

CAPABILITIES & FACILITIES



**Contributing
to Create
a New India**

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ABOUT BHEL

BHEL has played a pivotal role in shaping the engineering and manufacturing capability in India across several sectors, including power, transmission, transportation, renewables, water, oil & gas, aerospace and defence, touching an annual revenue of ~4 billion USD. BHEL has established strong linkages with other Public Sector Undertakings as well as research institutes in the country and is also having technology tie-ups with leading OEM's in various sectors.

BHEL also has extensive experience in executing EPC projects in power plants and other industrial sectors. BHEL supplied equipment account for 60% of India's power generation, with a global installed capacity base of 185 GW (coal, lignite, nuclear, solar, hydro). BHEL has also served several overseas customers, with a global footprint in over 83 countries.

BHEL has 16 manufacturing facilities spread across the country that manufacture equipment compliant with latest national and international standards. BHEL's state-of-the-art facilities specialize in engineering, manufacturing, testing, aftermarket services for equipment such as steam turbines, generators, boilers, valves, piping, control systems, hydro turbines and generators, and gas turbines in the power sector segment and other industrial sectors. The manufacturing units are supported by 4 overseas offices, 4 regional offices, 8 service centres and 15 regional marketing centres to deliver value to its customers.

BHEL is credited as one of India's largest employers, in the engineering sector with ~34,000 highly skilled employees which includes 9,000 engineers with qualifications, experience and skills spanning a wide range of technology areas. BHEL's employees have been one of the strongest pillars in building this successful business.

BHEL earmarks over 2.5% of the annual turnover for R&D spend, making it one the highest in the capital goods manufacturing industry in India. BHEL's dedicated R&D centre in Hyderabad has been instrumental in shaping technology and innovative manufacturing capabilities. BHEL has collaborated with several global players in establishing over 75 technology collaborations over the years. These partnerships have helped both parties, fruitfully benefit by sharing technology, know-how and resources.

BHEL's unique ability to provide pan India access has been one of its core strengths. There are about 150 ongoing projects in different parts of India, served through the manufacturing and business units spread across the country. With an installed base of 17 GW outside India and ongoing projects of ~6 GW, BHEL has experience in 83 countries and overseas offices in 4 countries. BHEL's expertise in exports can be utilized by global manufacturing firms to have a manufacturing hub in India.

BHEL's dedicated role in supporting the country's development as one of the leading public sector enterprises in the country, has amassed credibility to advocate big shifts in the country in close association with the Government, Research and Educational institutions, other public and private companies and industry associations.

1) BHOPAL

Led by a vision of India's first Prime Minister, Pandit Jawaharlal Nehru, the plant at Bhopal was established as Heavy Electricals (Private) Limited (HE(P)L) in August, 1956 with the help of Associated Electrical Limited of UK. About 5000 acres of land was transferred to HE(P)L by the Government of Bhopal annexing three villages, Gadia, Piplani and Berkhera. In November 1958 the foundations of HE(P)L was laid and the factory was dedicated to the nation in November 1960. Later HE(P)L was renamed Heavy Electricals (India) Limited (HE(I)L) with the transformation towards the total power-systems approach from the earlier products-based approach. In the year 1974 the Government of India merged HE(I)L with BHEL, which set-up ten years ago in 1964, to create a truly modern global engineering enterprise.

1.1) Centre of Excellence-Hydro Machines

Centre of Excellence-Hydro Machines at Bhopal unit, is fully dedicated facility for R&D activities of hydro turbines and lift irrigation pumps backed by a team of highly trained engineers and latest technological tools. It is equipped with a sophisticated and modern laboratory to evolve highly efficient hydro turbine profile designs by mathematical modelling and design-vetting and further detailed studies by experimental model tests.



Centre of Excellence-Hydro Machines at Bhopal.

COE-HM is accredited by National Accreditation Board for testing and calibration laboratories for testing of hydro turbine and pump models. It is recognised by Department of Scientific & Industrial Research (DSIR), Government of India as in-house R&D group for hydraulic design and development of hydro turbines. COE-HM is equipped by a CFD centre which forms the basic back-bone of hydraulic design and optimization of hydro turbine and pump profiles for achieving Internationally competitive designs.



Model Test Rig at Centre of Excellence-Hydro Machines

It is equipped with a high-performance blade cluster with super-computing power for high speed number crunching and solving huge problems. COE-HM is also equipped with three universal test stands capable of testing entire range and all types of Hydro turbines/pumps (Francis, Kaplan, Pelton, bulb, reversible pump-turbines and pumps).

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The laboratory is equipped with latest measuring instruments and technical advancements and consistently complies with IEC 60193 standards. COE-HM also has a dedicated group for turbine field efficiency testing at site in accordance to IEC 60041. It also has an in-house manufacturing facility for accurate manufacturing of hydro turbine model components.

1.2) Manufacturing and Testing Facilities for Transformers

BHEL is one of the first manufacturer of power transformer in India catering to the need of domestic and overseas utilities since 1961. The facilities at Bhopal unit are today equipped with state-of-the-art design, manufacturing and testing facilities for manufacturing of transformers and reactors up to 1200 kV class. The facilities are equipped with fully air-conditioned winding bay/enclosures with winding machines having load capacity up to 30 tons.



Transformers - Final Assembly Platform



Transformers - Vertical Winding Machine

There are pre-coil assembly platforms as well. Core shop is equipped with in-house slitting and cropping facility for core laminations. Assembly bay, equipped with assembly platforms and vapour phase drying ovens, is also pressurised to keep it dust free. Ultra-high voltage laboratory is fully equipped to conduct all type test and routine test on transformer and reactors. Along with power transformers, BHEL has long experience of supplying various ratings of instrument transformers, capacitors and bushings.

1.3) Traction Machines Engineering Division/Transportation Group

Traction Machines Engineering Division/Transportation Group at Bhopal unit has state-of-the-art design, development, manufacturing and testing facilities for electrics (viz. AC traction motor, DC traction motor, alternators and auxiliary machines) and train set system. The facility also caters requirement of electrics for oil field (AC & DC oil rig motors, oil rig alternators) and defence application.



Traction Motor Assembly Facility

The group has been a pioneer in design and engineering for supply of electrics to meet the demand of Indian Railways and various other customers. BHEL has been a reliable supplier of electrics as well as a partner of Indian Railways in development of new locomotives and EMUs.

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Its design centre is equipped with dedicated latest modern gear hobbing and 3D coordinate measurement centres for manufacturing of gears with highest level of precision. With the help of advanced software, new designs are analysed and checked for various design parameters.



The facility is equipped with latest CNC machining centres to meet accuracy and precision requirement of finally manufactured product at component level itself. Its shop is equipped with state-of-the-art dust free air-conditioned winding facility and vacuum pressure impregnation plants to meet ultimate electrical performance requirement of machines. For overall system testing, Centre for Electric Transportation (CET) is a unique facility envisaged to act as focal point for systems-oriented research in the area of electric transportation.

1.4) Thermal Group

Steam turbine group deals with a wide range of products for thermal power plants (120 MW, 195 MW, 210 MW, 250 MW, 270 MW, and repair and spares for all BHEL make steam turbines up to 500 MW), nuclear power plants (220 MW & 700 MW), submarines of Indian Navy (15000 SHP) and process industries (2.8 - 8.4 MW). Heat exchanger group deals with wide variety of products for all ratings of thermal and nuclear plants which covers HP heaters, surface condensers, LP heaters, moisture separator and reheater-MSRs for Nuclear plants along with allied equipment's like RE Joints, Butterfly Valves, Heat Exchangers etc.

Design Capability: Turbine group carries out all engineering activities and uses specialized proprietary software's for the thermal design and analysis of data. The group is associated with the manufacturing group in performing the functional test on computerized test setup for testing of various components and systems of thermal and nuclear plants. The group has the capability to conduct performance guarantee test of the steam turbines as per applicable international codes and its acceptance norms. Heat exchanger group carries out all engineering activities of HP heaters, condensers, MSRs and allied heat-exchangers, pressure vessels, etc. This group is a member of Heat Transfer Research Institute (HTRI) of USA and accreditation of ASME-U stamp.

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Significant Manufacturing Capabilities: Computerised functional Test setup for testing of LP valve with LP servo-motors for 700 MW nuclear turbines, turbine casing distortion removal/straightening facility for 500 MW IP turbines through specialized heating process, turbine rotor bend removal/straightening facility for 120 MW HP rotor, in-situ shot peening and glass bidding facility, CNC horizontal borer with head mounted on 8 m long bed and with vertical travel of 3.5 m, track mounted NC horizontal boring machine with two heads mounted on 30 m long bed with vertical travel of 10 m and 6 m and capable of machining along vertical axis, special turbine head for machining of diaphragm stages of HP turbine casings of 700 MW nuclear plants. CNC multi-spindle drilling machine with 8-spindles for drilling of holes in plates up to 120 mm thickness with drilling capacity of hole dia up to 40 mm with travels along X axis as 8000 mm and along Y-axis as 5000 mm, twin spindle CNC deep hole drilling machine for drilling of holes up to 30 mm dia in plates up to 600 mm thickness with travel along X axis as 4000 mm and Y-axis as 2000 mm and performance evaluation test setup for heat-exchangers used for cooling oil particularly in OFWF coolers used for transformer oil cooling and thus ascertaining product compliance as per design requirements.



Special Turbine Head for Diaphragm Machining



CNC Deep Hole Drilling Machine

2) EDN - BENGALURU

BHEL's Electronics Division (EDN) of BHEL was formed in 1976 through taking over the erstwhile Radio and Electricals Manufacturing Company (REMCO), a Karnataka Government Undertaking. The takeover was aimed at establishing a strong base in the areas of power electronics, to supplement the company's pioneering efforts in power generation and transmission equipment manufacturing. The unit has kept abreast of fast changing technologies in its areas of operations and has successfully adapted to the changing requirements of customers. It is this intrinsic strength of Electronics Division which has enabled to effectively and efficiently live up to the stiff competitive environment in the global market. The unit successfully maintains its growth rate and has become a major force to reckon in with power and industrial electronics.

2.1) State-of-art Facility for Solar Cell Manufacturing

A state-of-art multi-crystalline solar cell manufacturing facility has been established in the Electronics Division, Bengaluru. This is one among the most advanced and sophisticated facility in the country with robotics-based automation for wafer handling and a processing capability of 3000 solar cells per hour. The level of automation incorporated in this solar cell line ensures that wafers are not handled by hand. This line has a capability for processing multi-crystalline wafers of 157 mm square dimension with a thickness of 180 (+/- 20) microns. Process and utility equipment of the line are designed with advanced technical features which will ensure reliability, quality and safety of process operation. Special safety features for speciality gases and chemicals are incorporated in the machines. This facility also includes an exclusive integrated services complex housing process utility equipment for chilled water, air conditioning plant and compressed dry air.



Automated In-line Metalisation (Screen Printing) Stations of Solar Cell Manufacturing Facility



Acid Texturing Station of Solar Cell Manufacturing Facility

With over 100 MW solar cell facility in operation, BHEL can now go for tie-ups for setting up mono crystalline PERC Solar cell facility and further backward integration to mono crystalline wafer and poly silicon facility.

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Low Pressure Diffusion Furnace of Solar Cell Manufacturing Facility



SMT Assembly Lines



Solar PV Module Manufacturing Facility

2.2) Semiconductor Devices

BHEL is presently manufacturing various types of power thyristors and diodes at the Electronics Division, Bengaluru, which are used in power modules of various control equipment for generation, transmission and loco applications. These devices range in the rating from 1500V, 400 Amps to 6500V, 4500A. BHEL is also in the process of setting up a fab for assembly of IGBT modules. BHEL can take up manufacture of similar devices for industries, at Bengaluru.

2.3) Sub-assembly Manufacturing Capabilities

The electronic modules used in the control equipment for power and industry sectors and transportation equipment are manufactured in the state-of-the-art electronic module manufacturing facility at the Electronics Division, Bengaluru. This facility includes SMT lines consisting of automatic optical inspection and X-ray inspection, through hole assembly consisting of wave soldering with wave pallets, selective soldering machine and robotic soldering machine as well as automatic conformal coating machine, in circuit testing facility, automatic functional test jigs and environmental chambers for thermal cycling and burn-in testing.

2.4) State-of-the-art Facility for Lithium Ion Cell Manufacturing

India's first commercial state of art facility for manufacturing of Lithium ion cell has been established in Electronic Systems Division, Bengaluru with technology support from Vikram Sarabhai Space Centre, Thiruvananthapuram, to produce space grade lithium ion cells. The 10,000 class cleanroom facility can cater to production of space grade advanced lithium ion cells of capacity in the range of 5 Ah, 50 Ah and 100 Ah.



10,000-class Cleanroom With Controlled Relative Humidity

The processing of electrodes is carried out in a <10 % relative humidity zone of ~320 sq m area and the cell assembly is performed in a dry room with < 1 % relative humidity of ~ 380 sq, m area. Lithium ion chemistry is far superior in terms of energy and power density, life cycle and performance than that presently available lead acid battery technology.

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The high energy density NCA based lithium ion are manufactured in the present facility for use by Indian Space Research Organization (ISRO) as an import substitution product in its rocket launchers and satellites. The cells are prismatic cylinder in configuration with aluminium alloy casing and possess advanced ceramic to metal seals in higher capacity cells to provide hermetic sealing and superior safety features. The facility also can cater to other strategic applications like defence and aerospace.

2.5) Centre of Excellence for Power Electronics and IGBT & Controller Technology



CoE-PE RTDS Facility

The Centre of Excellence for Power Electronics and IGBT & Controller Technology has been established at Electronics Division, Bengaluru, to cater for the development needs for transportation electronics with an objective to absorb technologies from collaborators, rationalise the hardware, understand and use latest simulation software in design of power electronics circuits, indigenisation of items, subsystems and systems of IGBT based technology, IGBT device characterisation, type testing of equipment and functional testing requirements while executing commercial contracts. The major facilities include back-to-back testing of IGBT based systems, gate driver evaluation facility, real time testing of power circuits/controllers using real time digital simulator (RTDS), IGBT tester, controller for locomotives and EMU system, EMI/EMC testing for burst and surge testing.



CoE-PE Variable Frequency Drive System

2.6) Centre of Excellence for Control and Instrumentation



CoE-C&I Testing Software



CoE-C&I Model Test Facility

In order to match the current technology and upcoming challenges in the field of control and instrumentation (C&I), a Centre of Excellence for Control and Instrumentation has been established at Electronics Division, Bengaluru.

The capabilities of the centre includes core developments in DCS hardware and software, development and testing of hardware, software, interfaces and systems, incremental development on hardware and software for modules for C&I, DCS in related area of power plant SCADA, simulating and troubleshooting facilities for site reported problems in DCS, security and maintenance of software and systems, and pre-release testing of software. The centre is equipped with a model test setup which is useful in testing new features that are asked as part of contract specifications and is also helpful in simulating site conditions and to diagnose issues reported from sites.

2.7) Electric and Photovoltaic Division

The Electric and Photovoltaic Division (EPD), established in Bengaluru, is a multi-product and multi-capability unit of, catering to the needs of various industries and project needs of the country in the areas of solar PV modules, LT panels, transmission and distribution insulators, ceramic wear resistant products and high tech ceramic products. The solar PV module manufacturing facility is capable of manufacturing more than 650000 PV modules per annum of different variants with wattage ratings above 330 Wp. This is being expanded to 850000 PV modules per annum, taking the total output capacity to 1.5 Million PV modules per annum. The PV modules of EPD are certified to IEC and BIS standards and CE marked for European markets.

The salient features of the PV module line at EPD include automatic tabber and stringing of capacity of 1800 cells per hour, 6-axis robotic lay-up for handling up to 3600 cells per hour, auto cutting placement of EVA, Two stage lamination equipment with 4 numbers of matching capacity, automatic edge trimming and framing equipment, in-line curing with auto stacking and unloader with gantry robots, in-line testing stations, sorting/packing/material storage systems and utilities for power supply, HVAC and compressed air along with backups. EPD has also set up a new facility for manufacturing plate type SCR catalyst for de-NOx applications in thermal power plant and other areas. The state-of-the-art facility with latest equipment from global leaders is capable of manufacturing SCR plate type catalyst of about 6000 Cu M per annum equivalent to a thermal plant capacity of 4000 MW. EPD is the pioneer in the country for providing composite insulators for transmission and distribution systems with ratings up to 765 kV AC and 800 kV HVDC.

The manufacturing setup includes latest injection moulding equipment along with associated equipment for composite long rod insulators and two component injection equipment to cater various instrument. Another major offering from EPD is the range of ceramic components for multifarious industries for wear resistant applications in thermal power plants, structural support and other critical elements wherein ceramic is the material of choice. It is equipped with some of the unique facilities for fabrication of ceramic components. EPD also designs and manufactures LT panels for various industrial and utility applications up to a rating of 4000 Amps, meeting the needs in various industries and thermal power plants across the country.

3) HARIDWAR

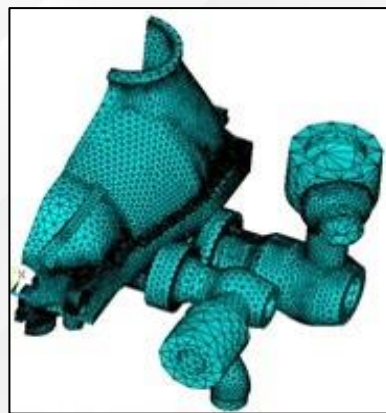
Envisaged with a vision to provide the nation with technological independence in high-tech power equipment, Heavy Electrical Equipment Plant (HEEP) at Haridwar is one of its kind in the whole of South East Asia having the capability to manufacture supercritical steam turbines, turbo-generators and condensers of ratings up to 1000 MW for thermal sets conforming to international specifications. The unit's customer profile ranges from state electricity boards, government power utilities and IPPs. The unit has also emerged as a reliable supplier of strategic equipment like super rapid gun mounts to Indian defence sector for over 25 years now.

3.1) Design Software Tools

Design software tools are extensively used to simulate a virtual image of the real installation or product is created. HEEP/Haridwar unit extensively employs the best among industry design and analysis tools to achieve 3D full featured solid modelling, dynamics, and for analysis purposes. The designs adhere to international standards and codes.



3D ProE Full Featured Solid Model FEA & CAM Application



3D Finite Element Meshing

3.2) Machining Facilities

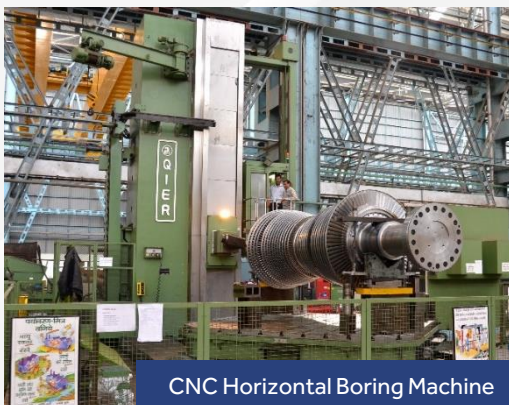
The HEEP/Haridwar unit is equipped with state-of-the-art modern CNC and heavy-duty machines for machining complicated shapes and contours to a high degree of precision. These facilities are supported by material handling facilities for large sized and heavy components, material testing and inspection facilities which ensure quality product manufacturing. Highly skilled manpower having diverse experience in manufacturing technology, cutting tools and CAM based CNC programming is also a great asset to the plant's machining capability. The unit has various CNC machines catering to diverse machining requirements for turbines and generators up to 1000 MW as well as small sized, intricate jobs. The unit also houses a dedicated machining block which caters to machining of turbine blades and turbo-generator cooling blades of lengths up to 1000 mm. This centre is capable of machining intricate shapes and contours for various sizes and types of blades at a mass scale involving diverse metallurgies and meeting stringent requirement of accuracy, tolerances and overall quality.



CNC Slot Cutting Machine

3.3) Fabrication Facilities and Welding Technology

The world class fabrication facility at HEEP/ Haridwar Unit is equipped with Heavy Rolling machines, Plasma Cutting machines, Horizontal Boring machines, Vertical Boring machines, Deep hole drilling machine, Heat Treatment Furnaces with testing facilities. HEEP Haridwar has developed around 400 welding procedures for different materials covering thickness up to 250 mm which adhere to international codes and standards. HEEP has developed expertise to weld and join materials of diverse metallurgies with similar as well as dissimilar metallurgies, especially for AUSC technology. HEEP can handle materials starting from generic materials like carbon steel, alloy steels, special grade stainless steels, quenched and tempered steels, austenitic stainless steels to copper-based alloys, aluminium bronze, brass, aluminium and exotic materials like titanium, nickel based alloys (inconel), clad steels with titanium.



CNC Horizontal Boring Machine



Weld Overlay Machine

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Recent major facilities employed at the fabrication shop includes hot wire narrow gap TIG welding machine, weld overlaying facility, groove stellite machine, CNC flame & plasma cutting machines, 3-roll & 4-roll bending machine, 1000T hydraulic press, CNC brake press, 1.8 MW bogie hearth furnace, to name a few.

3.4) Advanced Production and Testing Facilities

HEEP/Haridwar unit is equipped with advanced equipment to ensure production of supercritical turbines, electrical machines like turbo generator, exciters, permanent magnet generators, AC motors, etc. These include coil and insulation manufacturing shop, moulding shop, vacuum impregnation plant, brazing facility, balancing facility and testing facility for large size turbo-generators and auxiliaries.



600 MW Generator Assembly

The unit also takes up constant endeavours to upgrade its manufacturing setup to match the best in class in the world to keep it abreast with ever challenging technology advancements and product portfolio diversification.

3.5) World Class Blade Manufacturing Facility

HEEP/Haridwar has a dedicated and automated world class blade manufacturing facility, incorporating 26 nos. state-of-the-art 5-axis CNC machining centres, 16 nos. vertical and horizontal CNC machining centres, vibro-finishing machines and 3D coordinate measuring machines. The facility, capable of producing high quality products in minimum possible time with best accuracies, is a perfect example of global technology assimilation in Indian heavy industries.



CNC Machining Centres at Blade Shop

With more than 40 years of experience in robust and proven blade construction, the facility manufactures intricate shape, axially and radially twisted profile high efficiency 3DS and F profile blades for up to 800 MW super critical turbine high pressure, intermediate pressure and low pressure modules; as well as turbo generators. Free standing LP turbine blades of length up to 1300 mm are also being manufactured here. Latest capability addition and technology development manufacturing high nickel based super alloy turbine blades of high efficiency is surely a matter of pride for the facility.

3.6) Key Capabilities in Defence & Aerospace Production

BHEL takes pride in manufacturing the 76/62 super rapid gun mounting (SRGM) for Indian Navy. Over the years, HEEP/Haridwar unit has developed expertise in fabrication of aluminium alloys, special grade alloy steels, bronze, copper and dissimilar materials, and established excellent precision machining facility for complex and intricate profile in components made of titanium alloy, aluminium alloy, special grade alloy steel, bronze within close tolerances. Capabilities for surface protection treatments and special treatments have been established. The unit is set to take up jobs for defence and aerospace sector catering to prestigious customers like Indian Navy and ISRO.



3.7) Testing and Research Facilities

In-house facilities at HEEP/Haridwar unit are equipped to perform mandatory routine, type tests and customer specified supplementary tests on all products. In addition to testing facilities at all the manufacturing shops, there are dedicated NDT Laboratory, Central Plant Laboratory, Metals Research Laboratory and Generator Research Institute, located in the plant premises to support the product engineering, quality control and meeting testing requirements of our products. The services offered include material testing, investigational services, calibration, vendor development and performance enhancement. Electrical Calibration Laboratory under Central Plant Laboratory is NABL accredited as well.

3.8) Facilities and Capabilities of CFFP

Central Foundry Forge Plant (CFFP) is a strategic facility located in Haridwar unit. It caters to the needs of steel castings and forgings for power plant equipment, defence, steel plants, ship building, cement mills, mining industries, etc. It has the capacity to manufacture single piece castings weighing up to 60 MT (integral), 120 MT (cast weld) and forgings up to 34 MT in different material grades. CFFP has also recently developed and established IN625 alloy casting. Apart from having all general foundry and forge facilities, CFFP is well equipped with various specialized facilities including electric arc furnaces, secondary refining facility for liquid metal and associated vacuum tanks, forging presses of 2650 T and 9000 T capacities, heat treatment furnaces up to 100 T capacity, vertical shaft furnaces with air, water, mist and oil quenching facility and CNC machines.

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CFFP Molten Metal Pouring into Ladle



CFFP Heat Treatment on Rotor Shaft

In addition to this, CFFP has state-of-the-art simulation software for both castings and forgings. It has NABL accredited facilities for destructive testing including mechanical, metallography and spectroscopy laboratories along with gas analysis and H₂/O₂ measuring instruments, as well as non-destructive testing, including ultrasonic, radiography, magnetic particle and dye penetrant testing. CFFP is also equipped with in-house radiography testing facility, residual stress measurement facility for forgings, XRF & X Ray analysers and creep testing facilities.

3.9) Capabilities at Pollution Control Research Institute



PCRI External View



PCRI Laboratory

Pollution Control Research Institute (PCRI), is an OHSAS and ISO 9001 certified institute, set up by the Department of Heavy Industry (Government of India), under United Nations Development Programme (UNDP), at the Haridwar unit. The institute is equipped with latest analytical facilities for carrying out studies related to environmental pollution and control. This institute is recognized by Ministry of Environment and Forests and Central Pollution Control Board. PCRI is Member of CHD 032 Environmental Protection Sectional Committee of BIS. The National Mission for Clean Ganga (NMCG) has also nominated PCRI as Class-A Ganga Monitoring Centre (GMC) for carrying out water quality monitoring studies on River Ganga. The institute is actively engaged in providing services for environmental clearance of power projects, preparation of environmental statement of industries, conducting environmental monitoring for regulatory requirements and consultancy services.

4) HYDERABAD

The Heavy Power Equipment Plant (HPEP) at Hyderabad was set up as a result of Indo-Czechoslovak Economic Agreement of 1959. The unit entered into collaboration agreement with Techno Export, Czechoslovakia in 1963. Along with the HPEP, another facility for manufacturing switchgear (circuit breakers) was set up in collaboration with ASEA, Sweden. The production facilities were inaugurated in December 1965. The organizational structure at BHEL Hyderabad initially was focused on establishment of systems and processes. Since the modest beginning, the unit has been focusing on sustaining its technological strong-points. The concept of Quality Circles in India started at the unit in 1981.

4.1) Blade Manufacturing Facility

State of the art CNC 5-axis turbine blade manufacturing setup was established at blade shop at Hyderabad unit with integrated air conditioning plant and standalone compressed air facility. The automation systems incorporated on these machines helps in manufacturing the turbine blades with minimal operator interference. The machine allows the machining of the blade from bar stock in a single setup.



CNC-5 Axis Two Spindle Machine

The precision and accuracy of these machines helps to work on tighter tolerances required to be achieved on critical turbine blades. Better surface finish and faster material removal rates are achieved on these rigid machines. The available machines vary according to the size of the blades that can be machined and number of spindles on each machine.

4.2) Heavy-duty Gas Turbines



CNC Creep Feed Grinding Machine

Centre of Excellence – Gas Turbine Buckets and Nozzles: This facility has been established at Hyderabad unit for in-house manufacturing of gas turbine buckets and nozzles. It is equipped with special purpose machines, CNC creep feed grinding machine and CNC twin ram EDM machine, for machining the super alloy material and CMM machine for inspection of the jobs. The CNC creep feed grinding machine, which is used for in-house manufacturing of aero buckets of GTs, employs a deep cut and high metal removal rate and features a low feed rate.

Hydraulic clamping fixtures are used to clamp the bucket castings, diamond dressers are used to form the profile of bucket root and shroud areas on the grinding wheel. The CNC twin ram EDM machine is used for in-house manufacturing of GT nozzles. The twin rams of the machine help in machining chord length and seal slots on the concave side and convex sides of the nozzles in single set up. Machining is carried out by electric discharge machining with graphite electrodes. These special purpose machines are best fit for machining super alloy materials with close tolerances.

4.3) Electrical Machines

The Electrical Machines group in Hyderabad unit manufactures turbo generators for gas, coal and nuclear based power plants, defence and strategic applications. These turbo generators are for both indoor and outdoor applications designed as per customer specific requirements. Some of the state-of-the-art facilities include unique special purpose machines like CNC rotor slotting machine, CNC centre lathes of capacity up to 80 T, CNC horizontal machining centre, CNC vertical turning lathes and CNC horizontal boring machines, CNC 540° transposition of generator stator Roebel bars, 6-axis CNC taping machines, global vacuum pressure impregnation (GVPI) system and rotor dynamic balancing facilities ranging from 2 T to 120 T. Services are provided in areas like in-situ critical diagnostic tests, life assessment studies, strong support for field engineering services and reliable service-after-sales.

4.4) Switchgear

State-of-the-art facility for Robotic Plasma Coating: A state-of-the-art facility for robotic plasma coating (using plasma spray technology) has been established in switchgear shop at Hyderabad unit. This is one amongst the most advanced and sophisticated facility which is used for thermal barrier coating on combustion components of gas turbines, ceramic coatings on washers and chromium carbide coatings on spindles for compressors. These coatings are made using a robot with 6-axis rotation movement with accuracy of $\pm 0.07\text{mm}$ and a tilting cum rotating table with loading capacity of 400 kg. As robot has 6-axis of motion, any complex path can be coated with great ease. It is equipped with industrial pc loaded with robot studio software with online program editor, system parameters editor and event recorder. It presently has uni-coat spray controller type USC-120, containing PLC for process control and all safety interconnections including electronics for gas leak detectors with industrial pc connected for programming and monitoring the plasma spray process.

4.5) Design Capabilities and Manufacturing Facilities of HE&F Division

Heat Exchanger and Fabrication (HE&F) division at Hyderabad unit, offers entire gamut of heat exchangers in the regenerative cycle of a thermal power plant like condenser, ejector, gland steam condenser, drain cooler, LP heater and deaerator. This division has an excellent engineering, manufacturing and testing capabilities to offer tailor made solutions by customising, re-engineering there by developing new variants of heat exchangers to suit the unique and challenging requirements of each customer order, be it greenfield, brownfield or R&M projects. To be a global player in heat exchangers, this division has obtained international accreditations of ASME U and U2 stamp and has footprints in more than 10 countries world over.

To be a global player in heat exchangers, this division has obtained international accreditations and has foot prints in more than 10 countries world over. Apart from conventional cutting and welding facilities, this division is equipped with specialised facilities like narrow gap welding machines, CNC SAW welding machines, CNC deep hole drilling machines, plasma cutting machines, CS plate cutting machine and hydraulic four roll machine. Other facilities include hydro testing system, functional testing facilities for lube oil systems and heat treatment facilities for heat exchanger shells.

4.6) Manufacturing Capabilities of Pumps Division

Pump shop at Hyderabad unit has facilities to manufacture all types of centrifugal pumps used in thermal power stations. It is equipped with a CNC milling and drilling gantry machine for machining of inner casing of boiler feed pump, which has a high accuracy and a concentricity of 10 micron in one-meter length, as well as CNC vertical borer machines for machining of outer casing and casing cover of pumps.

It also has facility for hydraulic pressure testing of components up to 1000kg/cm². There are latest testing facilities for testing of sub critical and super critical pumps used in power plant application as per international standards and in-line with world class practices. Pumps testing have well established data acquisition system for capturing and controlling of test loop systems from control room and verification of computed results with the performance curves.

4.7) Turbines and Compressors

The Turbine and Compressor manufacturing facilities at Hyderabad unit include heavy-duty CNC gantry drilling machines, which are one of its kind as large sized jobs can be machined on them. These machines have vertical head, universal head and facing plate as special attachments so that most of the operations can be done in one setup. PP milling, drilling, threading and GBC roughing of steam turbine casings are being done on these machines in single set up.



Machining of big base frames of centrifugal compressors is also being done on these machines. Other major facilities in the shop include heavy-duty CNC horizontal centre lathes which are used for machining of steam turbine rotors, compressor shafts and GT components, CNC vertical lathe (double column) used for rough and finish turning of components like steam turbines and compressors, and 5-axis blade milling machines with single spindle, two spindles and three spindles. 125 T balancing tunnel in the shop is used for balancing TG rotors and utility turbine rotors up to 500 MW.

High Speed Vacuum Balancing Facilities: The state-of-the-art high speed vacuum balancing facilitates carrying out precision balancing of all rotors pertaining to steam turbines, turbo generators, compressors and exciter armatures, ranging from 100 Kg to 8000 Kg and balancing up to a speed of 15000 rpm, 1000 Kg to 50000 Kg and speeds up to 10000 rpm and 6500 Kg to 125000 Kg and speeds up to 4500 rpm.

CAPABILITIES & FACILITIES

Low and high speed balancing, centrifuging test for checking the mechanical integrity of rotors, thermal stabilization of turbo generator rotors (heat cycles) and over-speed governor pin trip setting for turbine rotors with mechanical governor are carried out in this facility. High speed dynamic balancing of rotors are carried out as per norms specified in the respective BHEL product standards which are much stringent in comparison to the applicable international standards.



Heavy Duty CNC Horizontal Center Lathe



Heavy Duty CNC Gantry Drilling & Milling Machine

4.8) Gas Turbine Testing Facilities

Gas Turbine Test Facility at Hyderabad unit is equipped with five fully dedicated test beds for testing of small, mid-size and large heavy duty gas turbines. These test beds were fully designed and developed by BHEL in-house engineering expertise and can cater to testing needs of gas turbines rating from 5 MW to 300 MW. These test facilities are used for full speed no-load mechanical run test of gas turbines and are also equipped with special hardware and instrumentation for evaluation of gas turbine aero and thermodynamic performance.



6-Axis CNC Robotic Tapping Machine

Each test bed is equipped with gas turbine TMR control system, vibration monitoring/diagnostics system, data acquisition system and associated operational systems. In addition to final testing of gas turbines, in-process testing facilities of gas turbine components like dynamic balancing, vertical balancing, spin test, governing component test, liquid fuel nozzle test, gas fuel nozzle test, combustion liner test and diesel engine test are also available.

5) JHANSI

By the end of 5th five-year plan, it was envisaged by the planning commission that the demand for power transformer would rise in the coming years. Anticipating this BHEL decided to set up a new transformer manufacturing plant at Jhansi, around 14 km from the city on Jhansi-Lalitpur Road. Its foundation was laid in January 1974. The commercial production of the unit began in 1976-77. This plant of BHEL was equipped with most modern manufacturing processing and testing facilities for the manufacture of power, special transformer and instrument transformer, diesel shunting locomotives and AC/DC locomotives. The layout of the plant is well streamlined to enable smooth material flow from the raw material stages to the finished goods. All the feeder bays have been laid perpendicular to the main assembly bay and in each feeder bay raw material smoothly gets converted to sub-assemblies, which after inspection are sent to main assembly bay.

5.1) Locomotive Manufacturing Facilities

Jhansi unit is equipped with 3-axis CNC bogie frame machine, mounted with CNC system, which is a unique machine equipped with universal head which can be used for angular drilling, boring, milling and facing. It is used for complete bogie frame machining for various locomotives. The maximum job envelope is 5800x2750x940. The machine is also equipped with automatic tool changer with 40 different tools in the magazine.



The special features of this network-ready machine are automatic job measurement system, automatic tool length measurement system, cam port for diagnostics and bi-directional up/down loading of software/programmes through external hardware. A CNC bogie machining centre is also being used in the locomotive manufacturing shop for bogie frame machining for various locomotives. In India, apart from Indian Railways, these machines are available only with BHEL. These two CNC systems can also be used for manufacturing products and systems for defence applications.



5.2) Transformer Manufacturing Facilities

Jhansi unit is one of the oldest transformer manufacturing unit with design, manufacture, test, erection and commissioning capabilities of wide variety of transformers under one roof. The range includes transformers for use in power generating stations, power transmission substations, solar power plants, railway rolling stock and coaches and for industries in general. The product range includes power transformers of 400 kV up to 135 MVA and of 220 kV up to 315 MVA, rectifier transformers up to 132 kV, 120 kA, ESP high voltage rectifier transformers up to 95 kV – 1400 mA, current transformers and voltage transformers up to 220 KV, traction transformers of 25 kV – up to 7775 kVA, ACEMU transformers of 25 kV – up to 1578 kVA and dry type transformers of 33 kV up to 15 MVA. The unit has fully air-conditioned winding shop and CRGO lamination slitting and cropping line. Power transformer assembly is a pressurised and dust-free shop. The vapour phase drying is extensively used for efficient moisture removal.



Transformer tank is made in house with state-of-the-art fabrication facility. All routine and type tests are conducted in-house complying to latest IEC.

6) TIRUCHIRAPPALLI

BHEL's Tiruchirappalli Complex is one of the four major manufacturing divisions of BHEL and comprises the High Pressure Boiler Plant and the Seamless Steel Tube Plant located at Tiruchirappalli, the Industrial Valves Plant at Goindwal, the Piping Centre at Chennai and the Power Plant Piping Unit at Thirumayam. Set up in the 1960s with technological support from Skoda Export of Czechoslovakia, the boiler plant updated its technology in the 1970s with a series of collaborations with leading equipment manufacturers in the USA, Germany, Sweden and Switzerland. Unit ratings of boilers supplied by the plant have been steadily enhanced from 60 MW to 110 MW, 210 MW, 500 MW and 600 MW in the sub-critical range and units of up to 1000 MW in supercritical range.

6.1) Centre of Excellence – Coal Research Centre

The Coal Research Centre has been established at the Tiruchirappalli unit to take up R&D activities specially focusing on deep understanding of Indian/imported coals with a view to determine its blending parameters including characterization to improve existing/contemporary technologies and develop new process/ system/ technologies to achieve lower environmental emission.



CoE Coal Research Centre

The major activities of the centre are generating and providing advanced coal analysis data to BHEL's boiler design engineers, root cause analyses for overcoming fuel related issues in coal based thermal power plants, analytical support for clean coal technology projects and establishment of a comprehensive coal databank for domestic and imported coals. The centre will also be a platform for interaction with experts of national and international research centres and laboratories, training of manpower, conducting of workshops for acquiring and dissemination of advanced knowledge and skills.

6.2) Centre of Excellence for Advanced Fabrication Technology



CoE Advanced Fabrication Technology

The Centre of Excellence for Advanced Fabrication Technology has been established at the Tiruchirappalli unit to develop and introduce highly productive advanced welding processes and technologies to improve quality and productivity of fabrication shops and to enhance R&D capability through addition of state-of-the-art research facility.

The facilities include friction stir welding system, CNC gantry welding system, laser hybrid welding system, pulsed SAW system, water jet cutting system, thermal cycle simulator, welding simulation facility.

6.3) Solution Heat Treatment Furnace with Quenching Facility

The LPG-fired 12MT solution heat treatment furnace with built-in automated quenching facility has been commissioned at Power Plant Piping Unit, Thirumayam. The pulse-firing controlled furnace has 24 self-recuperating burners. This facility has been set up to provide heat treatment for temperature range up to 1175 degrees celsius and is being primarily utilized for handling inconel pipes required for advanced ultra-supercritical (AUSC) projects. A dedicated quenching tank of 225 K litres capacity set up along with the furnace provides for quick quenching operation required to carry out annealing for AUSC related piping products. The furnace can also be used for conducting other processes including stress relieving and normalizing.



7) VISHAKHAPATNAM

One of India's public sector enterprise, Bharat Heavy Plate and Vessels (BHPV) incorporated in the year 1966 was taken over in May 2008 by BHEL as a 100% wholly owned subsidiary. After becoming a subsidiary of BHEL for five years, the erstwhile BHPV merged with BHEL in August 2013 and is now one of its integral manufacturing unit and named as Heavy Plates and Vessels Plant (HPVP). HPVP is engaged in the manufacture and supply of various sophisticated equipment and systems for process industries such as refineries, fertilizers, petrochemicals, steel plants, oil and gas and heavy chemicals.

7.1) EPCG/Static Equipment Capability

HPVP/Visakhapatnam unit caters to the need of different EPCC packages like crude distillation unit (CDU), vacuum distillation unit (VDU), purge gas recovery unit for oil & gas sector and other static equipment for process industries. It has in-house manufacturing capability for pressure vessel and columns fired heaters, reactors, shell and tube heat exchangers, air fin coolers and cryogenic equipment, etc. Its capabilities and experience cover thermal and mechanical design of high pressure and heat transfer static equipment using parameters provided by process licensors. For transporting over-dimensional vessels, it has a sea-front manufacturing base from where ODC equipment can be transported directly after manufacturing by sea route to its national and international customers. The unit has various state-of-the-art machinery like bending/rolling machines, shearing machine, gas and plasma cutting machines and welding facilities. It has gas and oil-fired large heat treatment furnace which can handle jobs even up to 33 mtr long. The unit is ASME certified and is enlisted with major process licensors for static equipment.



Distillation Column



Pressure Vessel

7.2) Industrial Boiler & HRSG Shop

HPVP/Visakhapatnam unit has capability to design and manufacture all capacity heat recovery steam generators (HRSGs), industrial boilers up to 200 MW (coal, oil and gas fired), small capacity oil/gas fired auxiliary boilers (75 TPH) for super critical power plants. Boiler and HRSG manufacturing facility of the unit is certified by IBR. The unit is equipped with latest technology PLC controlled push-through (moving tube) stationary welding machine having 20 torch tube panel welding station with top and bottom side welding. It is used in continuous welding of super critical/sub critical high pressure power boiler membrane wall panels, which is formed by welding of seamless tubes with intermediate fins. The machine is suitable for pulsed GMAW with mixed gas (Argon + CO₂) shielding type of welding process.

7.3) Centre of Excellence for Aerospace Grade Compact Heat Exchangers

HPVP/Visakhapatnam unit has a monopoly in India in designing and manufacturing of compact finned heat exchangers for aerospace and defence applications. The facility has been certified with AS 9100 Quality Management System by M/S Novostar. Its R&D shop is equipped with sophisticated measuring instruments and unique facilities like vacuum brazing furnace (aluminium and stainless steel) fin forming (up to 28FPI) machine, differential pressure testing facility and oil circulation test unit. The R&D division of HPVP/Visakhapatnam unit is closely engaged in developing environment control system, liquid circulation system, liquid control units and other type of heat exchangers along with DRDO.

8) RANIPET

Boiler Auxiliaries Plant (BAP), the 13th manufacturing unit of BHEL was set up at Ranipet in 1980 as a part of the 4000 MW expansion of the High Pressure Boiler Plant, Tiruchirapalli. BAP was set up as a spin-off plant for the manufacture of boiler auxiliaries like electrostatic precipitators (ESP), air pre-heaters (APH) and fans. Over the years, several products are also added to BAP's portfolio, like steel chimneys, gates and dampers, RO based desalination (for industrial and potable application), flue gas conditioning systems (FGC), flue gas desulphurization systems (FGD), wind electric generators (WEG) and missile launchers for defence. The unit has been a fore runner in creating history with its state-of-the-art design facilities, research and development capabilities, modernized manufacturing facilities with sophisticated metrology laboratory and NDT facilities to meet the growing demand for quality power. The unit has an extensive outsourcing facility which makes it possible to grow consistently over the years.

8.1) Fan Testing Station

Fan testing station with state-of-the-art technology to measure and conform the performance as per international standard BS EN ISO 5801 and AMCA 2010 has been set up at Ranipet unit. Both centrifugal fan and axial fans can be tested with the facility available. The test track is equipped with necessary ducts and automatic throttling device to provide necessary system resistance requirement through pressure and volume.



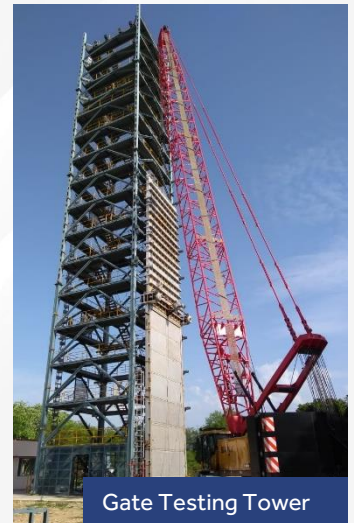
Fan Testing Station

The test tracks of various sizes dia 400, 800, 1400, 2800, 3500 & 4500mm are used to test all application fans such as forced draft, primary air, induced draft fan of 250, 500, 600, 660, 700, 800 & 1000 MW power plant and booster fan for FGD application of all models.

Very high capacity 3000 kW motor with VFD and necessary torque transducers are equipped to measure power consumption by the fan and to conform the efficiency of design as per standard.

8.2) State-of-the-art Gate Testing Station

A state-of-the-art guillotine gate testing stand (station) is established in Ranipet unit. This is the biggest and most rugged testing stand for guillotine gates in India. The tower structure is built up to a height of 50 meters. A maximum of two guillotine gates can be mounted on the structure at any given time. The gate stand is used to perform open/close (functional test) or leak tightness type tests for very large size gates. the gate stand is used to test guillotine gates of very large sizes of FGD applications for up to 1000 MW rating.



Gate Testing Tower

8.3) Flanging Machine

Generally, a flange on a cone or a cylinder will be fabricated and welded on it. But the flanging machine installed at Ranipet unit can do these types of fabrication of a flange at the apex of cone or a flange at the end of a cylinder with greater ease and with an improved geometry. This machine saves fabrication time by eliminating a joint either by welding or by riveting and also saves some material by way of combining the developments of individual components.



Flanging Machine

A fully automated hydraulically operated machine provided with part programs in the memory, can form incrementally the required shapes with in its capacity with much ease. Built-in with the advanced safety for operators, this is an eco-friendly machine as it doesn't need any coolant or produce any scrap.

8.4) Electro-Static Precipitator – Collecting Electrode Roll-Forming Line

A high-speed roll forming machine for manufacturing of collecting electrode, which is the main component of electrostatic precipitator (ESP), has been set up at Ranipet unit. This is a fully automated one with a fly shear, which eliminates the momentary stoppage for shearing. The manpower requirement is minimal with only two persons required till stacking. This helps in meeting the supply requirement in a very short time.



Roll Forming Line

8.5) Key Seating Machine

The internal key way is generally done in a slotting machine. Any slotting machine will have a limitation called throat depth, which will limit the maximum diameter of the component that can be accommodated in the machine. But, in any of the precision and rotating component that has to transmit a very high torque, the usual challenge is in two fronts, viz, accommodating the job in the machine and the geometry and finish of the key way. The key seating machine installed at Ranipet unit, is of a unique construction for very large and heavy job, which cannot be accommodated in generic slotting machines. In addition, the accuracy, geometry and the surface roughness will be far superior to a conventional machine or methods. This is a CNC controlled, state-of-the-art machine with proprietary software. The job setup in this machine is very easy and fool-proof, which takes care of the centering automatically.



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