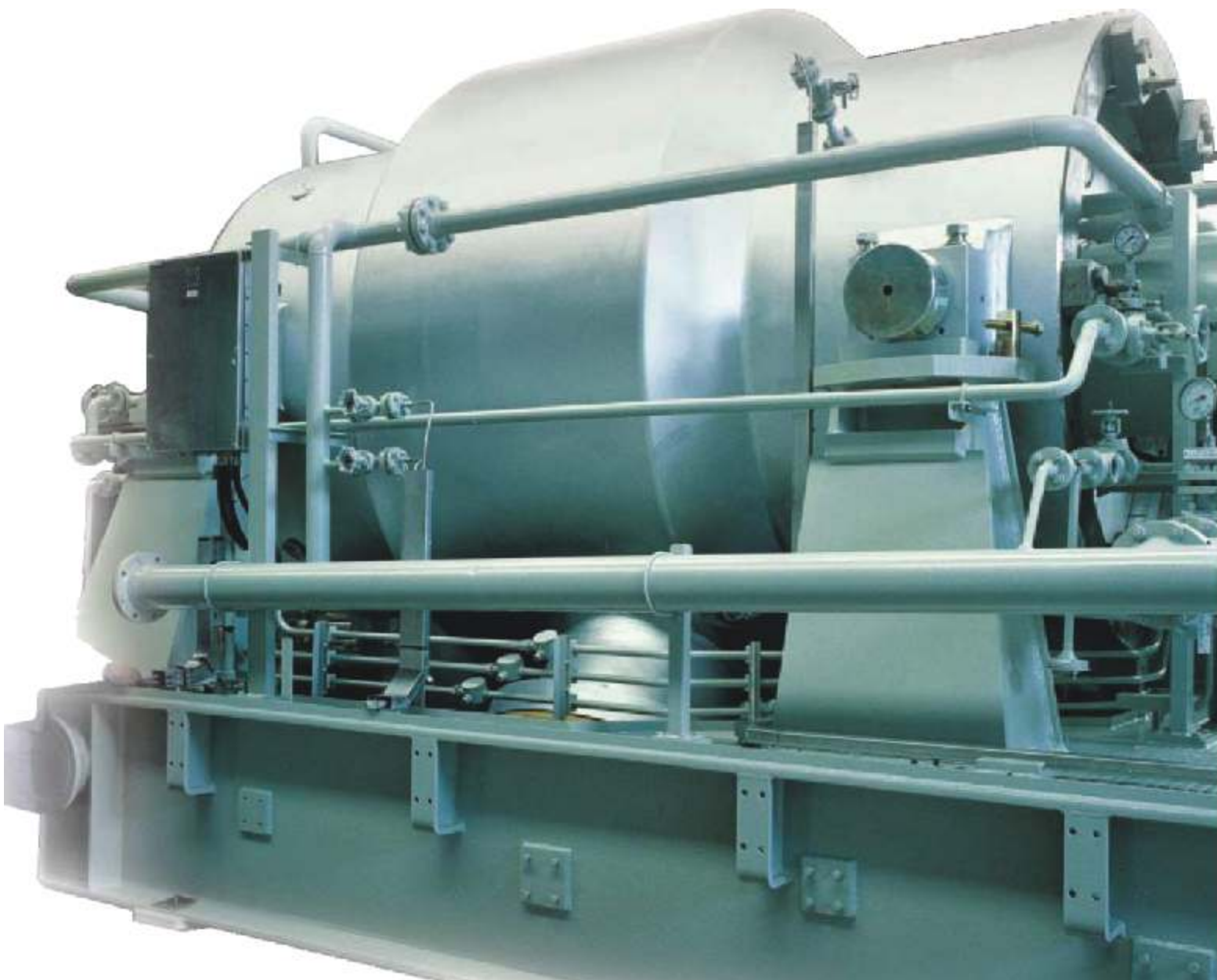


Bharat Heavy Electricals Limited



Centrifugal Compressors





Centrifugal Compressors

Introduction	1
MCL series	1
BCL series	2
PCL series	2
SRL Integrally Geared Series	3
Compressor Components	3
Oil and Dry Gas Seal Systems	6
Control Systems	6
Test Facilities	7
Service	8
Refinery, Petrochemicals, Pipeline & Fertiliser	8

Introduction

BHEL manufactures a complete range of centrifugal compressors for all major compression applications. They are used in oil & gas production, gas transportation, refinery and petrochemical industries, fuel gas boosting and other similar processes. Our licensor GE holds the record for centrifugal compressor applications having designed and manufactured the first high pressure compressor for ammonia and urea plants, the most powerful compressors for offshore applications (over 30,000 HP) and re-injection compressors with delivery pressures as high as 10,000 psi (700 bar).

Specific requirements are met by custom configuring each compressor using standardized advance technology components proven over a wide range of process conditions. This approach delivers reliable, high performance compressors for natural gas, refinery, petrochemical, and newer applications. Skilled staff of local engineers and technicians provides on-site technical support for installation, commissioning, overhaul, repair and maintenance of our equipment. Steam turbine, Gas turbine, Electric motor and VFD Systems can be provided for driving the compressors.



MCL series



MCL compressors are designed in several sizes and pressure ratings to cover different applications. The compressor casing and diaphragms are either cast (cast steel) or fabricated.

The impellers and diffusers are selected from a wide range of standard stages in accordance with the application and desired performance.

The radial and thrust bearings are of the tilting pad type.

Shaft-end seals are mainly dry gas seals but can be labyrinths or oil film seals.

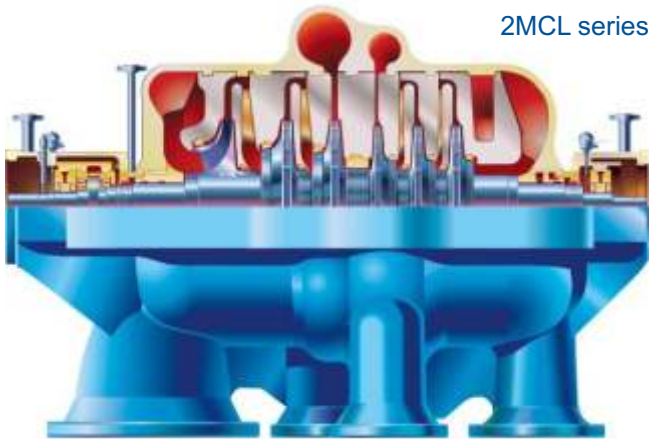
Inter-stage leakages are controlled by labyrinths (static or rotating) or abradable seals.

Double flow models (DMCL) are used to compress very high flows. This solution allows the casing size and speed to remain within an acceptable range to couple the compressor to drivers and/or other compressor casings.

Different washing options can be offered as desired.

Double stage models (2MCL) are used when intermediate cooling is required or when a process calls for two separate compression stages.

2MCL compressors have the same general features as the MCL type with the two compression stages in a back-to-back arrangement.



Additional side stream nozzles can be provided with the 3MCL model for special requirements such as in refrigeration applications. All connections can be oriented upward or downward to meet plant layout needs.

BCL Series

These compressors are designed to cover a wide range of applications and pressures (hydrogen mixtures, hazardous gases, high pressure).

Casings can be rolled steel or forged with one or two end covers bolted or secured by shear rings.

For improved performance, diaphragms are mostly machined.

Radial and thrust bearings are of the tilting pad type.

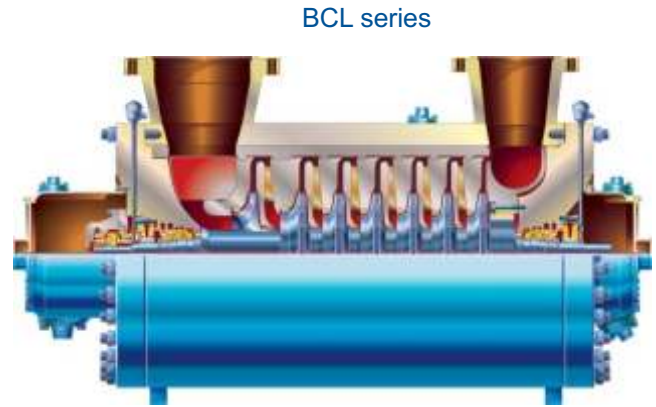
End seals are of the dry gas type. Other sealing solutions are also available.

In addition to conventional labyrinths, inter-stage seals can be abrasion or honeycomb seals to optimize the overall performance of the machine.

In-line, back-to-back or double flow configurations are also available.

Materials are adapted to the process requirements. Based upon extensive

experience in corrosive applications, specific materials are selected to withstand the various forms of corrosion present in sour or acid gas applications.



PCL series

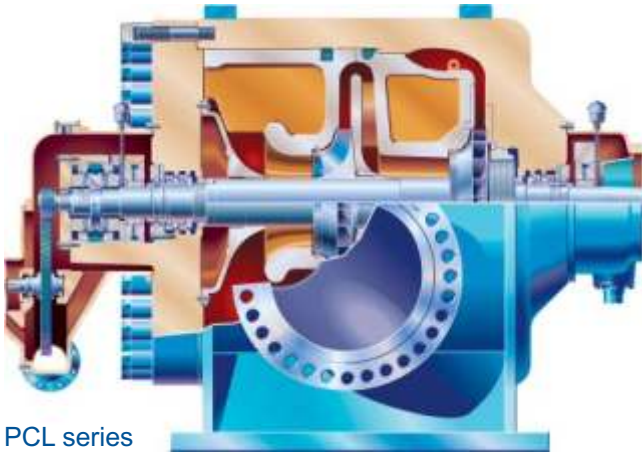
These compressors have been designed to meet the range of flow and compression ratios required by gas transportation stations.

A variety of standard casing sizes are available to cover a wide range of gas flow.

The same casing can house different numbers of impellers to optimize performance in terms of efficiency, compression ratio and operating range.

The compressor casings are made of forged steel to provide maximum material strength and metallurgical stability. Vibration-free operation is assured by positioning bearings at





PCL series

both casing ends which provides the necessary rigidity to the rotor.

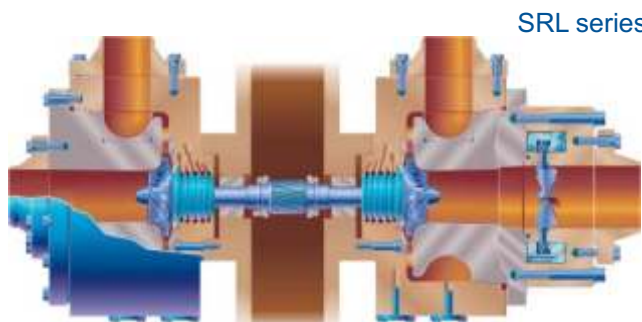
Dry gas seals are normally used to prevent gas leakage.

Floating bushing oil seals are also available on request.

The suction and delivery nozzles are generally located opposite each other to meet station layout requirements. Axial inlet is also available when the pressure ratio allows for a single impeller.

SRL Integrally Geared Series

Integrally Geared Compressors are used in several petrochemical applications, either for low-flow/high pressure, or high-flow/low pressure conditions. This type of compressor has a bull gear and from one to four high speed pinions. One or two impellers can be mounted



SRL series

on each pinion-shaft. Optimal impeller speed and the ability to inter-cool compression stages guarantee very high efficiency. Due to its rugged mechanical design, this type of machine has a very high reliability and is easy to maintain. A large variety of gases can be handled by this compressor line with appropriate construction materials and seal systems. This line is designed for process air and gas service.



Compressor Components

Casings

Depending on the compressor family the casings can be

- Horizontally split
- Vertically split

Horizontally-split casings consist of two half casings joined along the horizontal center-line. All connections such as suction and discharge nozzles, side stream nozzles (if any) and oil piping are normally fitted to the lower half so that the upper half becomes an easily removable cover. The casings may be cast or fabricated steel depending on the compressor duty, service temperatures, gas handled and compressor size.

Vertically split casings have different shapes and thickness depending on the pressure rating.

Casings up to 350 bars are steel cylinders with end covers either bolted or secured by shear rings. Nozzles can be welded to the casing or machined directly.

By removing the end cover it is possible to remove the rotor diaphragm bundle assembly and gain access to the internal components without removing the outer casing which remains connected to the plant piping package.

Diaphragms

Suction, intermediate and discharge diaphragms create the gas flow path within the stationary components. The suction diaphragm conveys the gas into the eye of the first impeller. Intermediate diaphragms perform the dual function of forming the diffuser passage (where gas velocity is transformed into pressure) and the return passage to channel gas to the eye of the next impeller. The discharge diaphragm forms the diffuser for the last impeller as well as the discharge volute. The diaphragms are usually horizontally-split.

In the small to medium sizes of the MCL series, the upper half of the diaphragms is fixed to the upper half casing to facilitate inspection, and for the large sizes, it is fixed to the lower half of the diaphragms, while the barrel family internals are assembled into a bundle which can be easily extracted from the casing.



The diaphragms are made of cast steel or stainless steel and machined.

Easily removable labyrinth seals are installed on the diaphragms at impeller shrouds, to prevent return flow from discharge to suction and on the shaft sleeves to eliminate inter-stage leakage.

Rotors

The rotor consists of shaft, impellers, sleeves, balance drum and thrust collar. Impellers are selected from a number of standard families. Each family groups a set of geometrically similar impellers with different flow coefficients to meet specific flow requirements. All geometries have been tested by the collaborator-GE. Impellers are shrunk on the shaft. Impellers may be either of the closed or open design. Closed impellers are made of



forged steel. Their blades may be welded to both the disc and the shroud or milled from a solid disc and welded to the shroud.

The blades are generally back-swept to different angles in accordance with the required performance.

Open impellers are machined from solid forgings.

Each impeller is dynamically balanced and over-speed tested before assembly.

The rotor is balanced after the assembly of each individual component on the shaft.

Seals

Shaft end seals eliminate or minimize the leakage of compressed gas or the entry of air into the compressor casing. Depending on the nature of the gas to be compressed and on the degree of sealing to be achieved, different types of seals may be used.

Labyrinth seals

They are used when the properties and pressure of a gas permit a minimal leakage. The labyrinths are made of light alloy or other corrosion-resistant material and are easily replaceable. The number of teeth and clearance depend on the operating conditions, as well as the geometry (plain, step, ring type, honey-comb, etc.). To minimize leakage, abrasion-resistant seals are used. In this case the labyrinth teeth are fitted to the rotor and are in contact with an abrasion-resistant material on the stator.

When no leakage whatsoever is permissible (poisonous or explosive gases, etc.) labyrinth seals are combined with extraction and/or injection systems.

Dry gas seals

Sealing is ensured by a gas lock created by the grooves machined into a rotating seal fitted on the rotor. Depending on the application it is possible to use gas taken off the compressor at different levels: first

impeller diffuser, intermediate or discharge nozzles or an inert gas.

Hydrostatic and hydrodynamic forces balance to maintain a clearance of a few microns between the rotating seals and the stationary face. This very small clearance reduces gas leakage to a negligible amount.

Different patented solutions are available through technology transfer from GENP to temper the seals to prevent liquid or hydrate formation or for controlling the temperature of the seal.

Extensive experience has been accumulated on dry gas seal systems that have been developed to meet specific process requirements

Bearings

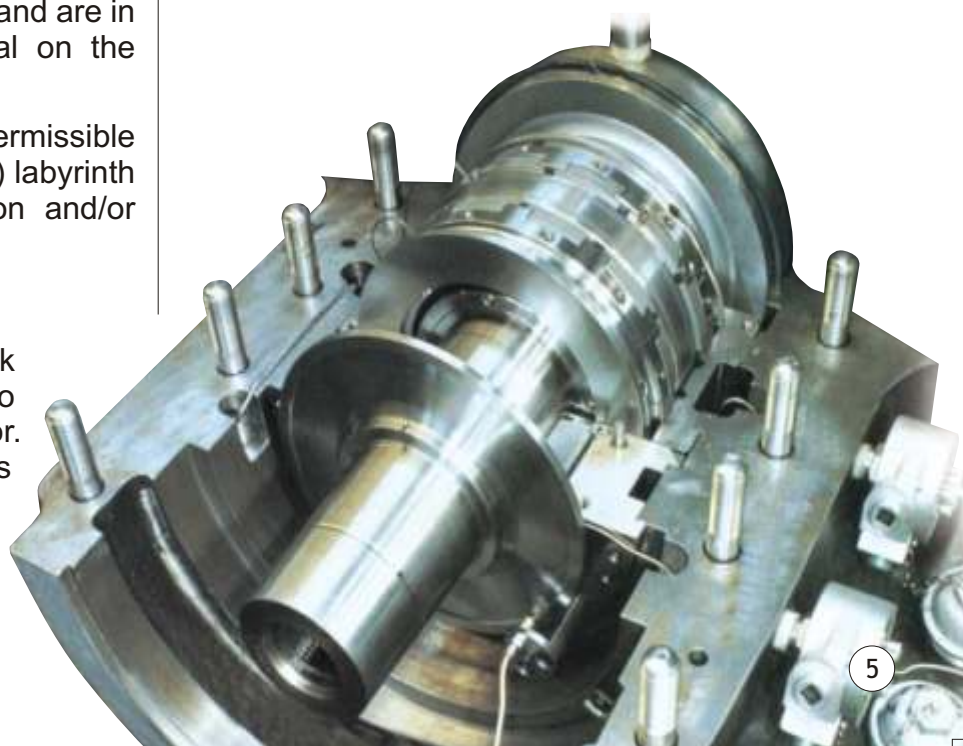
Hydrodynamic bearings

Journal bearings

Tilting pad bearings are generally used, and are normally equipped with thermocouples to monitor the bearing temperature.

Thrust bearings

Double-acting, tilting pad bearings with an equalizing device are typically installed. The bearing pads can be fitted with thermocouples for temperature monitoring.





Oil and Dry Gas Seal Systems

Oil systems

Pre-engineered solutions, designed in accordance with API 614 are implemented for continuous compressor operation. Integrating the experience from the large number of units in operation ensures high reliability and short cycle times.

The oil system can be a separate console or is integrated with compressor base plate for compact packages that are easy to install on-shore or off-shore locations.

The lube oil system provides lube oil to the radial and thrust bearing of the compressor, to the gear box, and to the driver (except for some gas turbines).

A seal oil system supplying filtered oil to the liquid film rings or to mechanical type seals at



the required pressure and temperature can be provided upon request.

The seal oil system may also be combined with the lube oil system. In this case the same oil reservoir is used for both functions.

Dry Gas Seal systems

This provides the required buffer gas for the primary, secondary and tertiary seals, and the instrumentation to monitor the seals properly. Dry gas seal systems are engineered to suit specific machine requirements.



Control Systems

With extensive experience as a manufacturer of compressors and all types of drivers, and engineering and field services for compression stations, our specialized teams develop systems to control the equipment packages and the associated auxiliaries or processes as required.

Anti-surge protection and process control

Anti-surge control algorithms implemented within the control system are based on the knowledge acquired through our expertise as a leading compressor manufacturer and experience on hundreds of applications. Different control strategies are available to meet the needs of the application. All provide closed and open loop controls to react to small and large process disturbances. Different process control functions can be provided.

Test Facilities

Centrifugal compressors are carefully tested throughout the manufacturing process in order to guarantee a perfect match to their design criteria and to assure long lasting, continuous operation.

The following tests are typically carried out on components and assembled machines:

- Casing - hydraulic pressure test
- Impellers - ultrasonic and dye penetrant liquid tests, over speed testing
- Impellers/rotors - over-speed testing
- Mechanical run test

Optional tests may be performed based on the specific job requirements, such as :

- performance tests (with air or other gases in an open or closed loop)
- full load-performance tests (including flammable gases) to check rotor stability and the performance of the machine
- mechanical string test (with steam turbine, gas turbine or motor)

Many indoor test beds together with a sophisticated system for data acquisition and processing of test results are present at Hyderabad facilities.

We have the largest and most complete testing capability (VFD driven 8 MW electric motor drive) in the industry in India to perform tests under actual load and pressure conditions for compressor trains.

String test of gas turbine driven light end fractions compressor for Vijaipur



String test of motor driven compressor along with job lube oil system



String test of natural gas compressor driven by job motor for Marmul, Oman



String test of Gas Lift Compressor train driven by motor for Lekhwair, Oman



Service

BHEL's business provides a complete set of services to support the entire centrifugal compressor product line. We offer an extensive portfolio of proactive and interactive service products such as condition-based maintenance, Conversions, Modifications and Uprates (CM&Us) complementing the traditional service offerings of OEM spare parts, repairs, and field services.

Regular customer training programs are organized for customer engineers to impart knowledge in equipment design philosophy, construction, assembly, operation and trouble shooting. Experienced faculty from the concerned disciplines provide the conceptual inputs backed up by shop visits.

BHEL engineers are supported by product design engineering groups and by the Corporate R&D where creative minds are working to provide the high-tech products and business solutions for the 21st century.

Refinery, Petrochemicals, Pipeline & Fertiliser



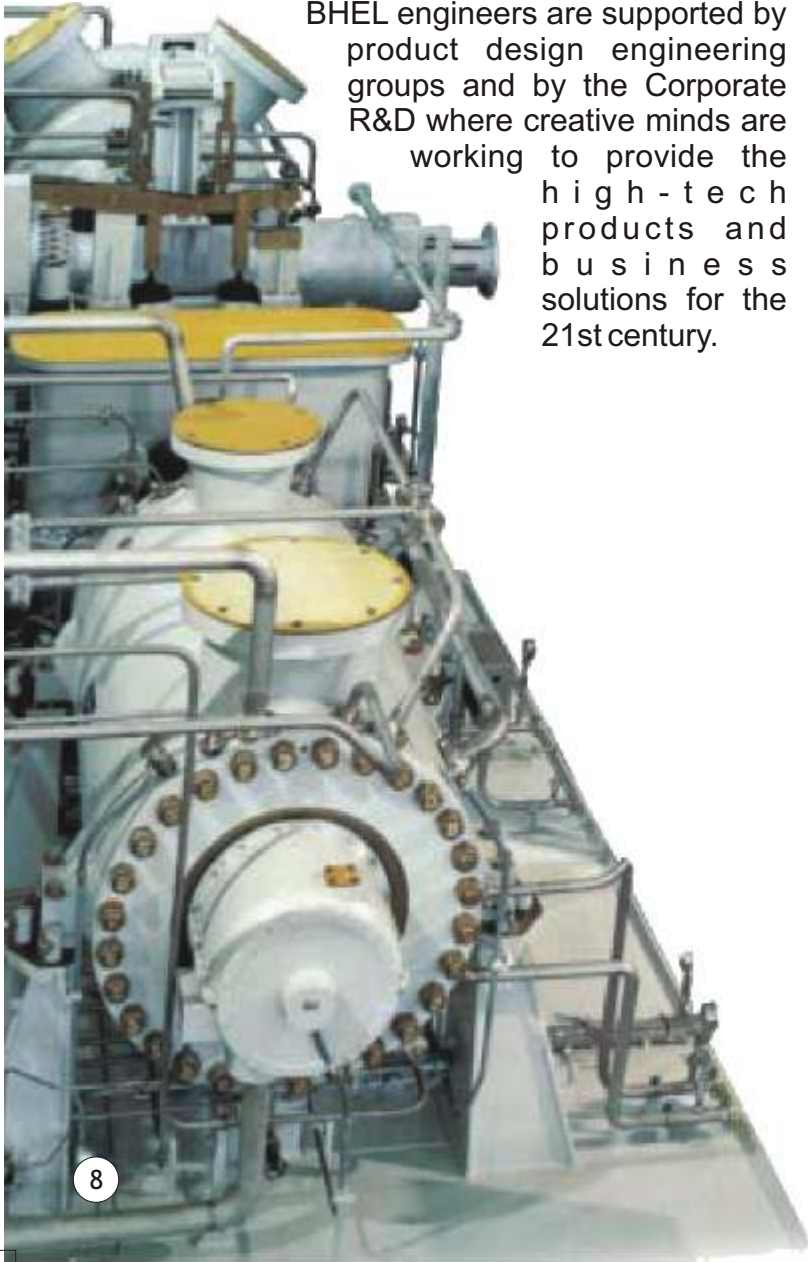
Fabricated wet gas compressor for refinery application



CO2 compressor train for a fertiliser plant in France



Isomerisation compressor for a refinery in Iraq



Double ended steam turbine driving LP & HP compressors for DHDT Service



4 casing Synthesis gas compressor train in a fertiliser plant



Steam turbine driven Wet Gas compressor for Refinery



Steam turbine driven H2 Recycle gas compressor for motor spirit quality upgradation



Fabricated compressor for inert gas application



Depletion Compressor installed at Oman

www.bhel.com

Bharat Heavy Electricals Limited

