

Mike Cocca

***1 Jornados Latinamericanas sobre
Compresion de Gas Natural
Centrifugal Compressors y Gas
TurbineUpgrading***



Centrifugal Compressors Upgrading

COMPRESSOR RECONFIGURATION

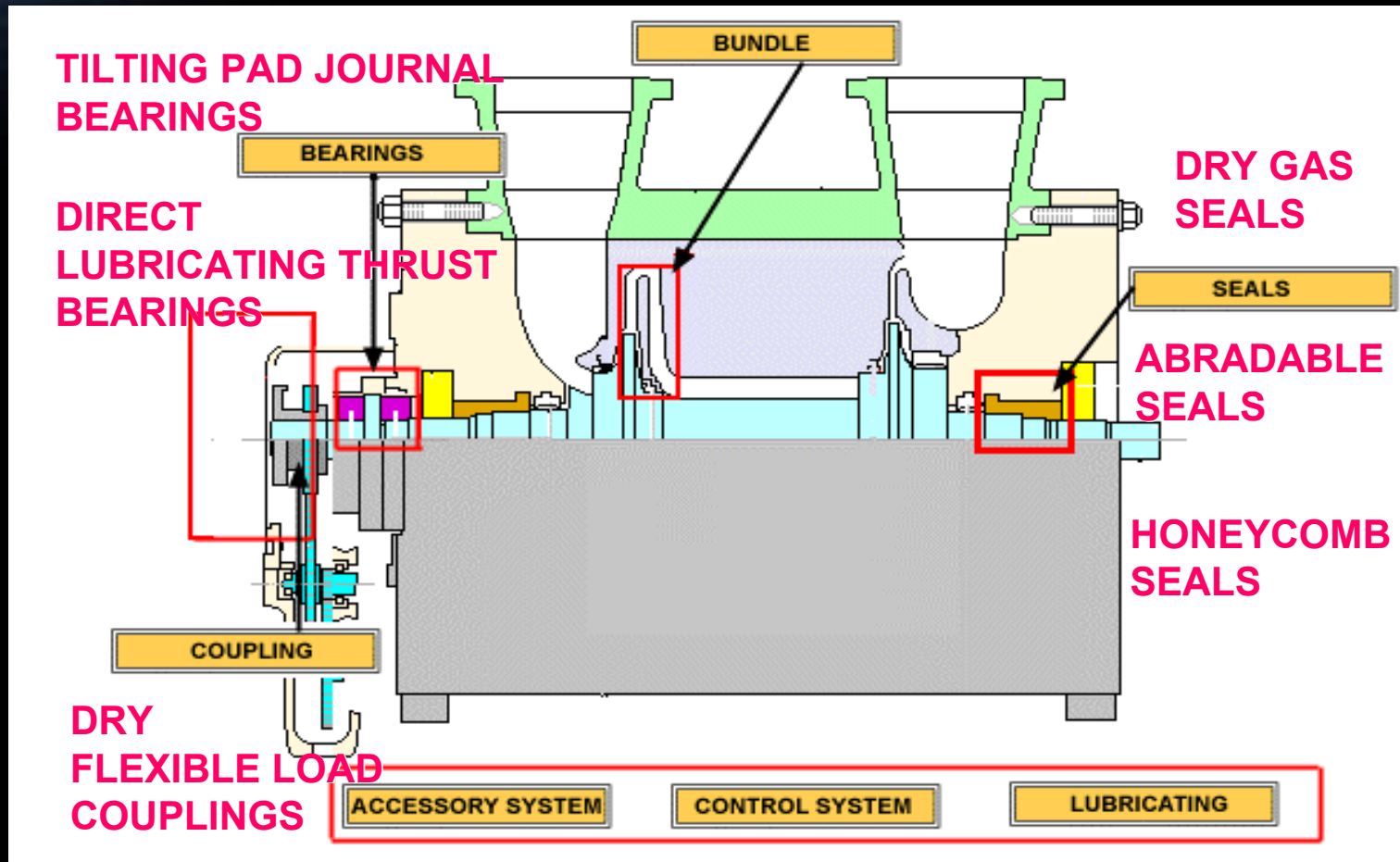
- Tailor made solutions for new process requirements
- Optimize use of existing equipment
- Proven modern design technology
- Minimize manufacturing and installation time

Attractive Project Economics

Centrifugal Compressors Upgrading

COMPRESSOR UPGRADE

Compressor Internal Parts



Centrifugal Compressors Upgrading

COMPRESSOR UPGRADE CM&Us

MACHINE	PROPOSED CM&Us	Major Benefits
Centrifugal Compressor	Tilting pad journal bearing	A, M, R
	Direct lubricating thrust bearings	A, M, P
	Dry flexible load coupling	A, M, R
	DRY GAS SEALS	A, M, P
	Abradable seals	A, M, P
	Honeycomb seals	A, M, R
	Compressor internal parts	A, M, R, P
Control System	• Antisurge control system • Displacement type vibration sensors • Bearing thermocouples	A, M

A ⇒ Availability
M ⇒ Maintainability
R ⇒ Rotor dynamic
P ⇒ Performance

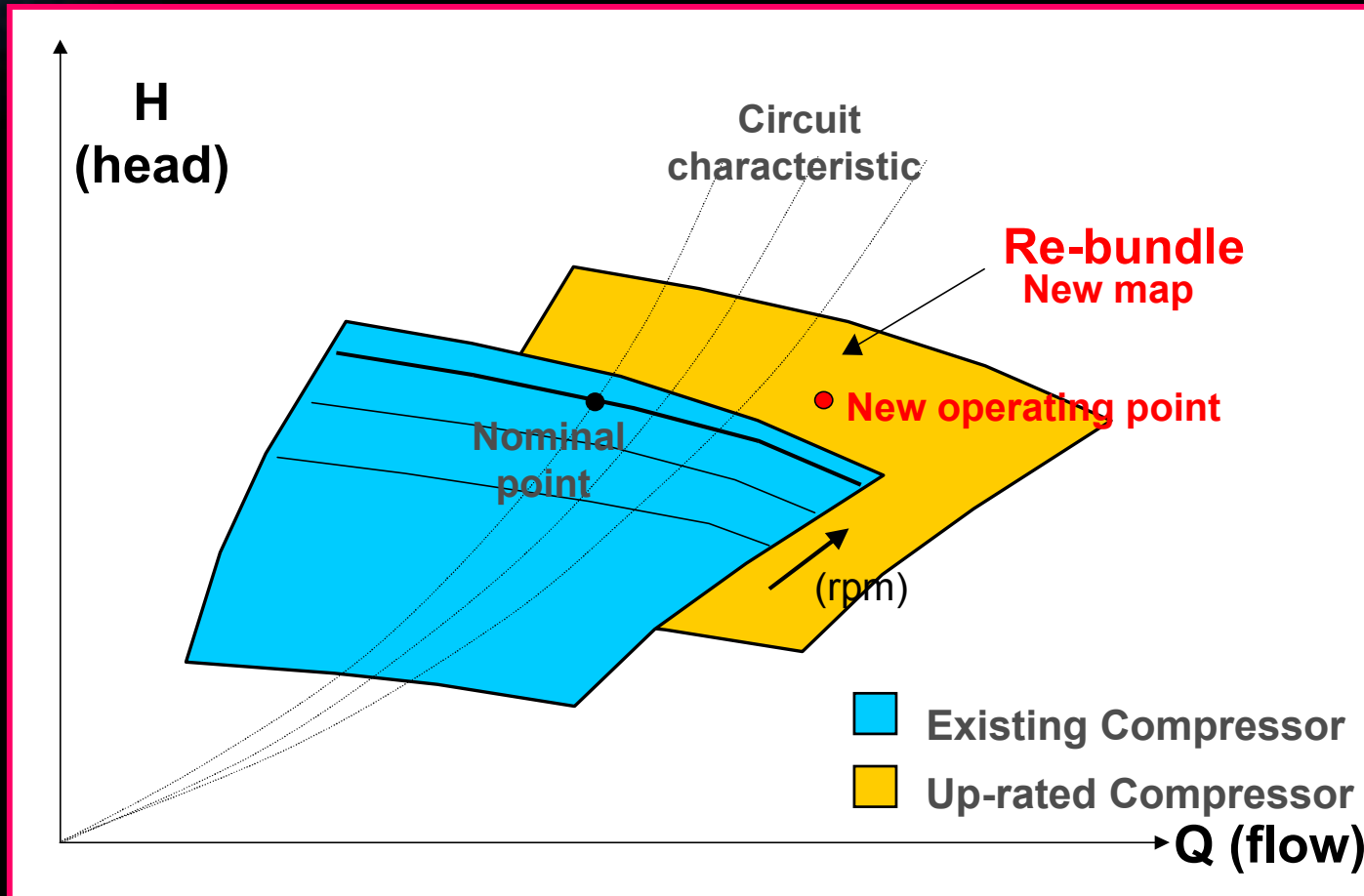
$$Power = \frac{H_{pol} \bullet G}{\eta_{pol}} + P_m + P_f$$

H_{pol} = polytropic head
 η_{pol} = polytropic efficiency
 G = flow rate
 P_m = power lost owing to mechanical losses
 P_f = power lost owing to leakage

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COMPRESSOR UPGRADE

New Bundle



Centrifugal Compressors Upgrading

COMPRESSOR UPGRADE

New Flange to Flange Working Conditions

- MASS FLOW
- SUCTION PRESSURE
- SUCTION TEMPERATURE
- GAS COMPOSITION
- DISCHARGE PRESSURE

NEW BUNDLE CAN BE
SELECTED



Centrifugal Compressors Upgrading

REVAMPING APPROACH

- **BUNDLE SELECTION**
- **GAS VELOCITY CHECK**
- **AUXILIARIES CHECK**
- **AERO/ROTOR – DYNAMIC CHECK**
- **MATERIALS SELECTION**

Minimize Impact on Existing Equipment

Centrifugal Compressors Upgrading

REVAMPING APPROACH

BUNDLE SELECTION

- Axial & radial spacing available inside casing
- Impellers & statoric parts selected to optimise performance

**Selected impellers within
NP range of experience**

GAS VELOCITY CHECK

- Inlet & discharge nozzles
- Discharge volute

**All gas velocities within
acceptable values**



NEW BUNDLE FITS EXISTING CASING



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REVAMPING APPROACH

AUXILIARIES CHECK

- Lube Oil System
- Seal System
- Antisurge System

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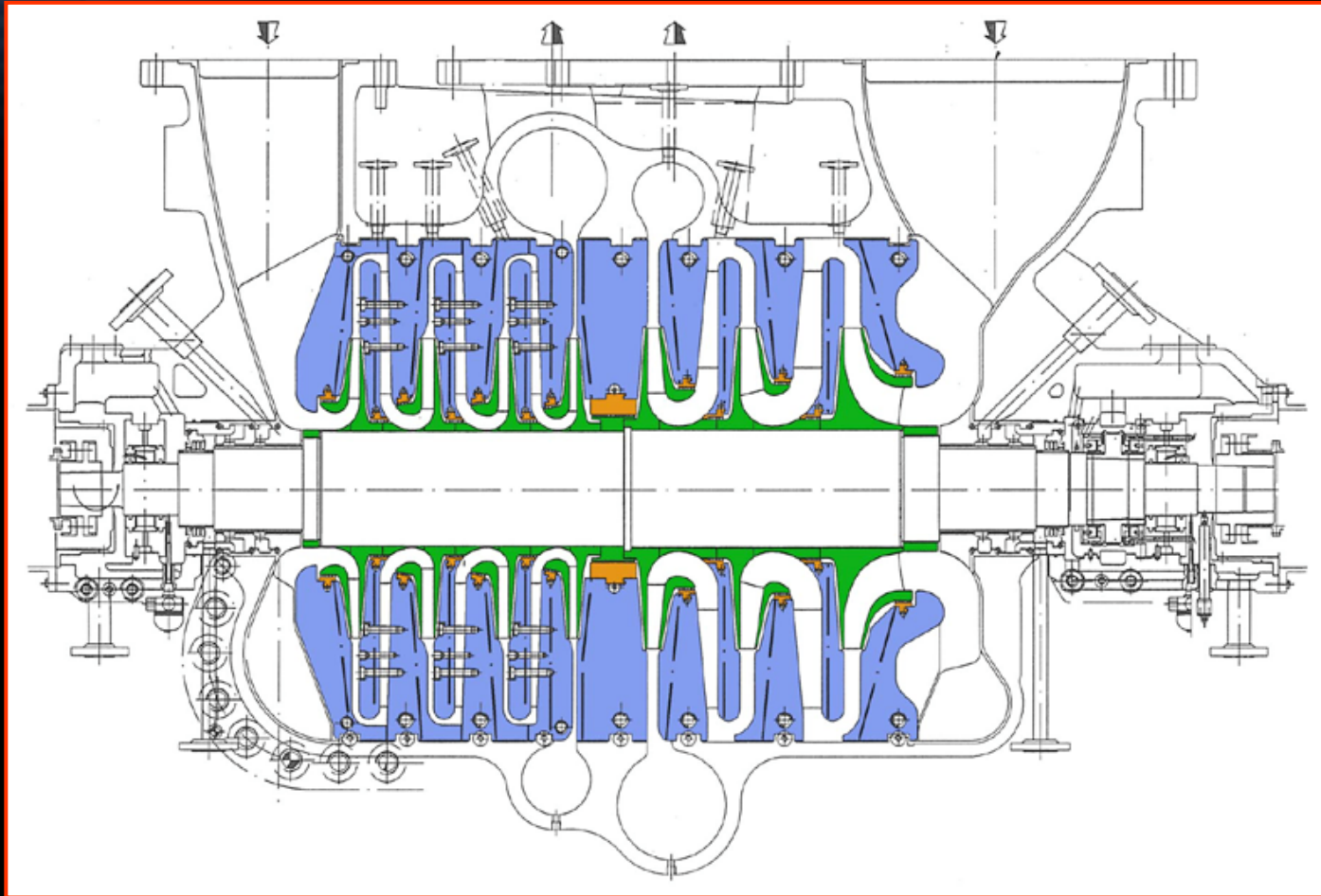
IMPELLERS SELECTION OVERVIEW

Nuovo Pignone constantly develops and tests new centrifugal compressor impeller to increase efficiency of the compressors and to supply taylor made solutions for new process requirements.

New T30 impeller has been designed ad hoc for Ammonia Syntesis Recycle stages and for all the applications which require low pressure ratios.

Centrifugal Compressors Upgrading

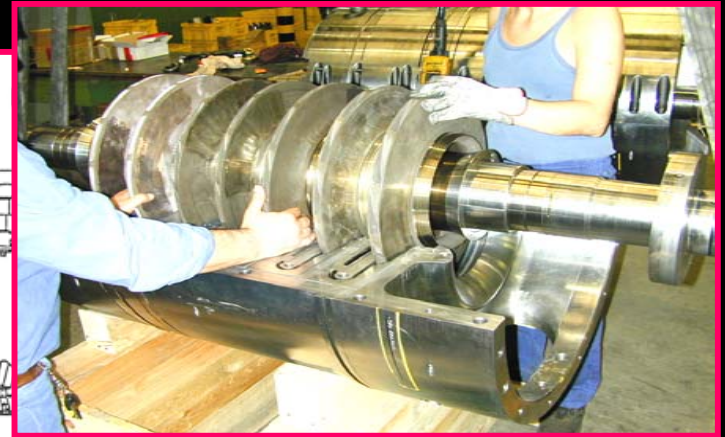
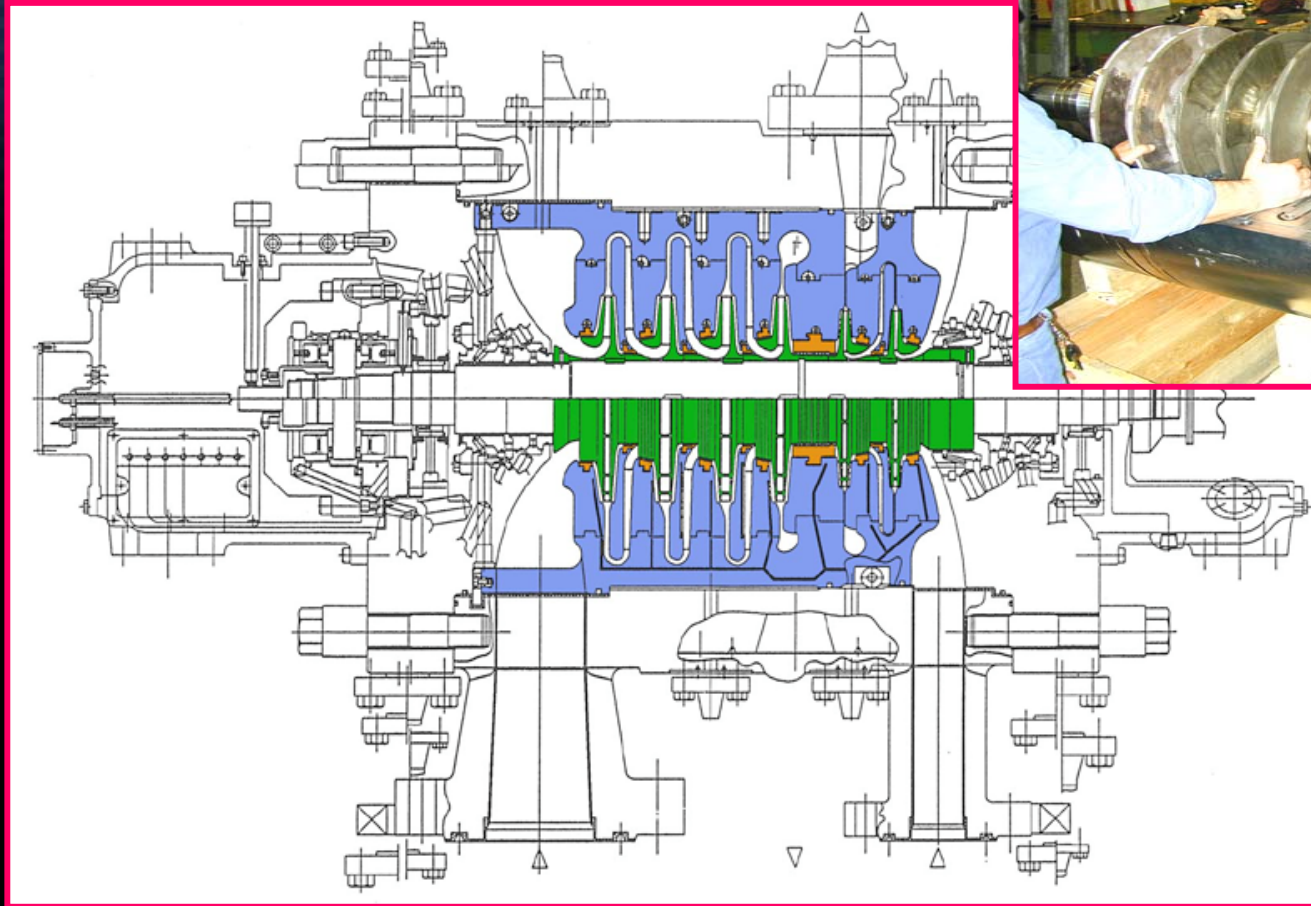
TYPICAL SCOPE OF SUPPLY



2MCL607 Compressor Model

Centrifugal Compressors Upgrading

TYPICAL SCOPE OF SUPPLY



2BCL306/A Compressor Model

Centrifugal Compressors Upgrading

Multi-Vendor Services

GE Oil and Gas

Can offer Multi Vendor Service to work on the majority of OEM products via Conmec



Conmec Rerated this
DR 08B Compressor for +35% More Flow

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ABRADABLE SEALS

Traditional labyrinth seals affect the performance of machines as follows:

- polytropic efficiency
- absorbed power
- internal recycle flows

A fundamental parameter in gas leakage through a labyrinth is the radial clearance between rotor and stator.



Drastic Reduction of Operating Clearance
(50% less than a conventional labyrinth)

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ABRADABLE SEALS

Static part with smooth internal surface made in a soft material (composite polymer) and a rotating part with an external surface edged with teeth in metal material (similar to a static labyrinth)



Balancing drum
abradable seal kit

Shaft end
abradable seal kit

Benefits

- increased polytropic efficiency
- increased flange to flange throughput

Applicability

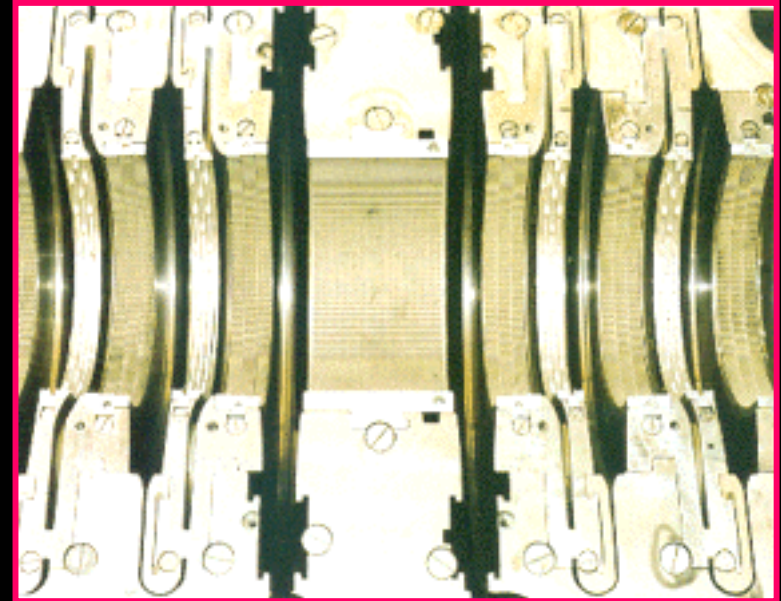
- Modification kits for all NP machines (up to 200 bar)

Absorbed Power Reduction

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HONEYCOMB SEALS

Labyrinth seals used in high pressure services can create destabilizing transverse aerodynamic forces



The instability effects, amplified by high molecular weight gas can raise vibration amplitude and cause trip of compressor for high vibration

Centrifugal Compressors Upgrading

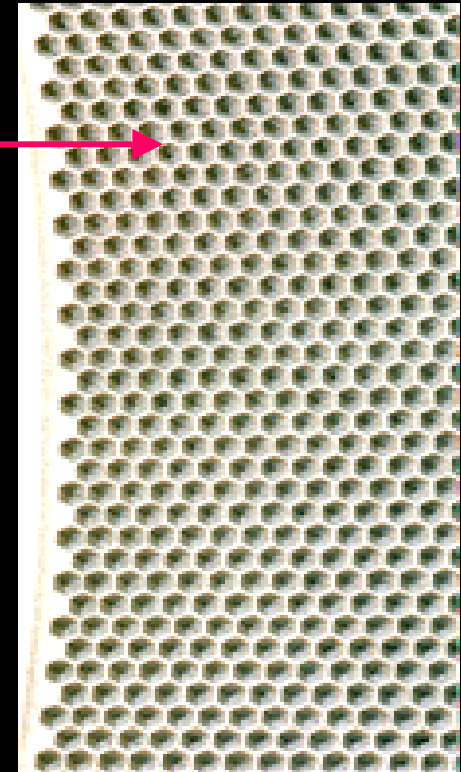
HONEYCOMB SEALS

Design of the stator surface: the mating face is fitted with honeycomb structure with cells approx. 1.2 mm per side and 2.5 mm deep.

Benefits

- *reduces lateral instability*
- *increase stiffness & damping characteristics*
- *decreases absorbed power*

Microwhirls form in every single cells (approx. 36 cell per cm^2) avoiding gas tangential flow and greatly increasing the sealing effect



Better Rotordynamic and Reduced Leakages

Centrifugal Compressors Upgrading

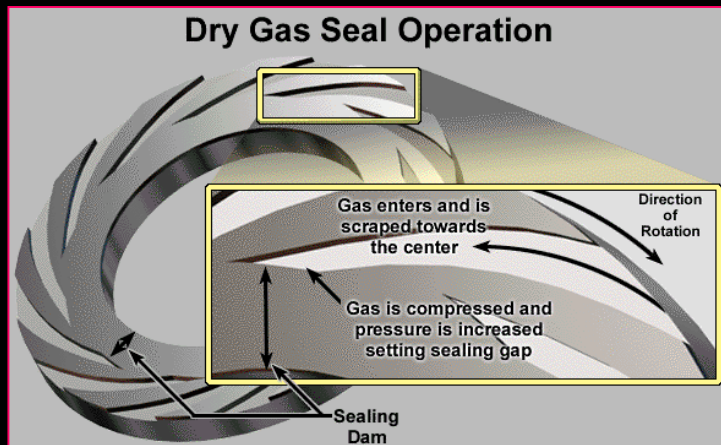
DRY GAS SEALS

Applicability

- for old-design compressors to replace seal oil system
- for NP and non-NP machines

Benefits

- increases reliability and reduced maintenance
- elimination of oil transfers, through seals, to the compressed gas
- economy of the system due to the reduction of oil consumption
- eliminate oil accumulation in pipelines



Over 90% of new compressors equipped with dry gas seals

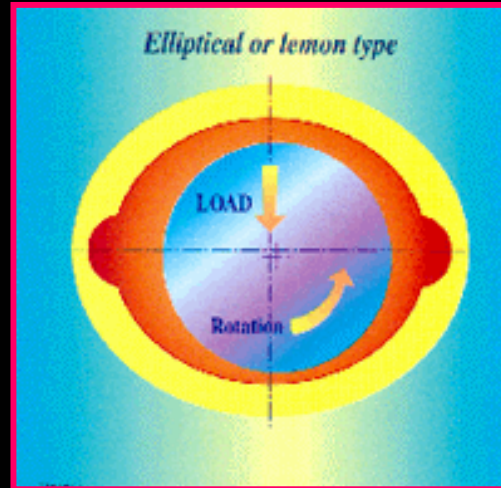
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TILTING PAD JOURNAL BEARINGS

Journal Bearing is a key component for:

- operating safety
- dynamic stability
- compressor availability

Old Elliptical or Lemon type can be replaced with tilting pad-journal bearing without any casing machining.



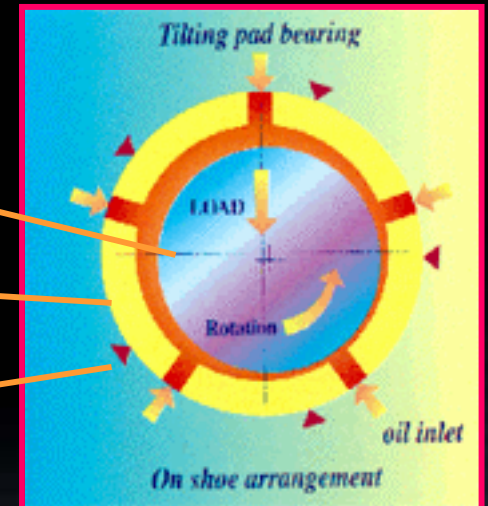
Tilting pad J.B. parts:

- casing
- PADS
- seal rings
- radial pin
- thermoelements (optional with separate kits)

SHAFT

PAD

RADIAL PIN



Centrifugal Compressors Upgrading

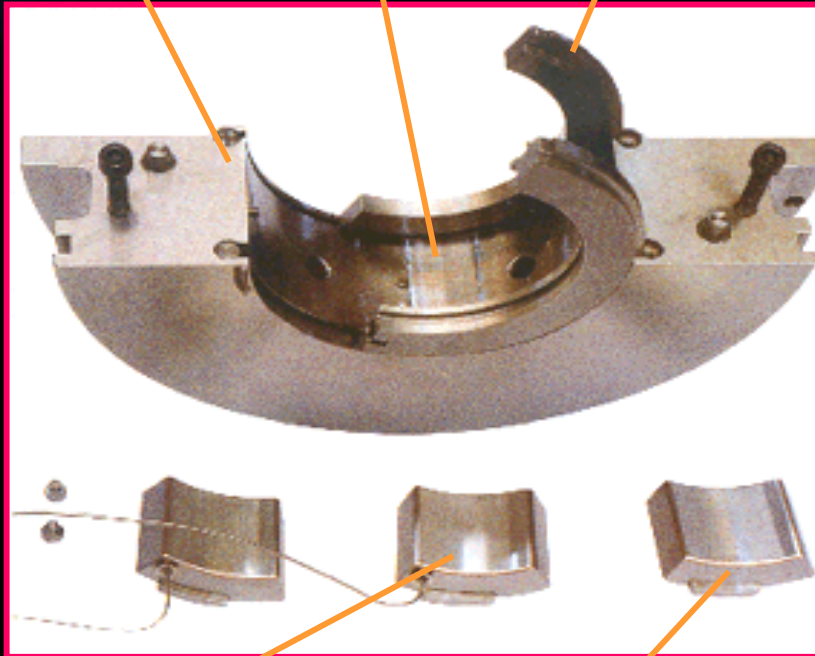
TILTING PAD JOURNAL BEARINGS

Casing

Radial pin

Seal ring

Benefits



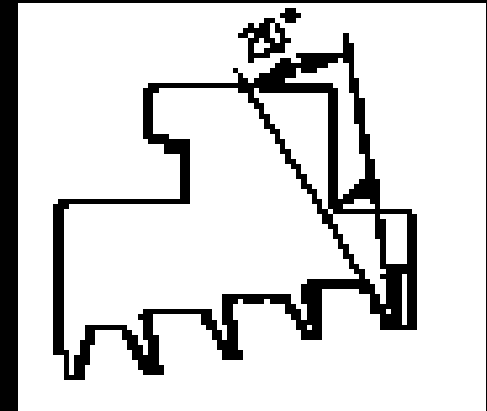
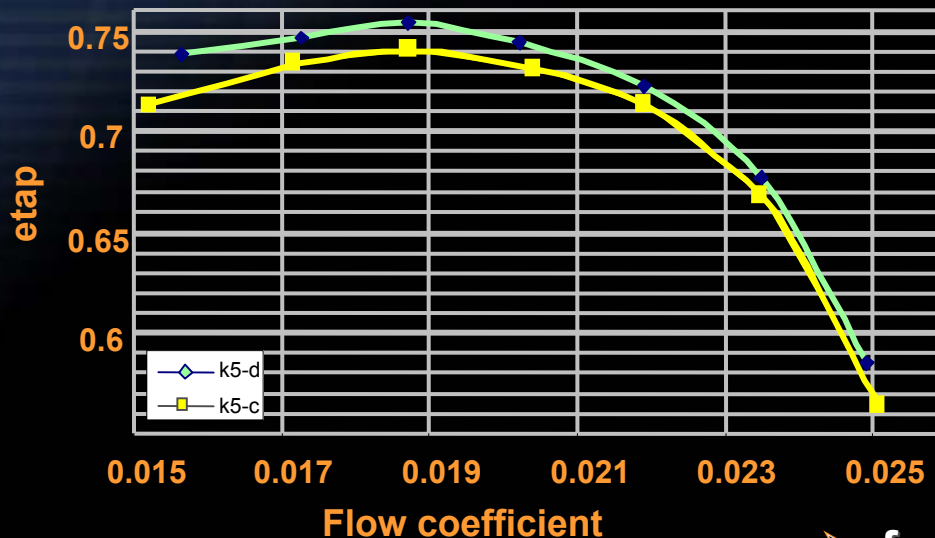
Thermoelements

Pad

- ✓ improves dynamic performance
- ✓ elimination of lube oil instability (oil-whip)
- ✓ reduced oil flow
- ✓ increased stability due to greater damping
- ✓ lower costs for spare parts as only pads need be changed
- ✓ possibility to install a monitoring system (thermoelements on pads) to monitor the temperature

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INCLINED TEETH LABYRINTH SEALS



Applicability

- for all NP compressors
- easy to install with no modifications

Benefits

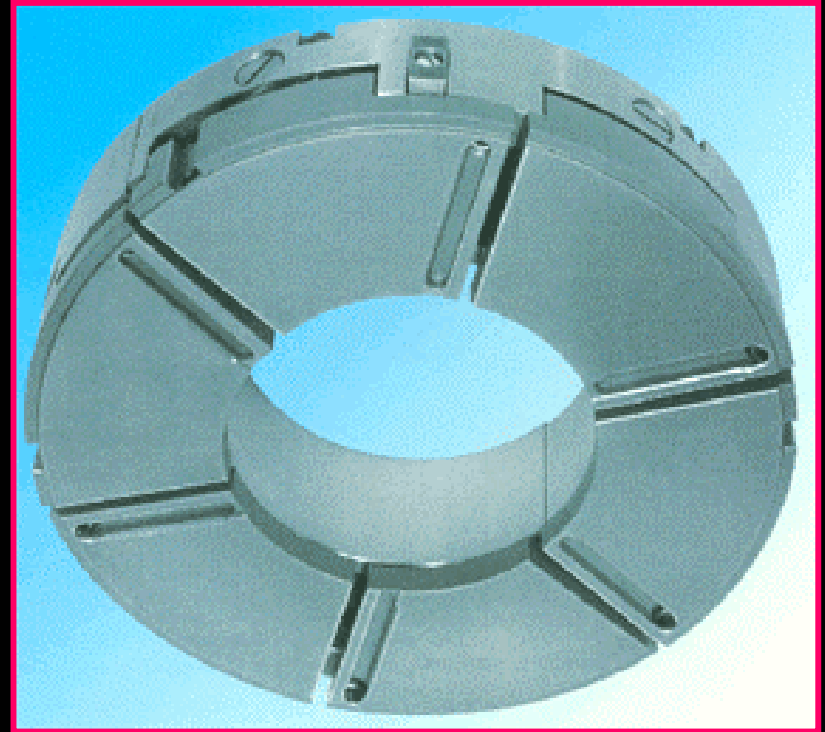
- absorbed power reduction
- flange to flange throughput increase

+1.5% efficiency increase

Centrifugal Compressors Upgrading

DIRECT LUBRICATED THRUST BEARINGS

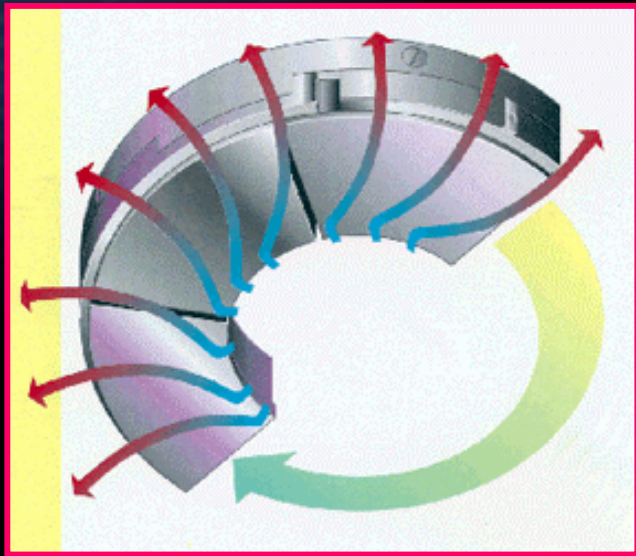
- Axial thrust on the rotor are balanced by balancing drum and thrust bearing to ensure stable axial position.
- On standard thrust bearings oil bath lubrication is used and oil flow is controlled by a calibrated orifice.



Thrust bearing housing is constantly filled with oil with considerable power losses

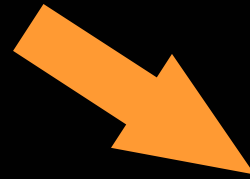
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DIRECT LUBRICATED THRUST BEARINGS



Benefits

- better lubrication of sensitive thrust bearing areas
- lower pad temperature (by 10 to 20 °C)
- Load capacity increase of 15-20%



Six pads with an axial oil inlet communicating with radial groove made along the leading edge of each pad. Fresh oil enter through the inlet and is distributed by the groove on the bearing pad face.



50% reduction of friction losses & Oil flowrate

Centrifugal Compressors Upgrading

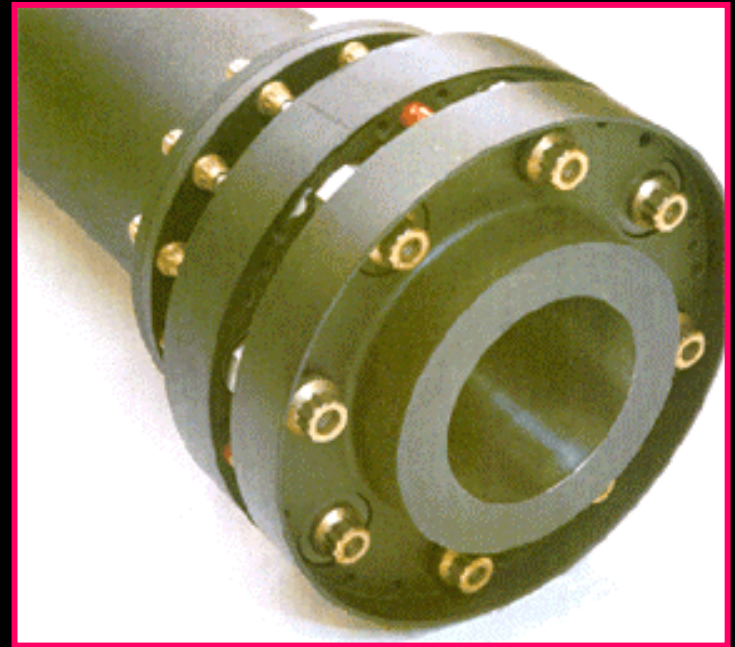
DRY COUPLINGS

Lubricated gear couplings are installed on most NP Compressors manufactured before 1990 but this type of coupling has some drawbacks:

- ↓ wear on gear teeth increases operating clearance
- ↓ malfunction or incorrect maintenance of lubrication system leads to fast deterioration of the toothed joint
- ↓ wear particles and dirt collect inside the coupling

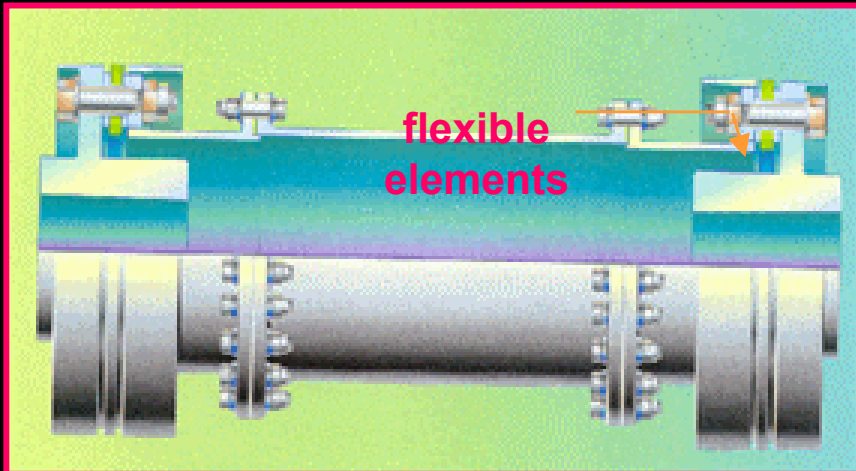
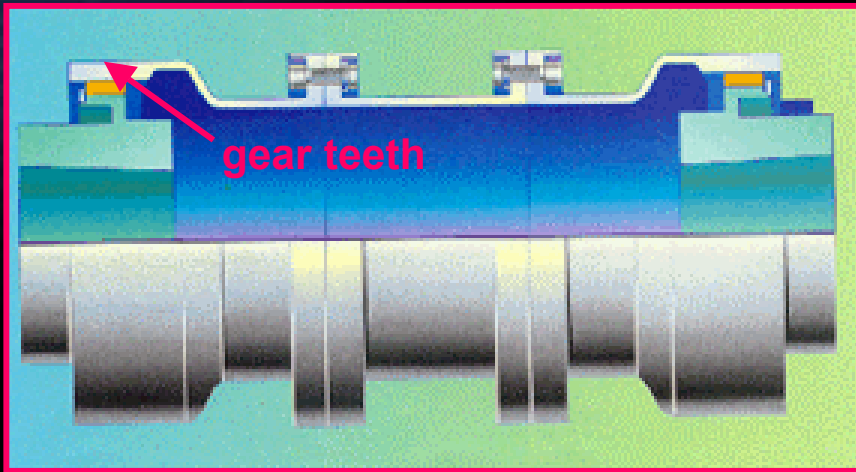
These problems can lead to:

- increasing levels of vibration amplitude
- increase misalignment between turbomachines
- higher expenditure of maintenance manhours



Centrifugal Compressors Upgrading

DRY COUPLINGS



Applicability

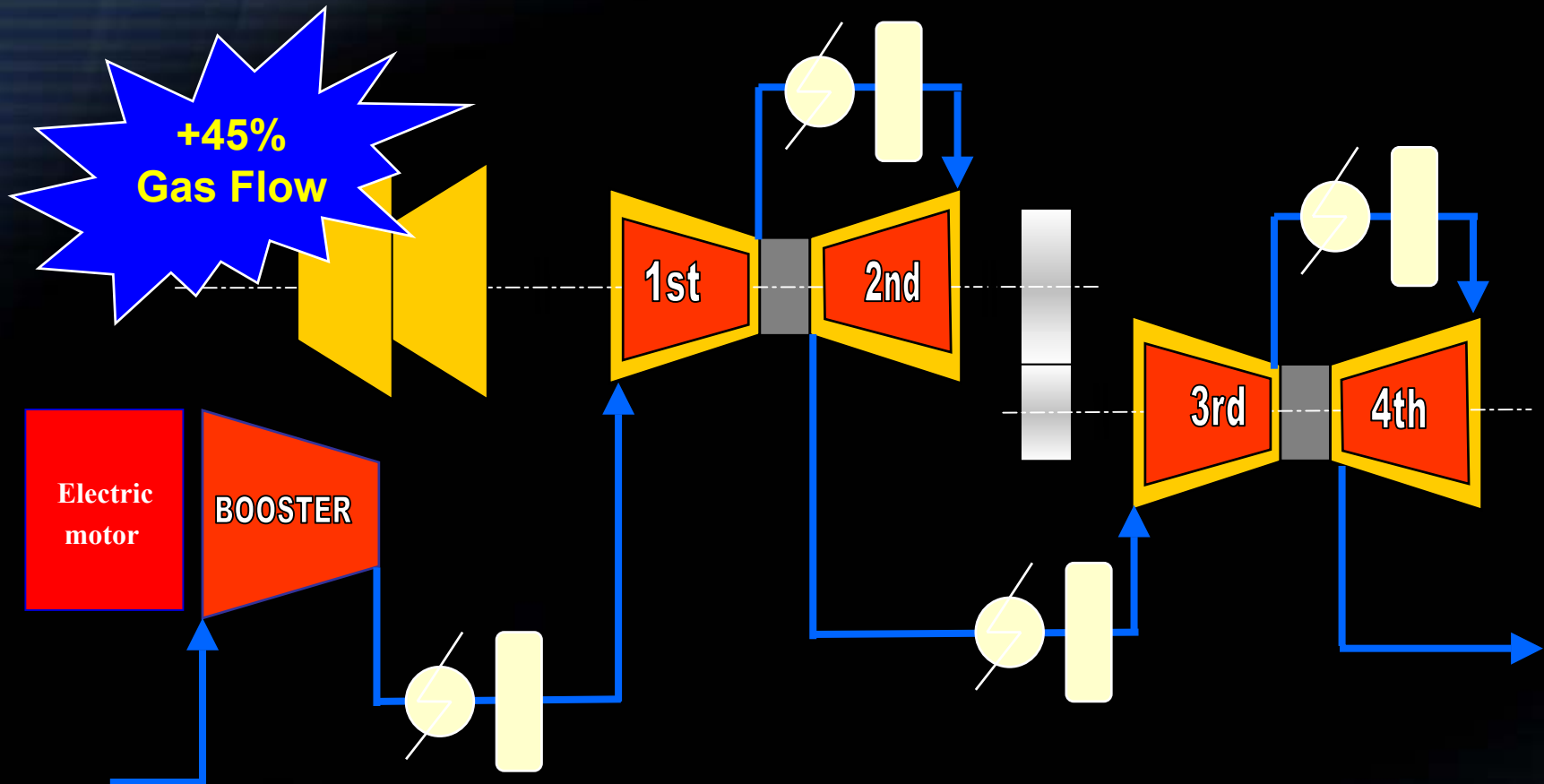
In all Compressor applications Lubricated gear couplings can be retro-fitted without modifying the machine rotor and coupling guard arrangement.

Benefits

- ✓ Maintenance free system
- ✓ Higher reliability/availability compared to the gear type
- ✓ Lower expenditure of maintenance manhours
- ✓ Elimination of lateral instability caused by lube oil flow
- ✓ Lower axial load
- ✓ Higher flexibility of joint to
- ✓ misalignment

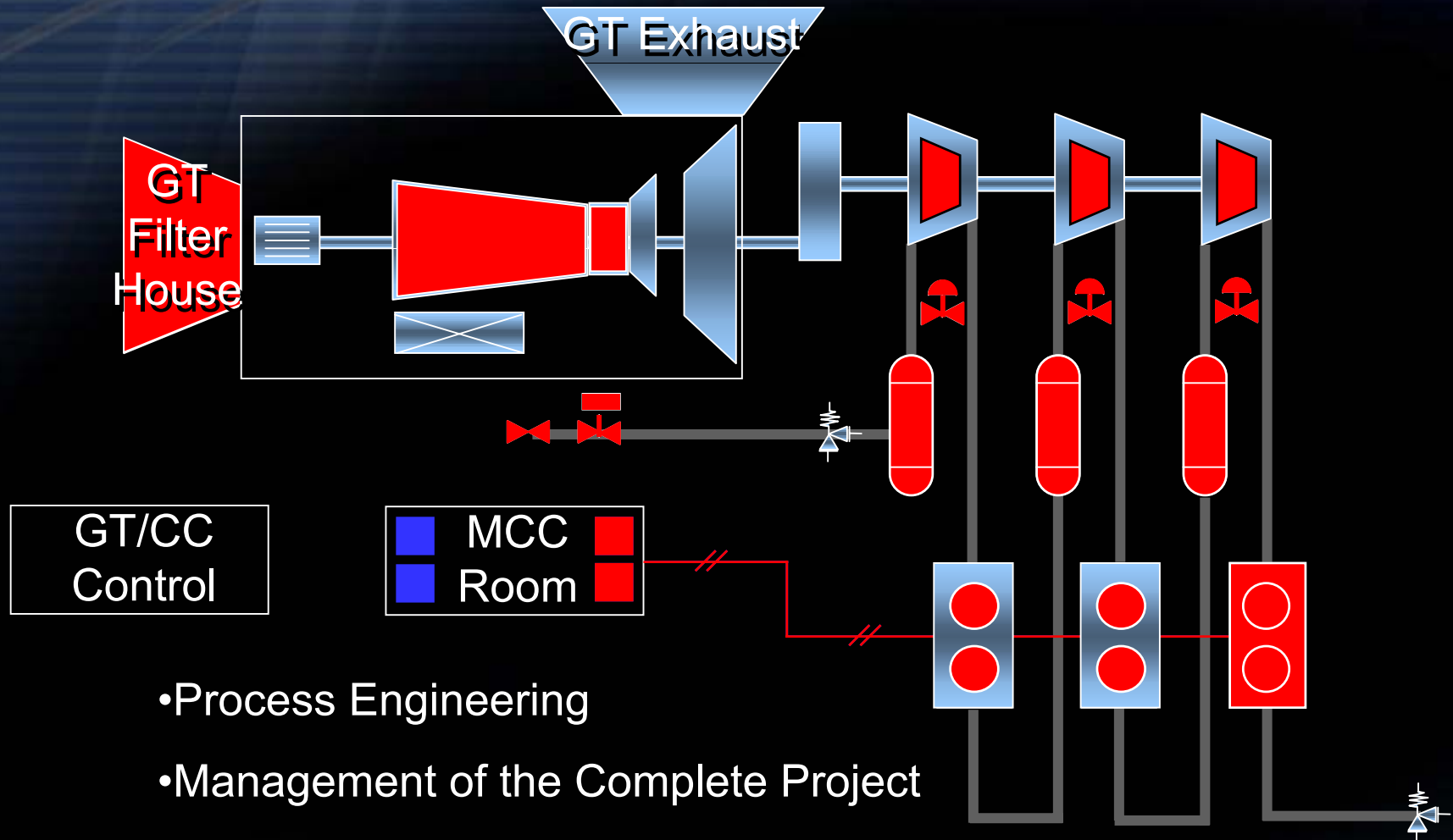
CO₂ Compressors Upgrading

CO₂ REVAMPING China



New Booster + New Compressor Bundles

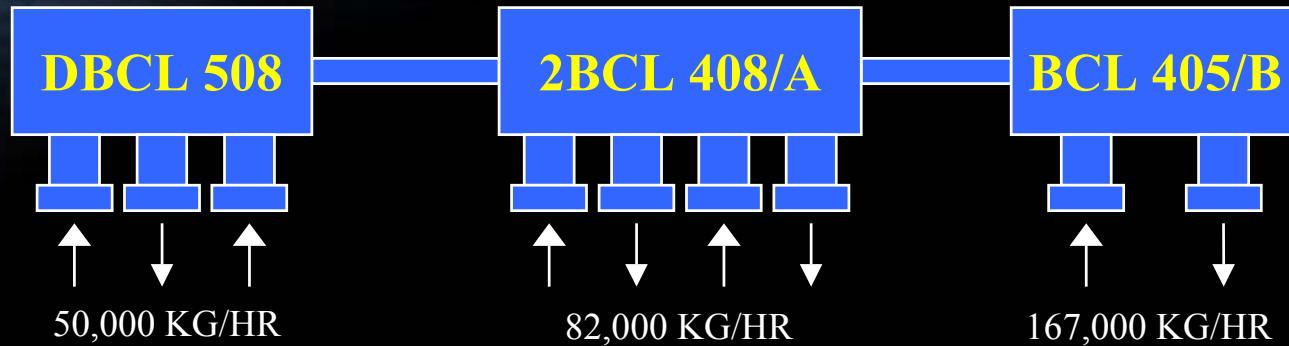
Plant Upgrading with 2 TC Trains



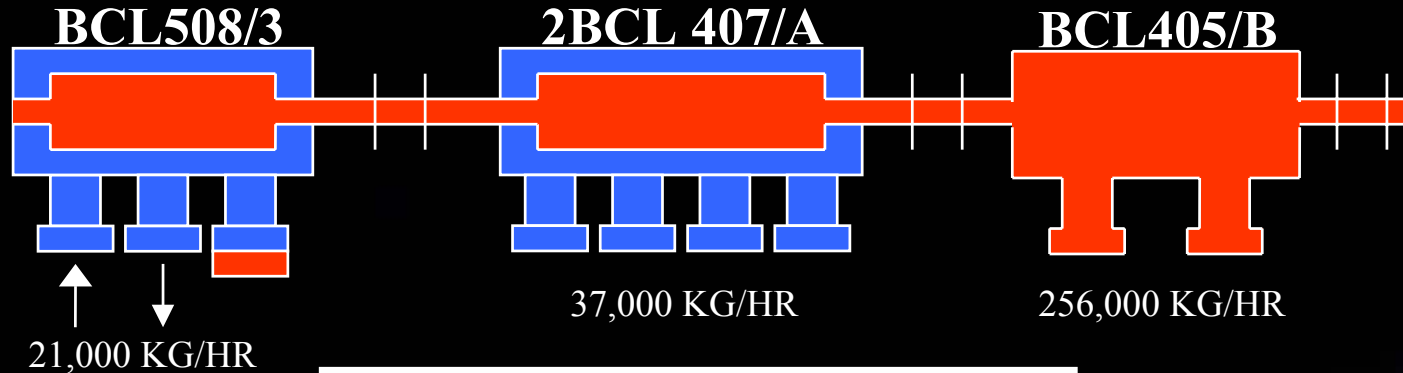
- Process Engineering
- Management of the Complete Project

Intervention at Site with Turn-key Responsibility

OIL PRODUCTION PLATFORM TRANSFORMATION FOR GAS EXPORT



INJECTION - AS IT WAS



EXPORT - AS IT IS

Conclusions

MINIMIZE IMPACT ON EXISTING EQUIPMENT

MINIMIZE MANUFACTURING

MINIMIZE INSTALLATION TIME & SHUTDOWN

REDUCE COSTS

Attractive Project Economics