BHEL DESIGNS & COMMISSIONS
MICROPROCESSOR-BASED DIGITAL CONTROL & DRIVE SYSTEM FOR
6Hi-CVC COLD-ROLLING MILL IN BANGLADESH

BHEL has recently designed, supplied and successfully commissioned the electrics and automation system for single stand, 6 Hi-CVC cold-rolling mill at KYCR Coil Industries Limited, Chittagong, Bangladesh. The mill comprises reversible main stand with hydraulic screw down, two tension reels and a pay off reel. The mill is intended to produce annually 100,000 tons of cold-rolled coils of thickness 0.12 mm to 0.5 mm from the entry thickness of 1.6 mm to 3 mm of hot-rolled low-carbon steel coils. At present, the mill is running at full capacity, to the utmost satisfaction of the customer.

The mill electrics and the mill automation systems designed and supplied by BHEL include: microprocessor-based digital drive system for the coordinated main DC drives, automatic gauge control, mill auto slow-down, Continuously Variable Crown (CVC) control through intermediate rolls, PLC for mill sequencing & interlocking, automatic roll changing system and PC-based human-machine interface system for centralized operator interface with the mill.

The main feature of the mill control is the Automatic Gauge Control (AGC) and CVC–control designed with SIMADYN-D hardware 32-bit processor. The hydraulic roll gap adjusting cylinders are position / pressure controlled through feed forward / feed back control, mass flow control and gauge meter control in conjunction with mill-entry and exit-side two isotope thickness gauges. The above anticipated controls work as an outer loop to the inner position loop, and provide better than +/- 0.4 micron thickness tolerance for the exit strip of the top and bottom intermediate rolls to achieve flatness in the strip. The AGC system is implemented with the latest-technology hardwares and application software developed by BHEL.

Another salient feature is the network configuration designed and developed for Human-Machine Interface (HMI) with the mill, using high-speed communication bus for the drive control, mill automations and AGC functions. The HMI downloads the set point reference, rolling schedule data from pulpit and PROFIBUS network on which the drive controllers, mill automation equipment and operator workstations & PCs are connected. The application software developed for HMI provides animated MIMIC displays, report generation, fault logging, mill faults etc.

For this project, BHEL has also supplied DC motors for the main drives, 33 kV sub-station equipment, HT & LT switchgear, HT transformers, LT AC motors for auxiliary equipment, operator desks, MCCs etc. The main drives are powered through anti-parallel circulating current-free thyristor converters with digital regulation system having speed control for the main stand and current / tension controls for the reel drives.

With this success, BHEL has established its capability to design & supply such sophisticated control systems for mills of steel plants.

AUTOMATED STORAGE & RETRIEVAL SYSTEM WITH ADVANCED FEATURES INSTALLED

BHEL has already developed an automated storage and retrieval system (ASRS), with advanced features like radio frequency (RF) communication and power supply through busbars. The system has been recently installed at the New Blade Shop at BHEL-Haridwar.

This advanced ASRS can accommodate 544 bins, and operates as per the commands given by the ground controller to the onboard controller through RF signals. Three-phase power is fed to
the system through shrouded busbars. This arrangement totally eliminates the need for both communication cables and power cables which were earlier trailing alongside the stacker crane. The new features make the ASRS more reliable and maintenance-free.

ADVANCED VOLTAGE AND CURRENT SENSORS FOR MEDIUM-VOLTAGE SWITCHGEAR DEVELOPED

Modern medium-voltage switchgear employs microprocessor relay-based system for protection purpose. These relays consist of digital electronic circuits, which require low-power input signals for their operation. At present, the current and voltage inputs are made available to such relays in two stages viz. the conventional instrument transformers and a second transformer to bring down the signal to a very low level. As an innovation, BHEL has recently developed advanced voltage and current sensors which can directly give the low-power signals from the high-voltage circuit.

The voltage sensor basically consists of a non-inductive voltage divider. The high-voltage arm of the divider is a high-power resistor, specially designed for this purpose. It consists of a ceramic tube over which a thin resistive film is coated to obtain the required resistance value. This resistor is completely shielded against external interference. The low-voltage arm is a high-voltage resistor with a suitable protection and output of 3.6 volts for an 11 kV system.

The current sensor is a ring type Rogowski coil and consists of two coils wound in the opposite direction to form one single unit. This reduces the total inductance and external interference. The coil has a resistive burden to get the required output. The conductor is a copper cylinder, coated with silver to minimize contact resistance. The sensor was designed for an 11 kV system with a maximum current of 800 Amps and output of 350 mV for 800 Amps primary current. Both voltage and current sensors are totally encapsulated with epoxy resin.

The sensors when used with numerical relays, can replace the existing conventional CTs and PTs. The sensors do not have iron core and hence there is no magnetic core saturation. This results in a perfect linear relationship between input and output. Further, construction of the sensors is very simple, thereby reducing the manufacturing cost.

The prototypes have been tested for voltage ratio test, current output voltage calibration, power frequency over-voltage test, impulse voltage test etc.

MINIATURE LOAD CELLS FOR AXIAL THRUST MEASUREMENT IN STEAM TURBINES DEVELOPED

BHEL has developed miniature load cells, utilizing diaphragm strain gauges, for measurement of axial thrust in steam turbines. A set of such miniature load cells was designed and fabricated.
for the measurement of axial thrust in an 8 MW steam turbine to verify the theoretically computed thrust value. The bearing selected for the 8 MW steam turbine was double-acting tilting-pad thrust bearing. Each bearing consisted of 8 tilting pads supported in a carrier ring. The output of the load cells was found to be matching the theoretical value, with very high sensitivity.

Axial thrust in KWU type 210 MW turbines can be measured directly at site under actual running condition, by replacing alternate spring elements in the thrust bearing with spring elements converted as load cells. This developed method will be used in a 210 MW turbine in one of the power plants, for measuring the axial thrust.

The above load cell development concept can be extended to many other applications. BHEL has already received enquiries for development of load cells for gravimetric feeder to deliver coal to pulveriser, and for ship hauling system for Goa Shipyard, which will be taken up on commercial basis.

**DRY-TYPE AIR-TO-CABLE TERMINATION SUITABLE FOR 145 kV APPLICATION DEVELOPED**

Air-to-cable termination is an electrical interface between underground cable and the open air terminals of a transmission/distribution network. Porcelain-clad oil-filled termination is the conventional termination which is used to accomplish this requirement. As an alternative to this, BHEL has recently developed the technology for a dry-type air-to-cable termination, suitable for 145 kV application. Dry air-to-cable terminations are factory-moulded assemblies without use of any liquid or gas insulation. The required length of cable is terminated suitably at both ends of the cable using dry-type termination technology. These terminations are especially suitable for short lengths required for terminating equipment like GIS.

The design of the termination involved electric field analysis. The final geometry, dimensions and materials for various parts of the terminations were finalized after modifications in the design, based on the feedback of the electric field analysis. The process of moulding the termination and technology for stress grading was established based on the electric field analysis.

The termination consists mainly of the XLPE cable, the stress-grading portion, the silicon shades and the connector. The stress-grading portion of the termination consists of two parts: the semiconducting boot and the insulating cover. The stress-grading portion of the termination ensures distribution of the electric field at the joint such that the stress is well within the limits of the breakdown strength of the respective mediums.

The mould was fabricated and the termination was moulded directly on the XLPE cable using silicon rubber. Two prototypes of the termination were made at the either ends of an XLPE cable. The termination was successfully subjected to various tests: A.C. power frequency PD tests; basic impulse level; and also the tests required to evaluate the termination for commercial use.

The above development facilitates the availability of such termination in-house, which can be offered with the existing

![Dry-type air-to-cable termination](image1)

**145 kV GIS being supplied by BHEL. It can also be marketed as an independent product. This development has the potential of import substitution at much cheaper price.**

**“CHOKE AND KILL MANIFOLD”, AN OILFIELD EQUIPMENT, DEVELOPED — AN ACHIEVEMENT IN IMPORT SUBSTITUTION**

BHEL is the leading supplier of oilfield equipment, including wellheads and Xmas trees, in the country. In the recent past, the company has developed various new and spin-off products & services used in drilling and production of oil and gas. One such product, developed for M/s OIL as an import substitution, against a commercial order, is the “Choke and Kill Manifold”. The order from M/s OIL, for 4 sets of this product of 5,000 psi rating and 1 set of 10,000 psi rating, has already been executed. The order was obtained against stiff global competition.

“Choke and Kill Manifold” is an assembly of full-bore gate valves, crosses, adjustable / positive chokes, flanges and flow fittings mounted on a skid (platform). Different arrangements to suit Customer’s specific needs can be adhered to. The pressure ratings are 5000 psi and 10000 psi with valves of sizes 3 inch and 4 inch.

![“Choke and Kill Manifold” unit](image2)
The arrangement of the valves and their assembly requirements were checked using “IDEAS” 3D software package available in-house, to ensure ease of assembly at the BHEL Shops. Sample output of analysis for interference is shown below. The output shows five full-bore valves assembled on a 5-way cross, and zones of interference. Different alternatives were examined, and the optimum valve orientation was arrived at.

With the above successful development, BHEL is confident of meeting the future requirements of both of its esteemed Customers for oilfield equipment viz., M/s OIL and M/s ONGC.

OVERLOAD BY-PASS VALVE FOR IMPROVING PART-LOAD EFFICIENCY IN 120 MW KN SERIES STEAM TURBINE DEVELOPED

BHEL has supplied specially-developed two-cylinder 120 MW steam turbine type K30-16+N30-2x3.2, with overload by-pass valve, to M/s NALCO (Angul). The by-pass valve has been developed to meet the requirement of improved heat rate at part-load operation. NALCO indicated 60% weightage for operation at 90 MW and 40% weightage for operation at 120 MW, in arriving at the weighted average heat rate. This necessitated optimization of the thermal design by providing the overload by-pass valve in HP part of the turbine. The turbine has been successfully commissioned, and running satisfactorily since January, 2003.

The overload by-pass valve offers the designer the flexibility to optimize the blading design and to reduce the throttle losses in the HP governing valves at lower loads. For the present project, the overload valve is required to open at loads greater than 90 MW to admit the steam after the sixth HP stage, and progressively opens further to achieve the full load of 120 MW.

The design has been evolved from the recently introduced two-cylinder K30-16+N30-2x3.2 reheat turbines for 120 to 150 MW, which were supplied to GIPCL, Jindal Tractebel and Tata (Jojobera). These turbines have several attractive features such as better heat rate, shorter length, lesser number of parts, lower weight, high-pressure electro-hydraulic actuators and control system, and shorter manufacturing and erection cycle time, compared to the earlier three-casing HMN series turbines.

The developmental work for the turbine supplied to M/s NALCO involved design of the overload by-pass valve and modifications in the outer casing, inner casing and rotor to accommodate the valve in the HP part of the turbine. Detailed thermodynamic calculations were carried out to optimize the flow path design. Elaborate stress analysis by FEM for the critical components was carried out to check the deformation behaviour under transient and steady-state conditions, and to ensure adequate running clearance between the static component and the rotor during all operating conditions.