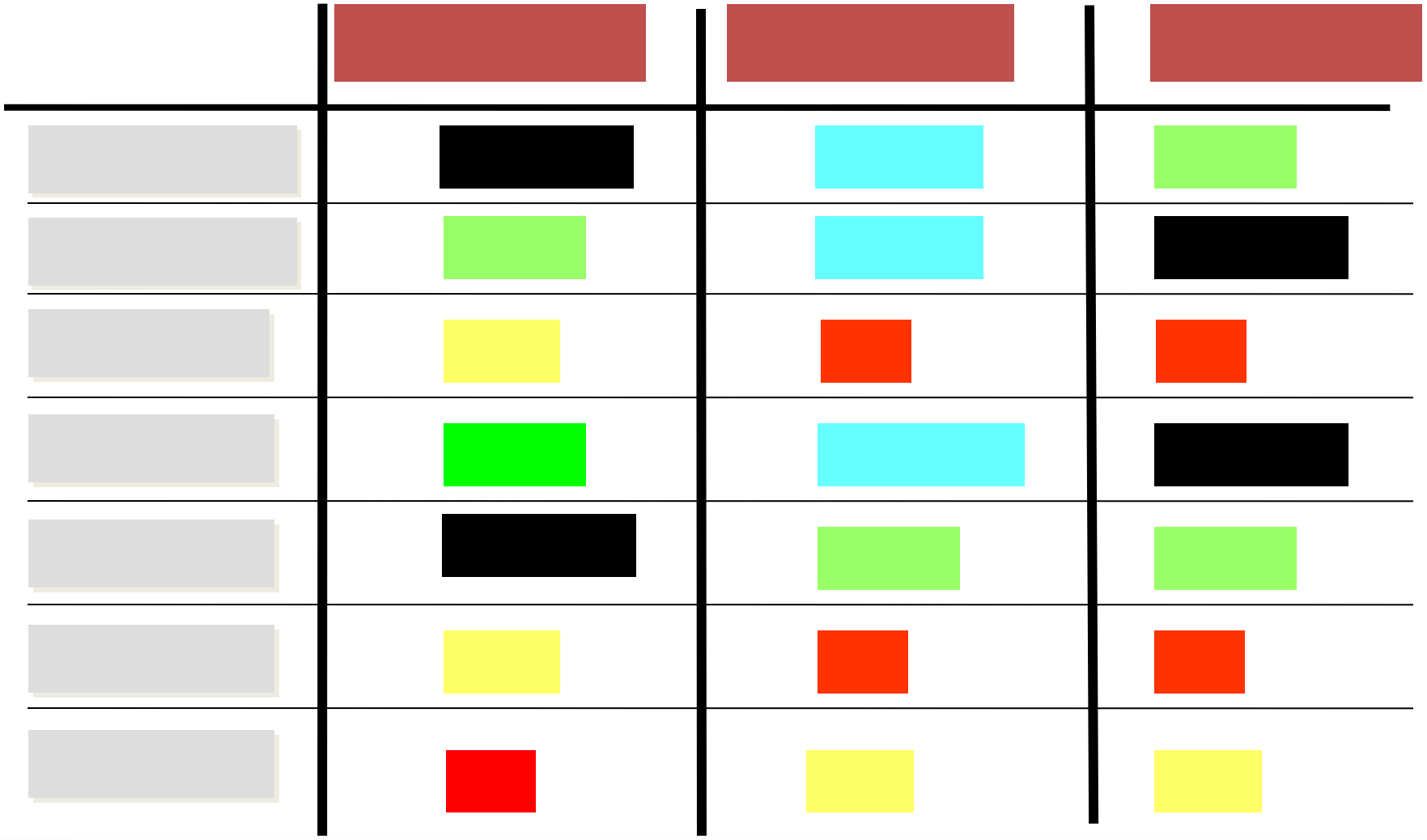
*Screw

* Lobe

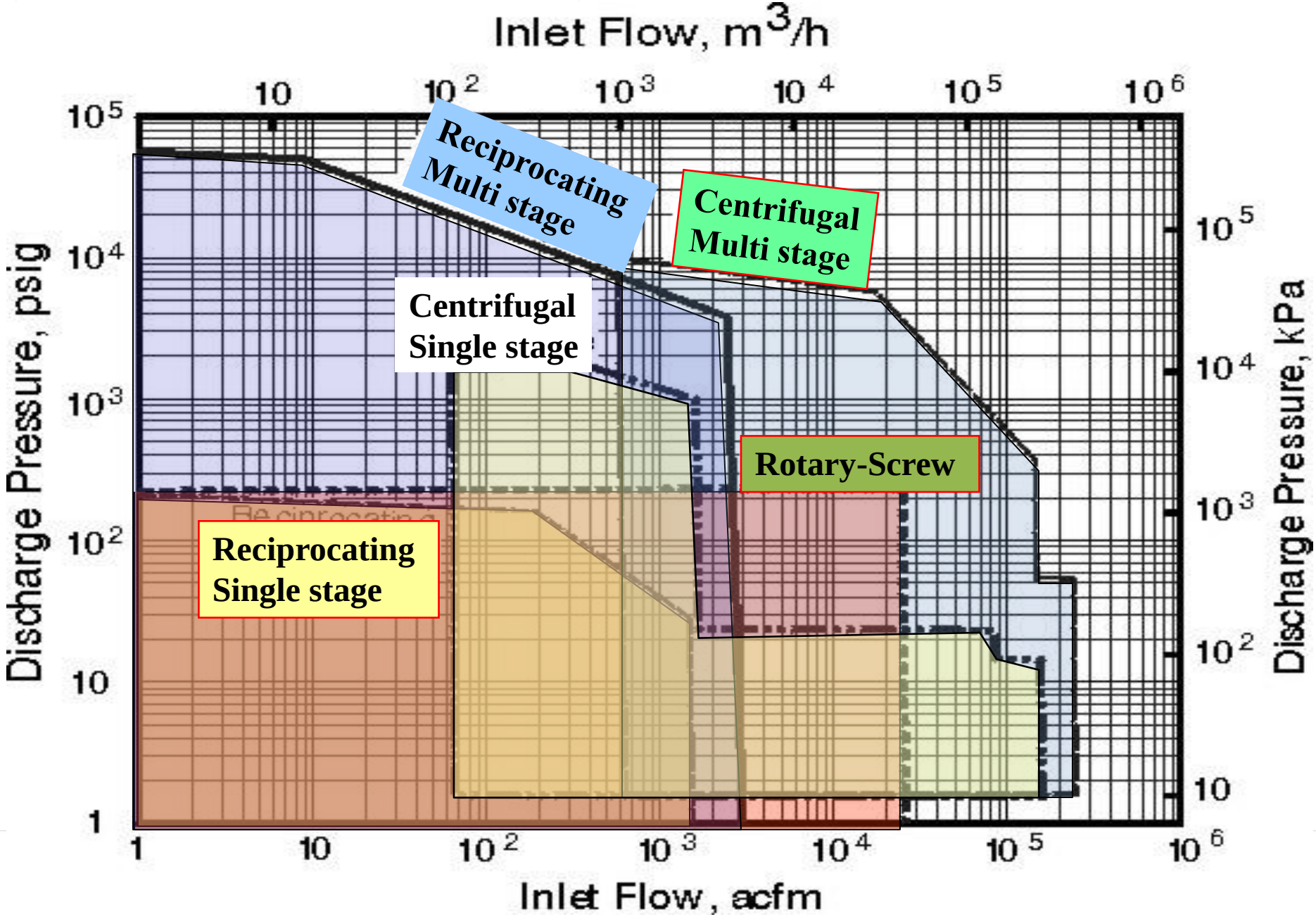
*Sliding Vane

*Gear

* Others

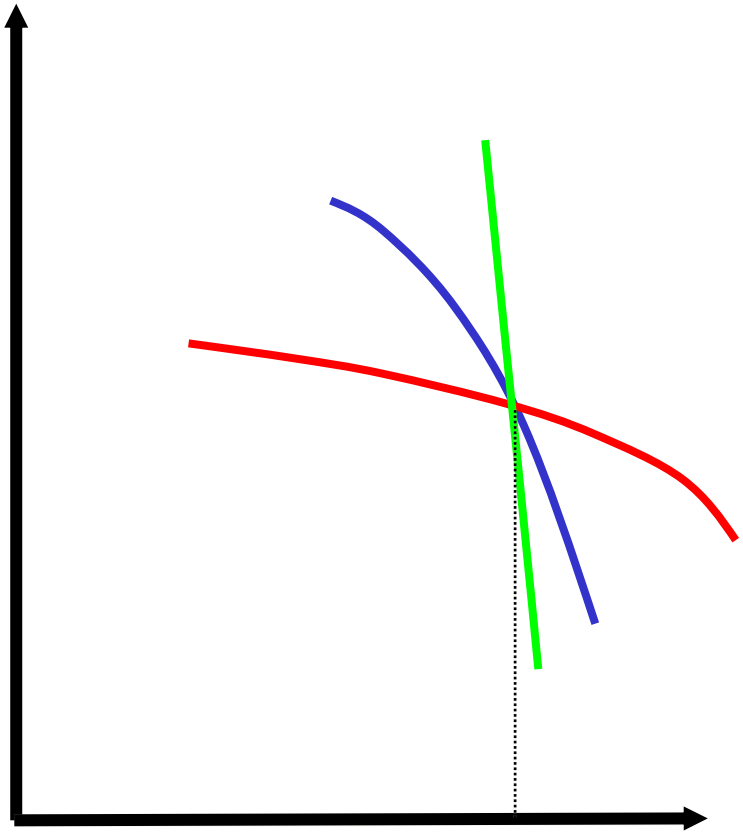


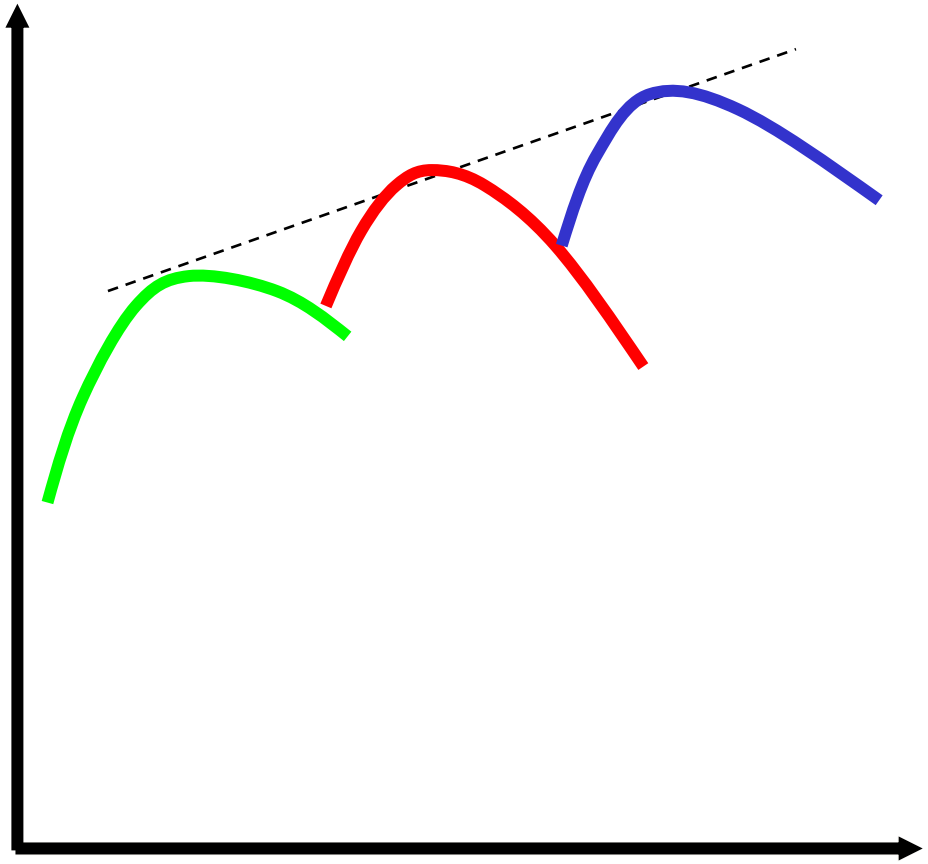
Compressor Selection

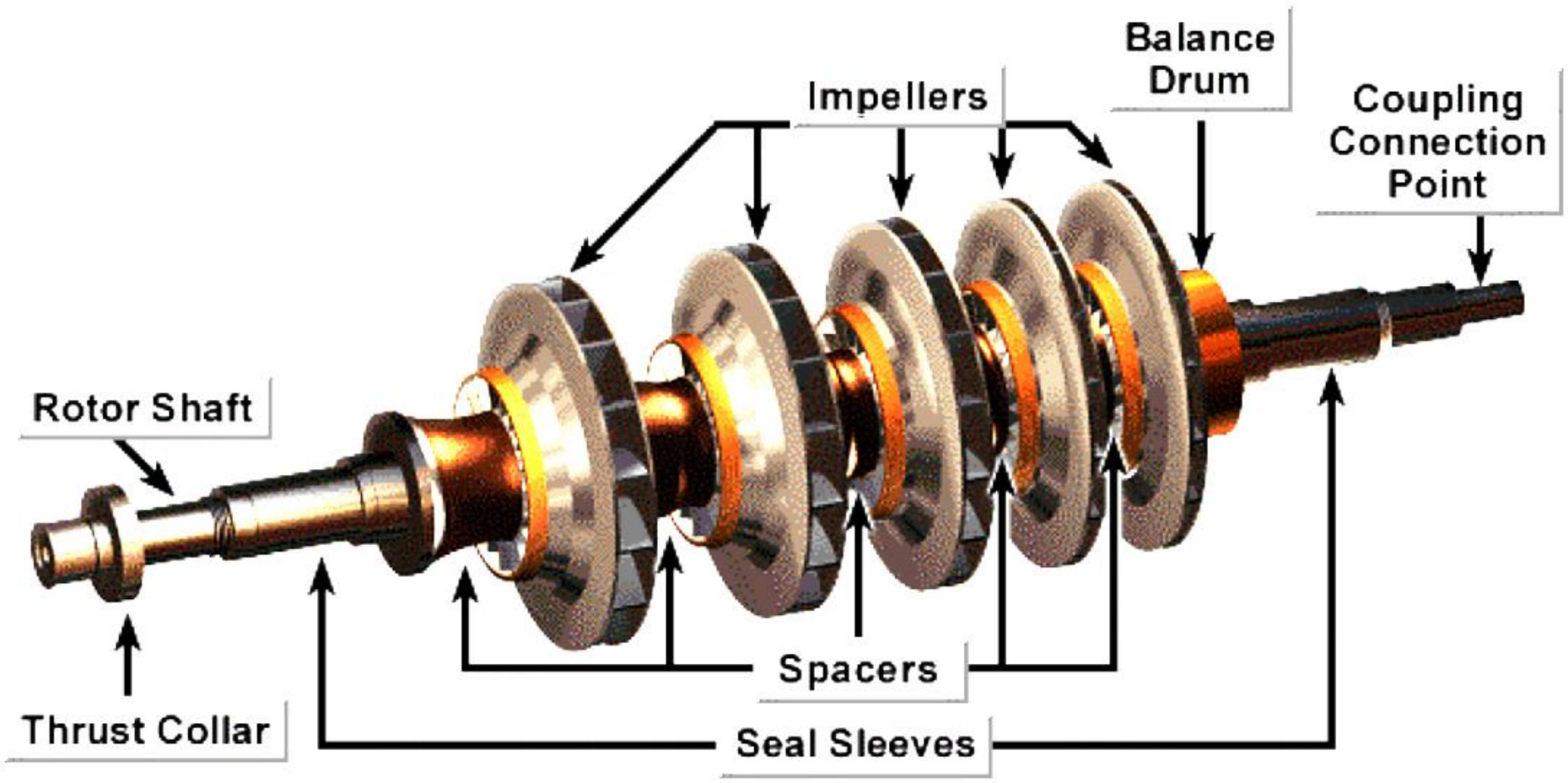


Different Types of Compressors

Type	Advantages	Disadvantages
Centrifugal	- Wide operating range - Low maintenance - High reliability	- Unstable at low flow - Moderate efficiency
Axial	- High efficiency - High speed capability - Higher flow for a given size	- Low pressure ratio per stage - Narrow flow range - Fragile and expensive blading
Positive displacement	- Pressure ratio capability not affected by gas properties - Good efficiencies at low specific speed	- - Limited capacity - High weight to capacity ratio - Higher maintenance requirements Introduces vibrations into the system - Bigger foundation requirements

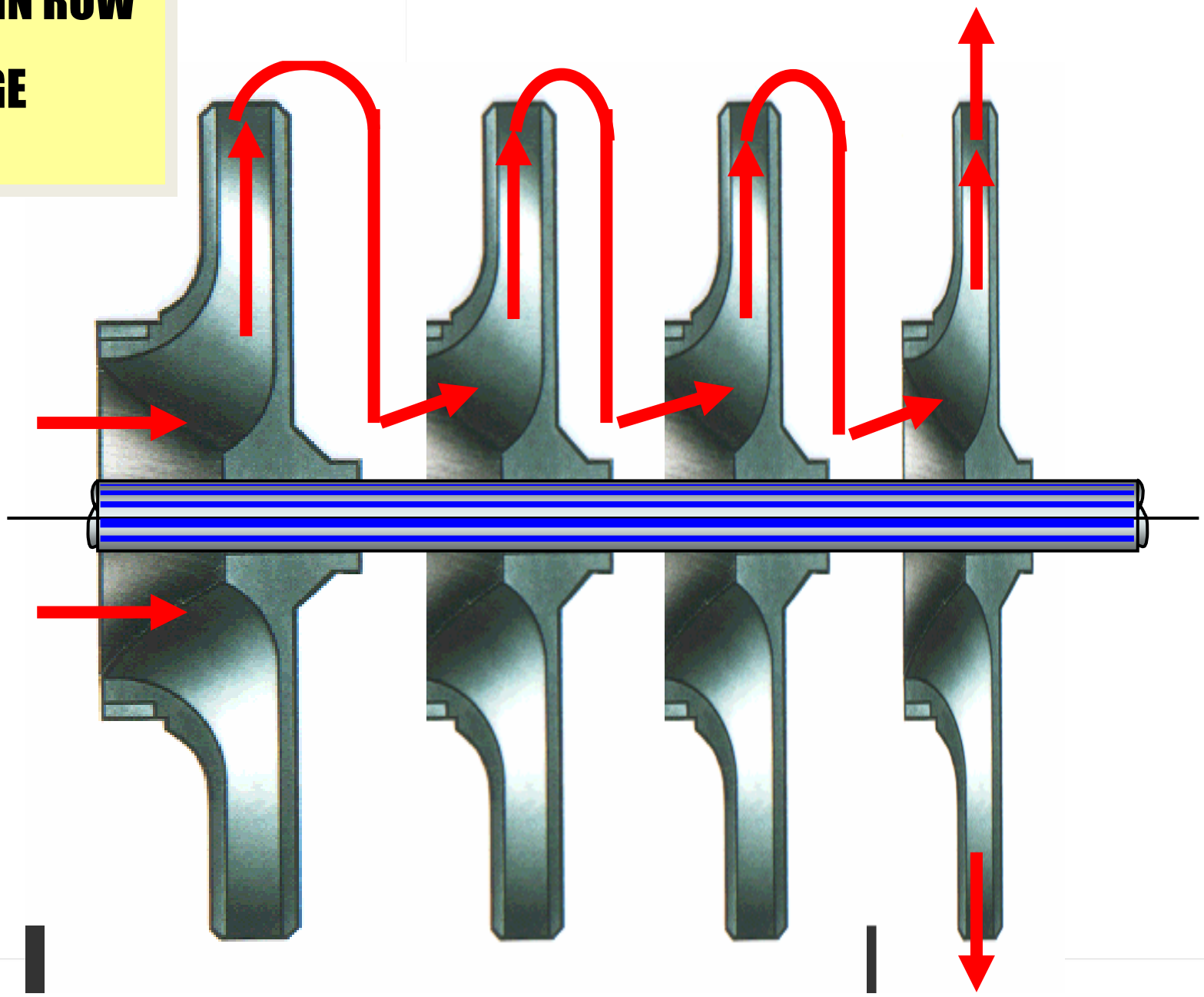





Balance
Drum
Impellers
Coupling
Connection
Point
Rotor Shaft
Spacers
Thrust Collar
Seal Sleeves

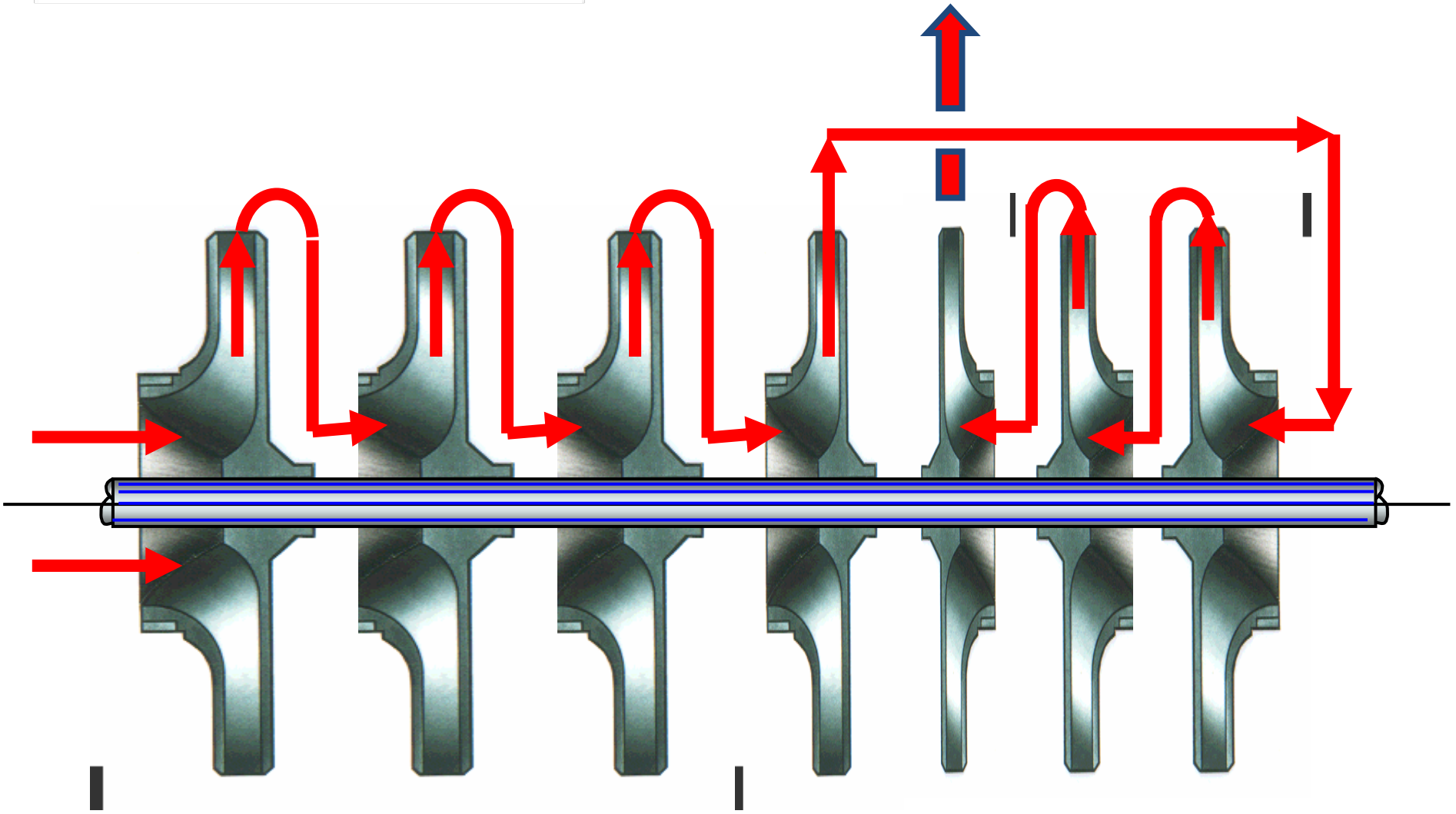
IMPELLERS IN ROW

MULTI-STAGE COMP.



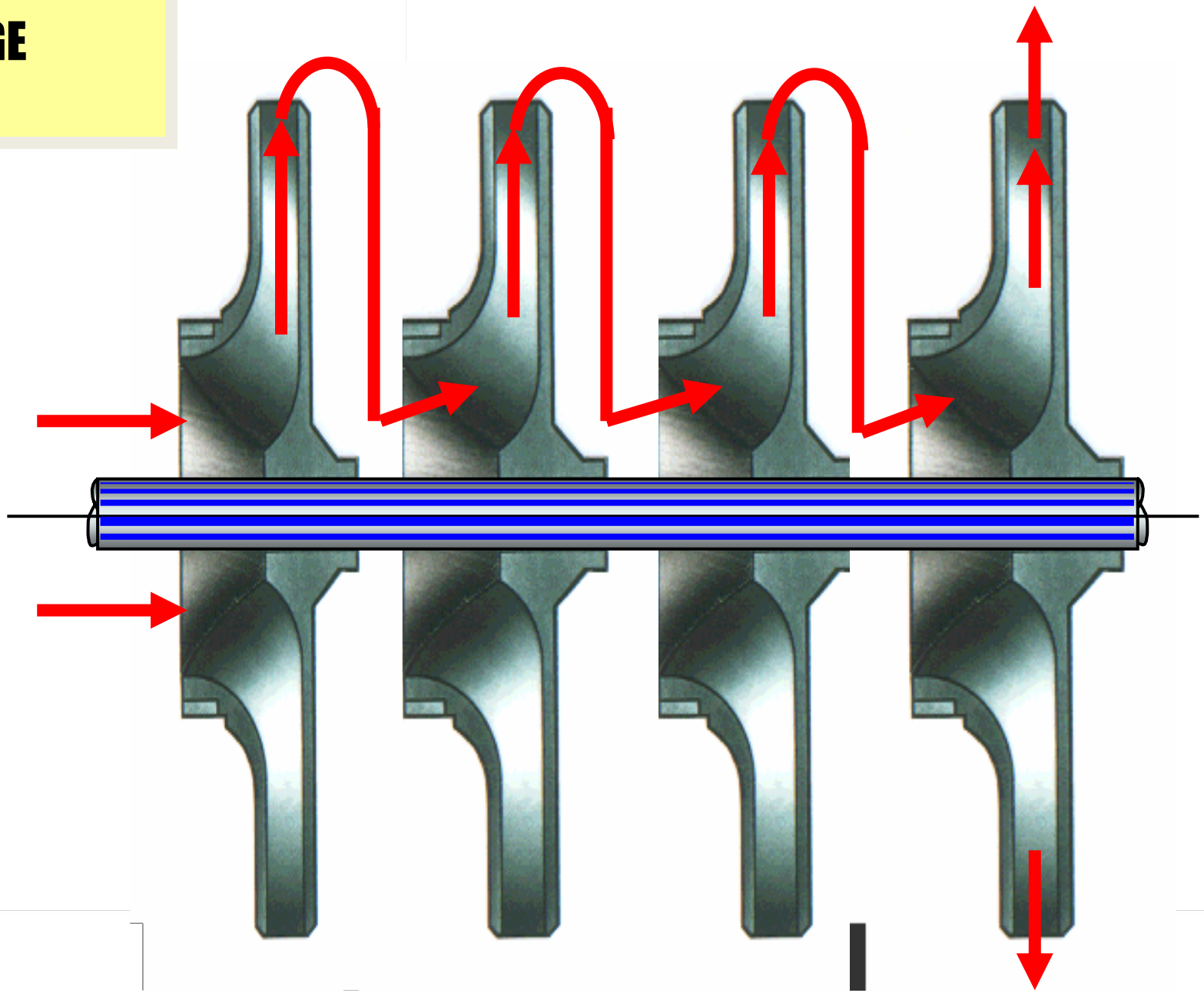
OPPOSITE IMPELLERS

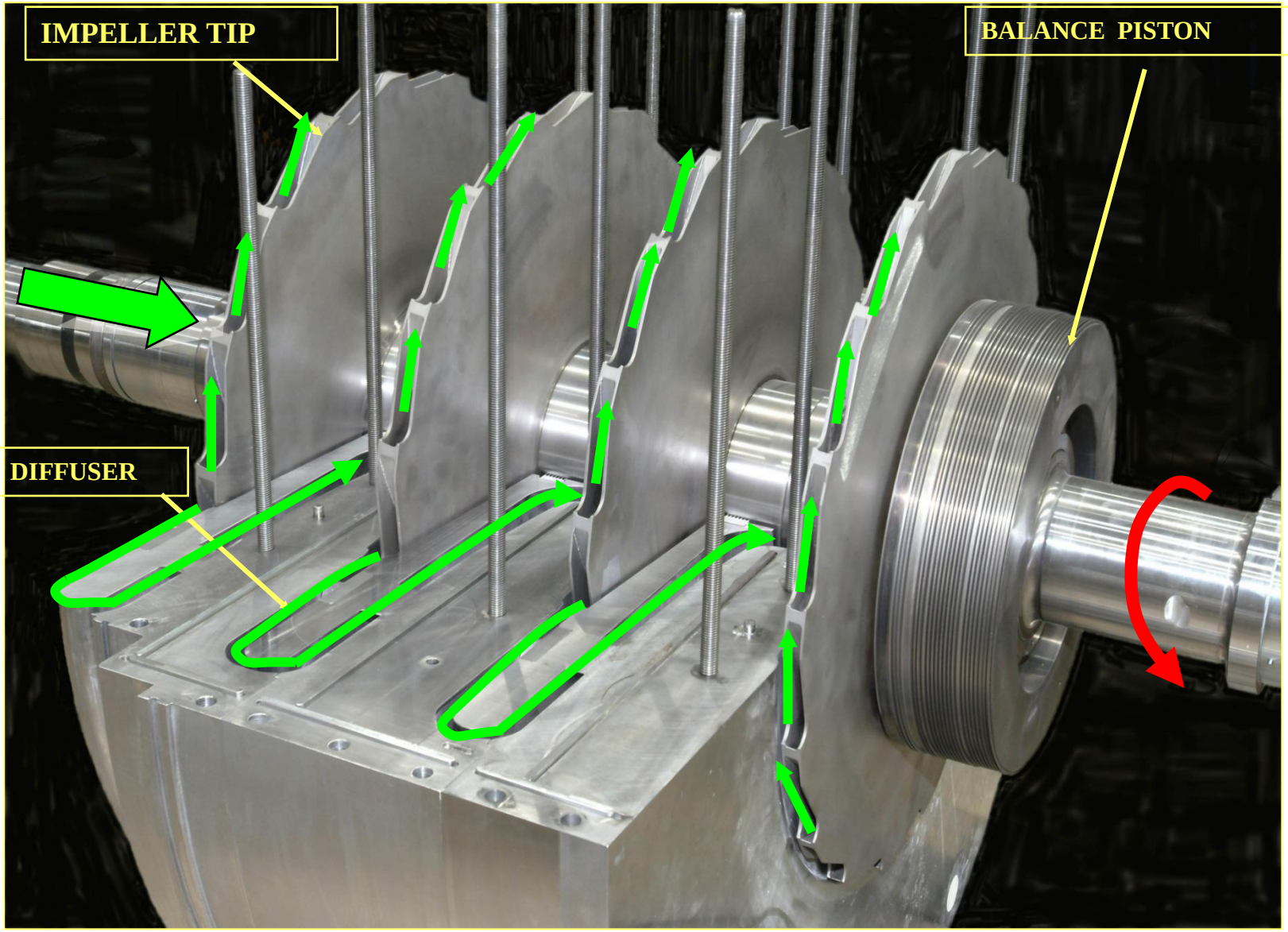
MULTI-STAGE COMP.



IMPELLERS IN ROW

MULTI-STAGE PUMP

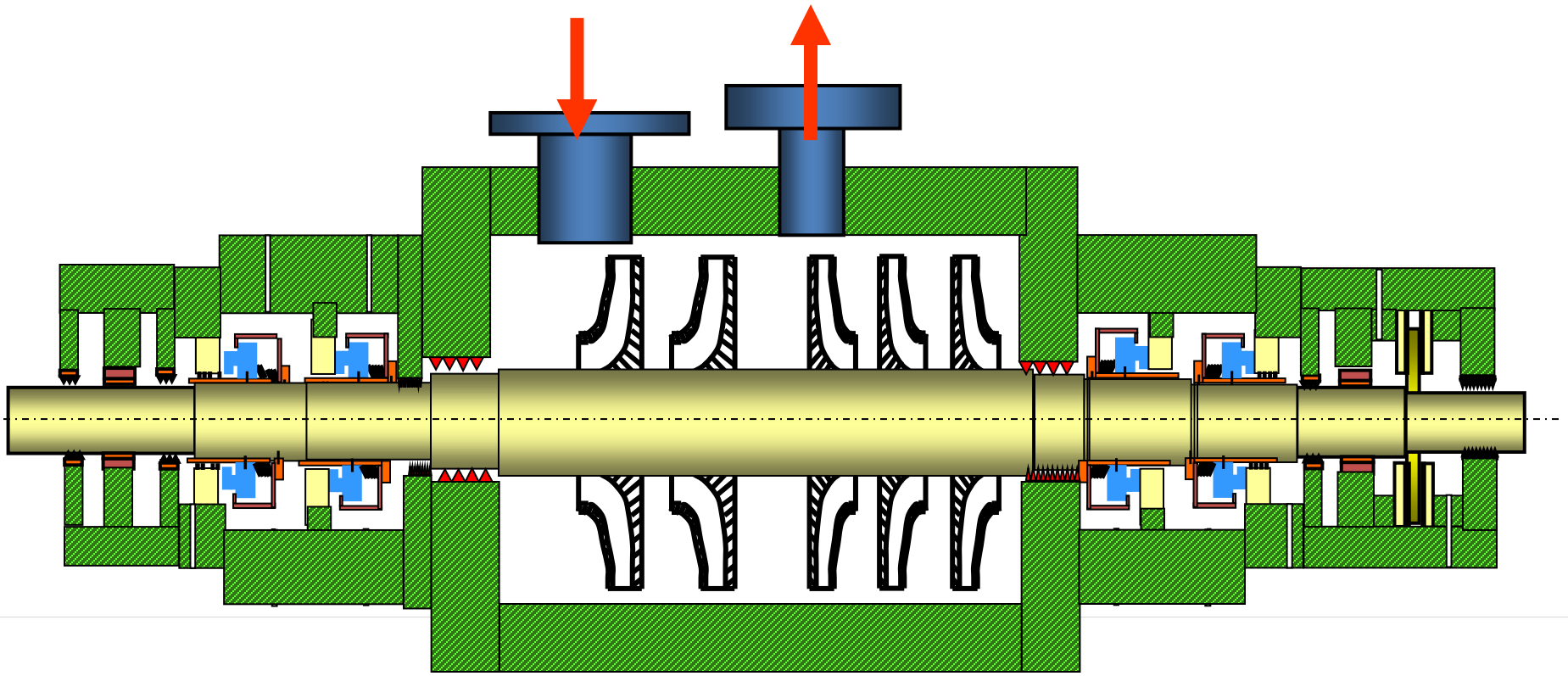



IMPELLER TIP
BALANCE PISTON
DIFFUSER

SPLIT TYPE COMPRESSORS

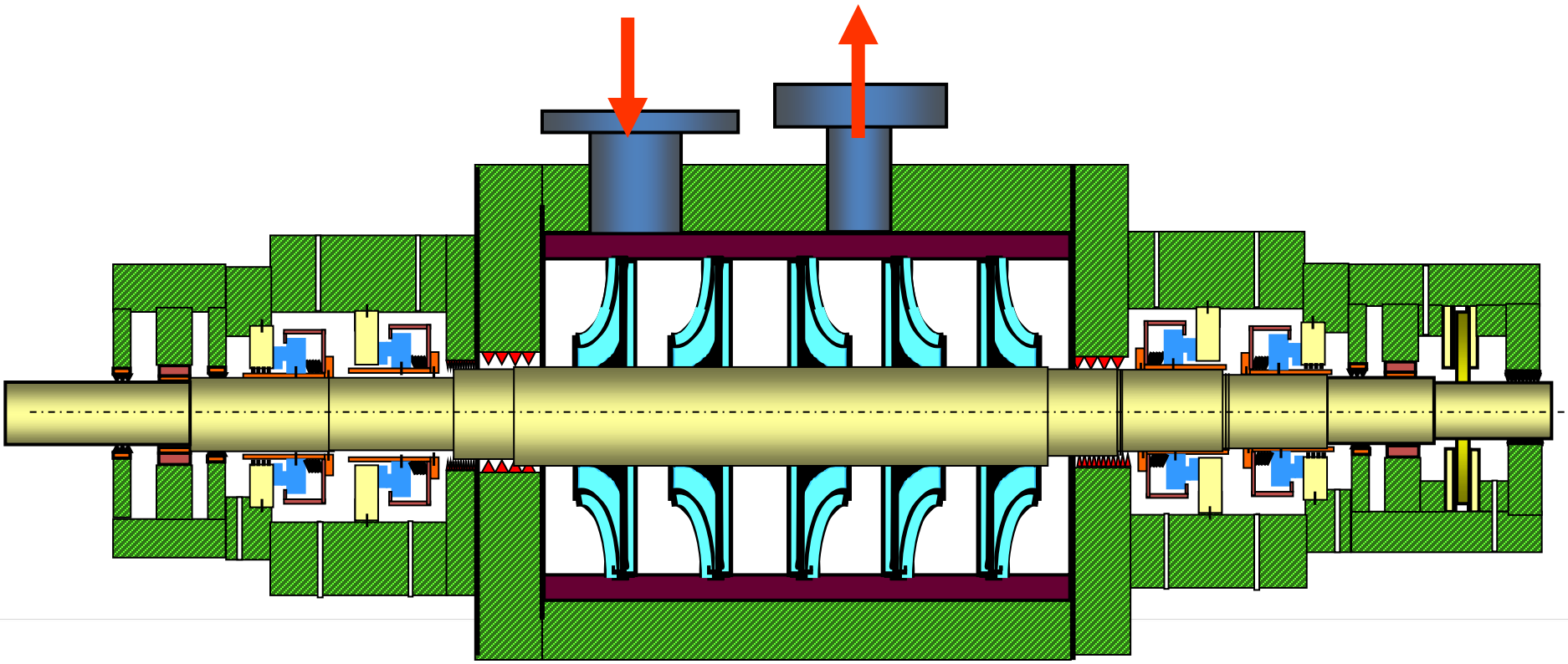
1- Horizontally Split

High Flow Medium pressure



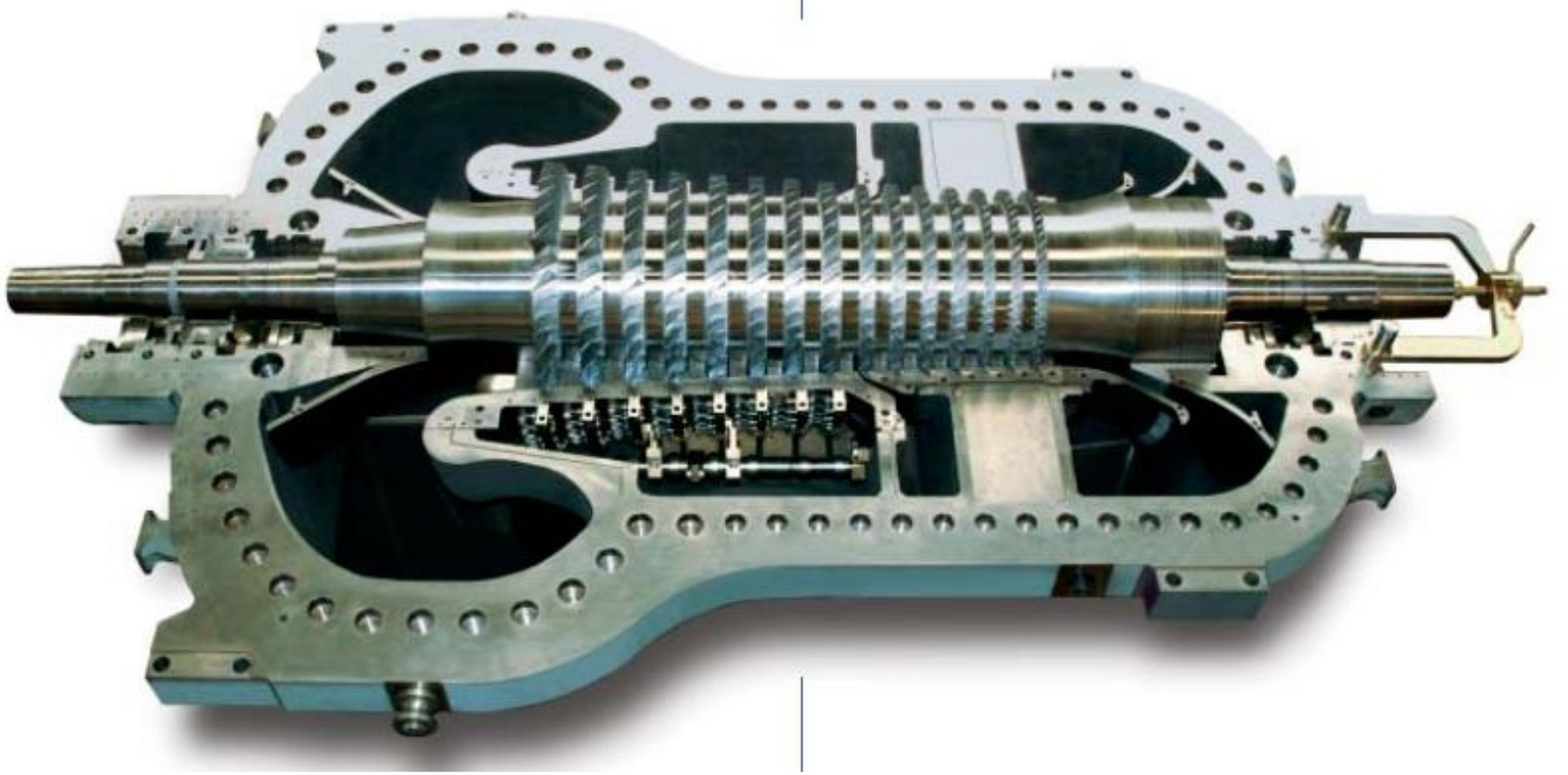
2- Vertically Split (Double Barrel)

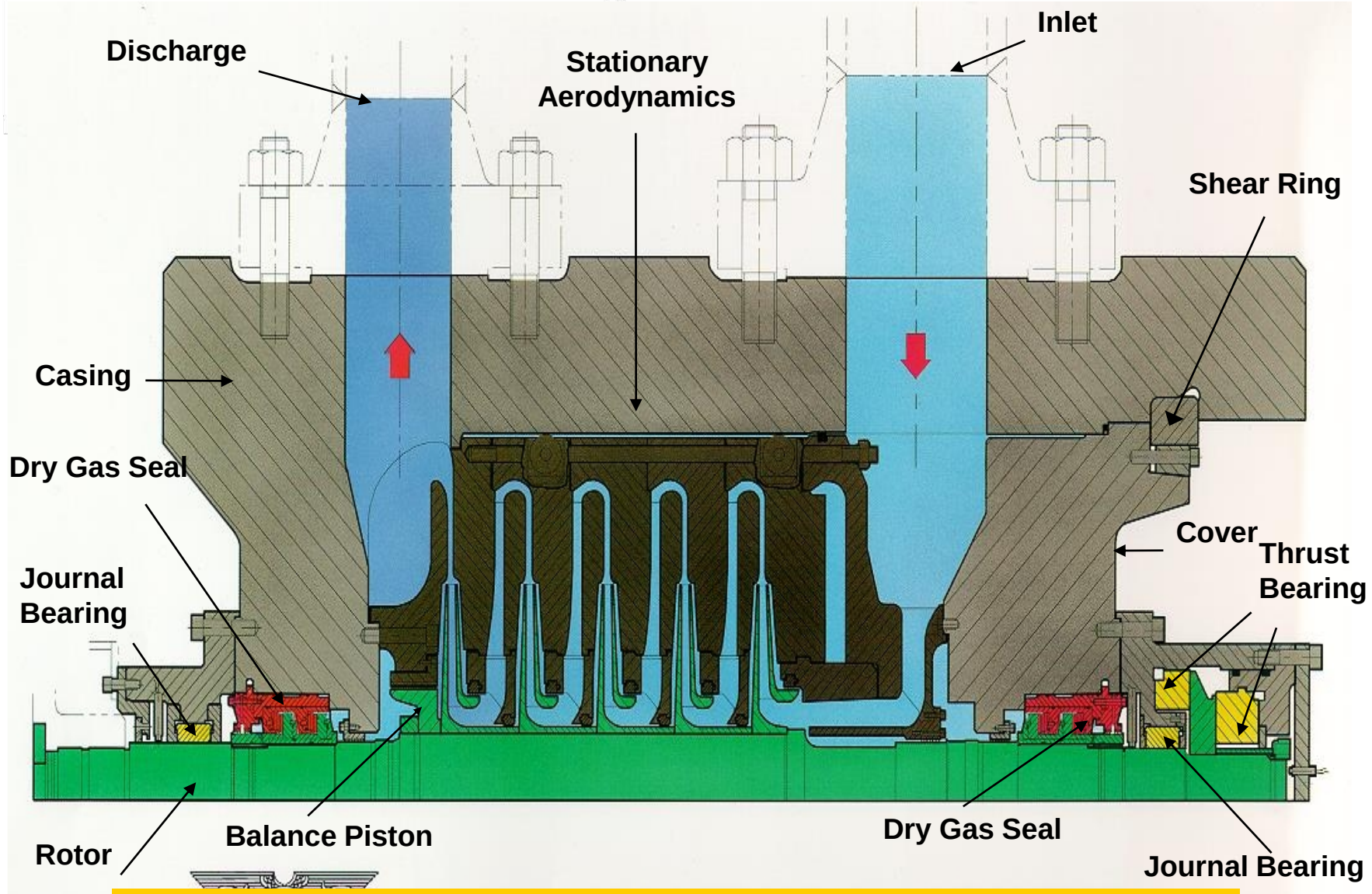
high pressure and medium Flow



Axial Flow Compressors

* API 617
* Very High Flow rate
* Low pressure
* Very High efficiency





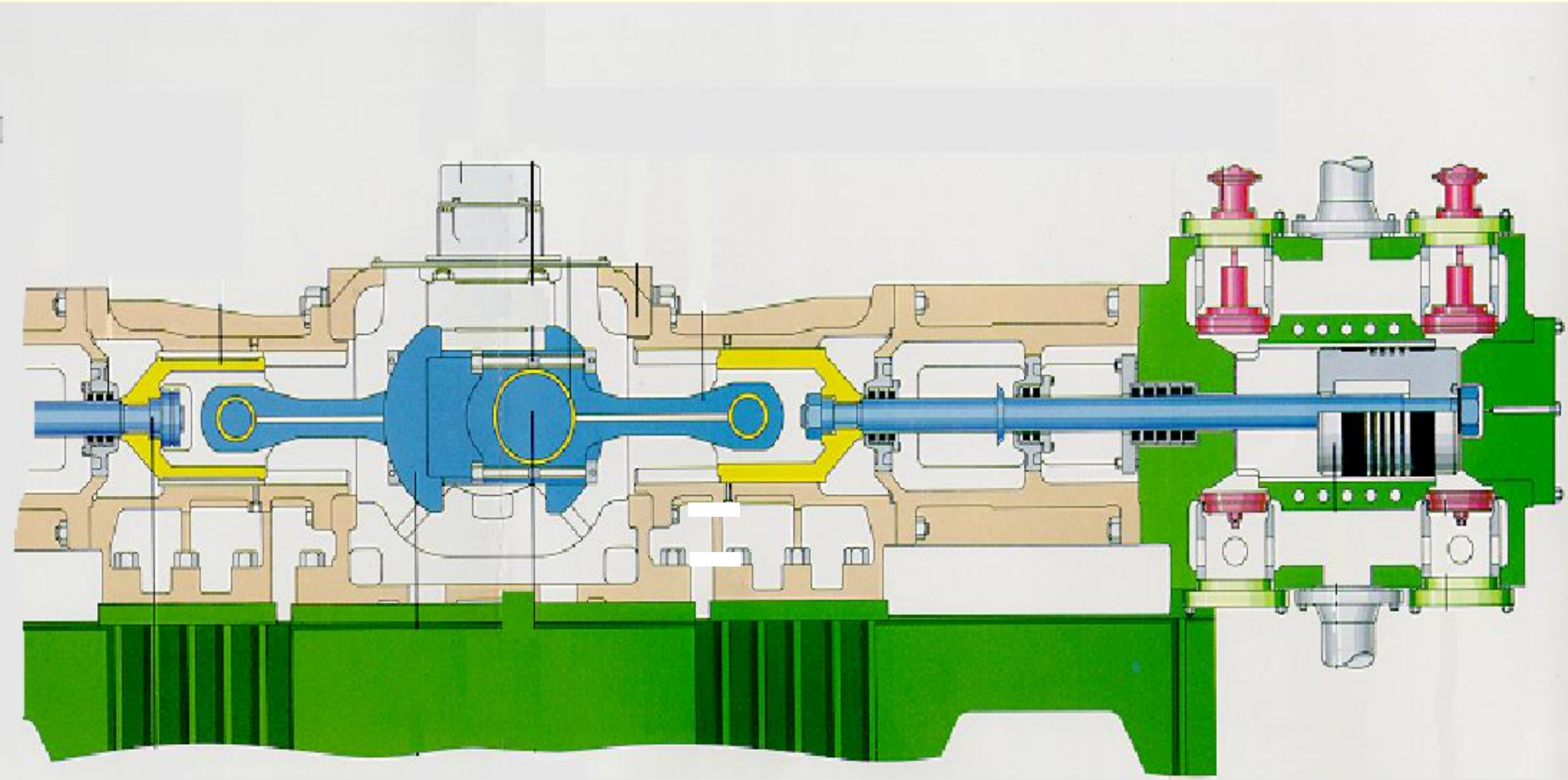
*API 617

* Medium pressure

* High Flow rate

* High efficiency

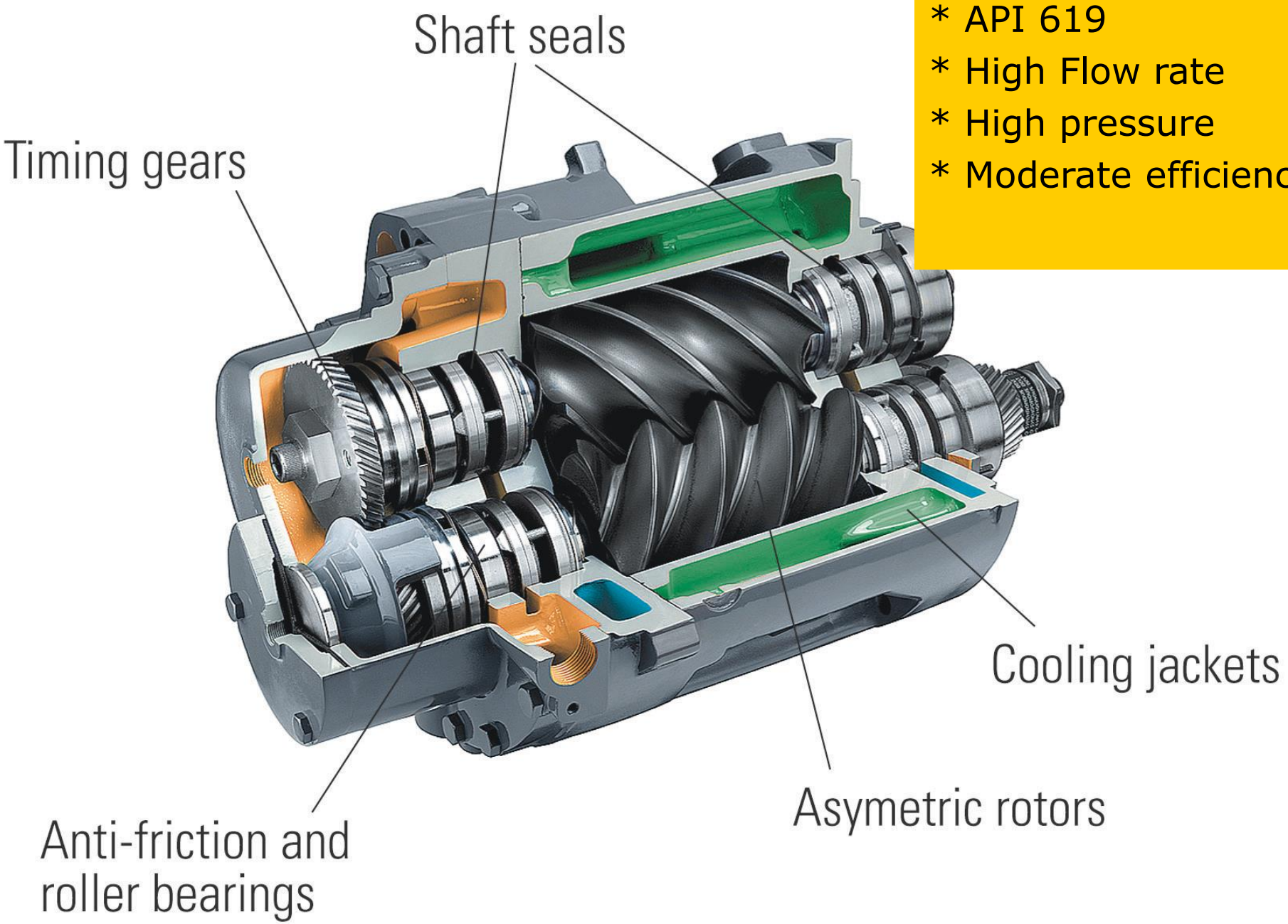
Reciprocating Compressor



* API 618 * Low Flow rate
* High pressure * Moderate efficiency

Rotary-Screw Compressor

* API 619
* High Flow rate
* High pressure
* Moderate efficiency



** Compressor Selection

Application

Operating parameter

footprint/weight

Availability

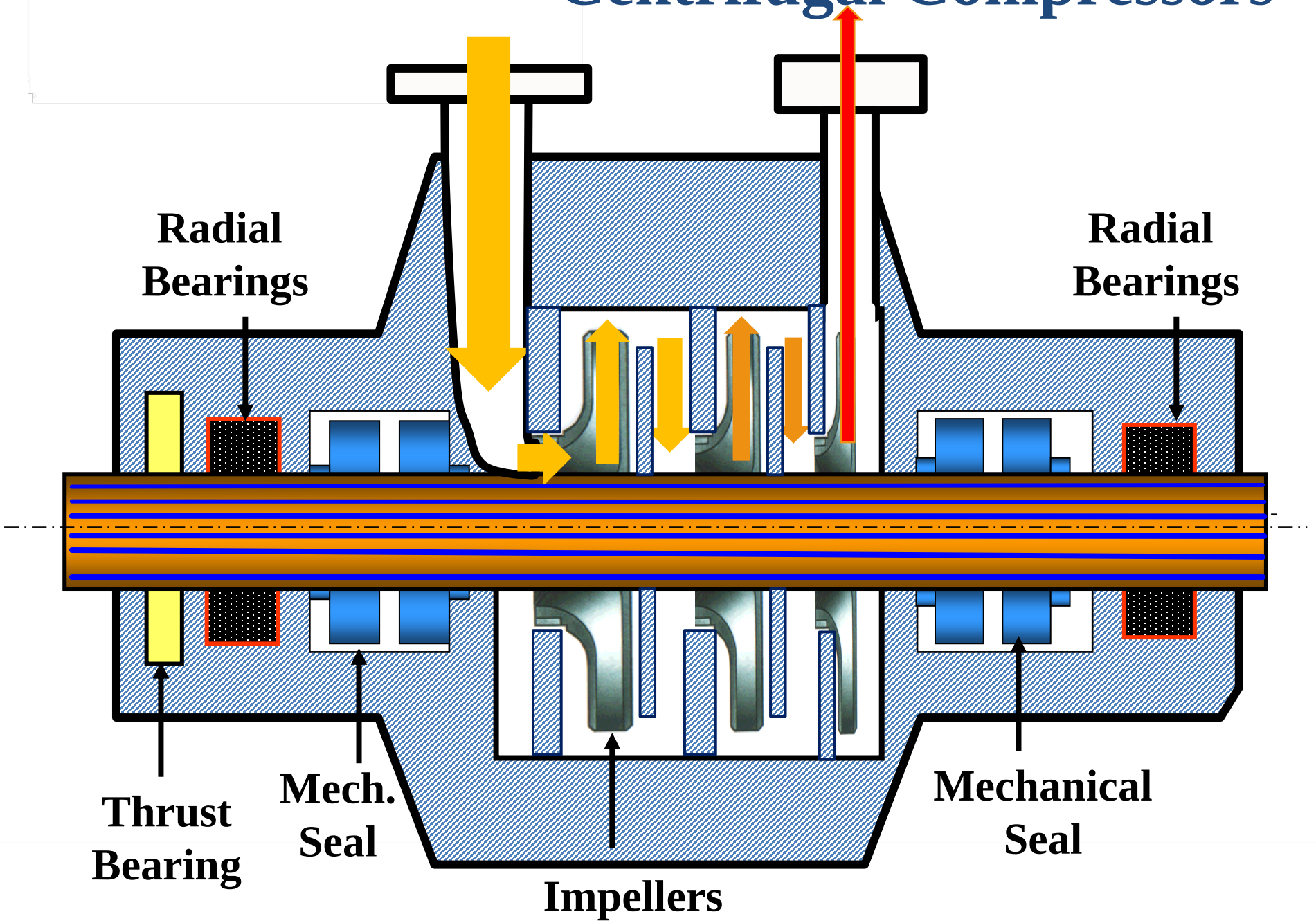
Reliability

maintenance

drivers

Centrifugal Compressor

Centrifugal Compressors



Centrifugal Compressor

** *Compressors components*

Rotor Shaft Impellers Thrust collars Spacers

Diffusers

Casing

Labyrinths

Mechanical Seals

Couplings HSC LSC

Gear Box

Anti- Surge System

Lube Oil System

Driver

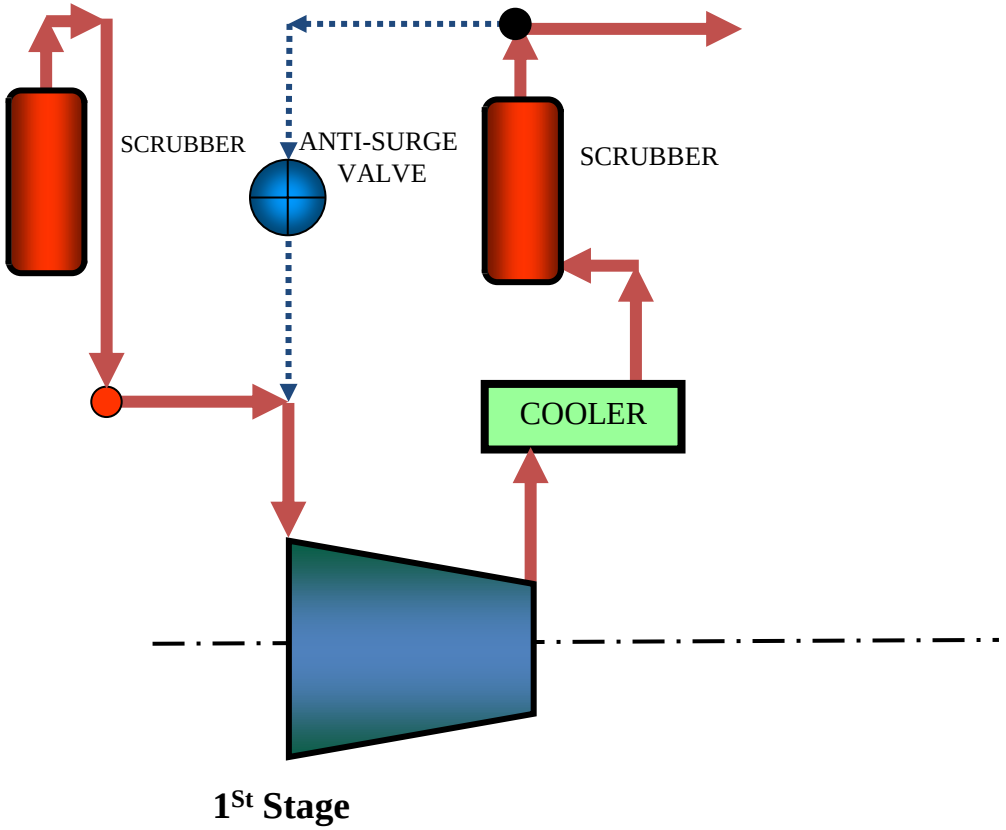
General aspects

1- A Complete spare balanced rotor to be ideally stored in ware house

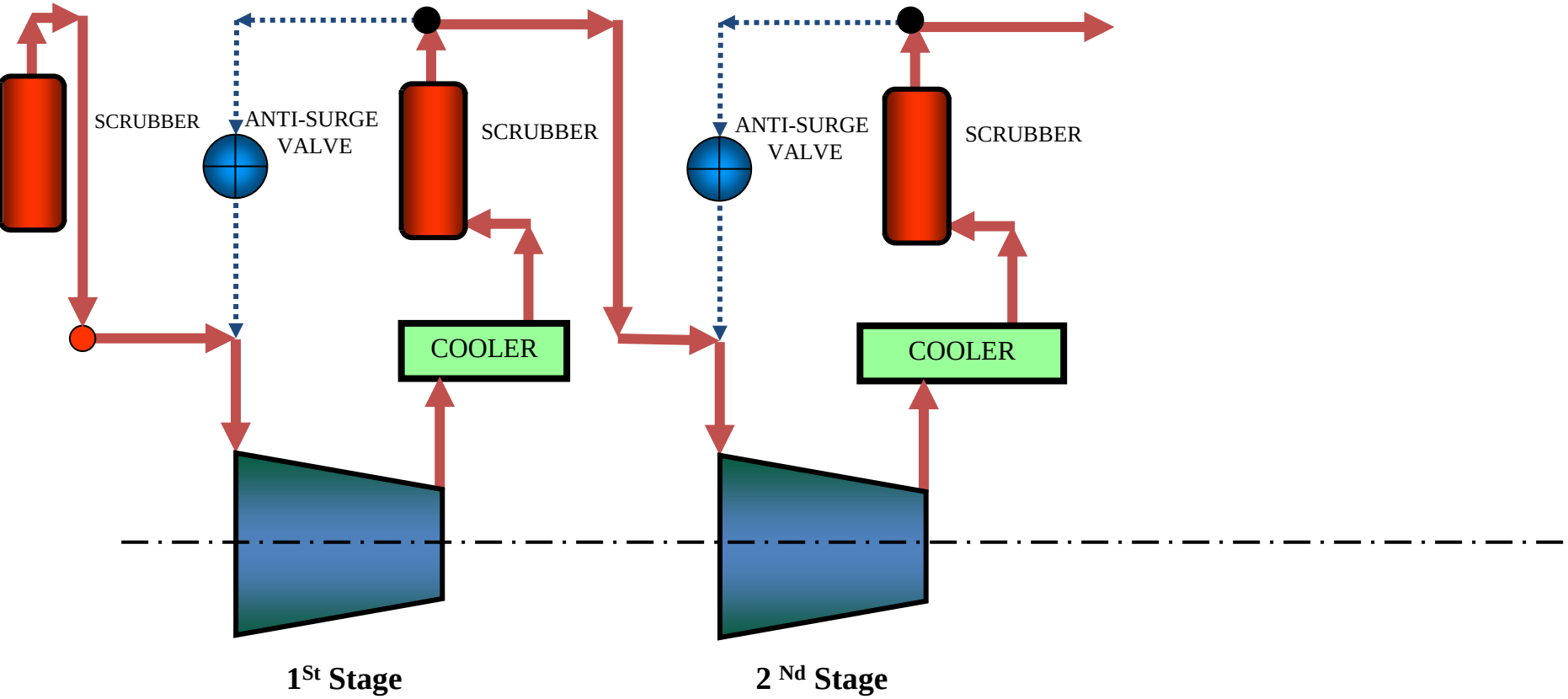
2- Compressor will be equipped with a complete surge control system.

3- It is advisable to use dry gas mechanical seal system instead of wet mechanical seal one.

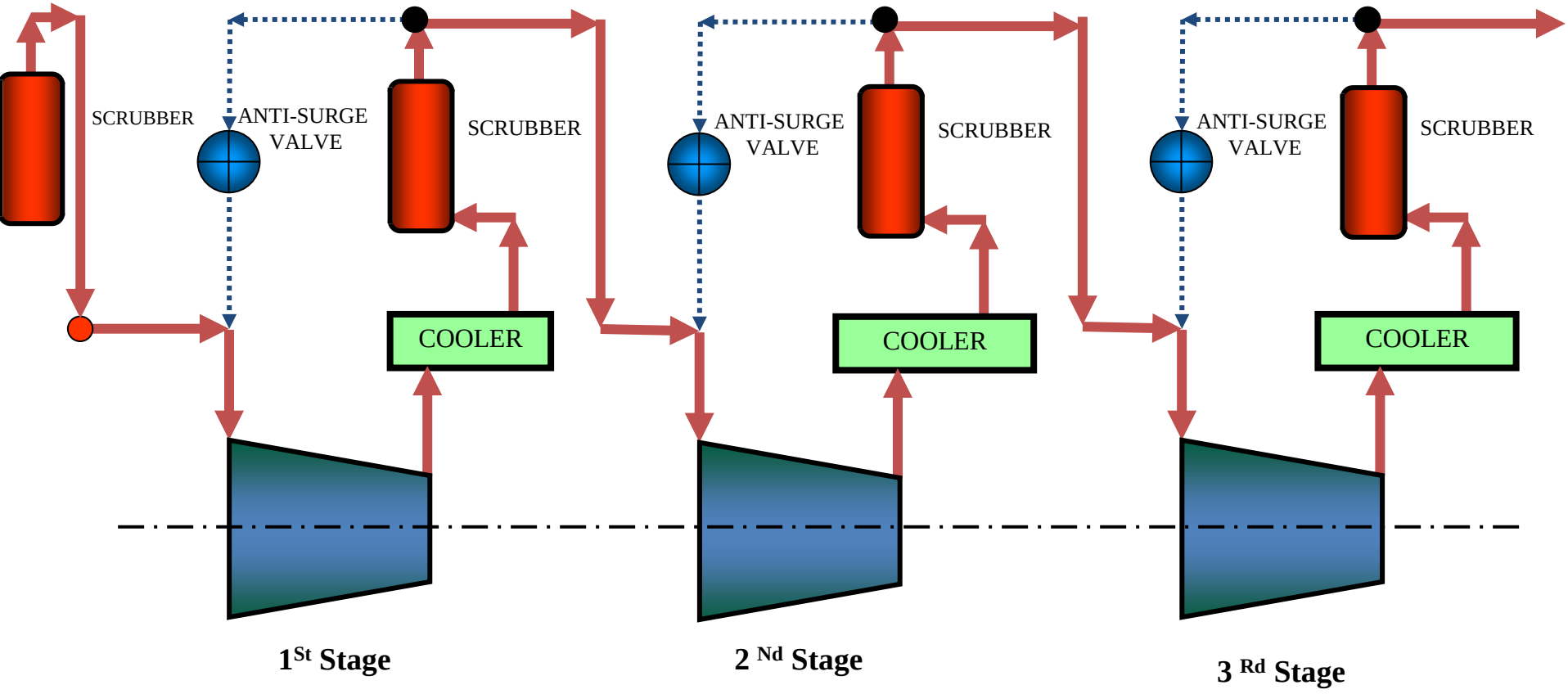
** Centrifugal Compressor Operation



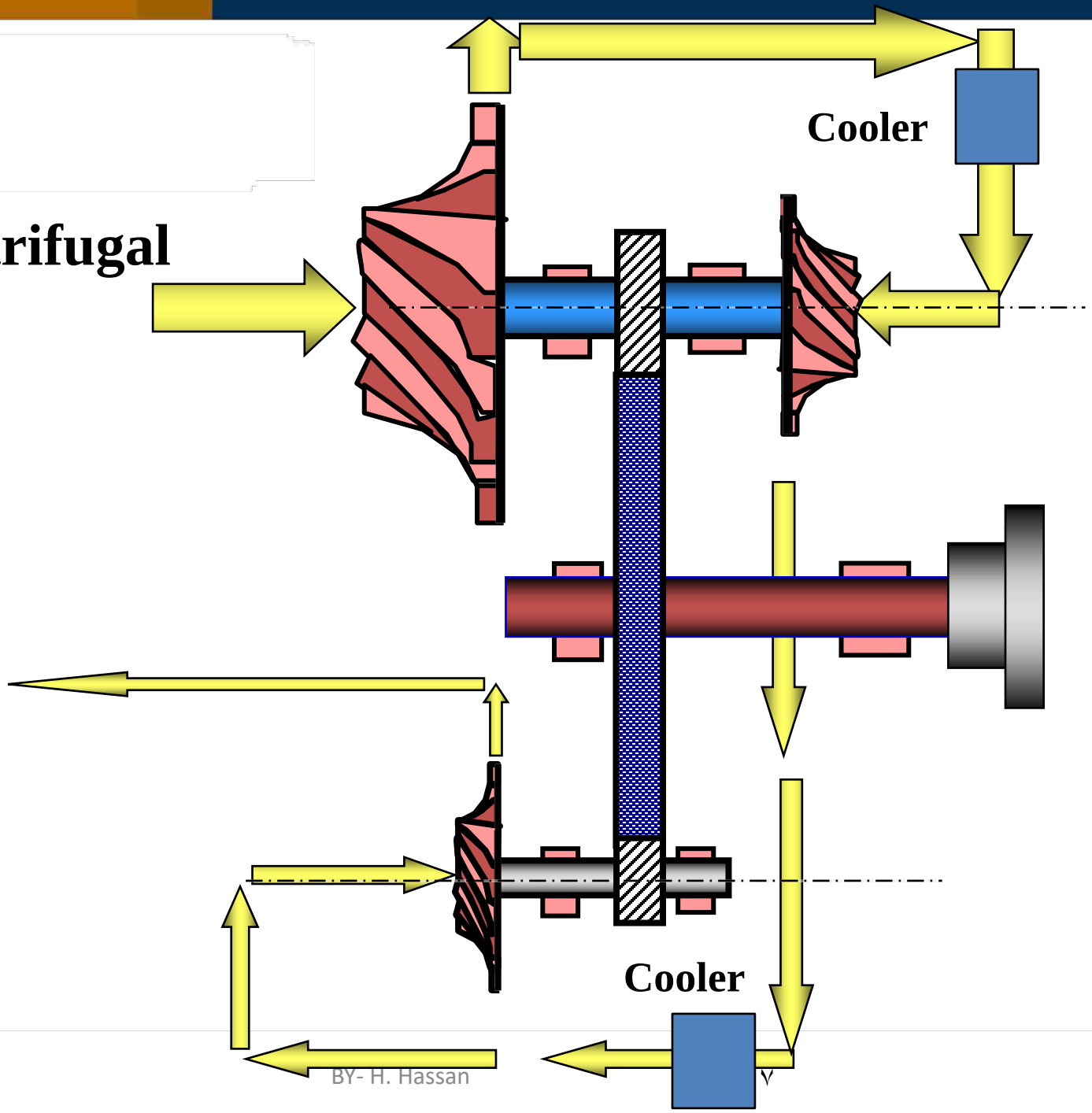
** Centrifugal Compressor Operation



** Centrifugal Compressor Operation



3 Stages Geared Centrifugal Compressor



Surge Phenomenon

HAPPENS ONLY TO :

CENTRIFGAL COMPRESSORS

AND

AXIAL FLOW COMPRESSORS

But Does not Happen to Reciprocating Compressors

SURGE PHENOMEN

It is the flow back of gases from the outlet of the Last stage of the compressor towards the suction and return again to discharge

SURGE PHENOMEN

Why

- FLOW-RATE IS NOT ENOUGH
- GAS PROPERTY
- COMPRESSOR PERFORMANCE
- FLATENESS OF P.C. AT LOW Q

- **FLOW-RATE IS NOT ENOUGH**

This will happen at
starting and shutdown,
also at abnormal conditions.

- **GAS PROPERTY**

Gas is compressible but liquid is not.

- **COMPRESSOR PERFORMANCE**

Centrifugal and Axial compressors are pumping gas continuously but reciprocating is not.

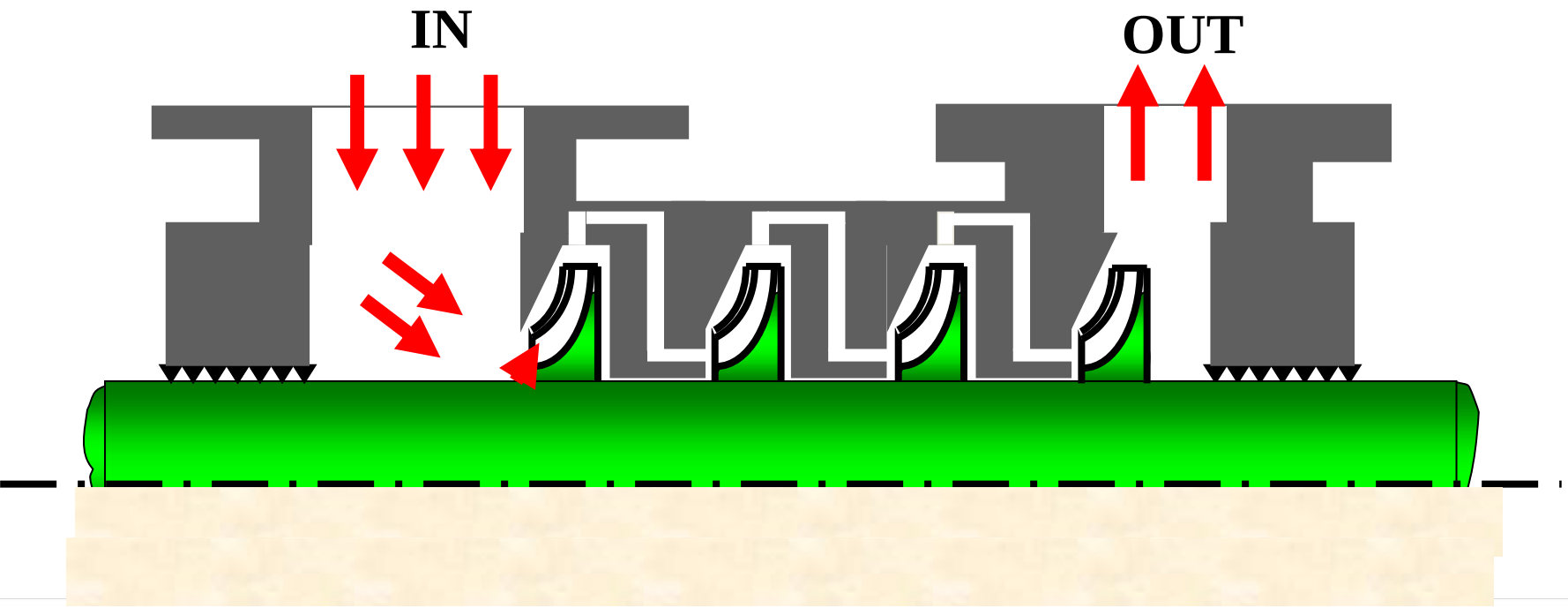
- **FLATENESS OF P.C. AT LOW Q**

Gas pressure has the same energy at horizontal portions of the performance curve

NO SURGE

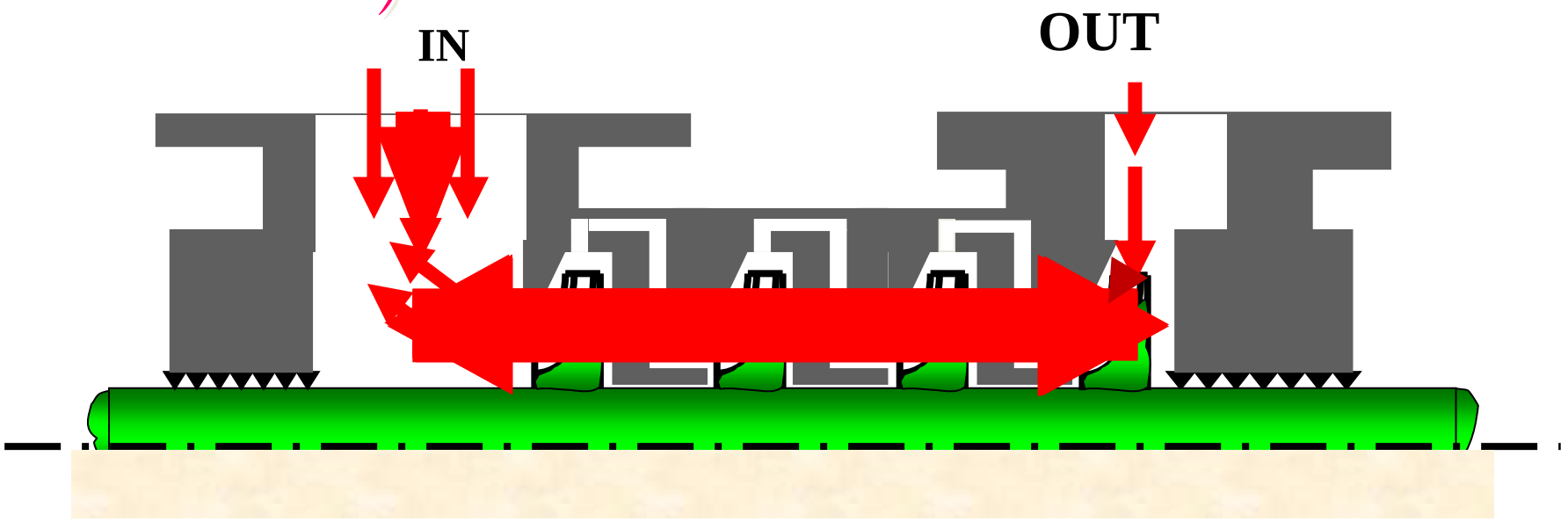
IF

INLET FLOW RATE Q IS ENOUGH



IF INLET FLOW RATE Q IS NOT ENOUGH

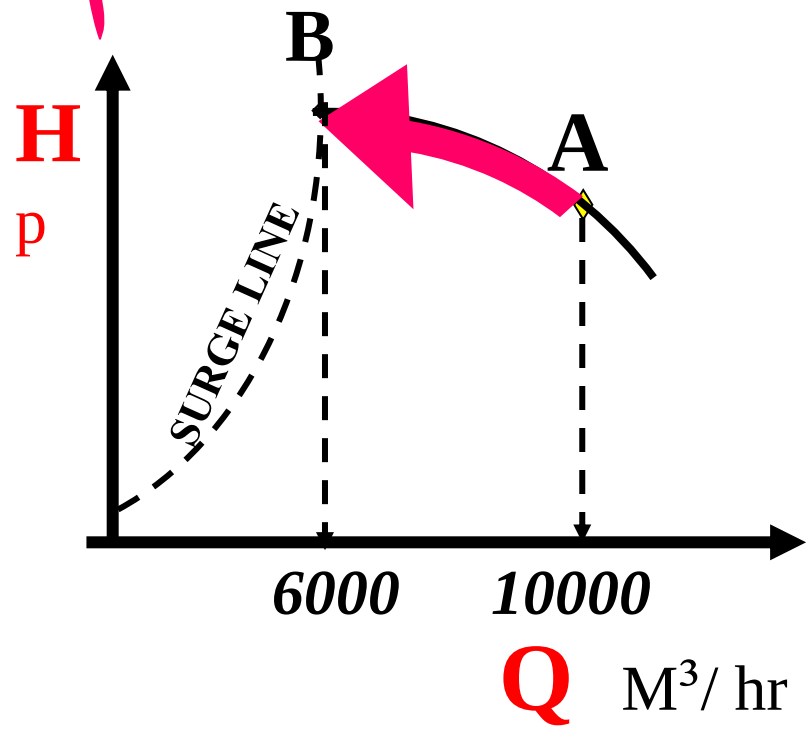
COMPRESSOR IS SURGING



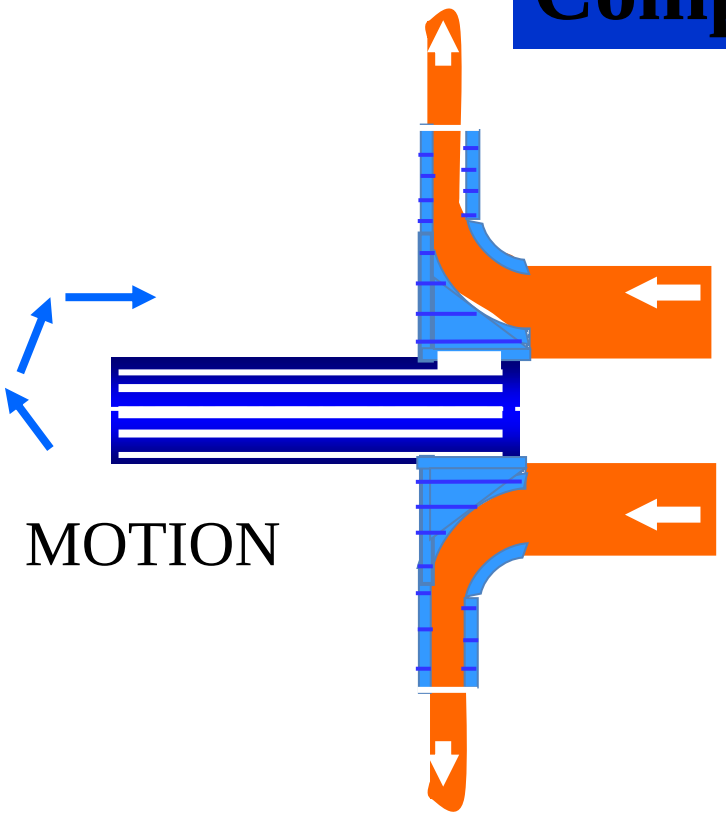
5 to 20 cycles per second

SURGE PHENOMENON

COMPRESSOR SURGING



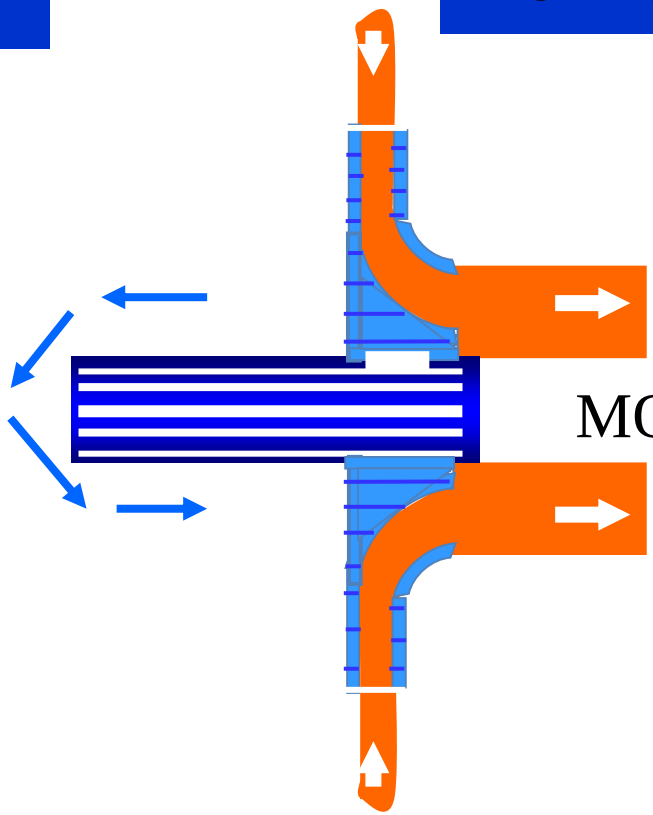
Compressor



MOTION

HYDRAULIC ENERGY

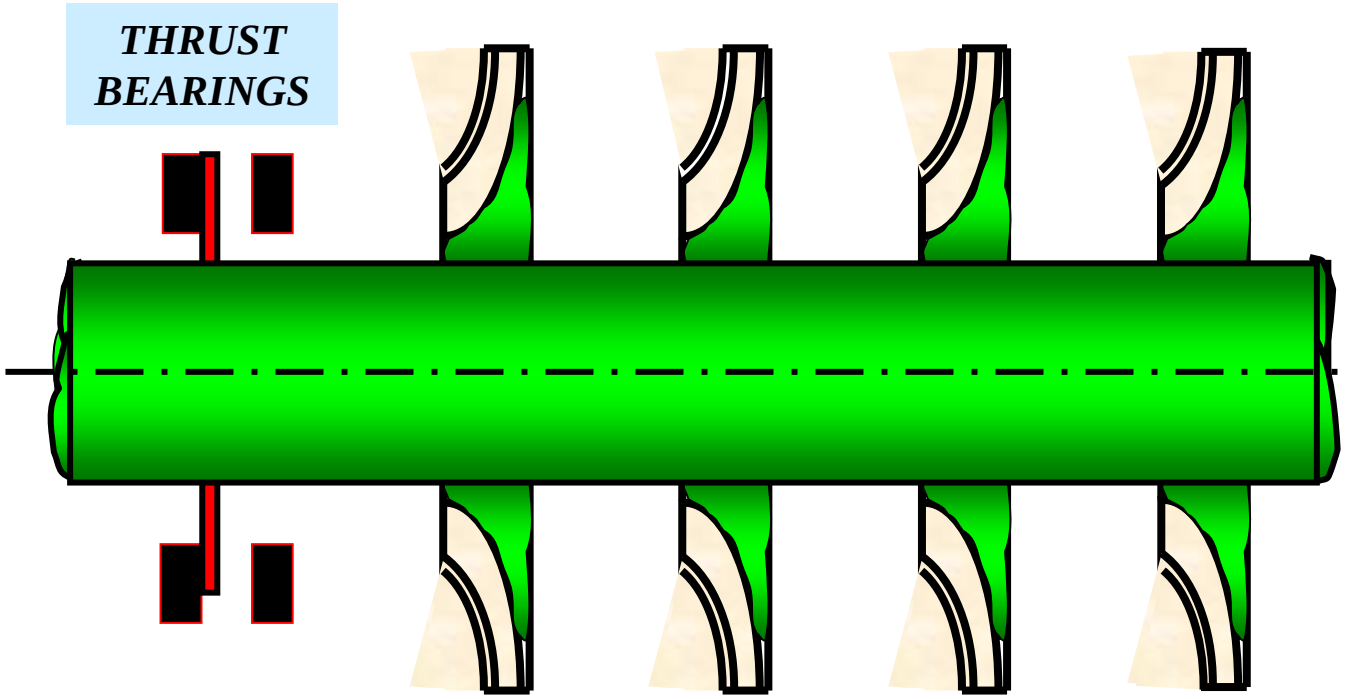
Turbine



MOTION

HYDRAULIC ENERGY

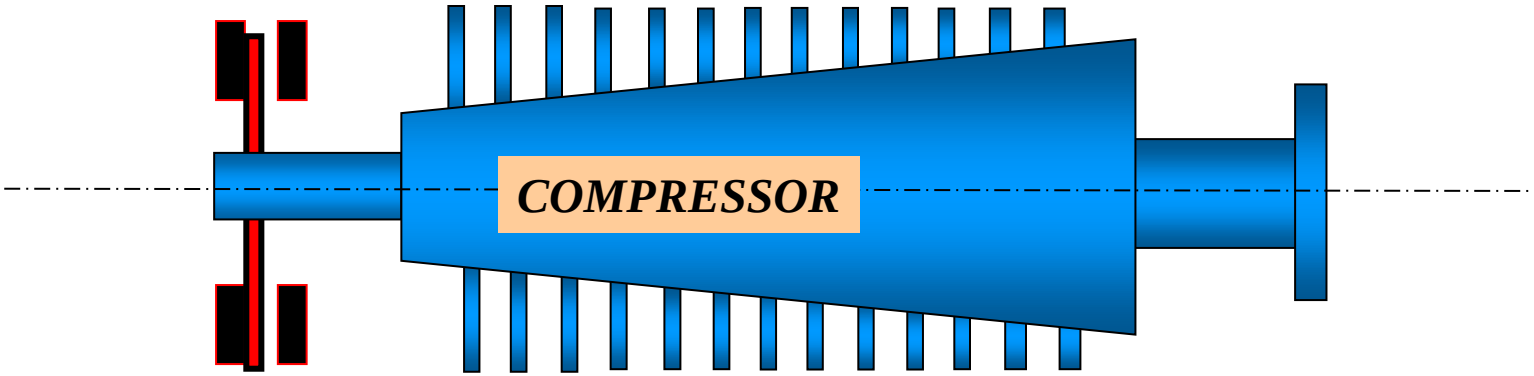
EFFECT OF SURGE ON CENTRIFGAL COMPRESSOR ROTOR



SURGE WILL DAMAGE THE COMPRESSOR

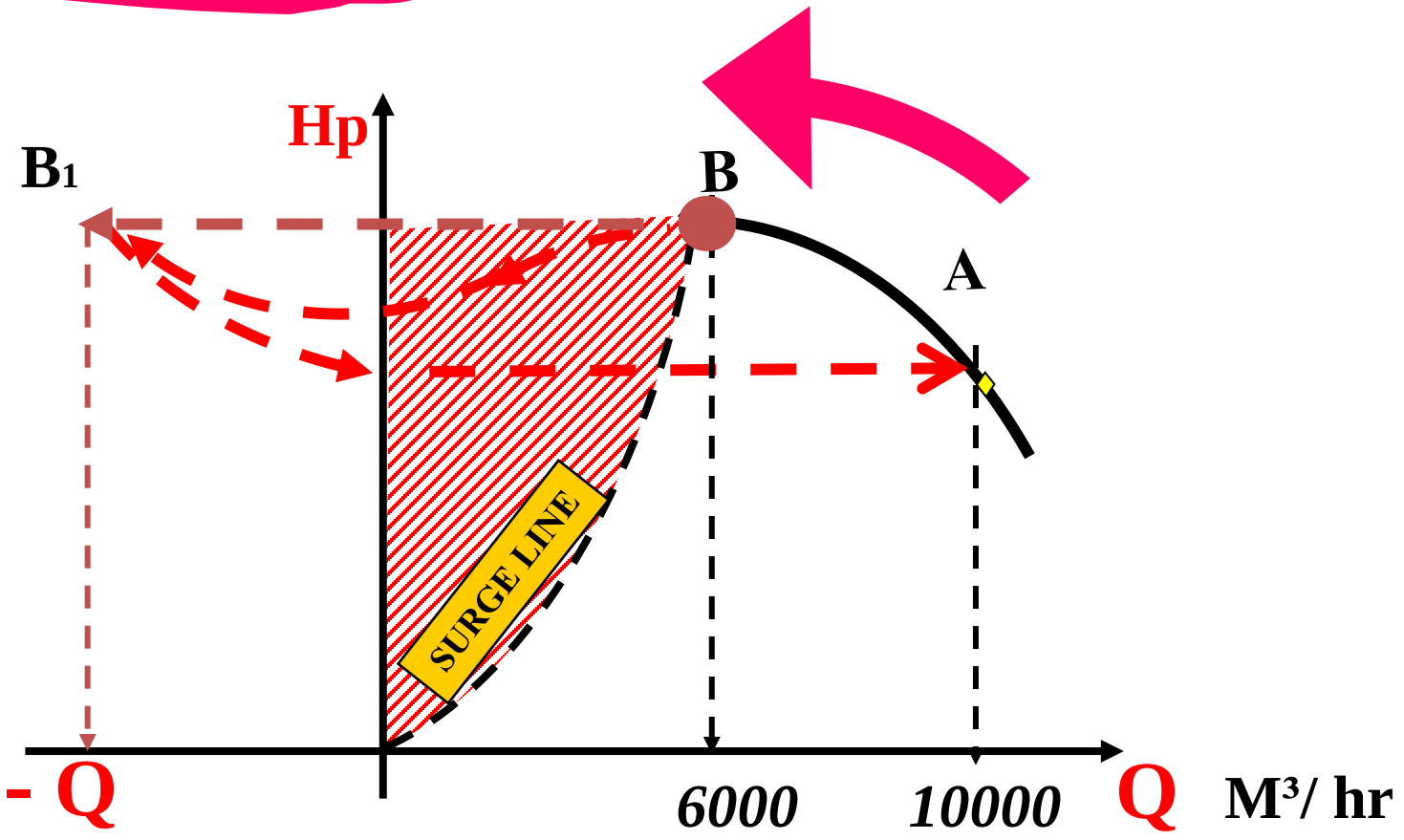
THRUST BEARINGS

THRUST BEARINGS



SURGE WILL DAMAGE THE COMPRESSOR THRUST BEARINGS

SURGE CYCLE



5 to 20 cycles per second

ANTI-SURGE METHODS

1- *BY PASS WITH ANTI - SURGE VALVE*

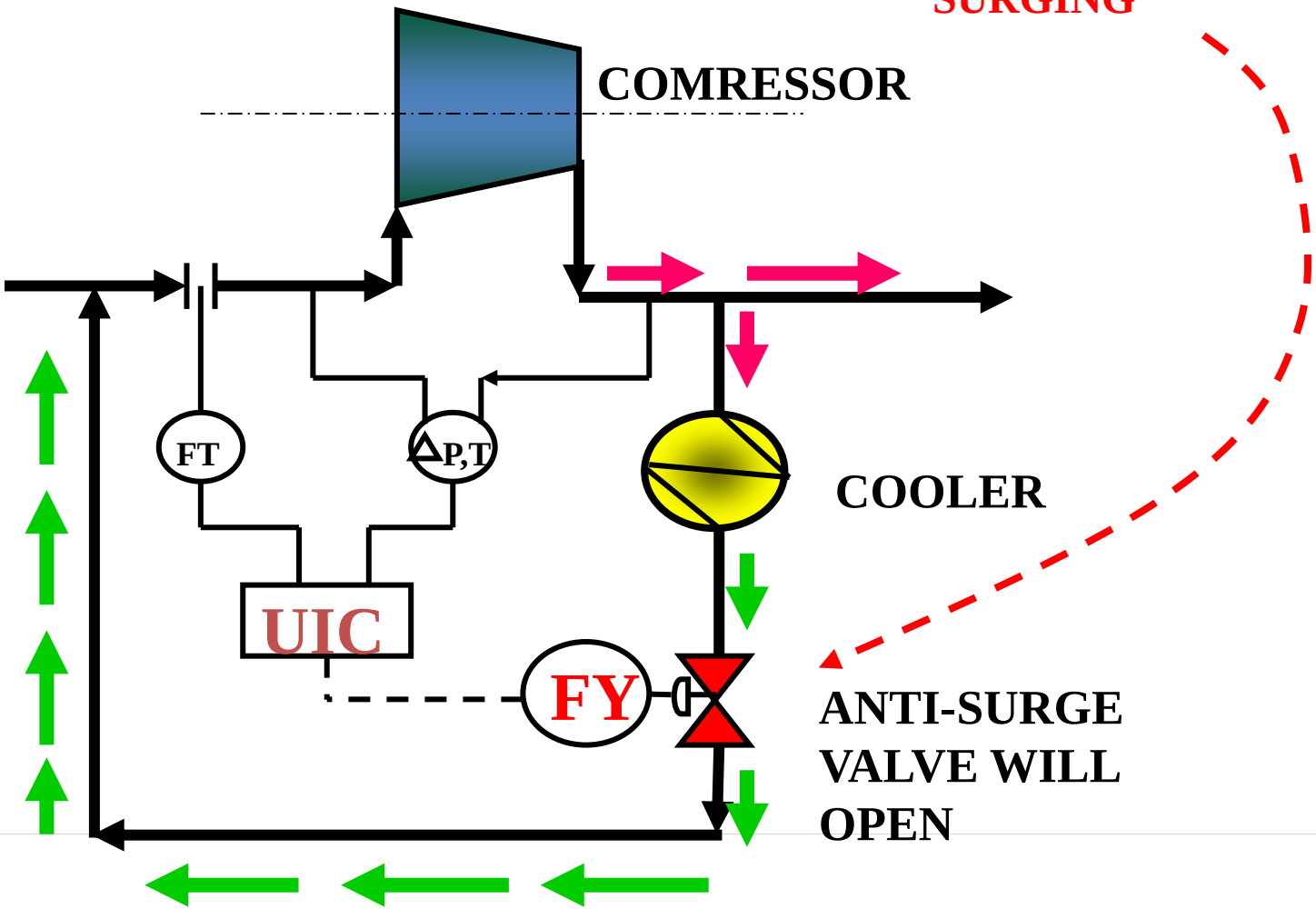
THIS METHODS IS COMMONLY USED FOR GAS COMPRESSORS

2 –*BLOW OFF VALVE*

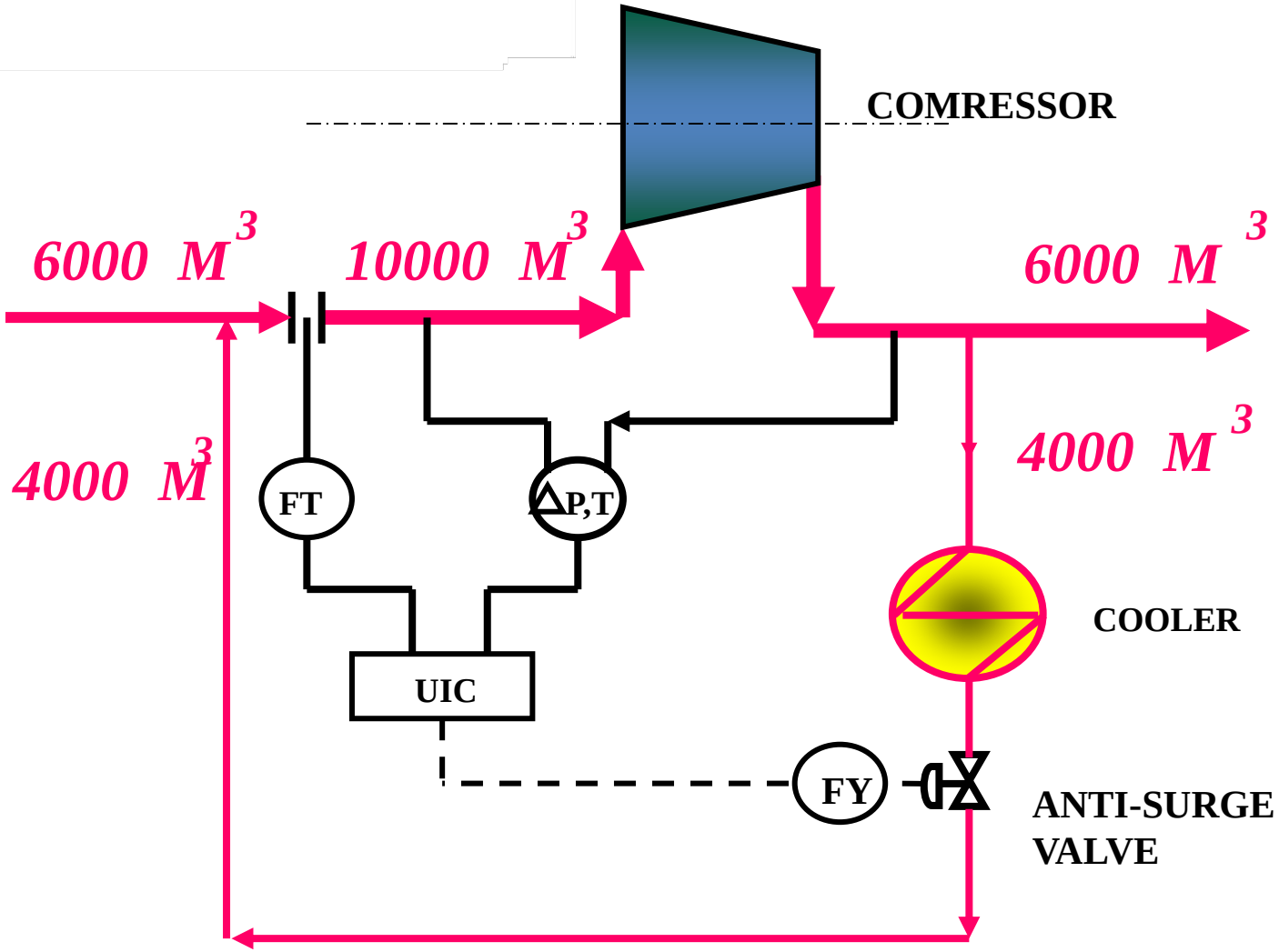
THIS METHODS IS COMONLY USED FOR AIR COMPRESSORS

ANTI-SURGE METHODS

1- *BY PASS WITH ANTI - SURGE VALVE*



1- BY PASS WITH ANTI - SURGE VALVE

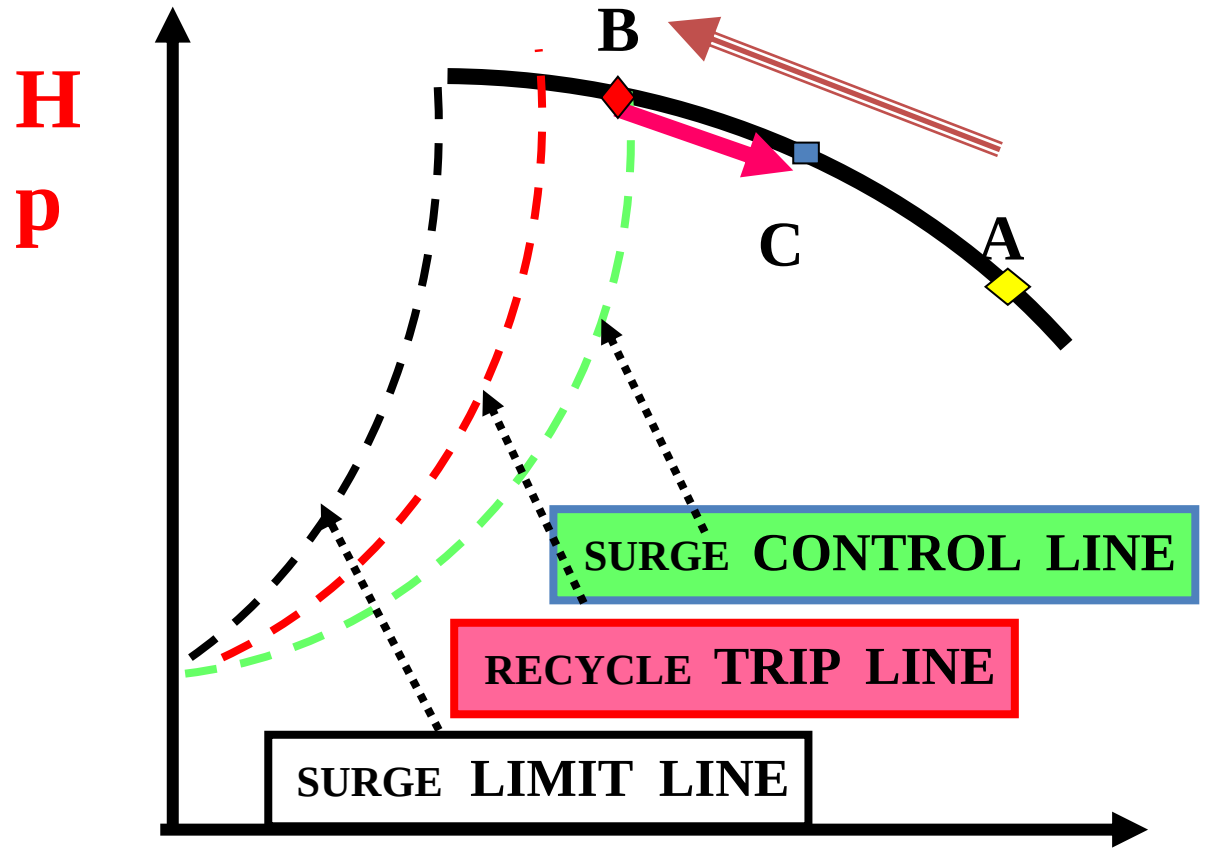


UIC = ANTI- SURGE INTEGRATED CONTROLER

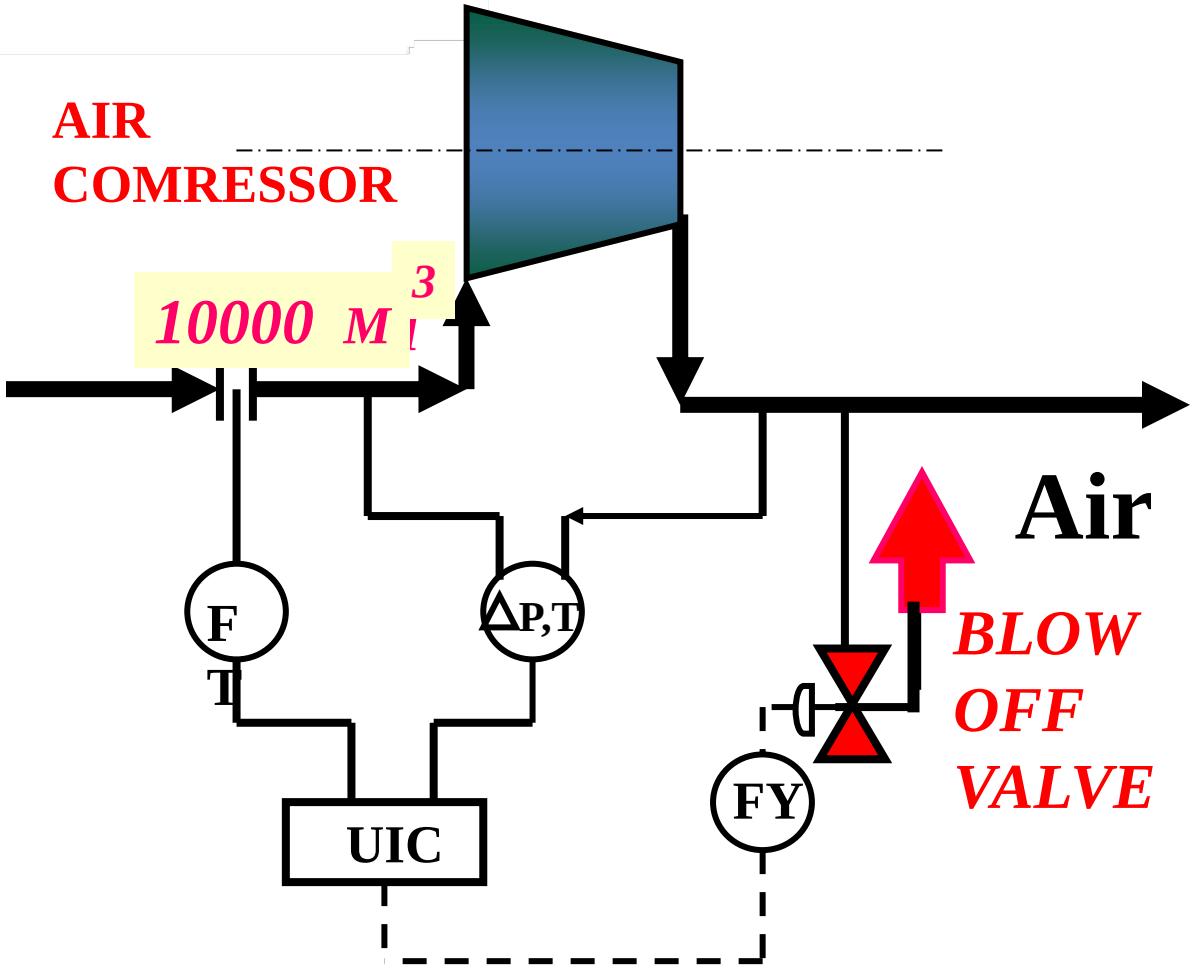
FY = TRANSDUCER

BY PASS WITH ANTI - SURGE VALVE

GRAPHICALLY



2 –BLOW OFF VALVE

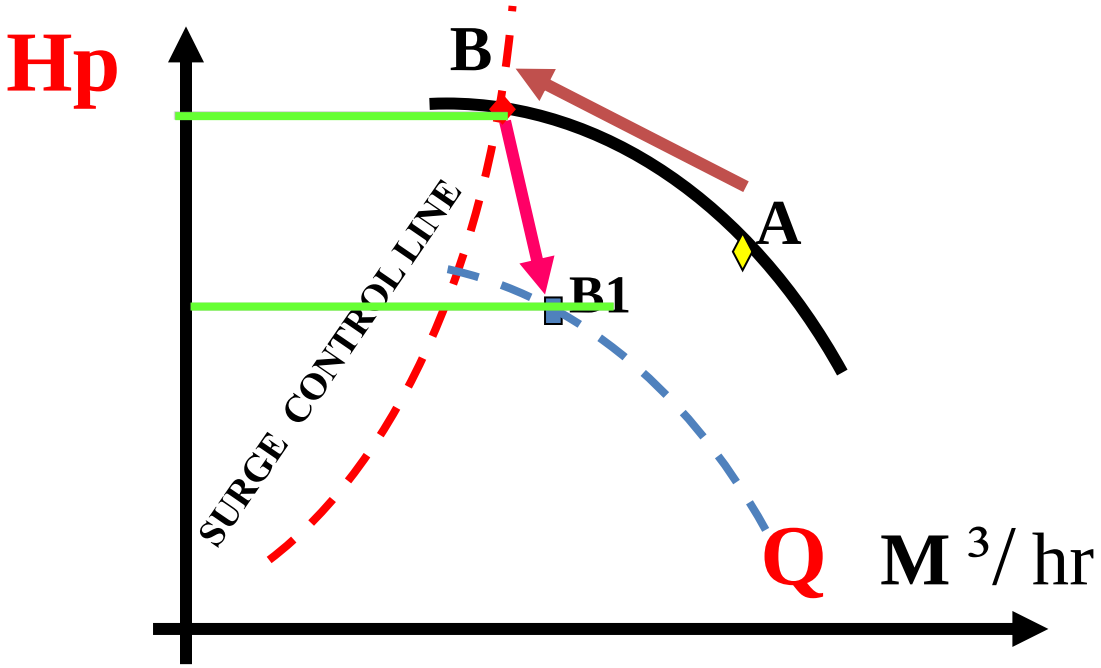


UIC = ANTI- SURGE INTEGRATED CONTROLLER

FY٤٥ = TRANSDUCER

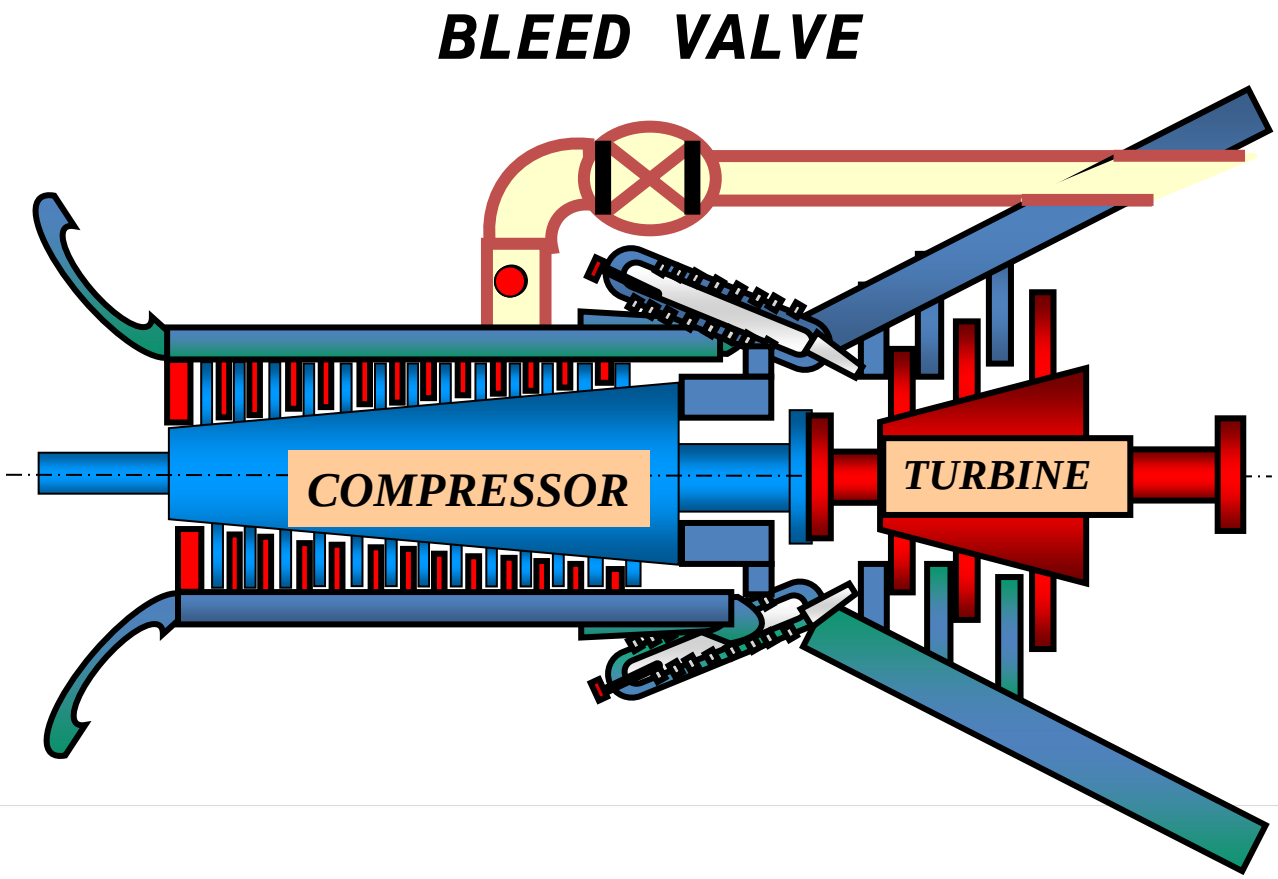
2 – BLOW OFF VALVE

GRAPHICALLY



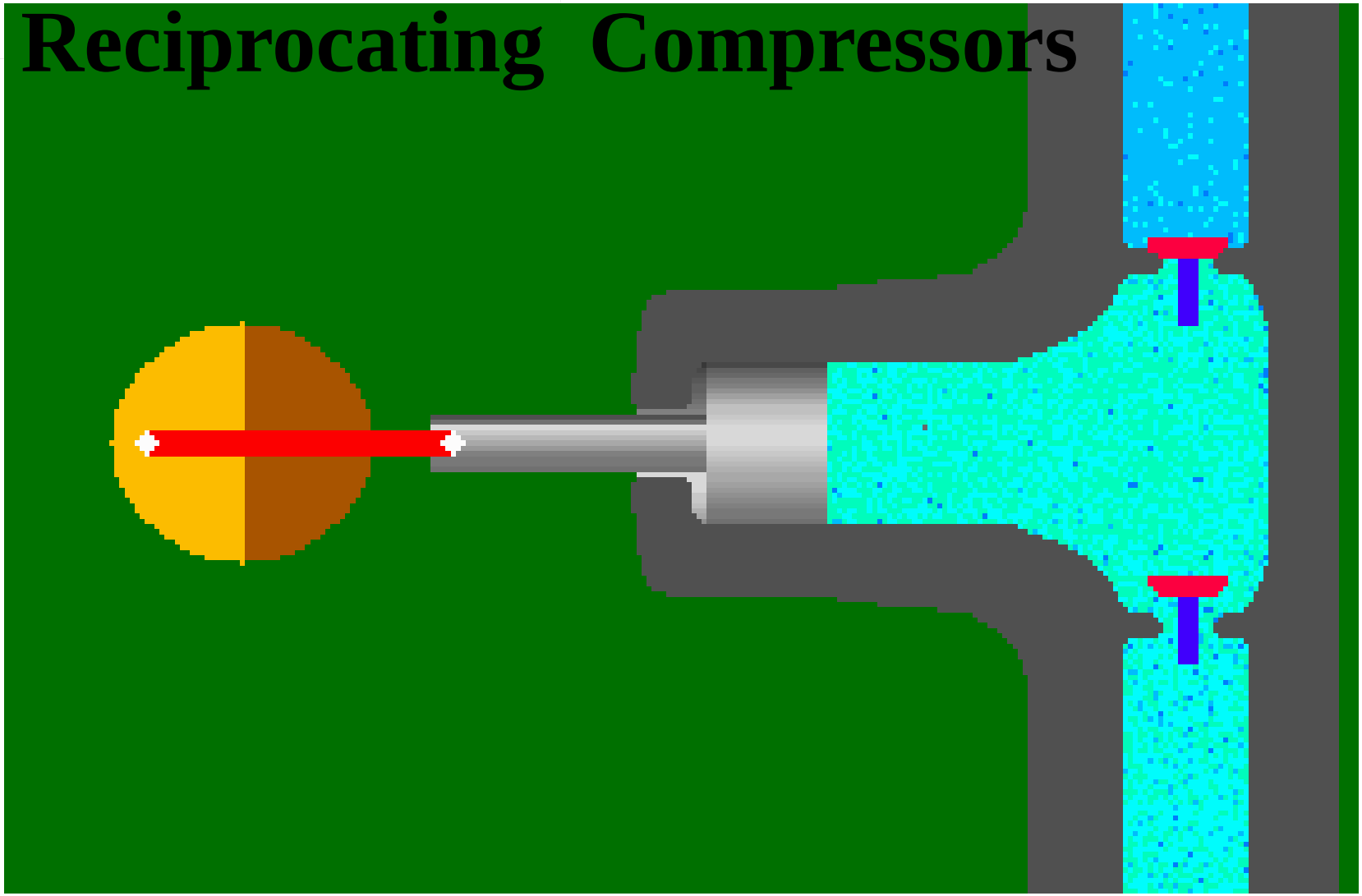
IN CASE OF GAS TURBINE AIR COMPRESSOR SURGE

BLEED VALVE WILL OPEN

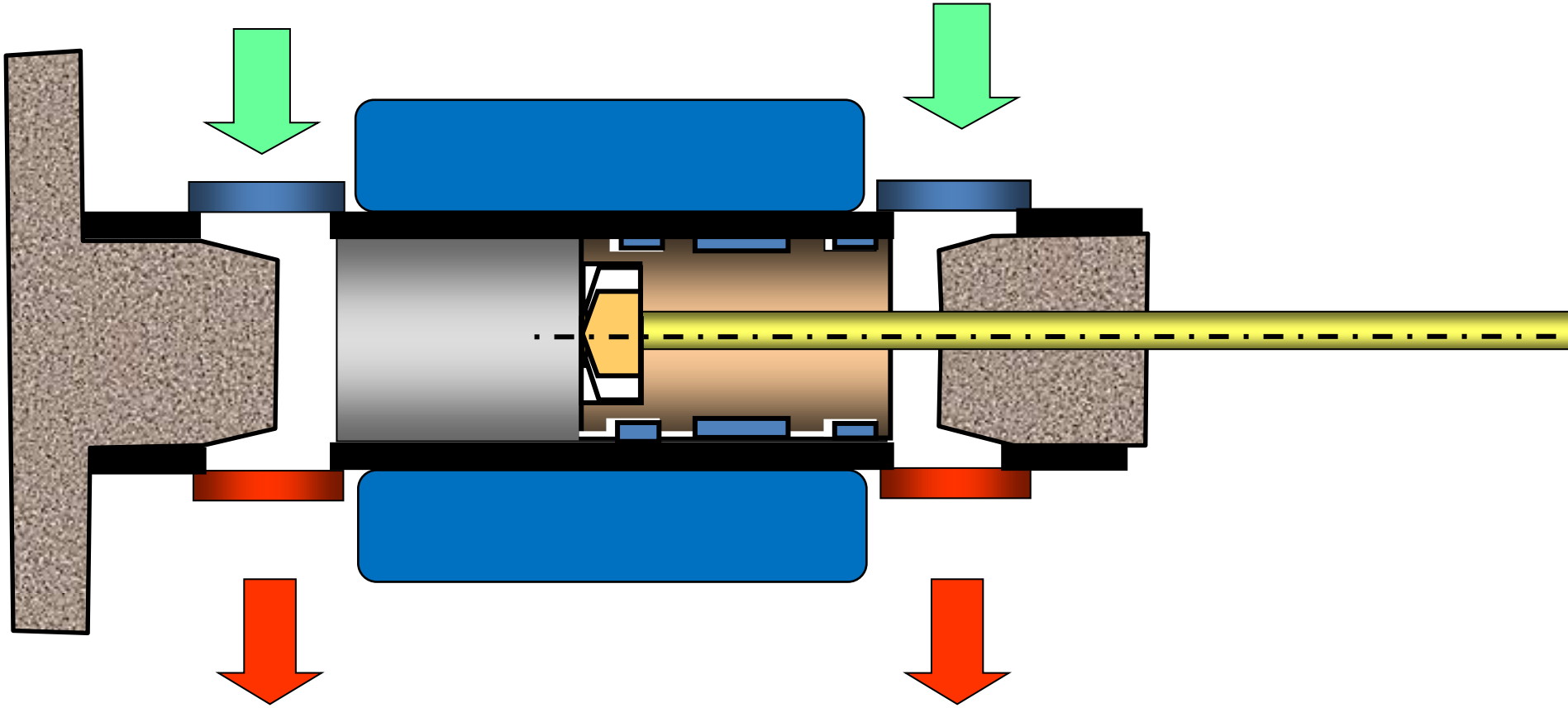


Positive Displacement Compressors

Reciprocating Compressors



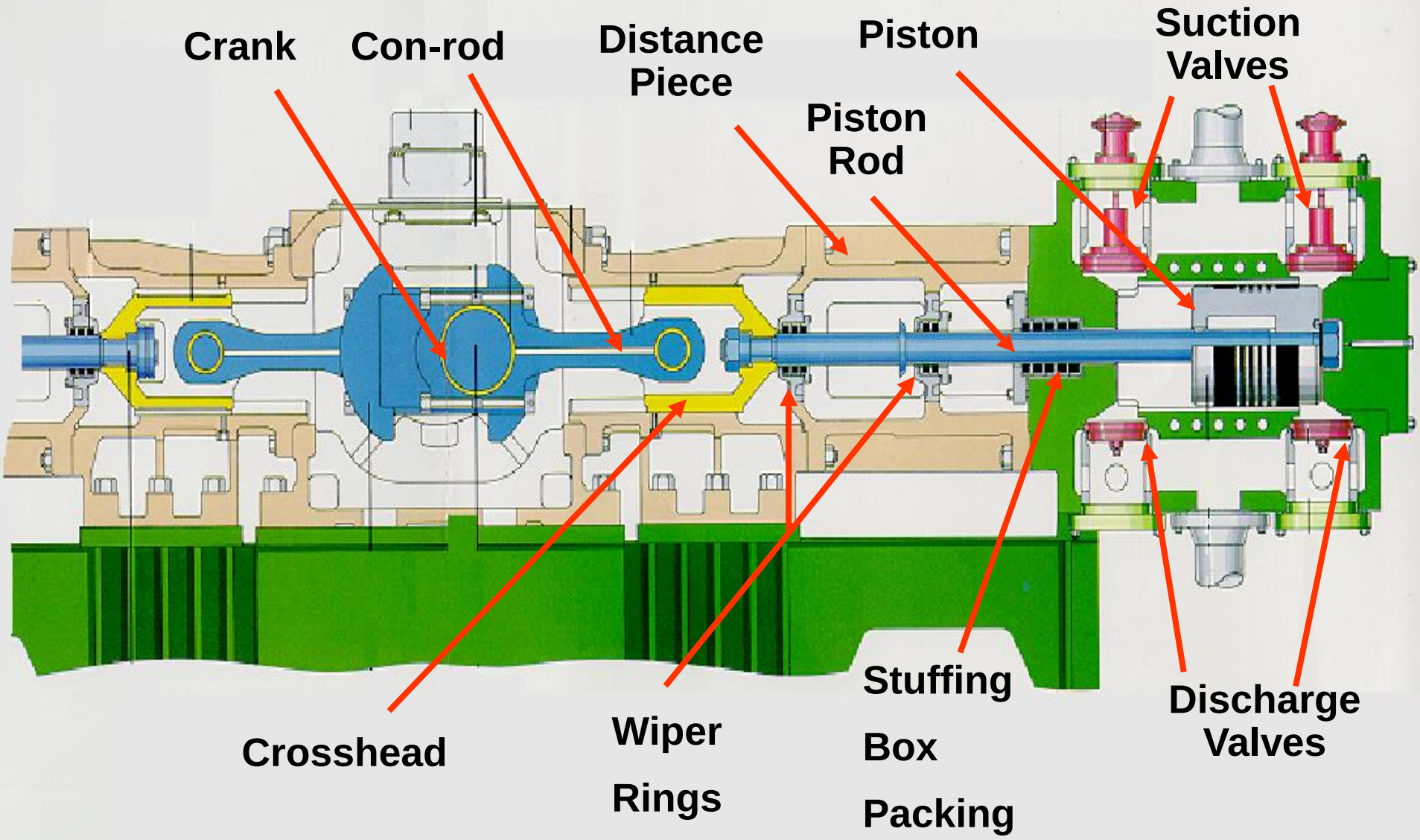
Reciprocating Compressors Construction



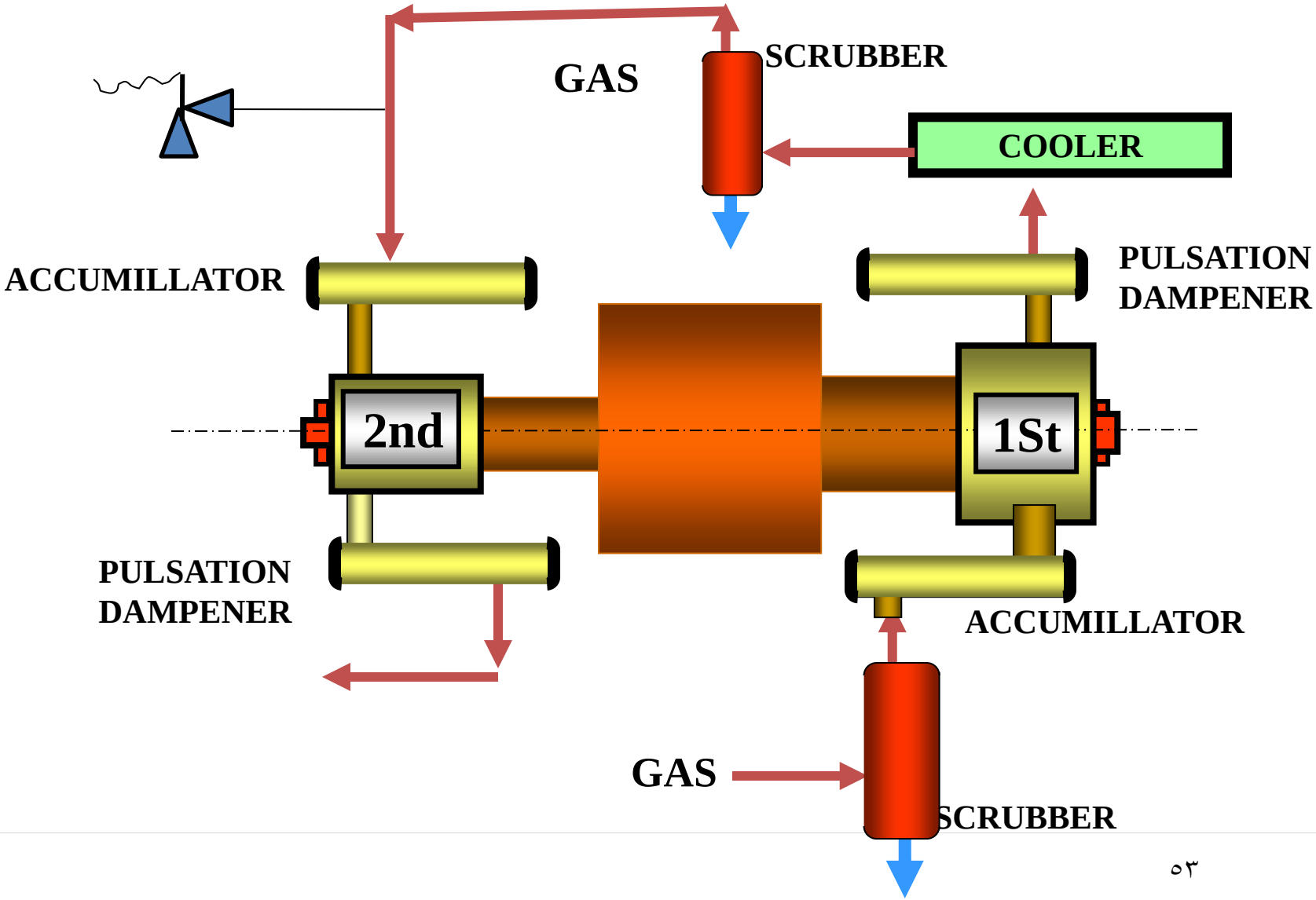
Reciprocating Compressors properties

- **Lower Power Density**
- **Low Speed (300–1800 rpm)**
- **Generally used in low volumetric rate applications (< 500 acfm [850 m^3/h])**
- **Higher maintenance**
- **Unaffected by changes in gas properties (MW, T)**
- **Most common driver – gas engine, electric motor**
- **Pulsating flow/vibration**

Reciprocating Compressors construction

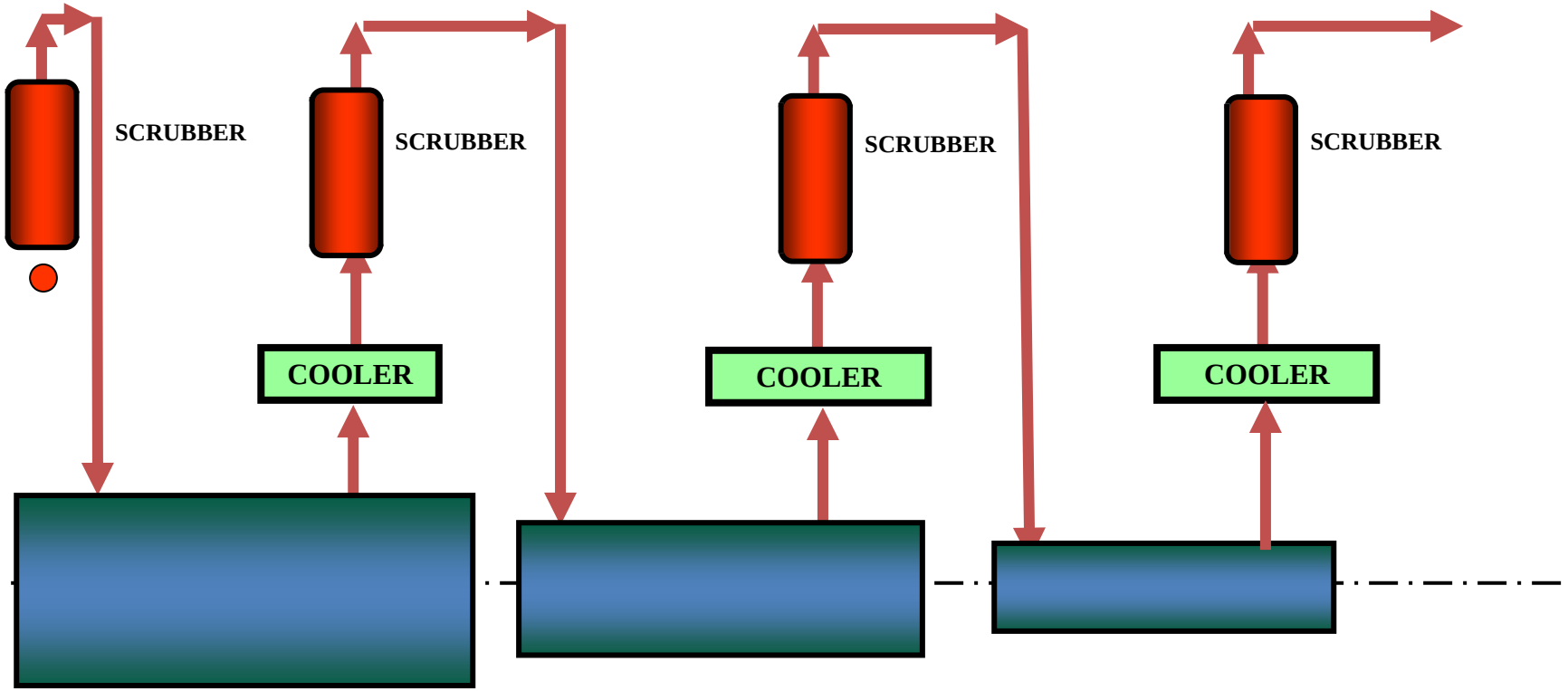


Multi stage reciprocating compressor

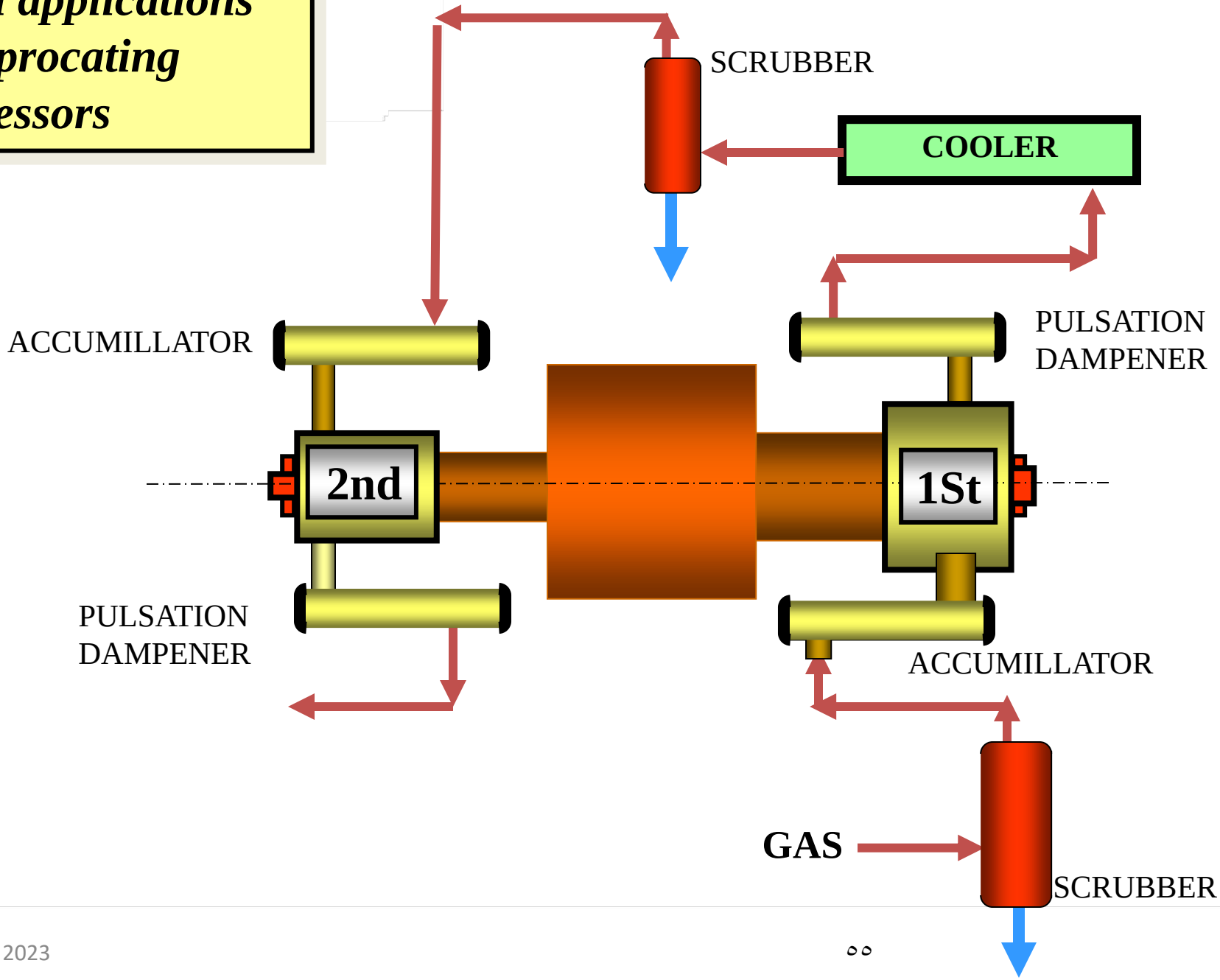


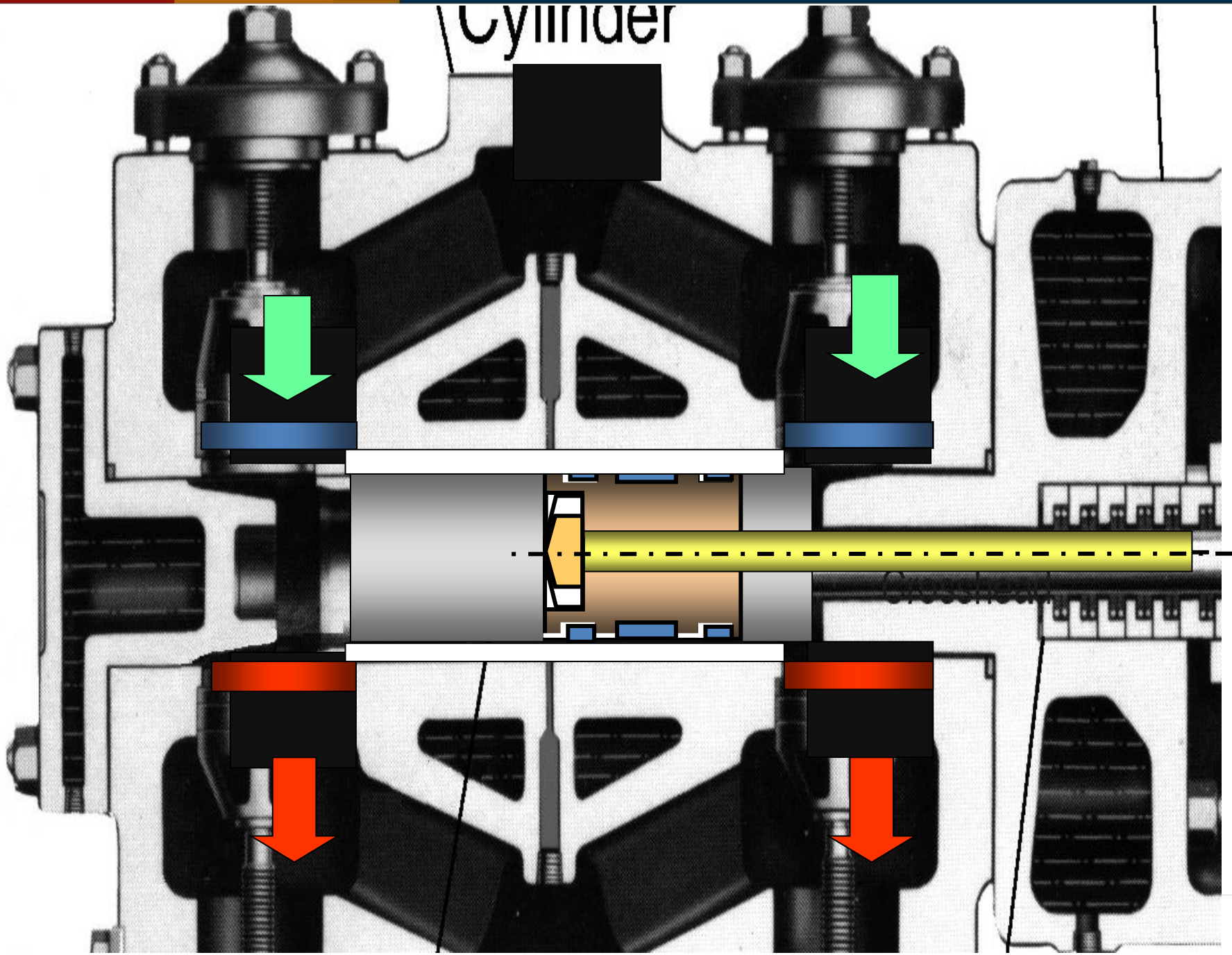
Multi stage reciprocating compressor

Compressors intermediate pressures



Design applications of reciprocating compressors




Cylinder

Reciprocating Compressors Flow Regulation

1- VARIABLE CLEARANCE

- Manual Operated Clearance
- Pneumatic Operated Clearance

2- SUCTION VALVE UNLOADERS

3- VARIABLE SPEED

4- BYPASS

5- Shut down the Compressor Periodically (Start-Stop Operation)

1- VARIABLE CLEARANCE

Manual Operated Clearance

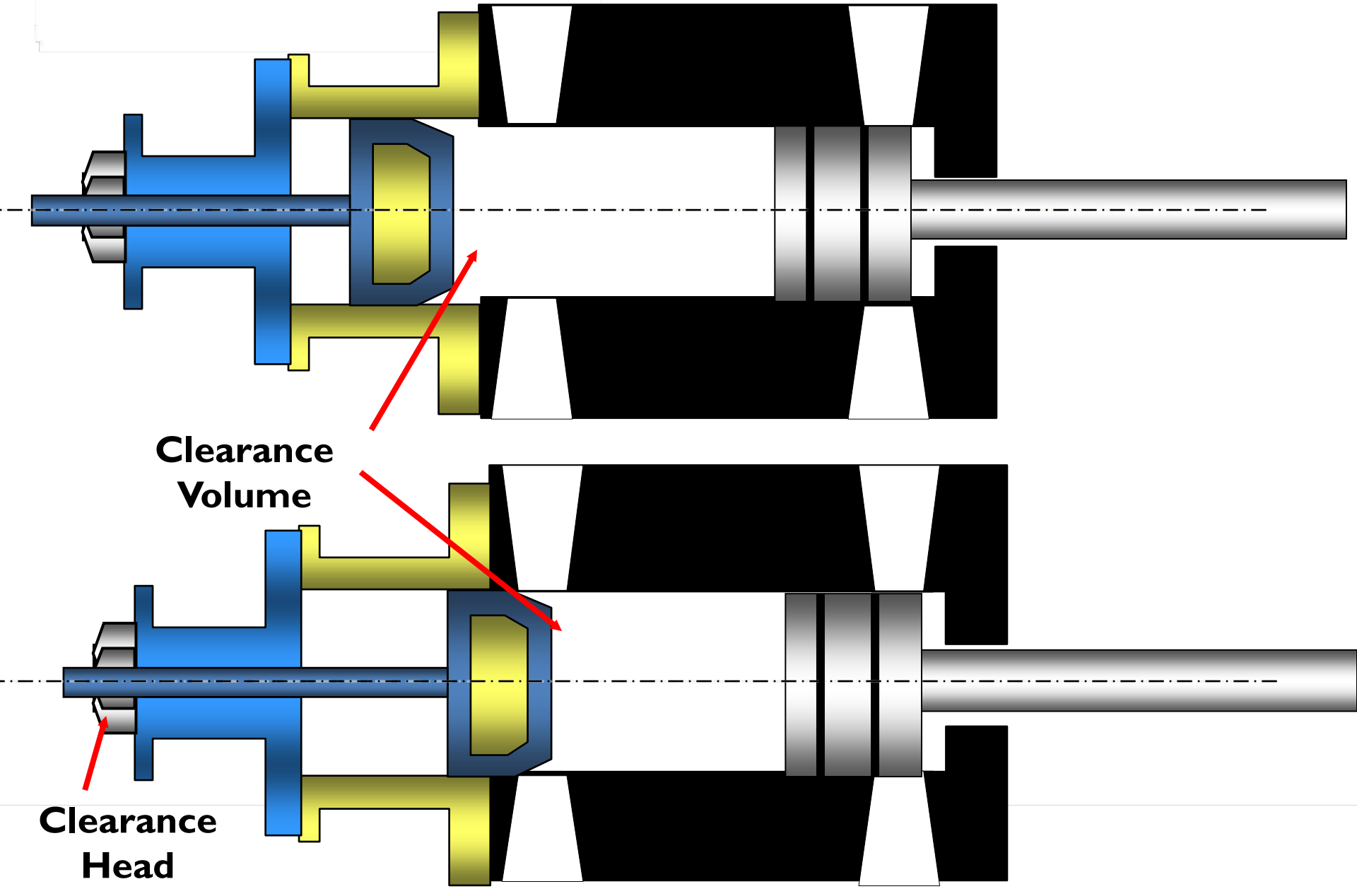
There is a clearance existed in the cylinder head.

A piston rod complete with an adjustable nut is connected to piston with packing to seal the clearance volume in font of the compressor piston.

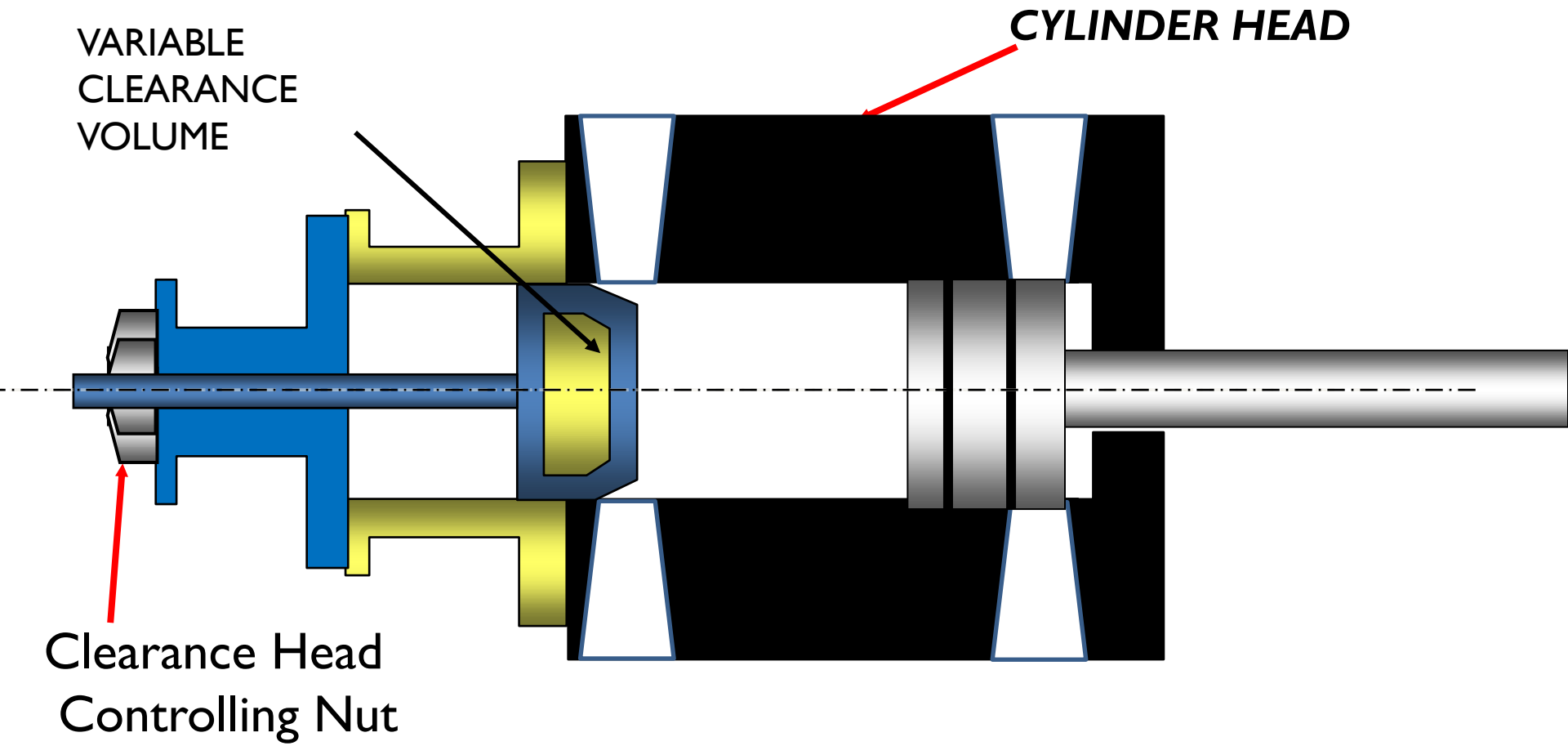
The more the clearance volume in font of the comp. piston, The less the compressor flow rate.

No effect of the clearance volume in font of the piston on the compressor discharge pressure.

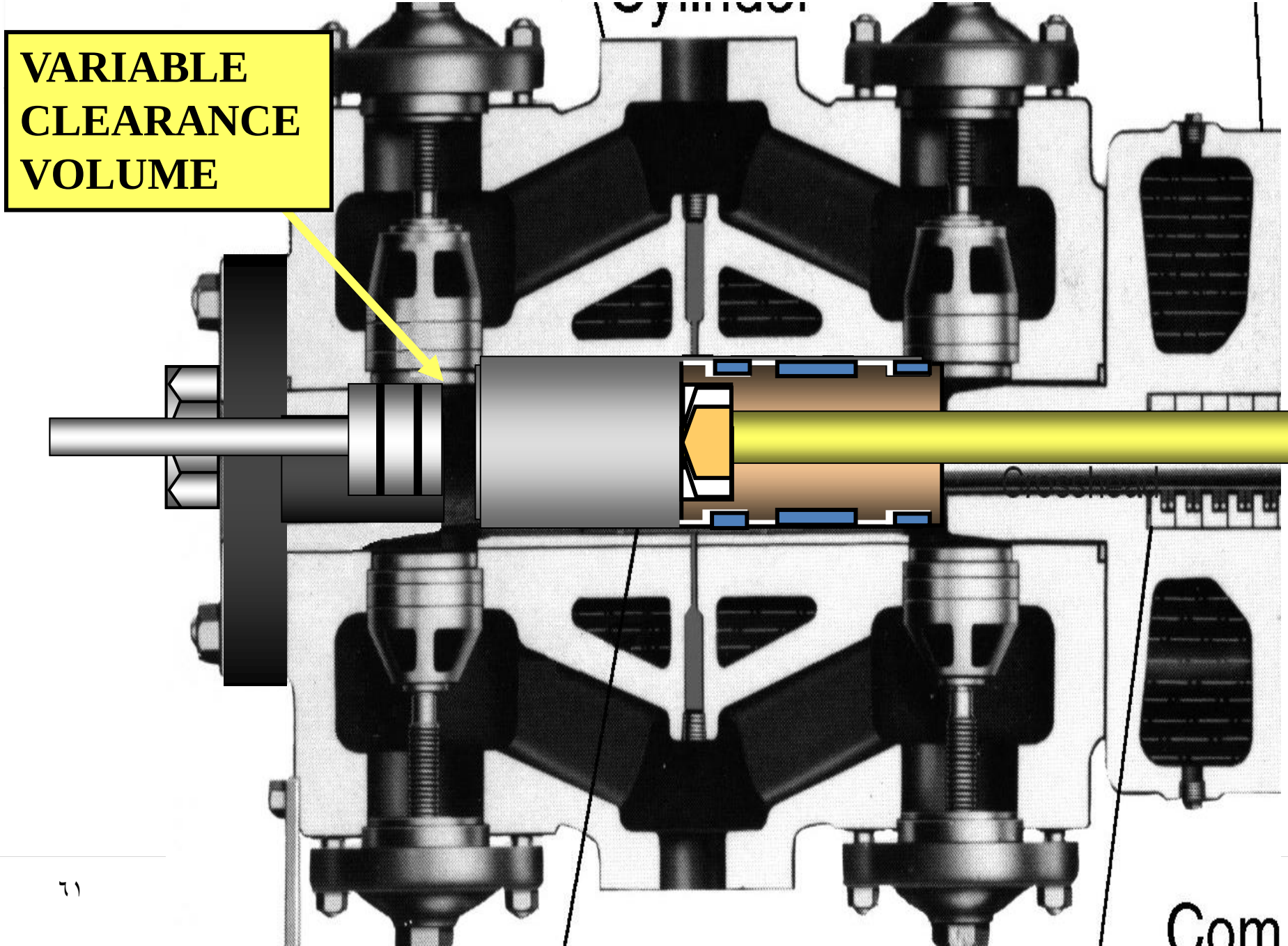
Clearance Volume Effect



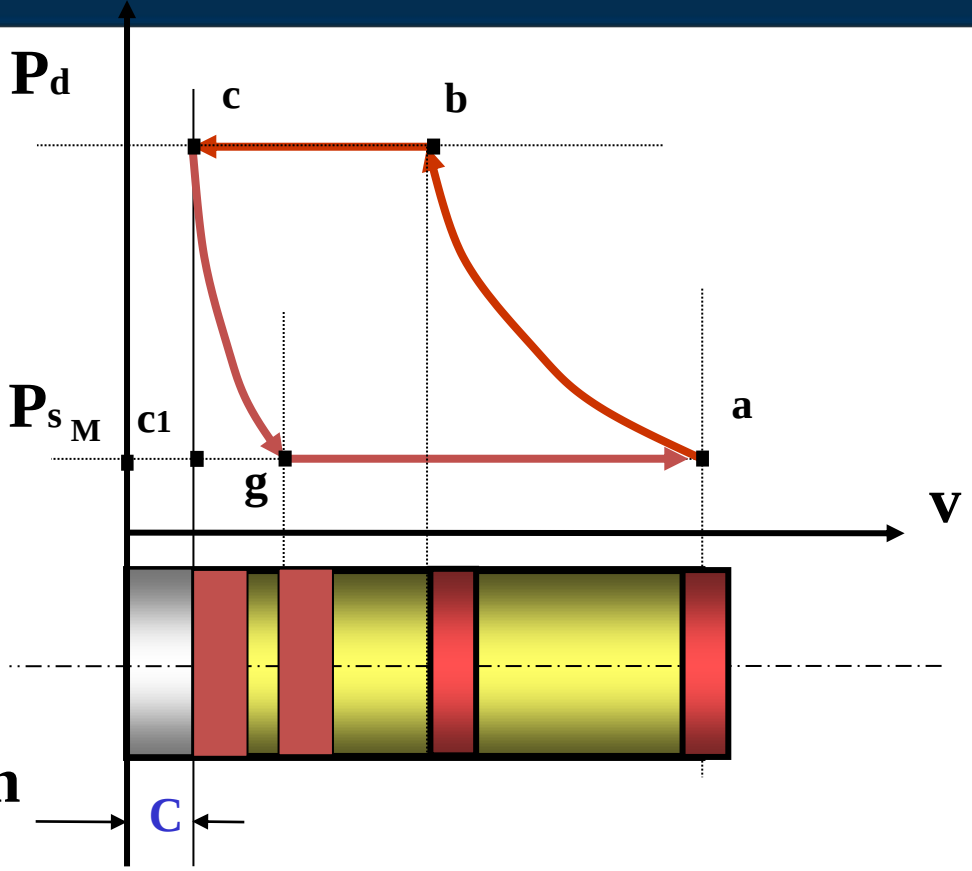
Clearance Volume Effect



Manual Operated Clearance


VARIABLE
CLEARANCE
VOLUME

EFFECT OF CLEARANCE VOLUME



At

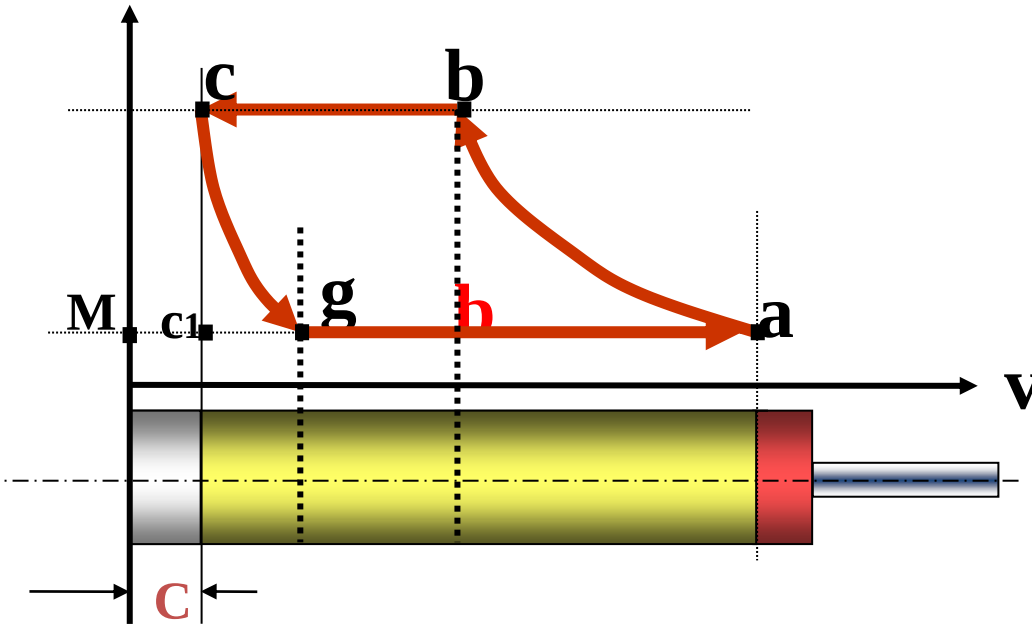
Point a suction valves closed

Point b discharge valves open

Point c discharge valves closed

Point g suction valves open

C = Clearance volume



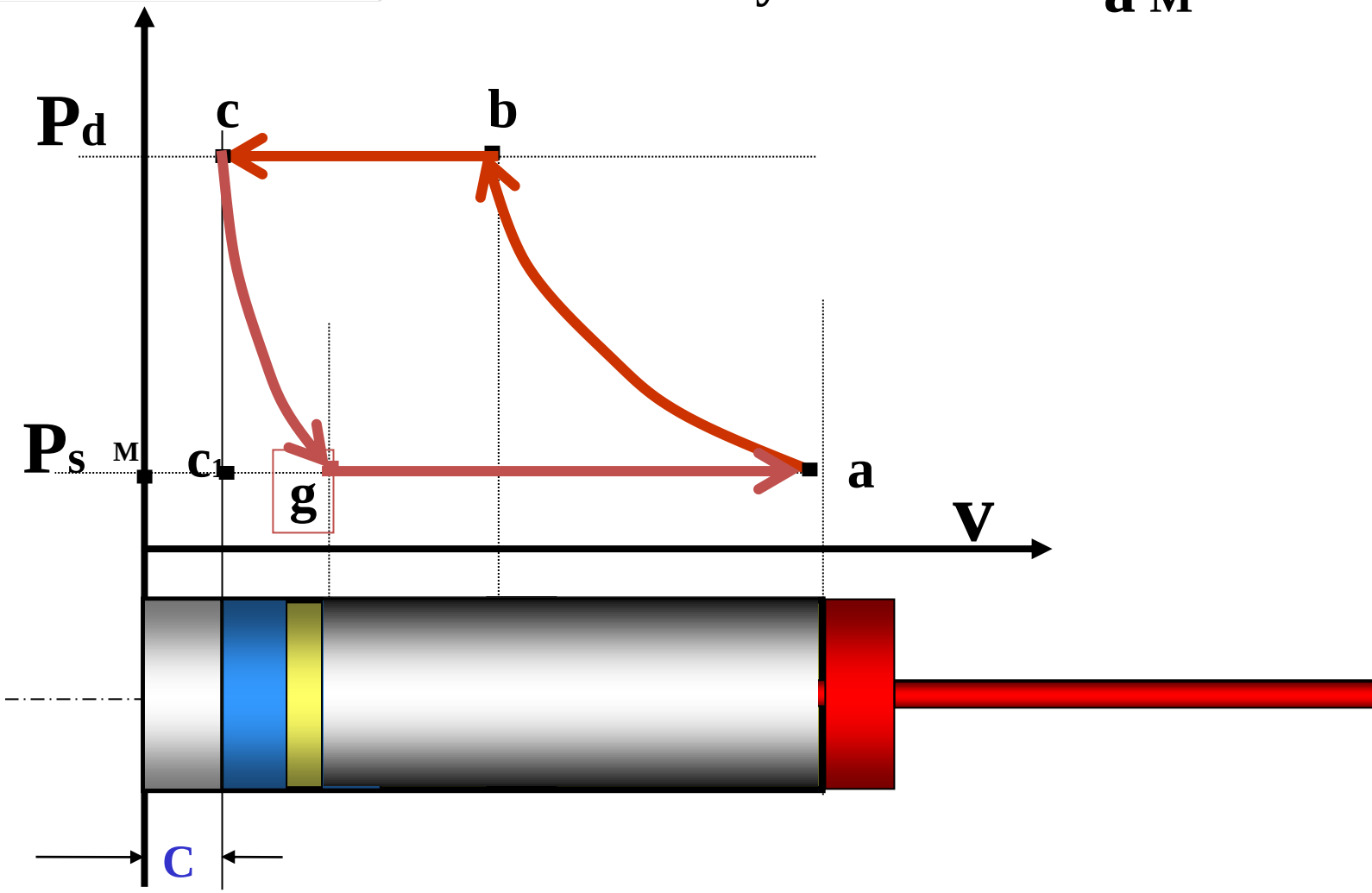
Pressure ratio $= \dfrac{P_d}{P_s}$ **(ABSOLUTE)**

Volumetric efficiency $= \dfrac{V_{ag}}{V_{cylinder}} = \dfrac{ag}{aM}$

Compression ratio $= \dfrac{V_{cylinder}}{V_{bM}} = \dfrac{aM}{bM}$

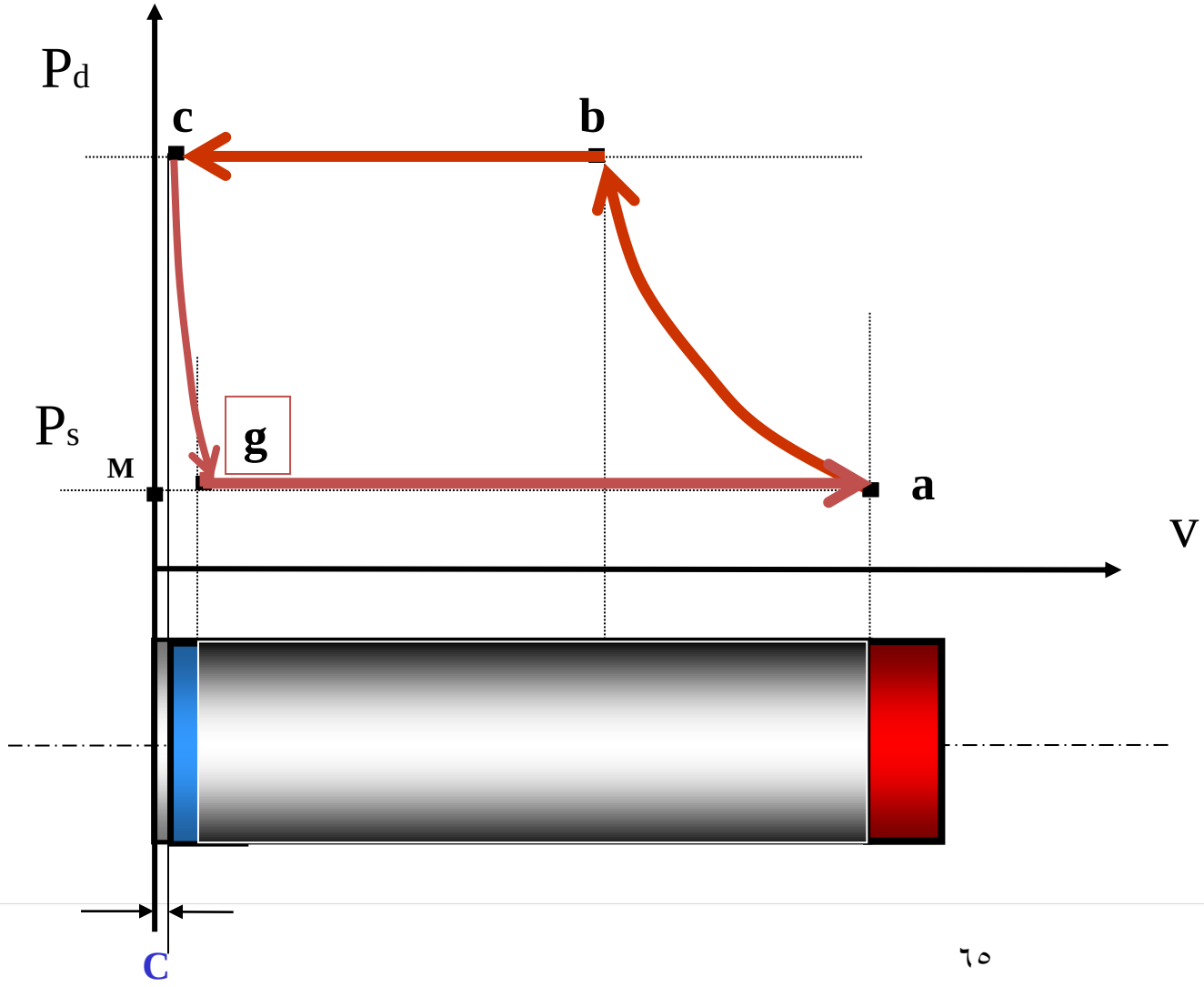
Volumetric efficiency

$$= \frac{V_{ag}}{V_{cylinder}} = \frac{ag}{aM}$$



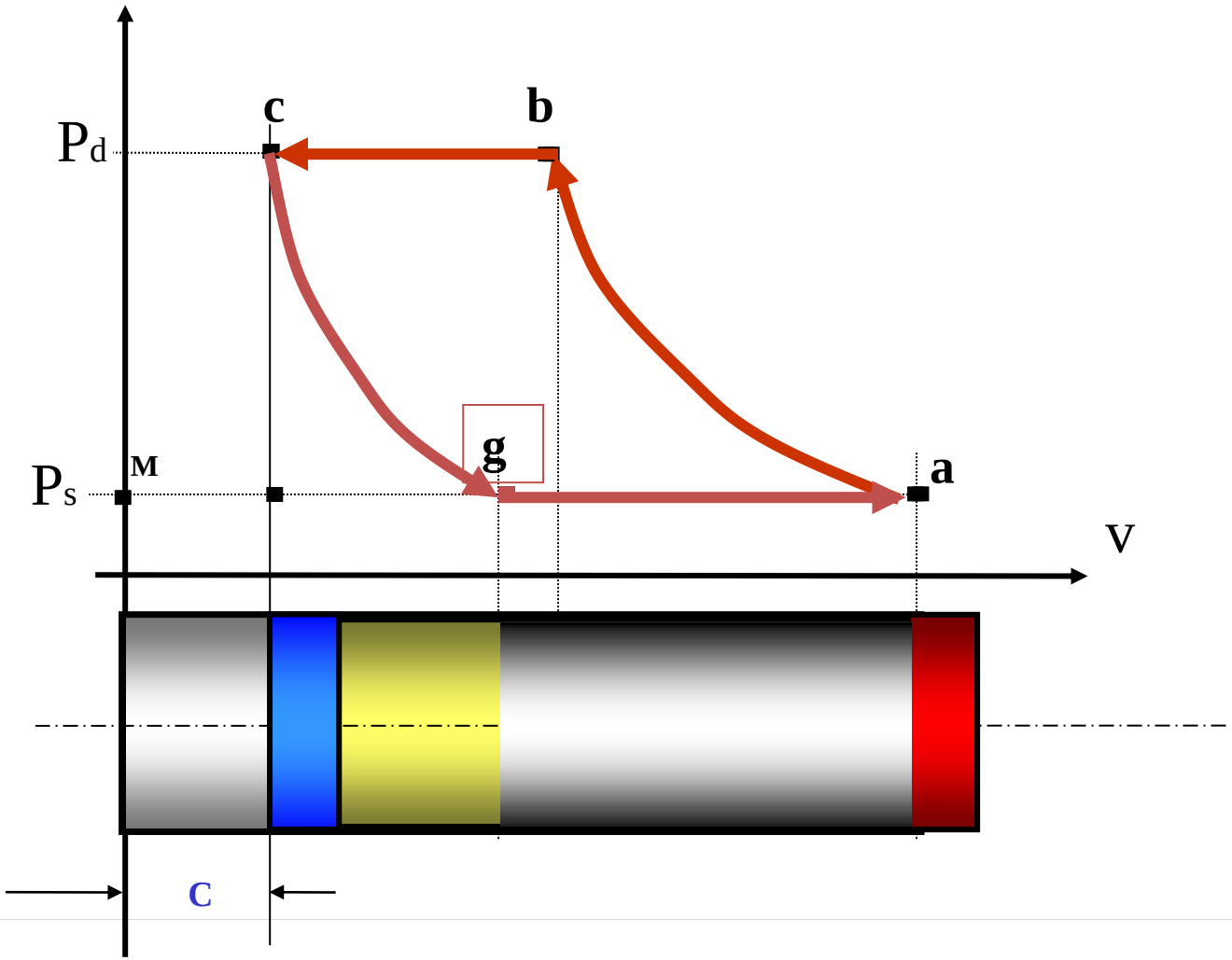
Volumetric efficiency

$$= \frac{V_{ag}}{V_{cylinder}} = \frac{ag}{aM}$$



Volumetric efficiency

$$= \frac{V_{ag}}{V_{cylinder}} = \frac{a\,g}{a\,M}$$

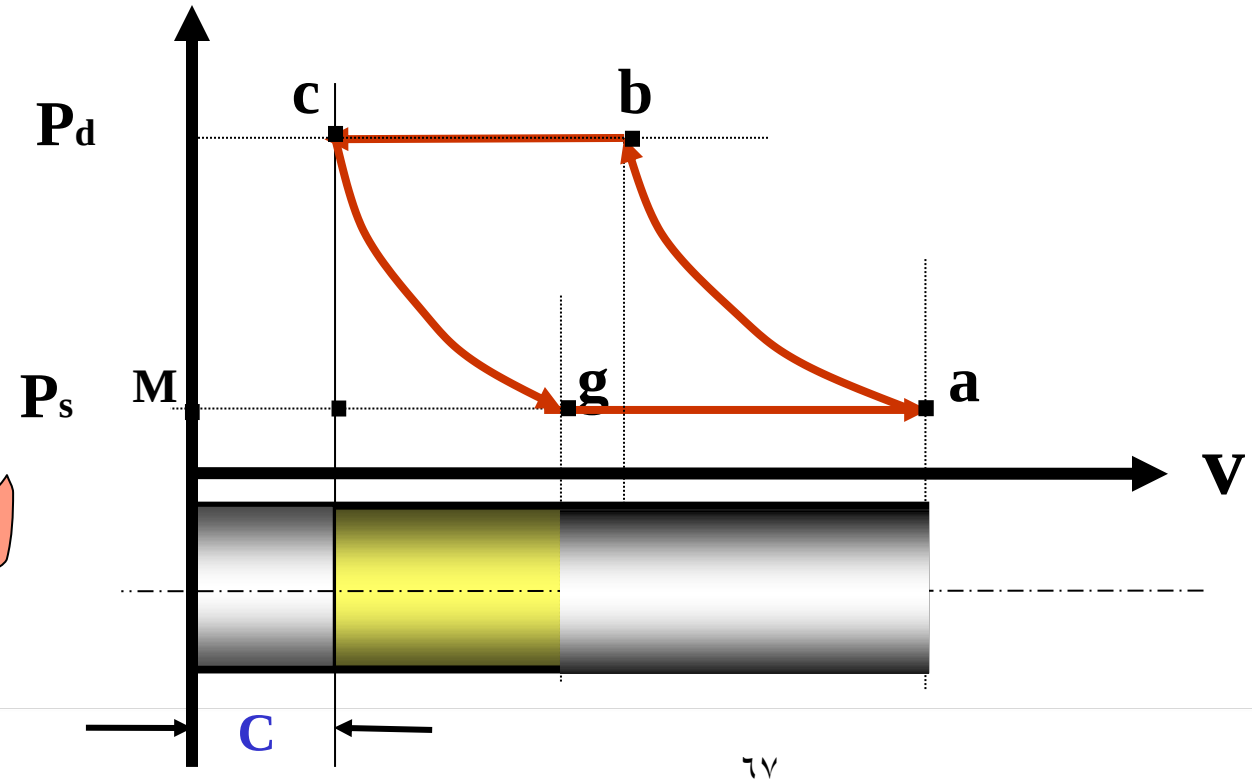


If C Increased suction valves will open at (g)

Volumetric efficiency $= \dfrac{V_{ag}}{V_{cylinder}} = \dfrac{ag}{aM}$

EV DECREASES

Q DECREASES

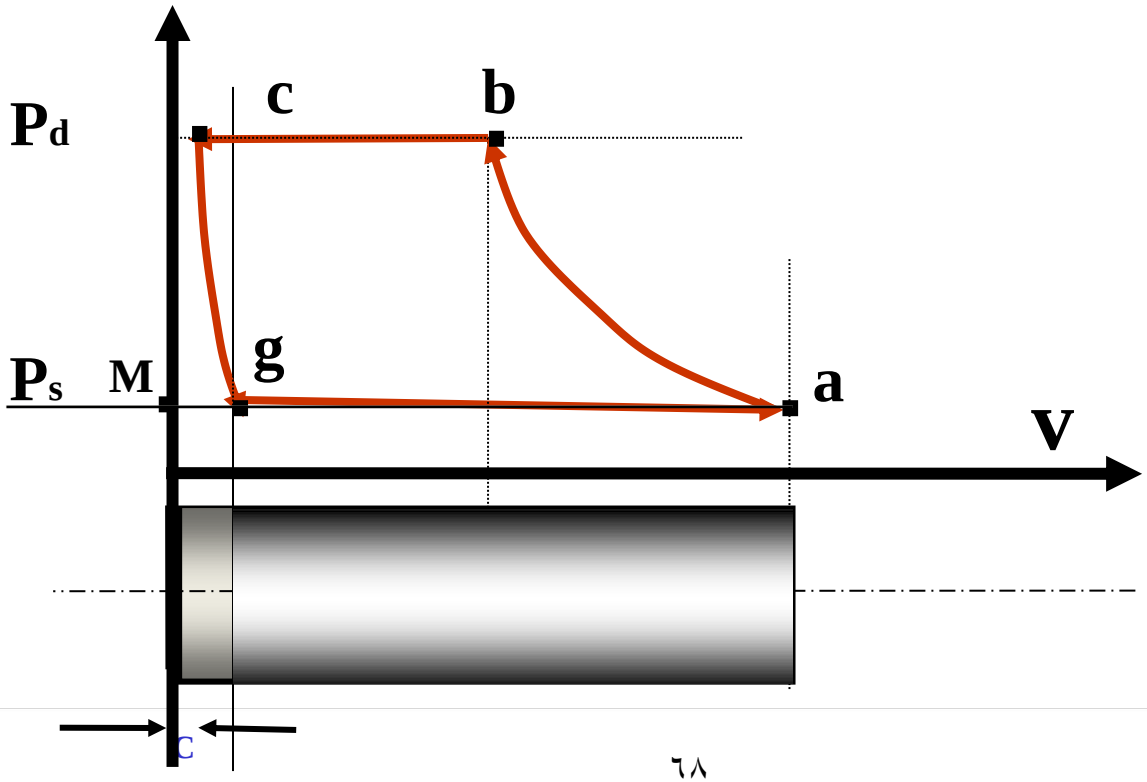


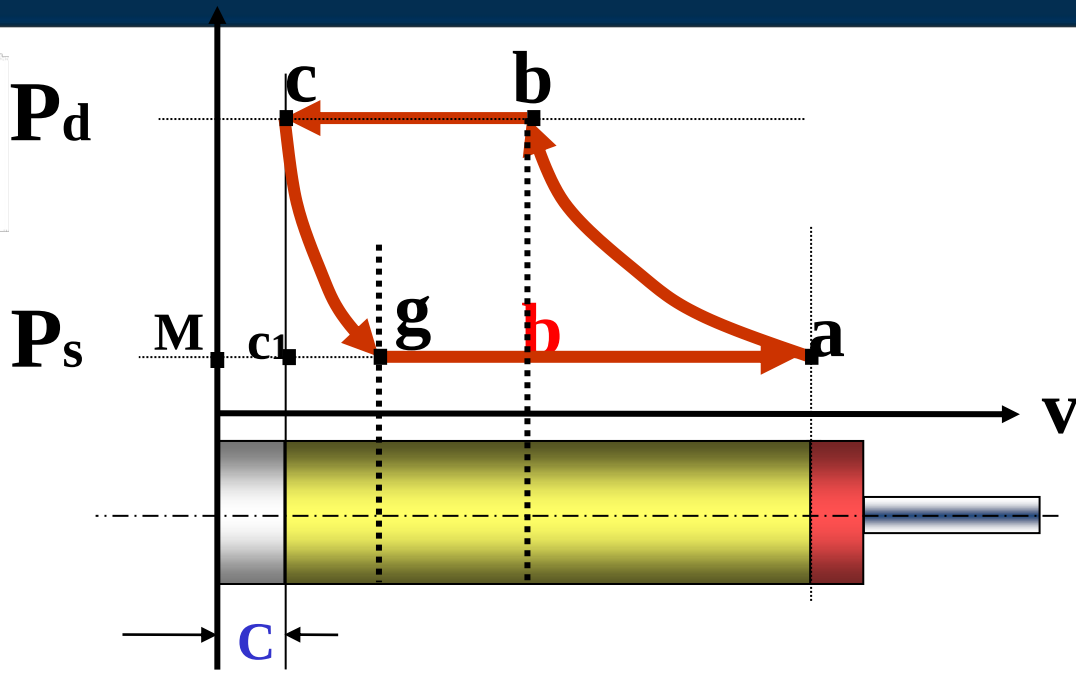
If C Decreased suction valves will open at (g)

Volumetric efficiency $= \dfrac{V_{ag}}{V_{cylinder}} = \dfrac{ag}{aM}$

EV INCREASES

Q INCREASES





Pressure ratio $= \dfrac{P_d}{P_s}$ **(ABSOLUTE)**

Volumetric efficiency $= \dfrac{V_{ag}}{V_{cylinder}} = \dfrac{ag}{aM}$

Compression ratio $= \dfrac{V_{cylinder}}{V_{bM}} = \dfrac{aM}{bM}$

• SUCTION VALVE UNLOADERS

There are an unloaders existed on suction valves of the compressor and pneumatically operated

If the unloaders energized, the suction valves will be opened.

If there are 4 suction valves and the unloaders are energized for :

1- One suction valve (Capacity will be ¾ max. Q)

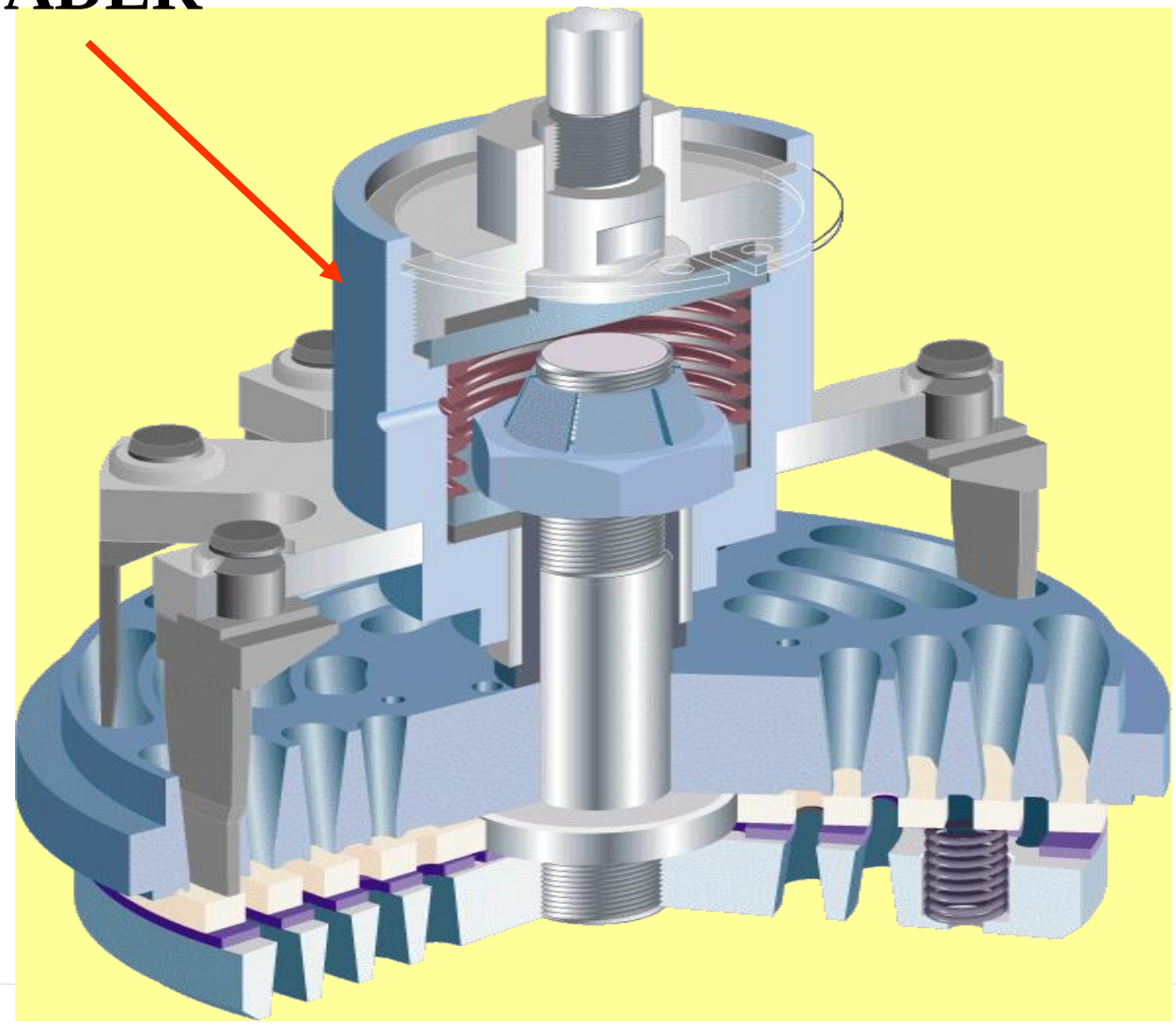
2- Two suction valve (Capacity will be ½ max. Q)

3- Three suction valve (Capacity will be ¼ max. Q)

4- Four suction valve (Capacity will be = 0 Q)

SUCTION VALVE

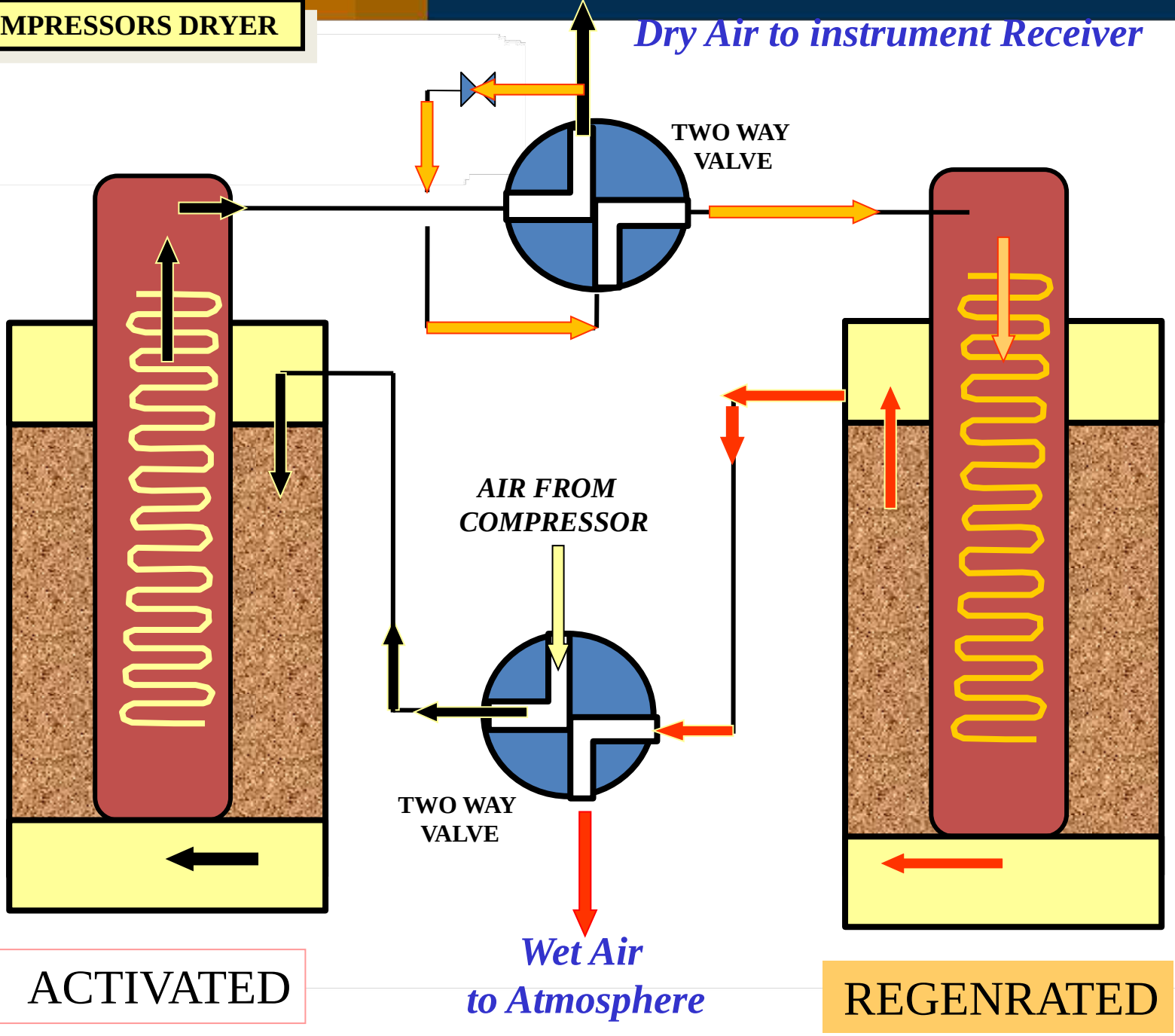
UNLOADER



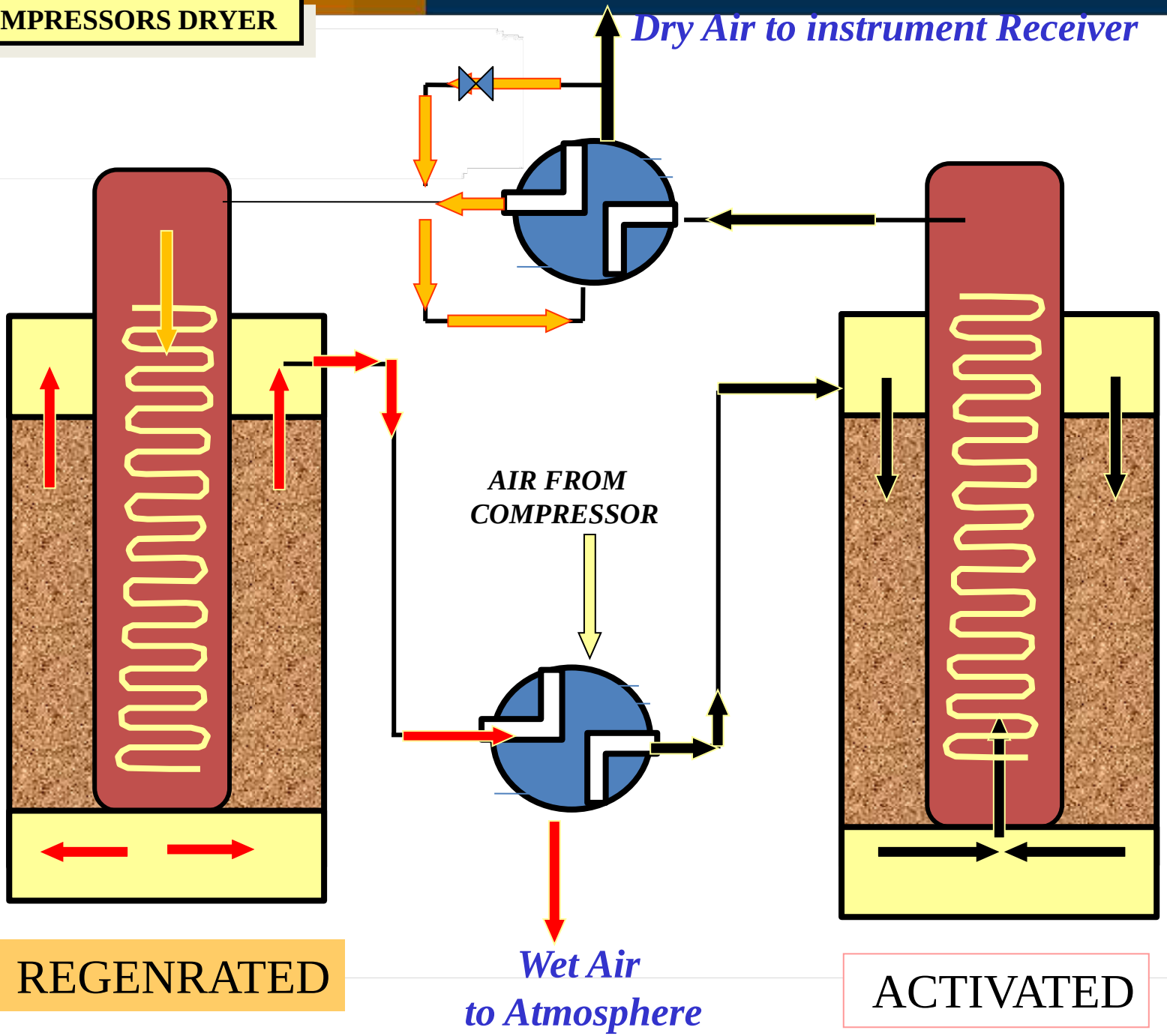
Air Compressor Dryer

https://www.youtube.com/watch?v=6tVw9VYQDIg

AIR COMPRESSORS DRYER



AIR COMPRESSORS DRYER



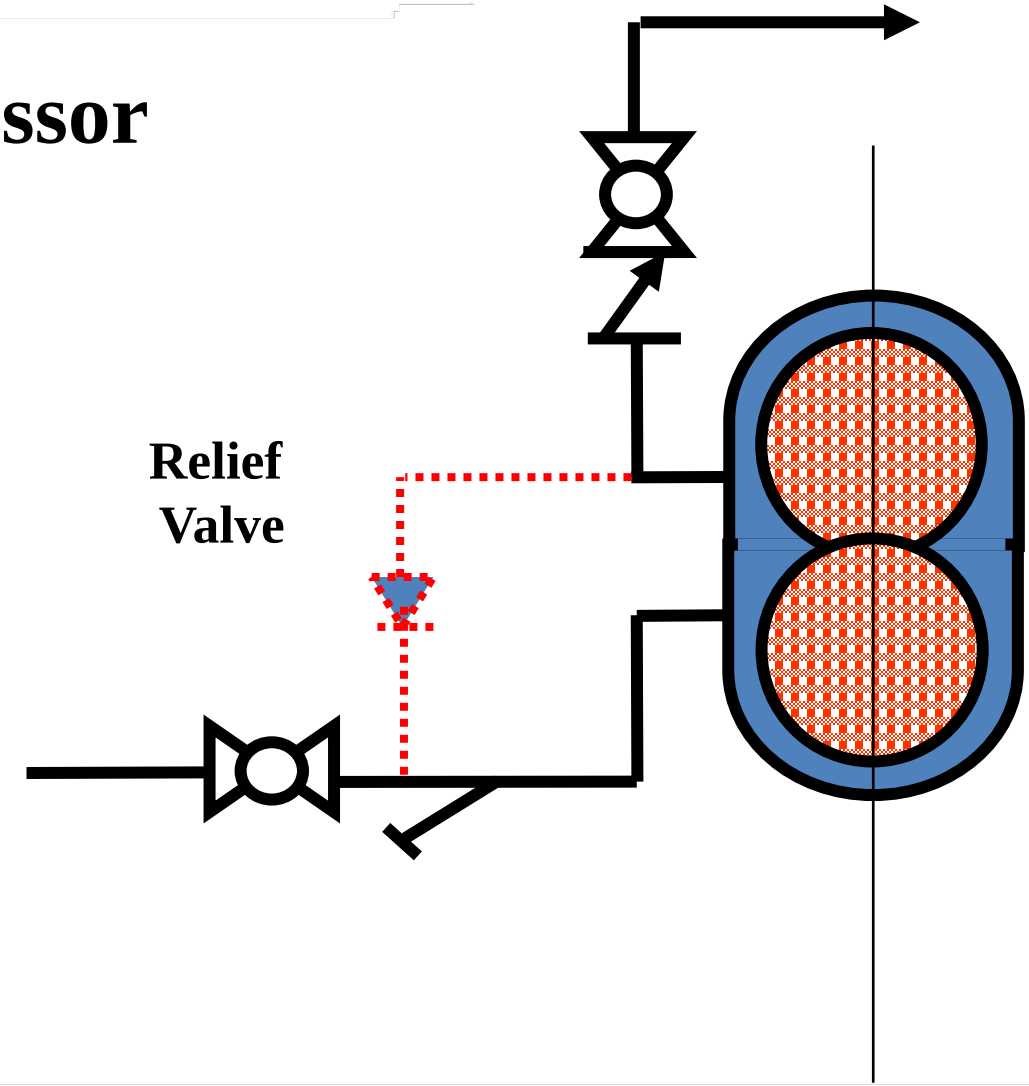
Reciprocating Compressor Operations

https://www.youtube.com/watch?v=ooBJMI0H7PQ

Discussion

Rotary Compressors

Rotary Compressor

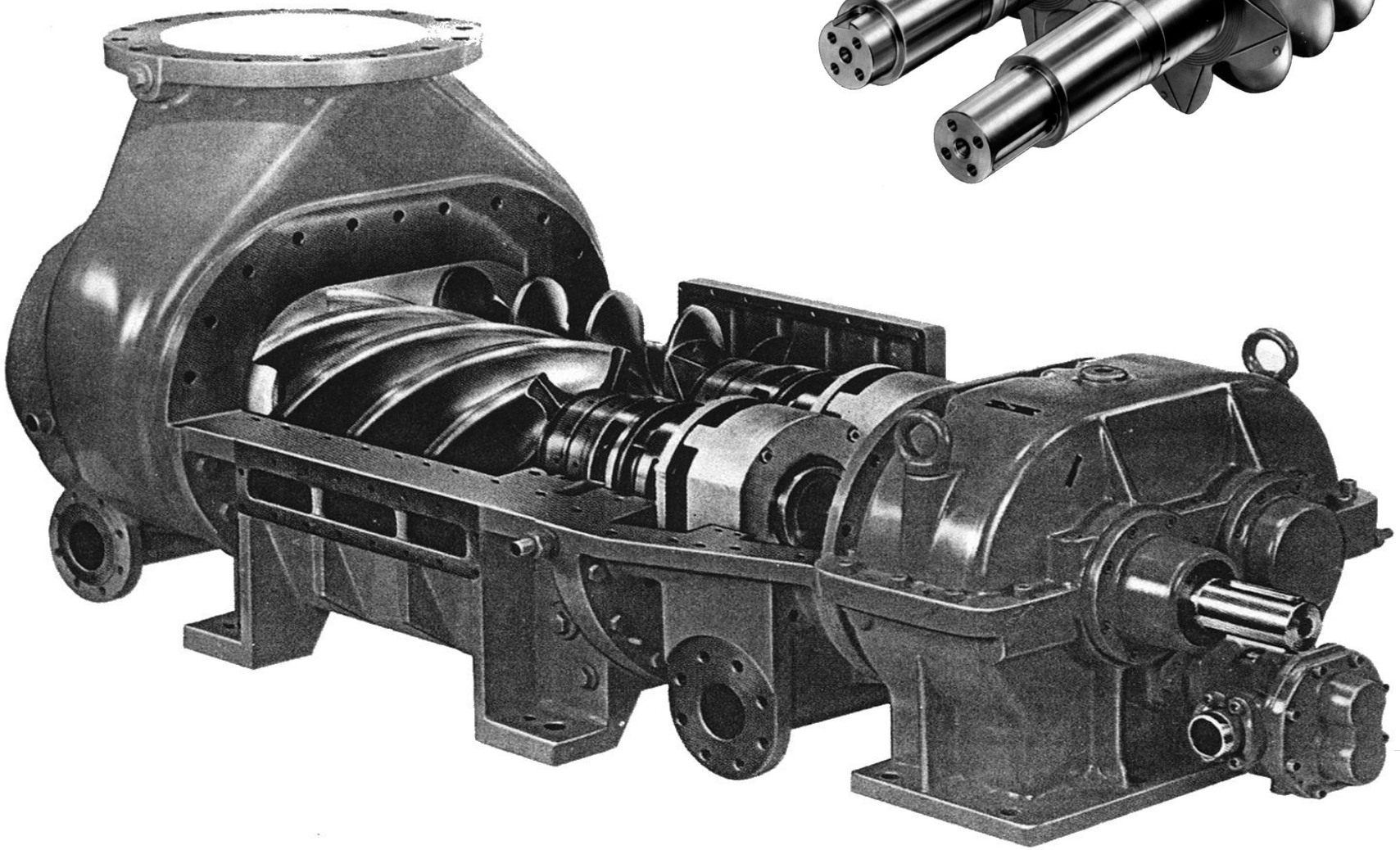


Screw compressor

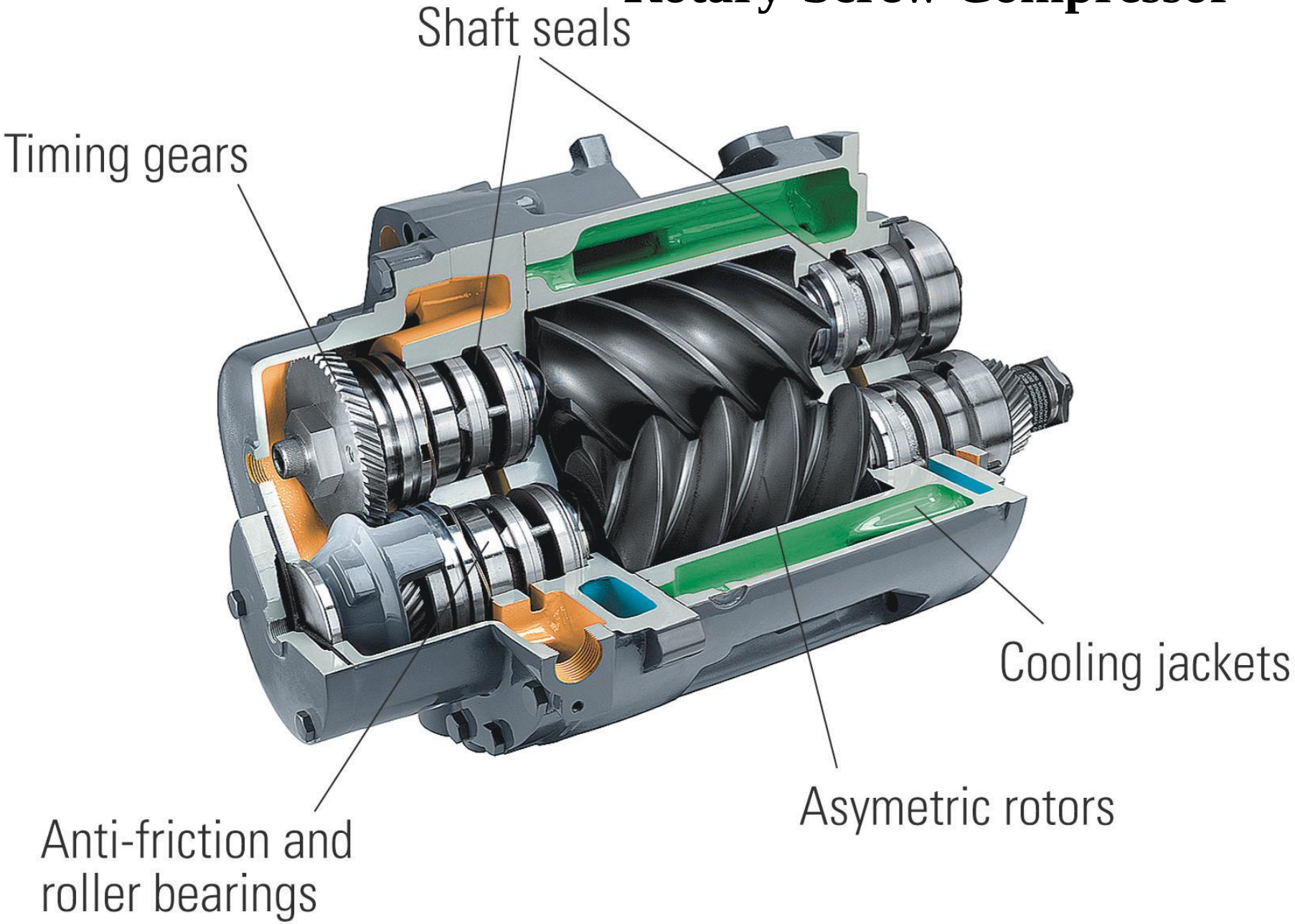
- **Dry Screw Compressor**

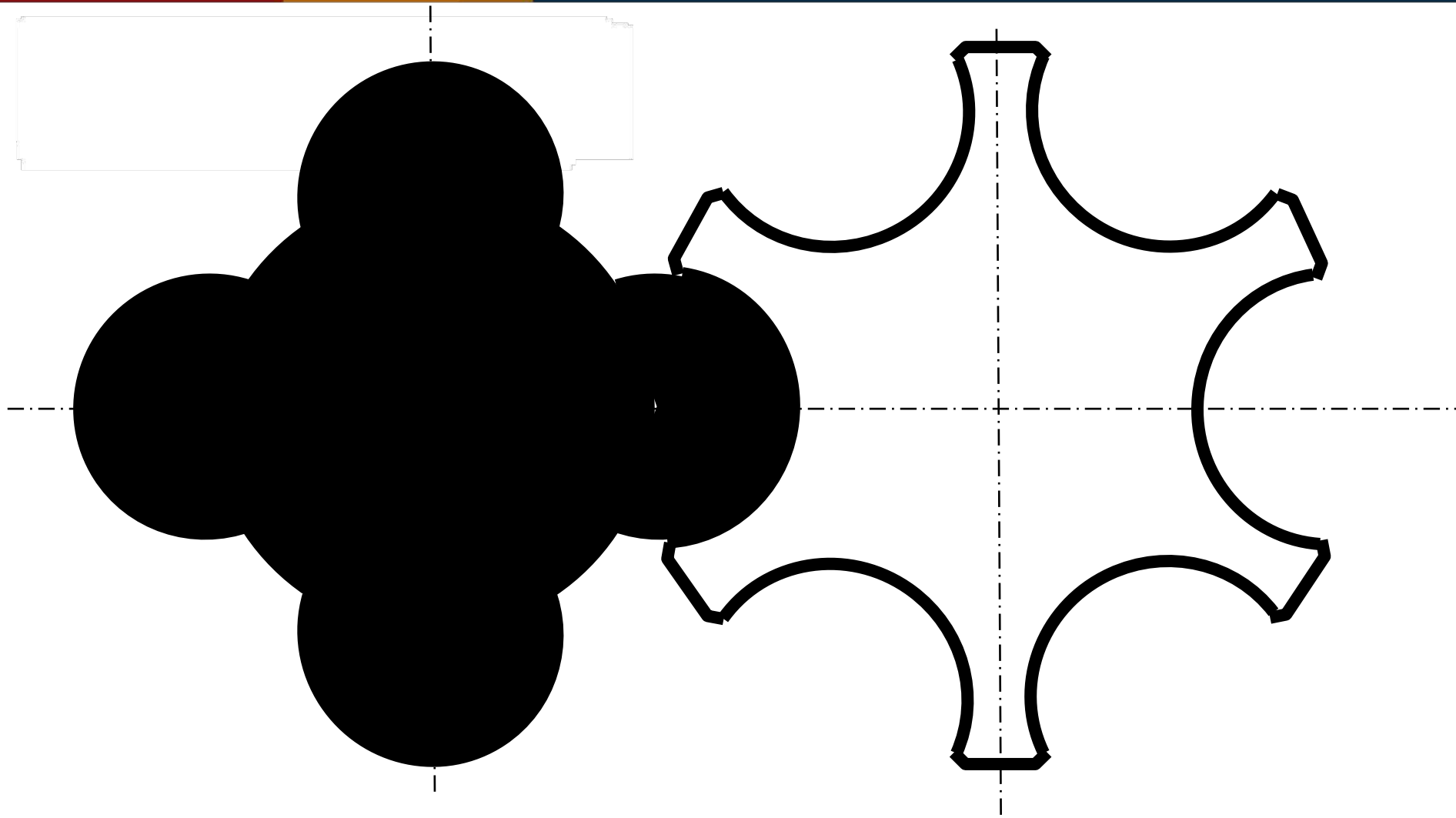
- **Oil Flooded Screw Compressor**

Rotary Screw Compressors



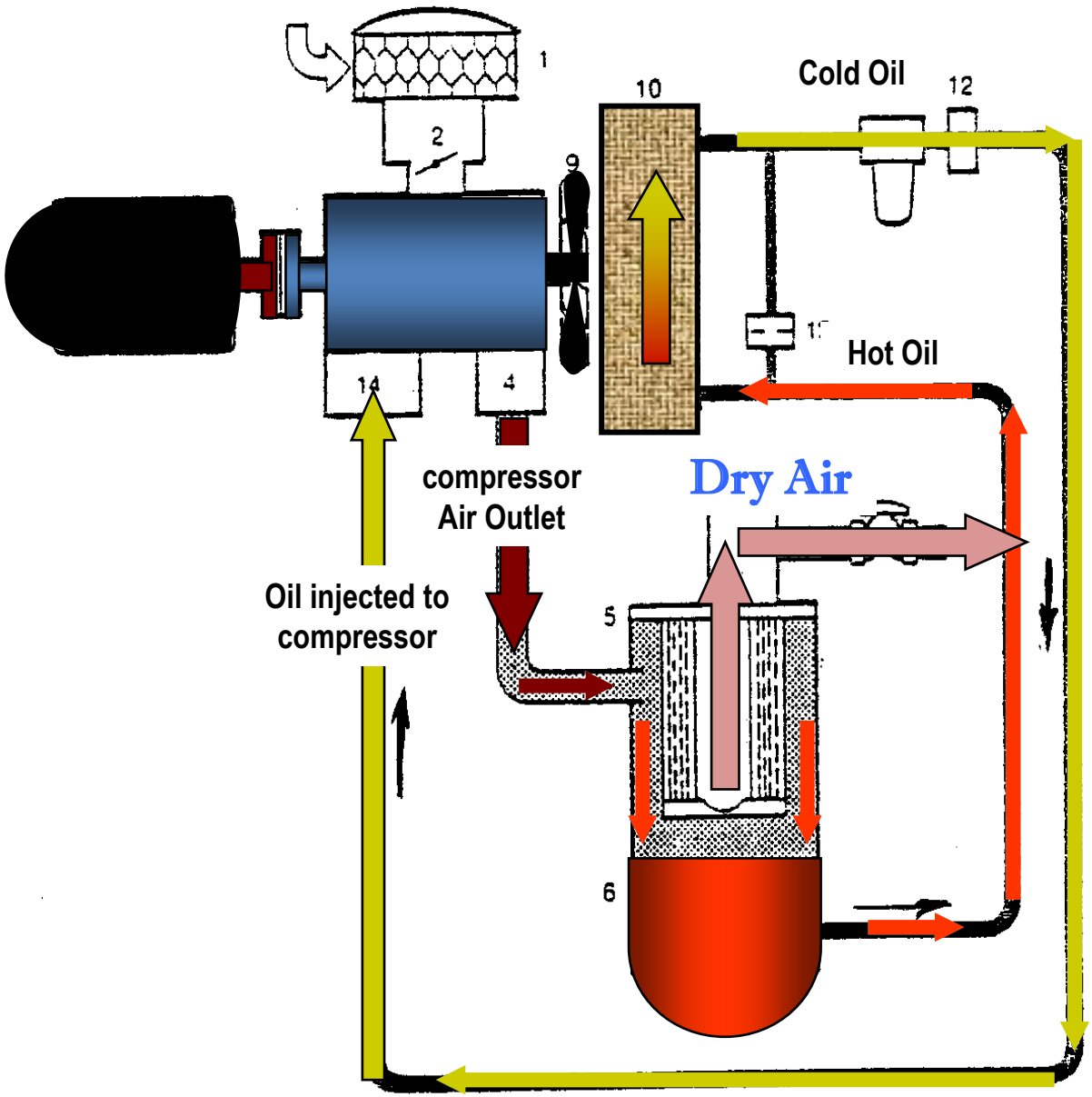
Rotary-Screw Compressor



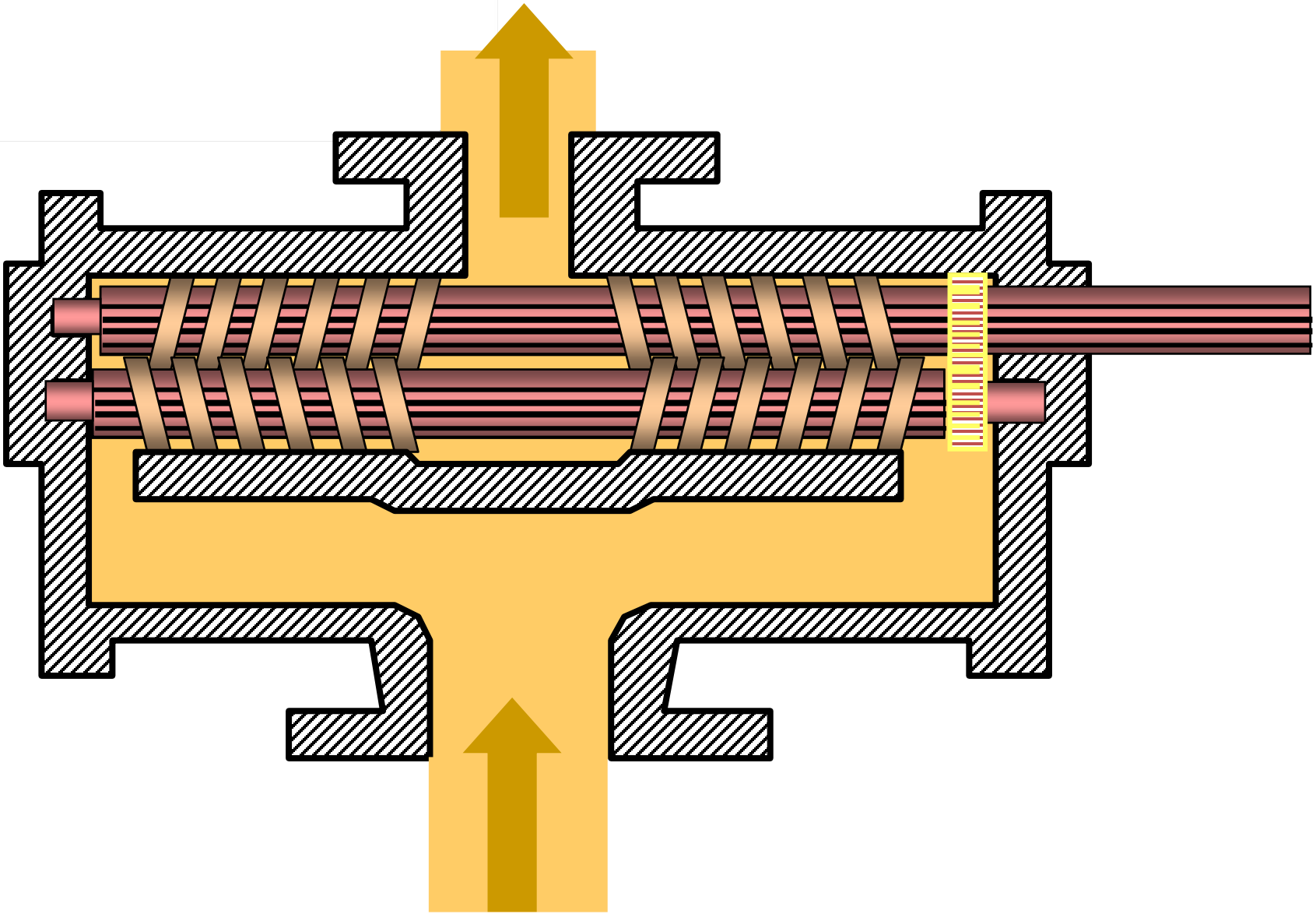


Rotor profile of <u>the four</u> ------lobe male and <u>the six</u> lobe female

Oil – flooding system for a rotary screw air compressor.



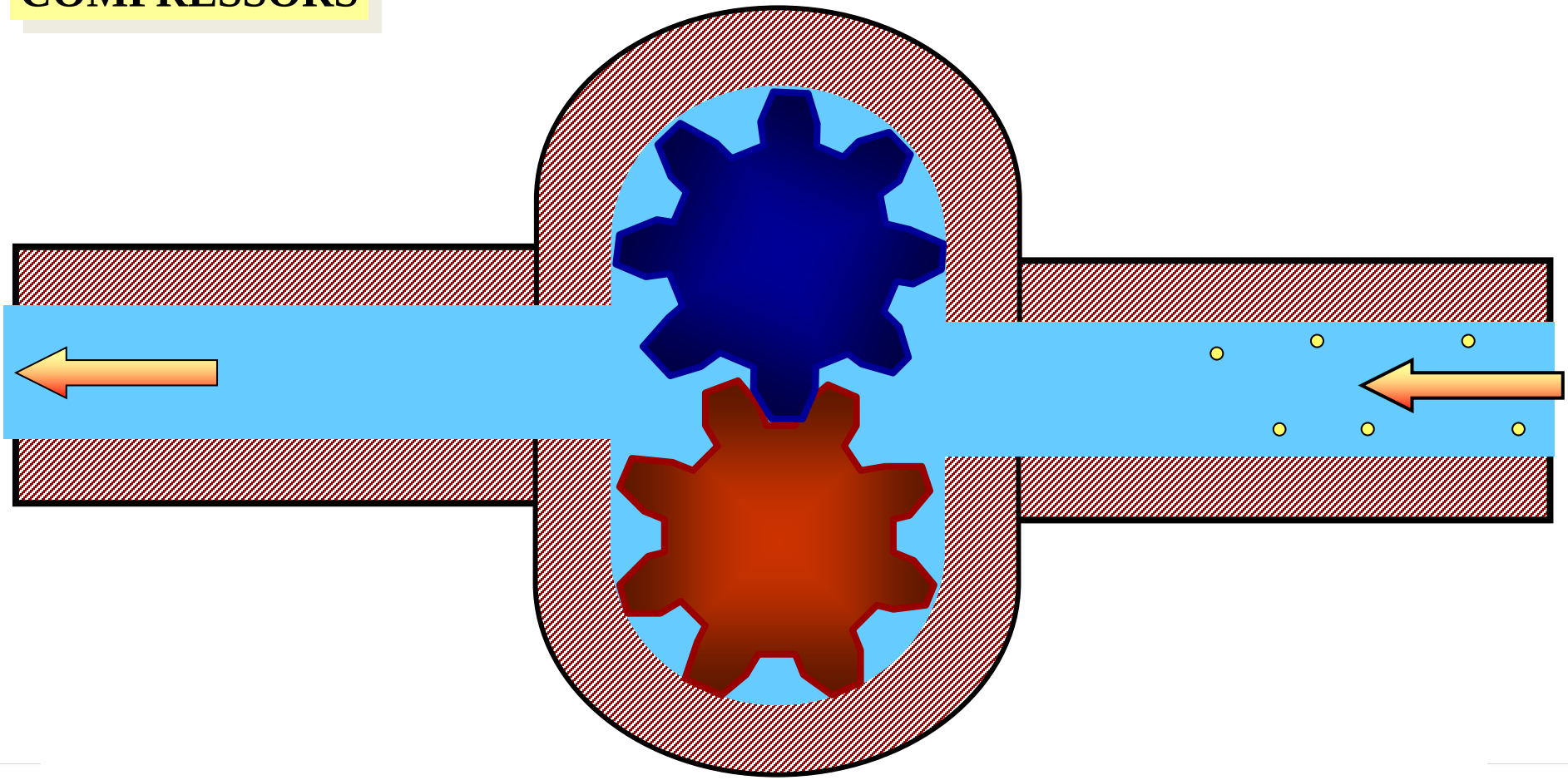
1 – air filter
2 – inlet throttle
3 – compressor element
4 – non-return valve
5 – oil separator
6 – oil sump
7 – oil separating filter
8 – non-return valve
9 – cooling fan
10 – oil cooler
11 – oil filter
12 – throttling
13 – thermostatic valve
14 – non-return valve



Multiple-screw double-end arrangement

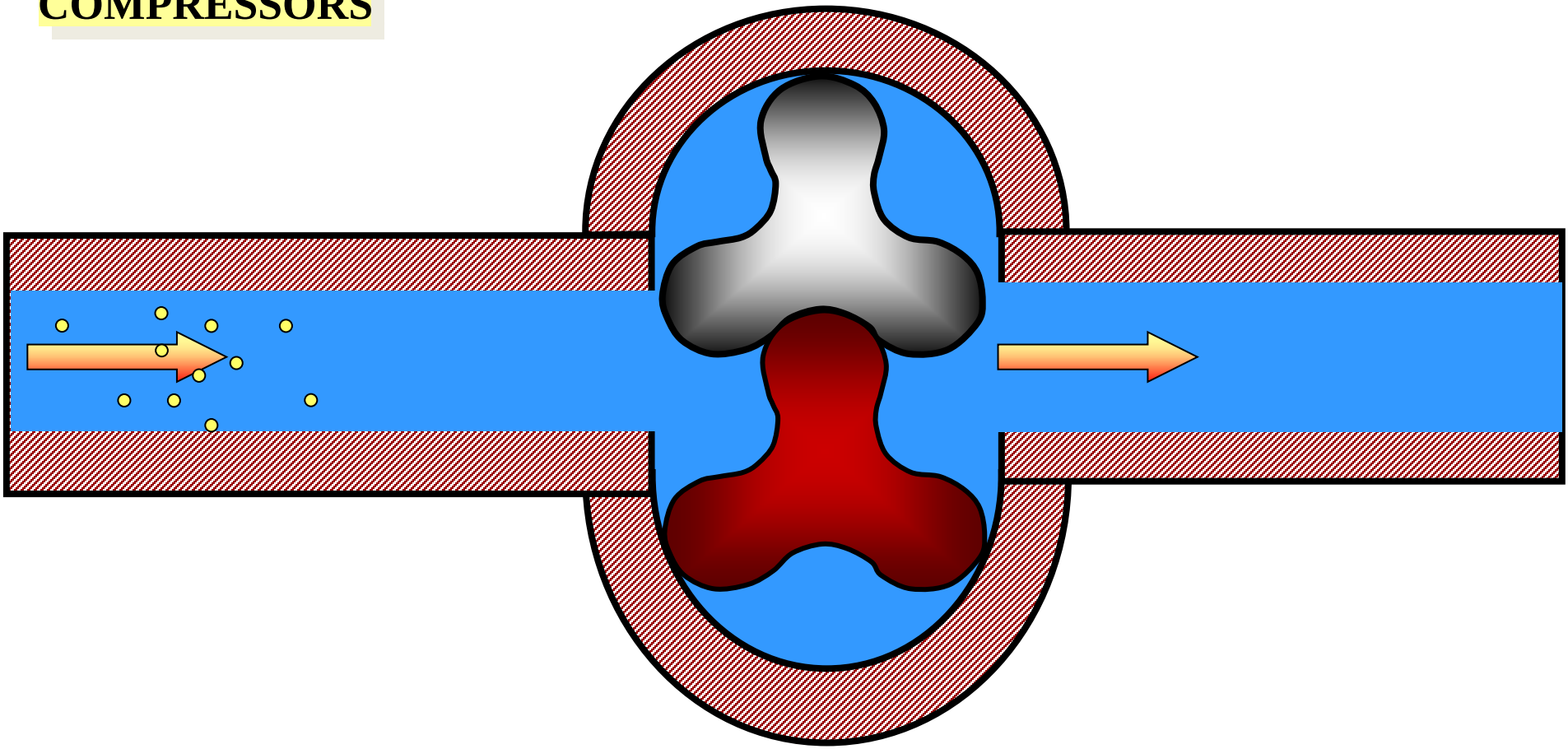
ROTARY
COMPRESSORS

External Gear

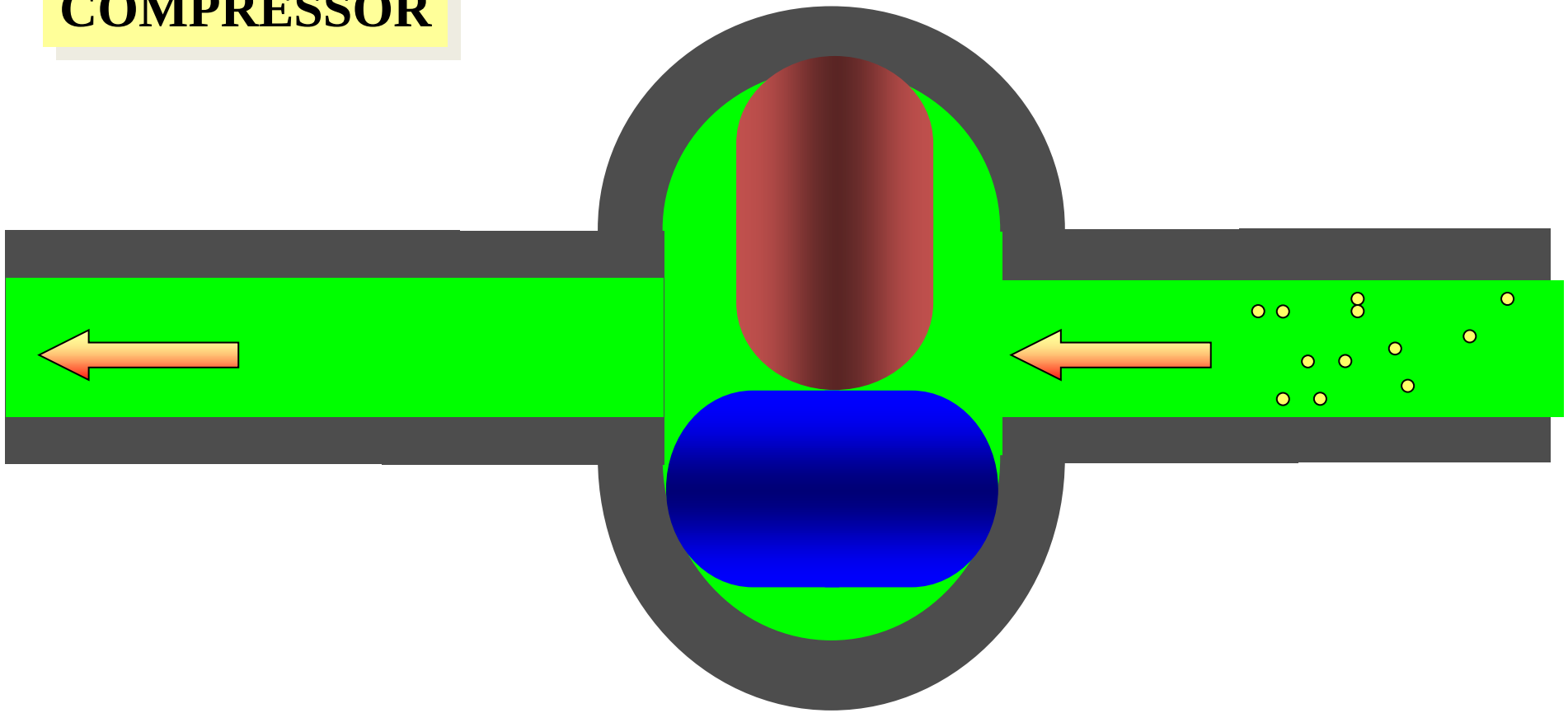


THE FLUID IS TRAPPED BETWEEN ROTOR AND CASING

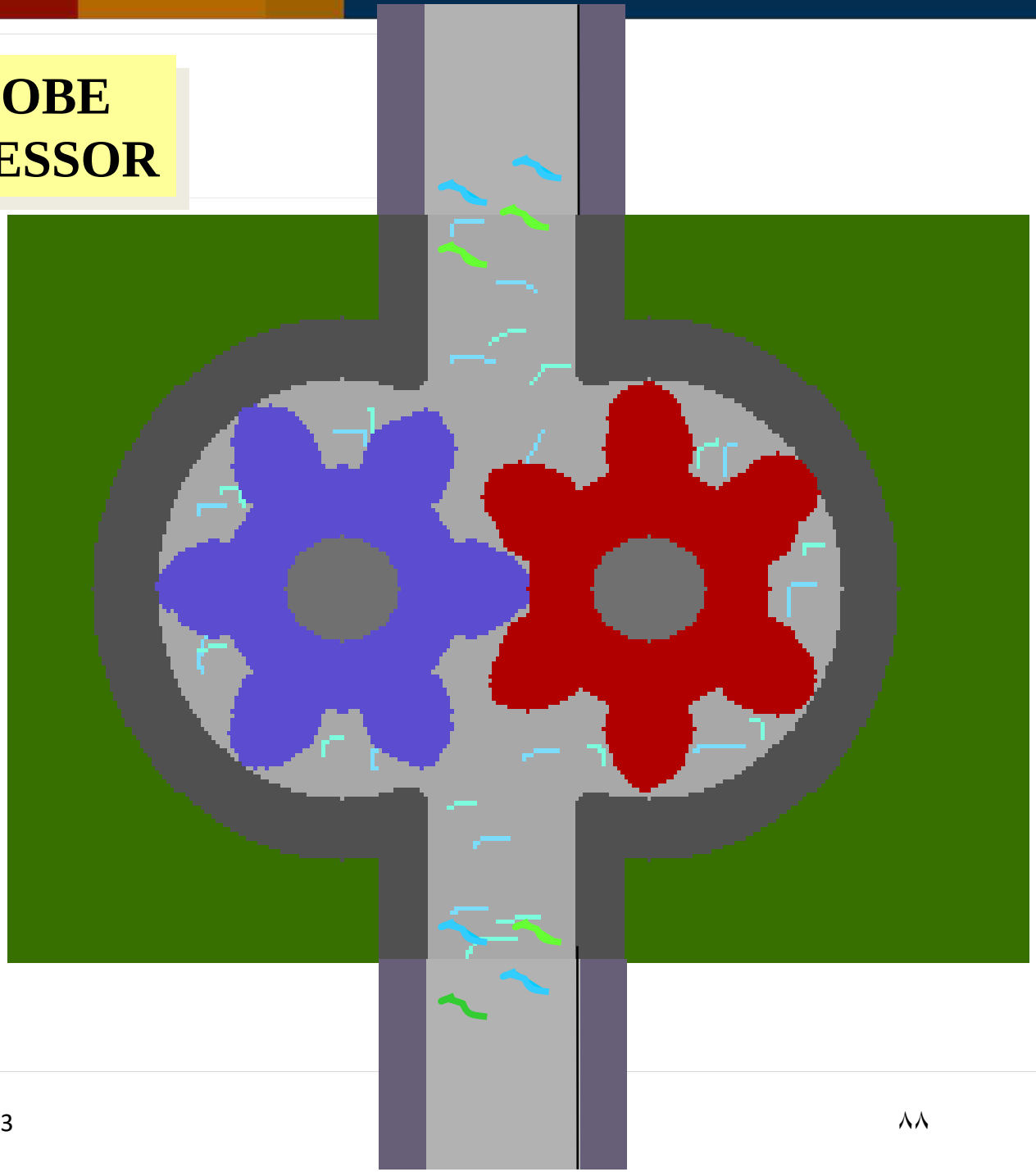
THREE LOBE COMPRESSORS



TWO LOBE COMPRESSOR

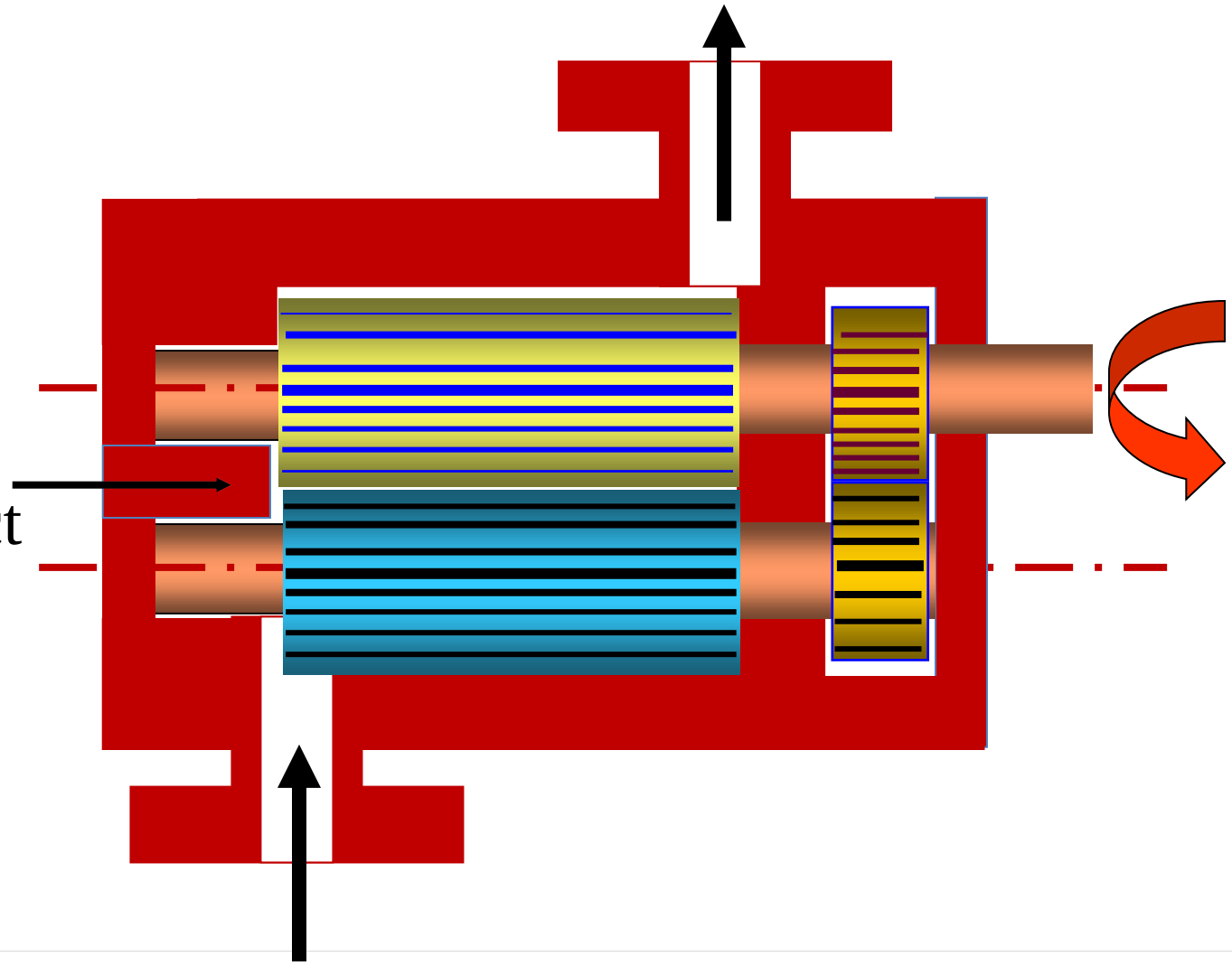


TWO LOBE COMPRESSOR



Dry helical screw compressors.
(driven by external timing gears).

Gap,
no contact

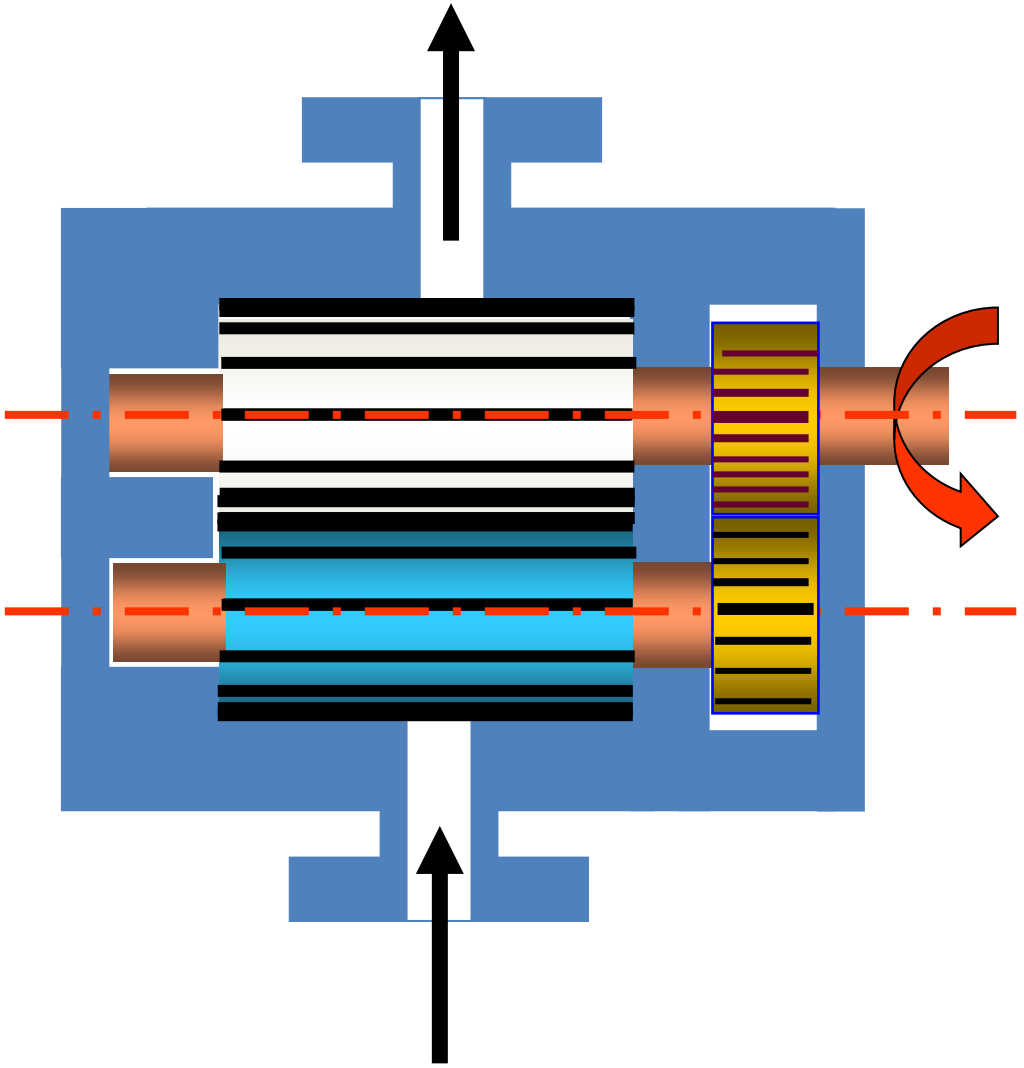


TIMING GEAR FUNCTION

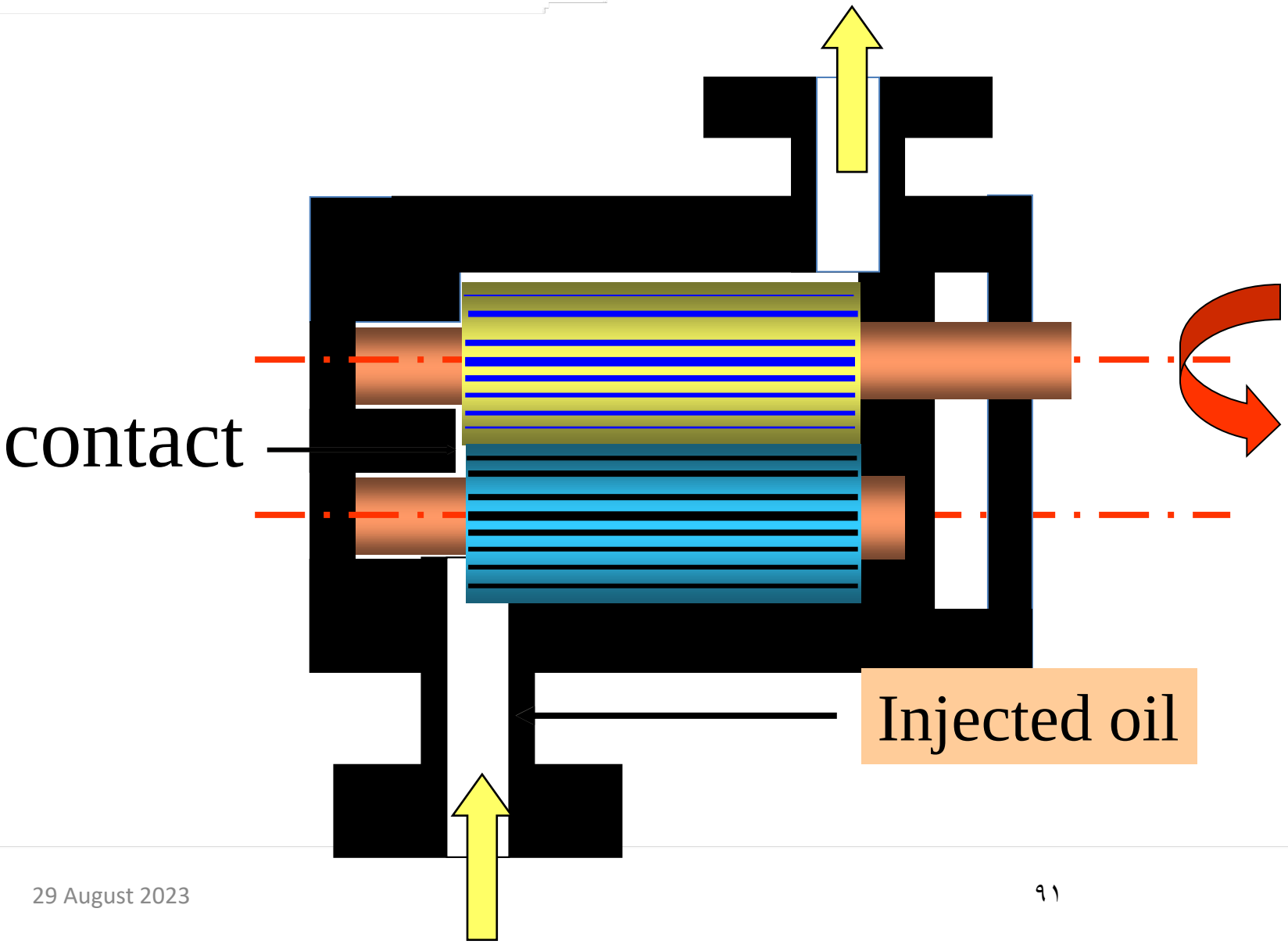
1- Transmit Motion To Other Rotor

2- Keeps No Contact Between Rotors

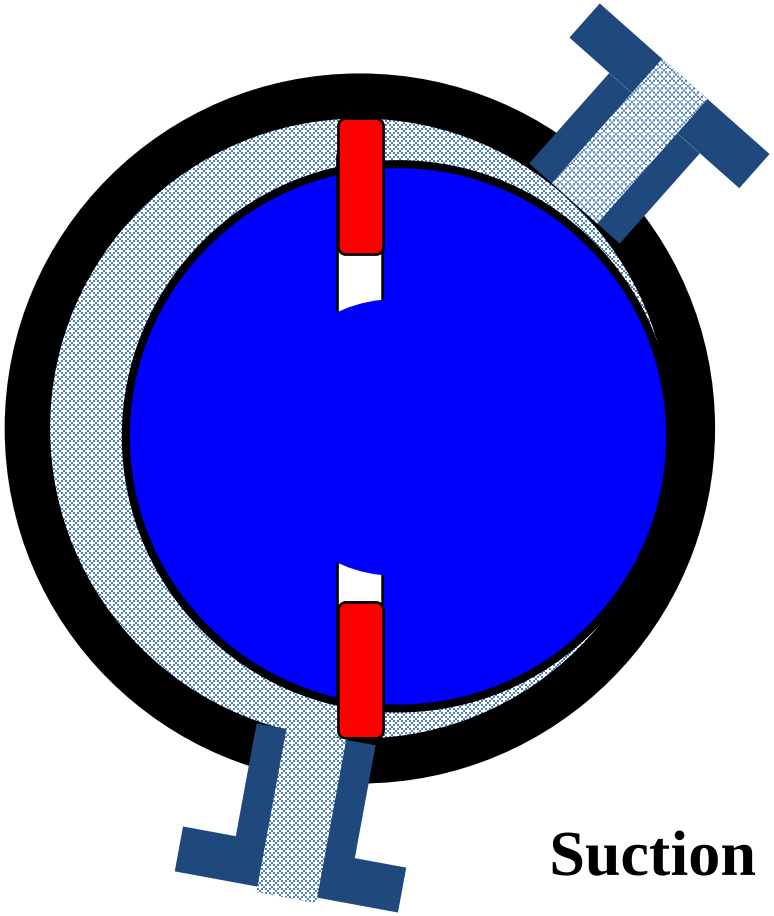
3- Prevent Wear Between Rotors



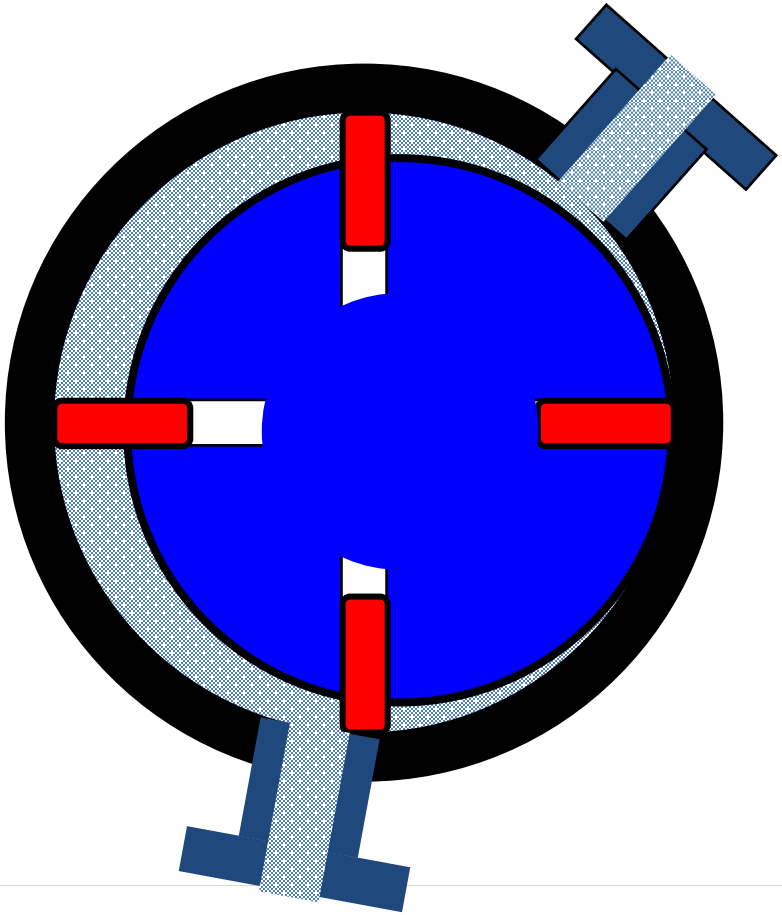
Rotary helical screw oil injected compressor



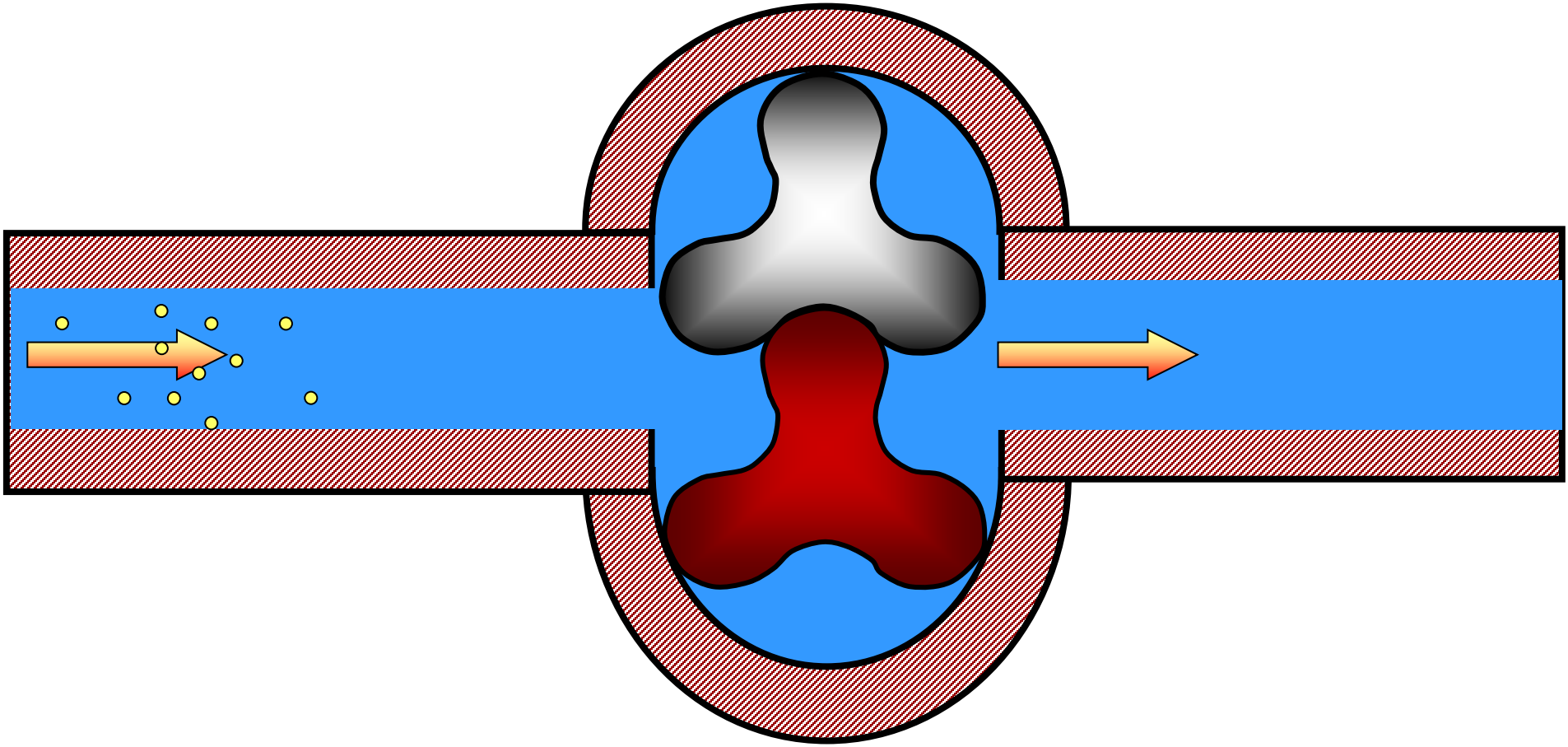
Rotary Vane Compressor



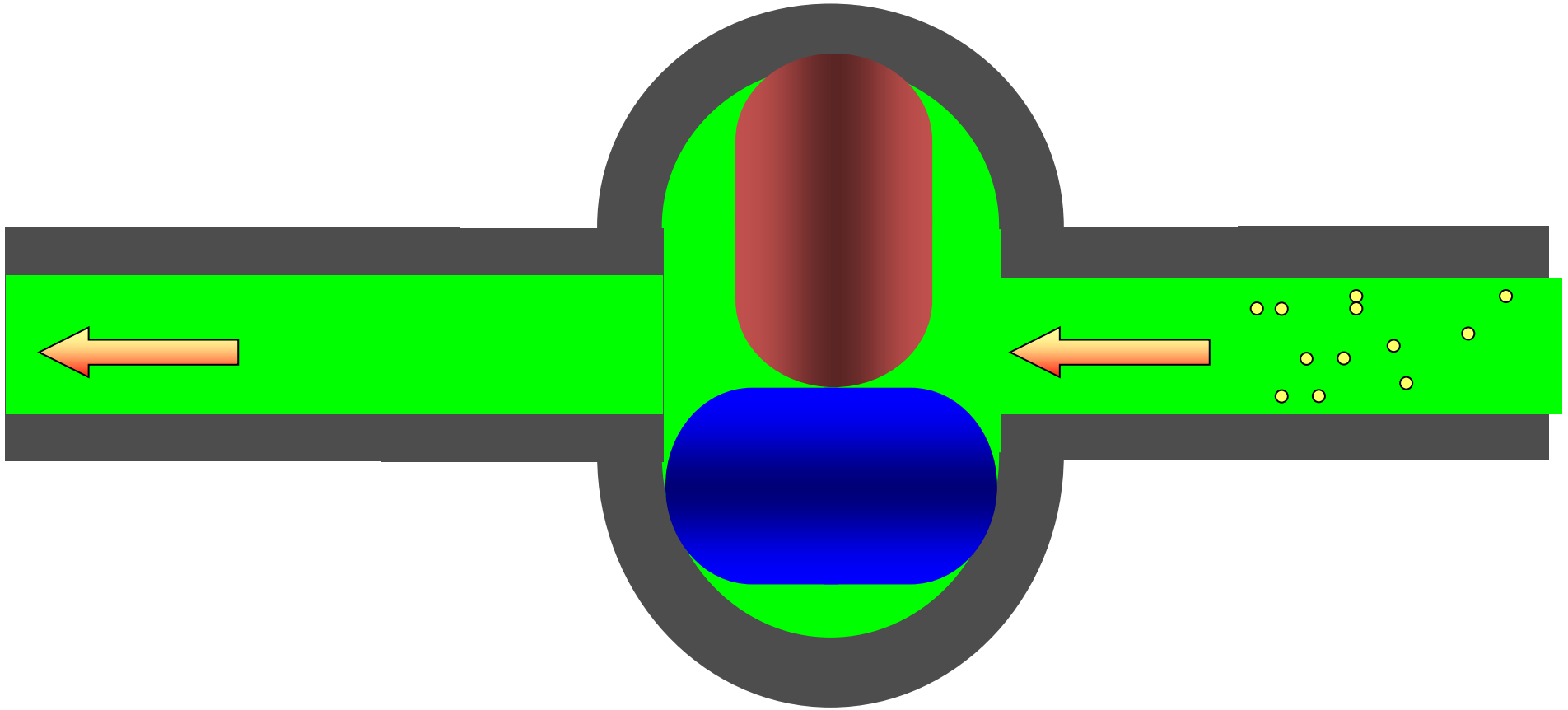
Rotary Vane Gas Compressors



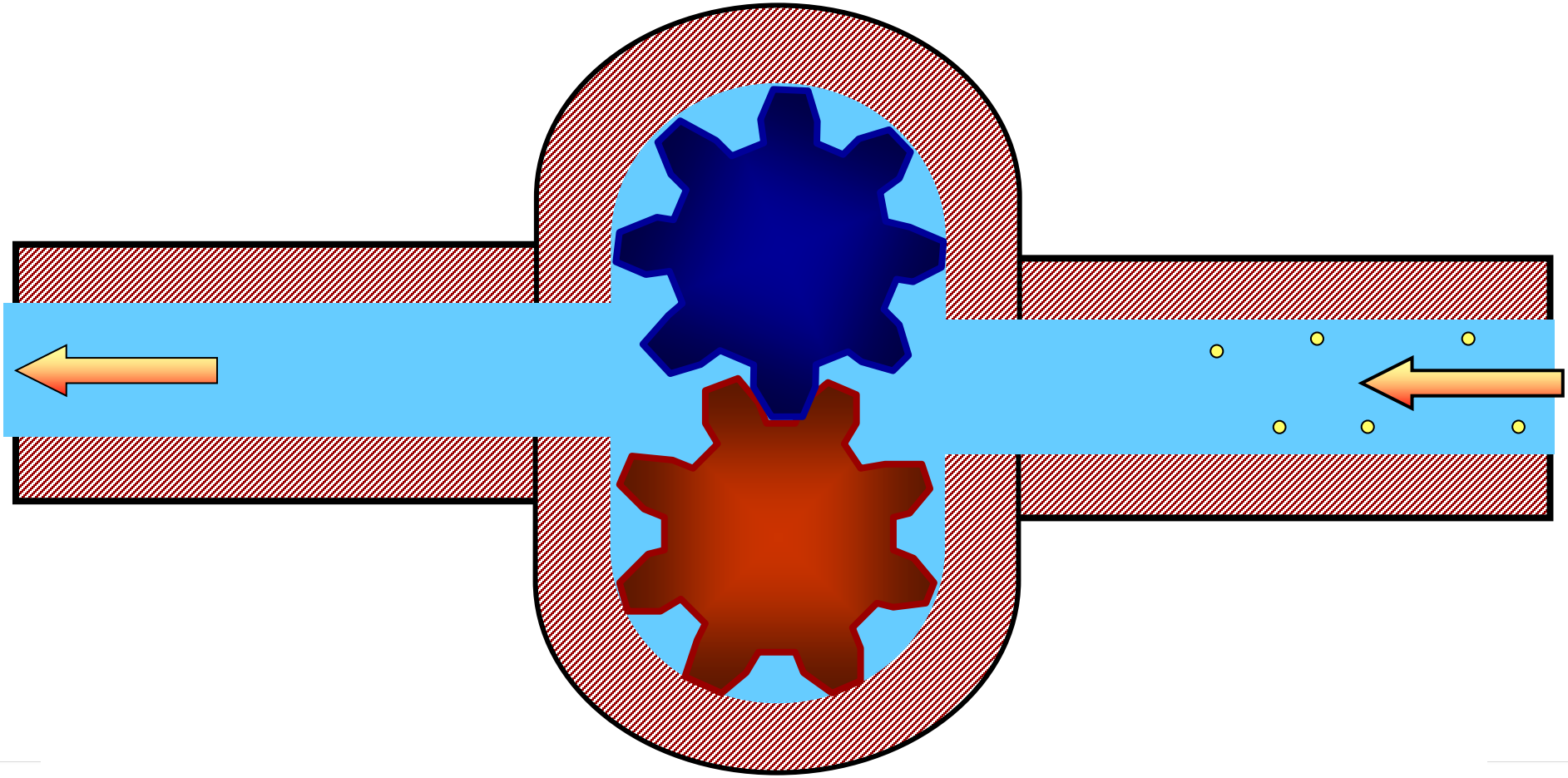
THREE LOBE COMPRESSORS



TWO LOBE COMPRESSOR

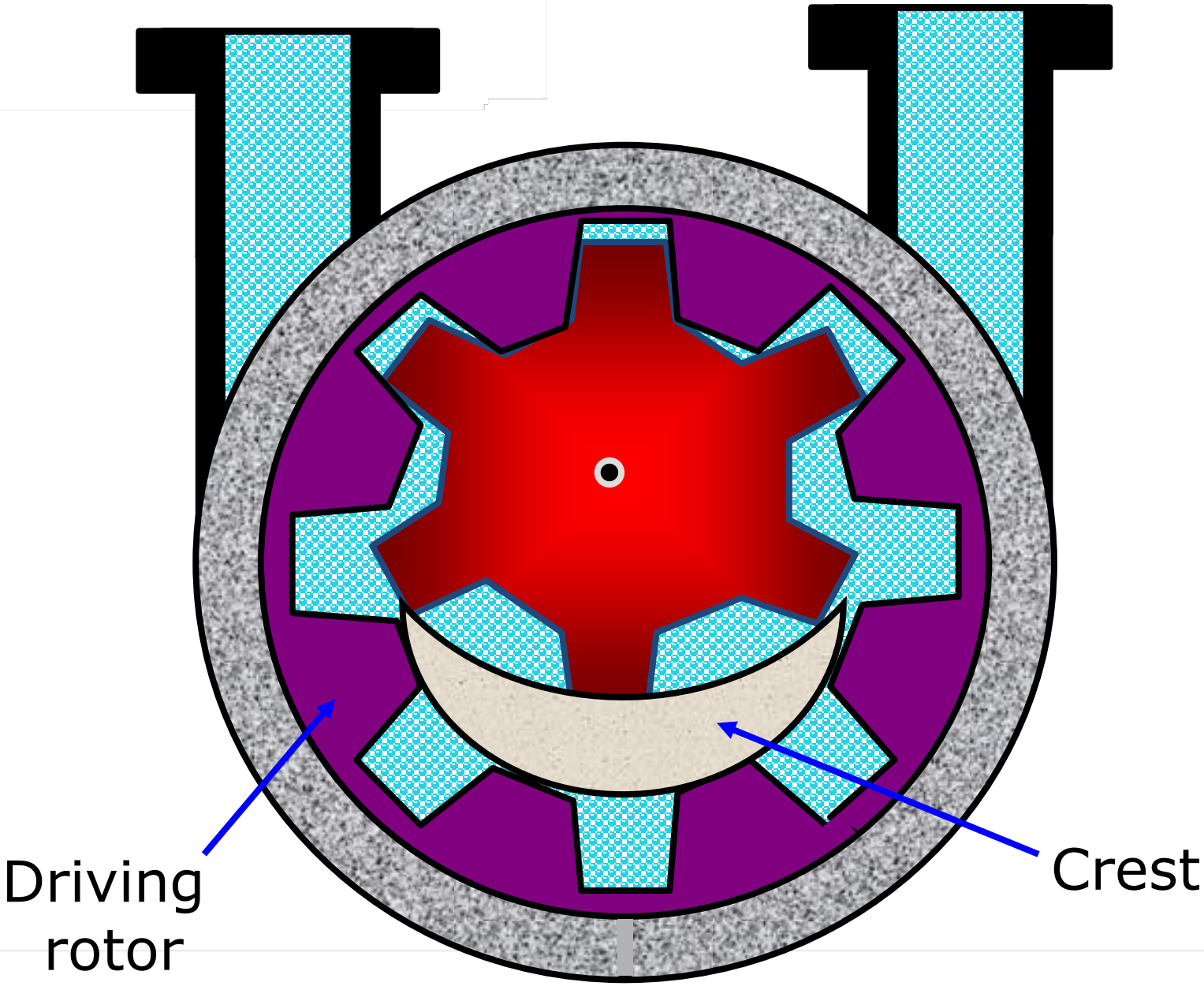


External Gear



THE FLUID IS TRAPPED BETWEEN ROTOR AND CASING

Internal Gear


Driving
rotor
Crest