

**RECONDITIONING & RETROFITTING OF CNC SYSTEM ON
VERTICAL BORING M/C ITEM NO: 2/A/40 OF WTM DIVISION**

A MACHINE:

- A.1 Make: **RICHARDS, GREAT BRITAIN**
- A.2 Type: **Double column vertical boring machine.**
- A.3 Table diameter: **2440 mm.**
- A.4 Maximum turning diameter: **2490 mm**
- A.5 Height under tool holder / Cross slide: **2083 mm**
- A.6 Maximum load capacity: **16 Tons**
- A.7 Swivelling of Ram: **30⁰ to vertical**

B REQUIREMENTS:

- B.1 Machine should be reconditioned suitably for CNC Retrofitting on Right Hand Ram.
- B.2 A CNC Controller with PLC should be able to carry out all the primary (axes & table) & auxiliary functions of the machine.
- B.3 AC Servo drives and Servo Motors of suitable rating for Cross (X) and Longitudinal (Z) feeds for CNC RH Ram and conventional LH Ram should be provided.
- B.4 Existing table drive and table motor is to be retained.
- B.5 The Right Hand Ram should be capable of machining contours with machine **positioning accuracies better than 0.02mm/m with repeatability better than 0.01mm/m** as per VDI/DGQ 3441/ ISO 230-2.
- B.6 The RH Ram & Table should have the capacity to take depth of cut of 10mm at feed rate of 0.6mm/rev with latest generation of coated carbide tool.
- B.7 Original capacity of the machine as per OEM specifications should be restored.

C SCOPE OF SUPPLY:

- C.1 A CNC Controller with PLC to perform the functions as per detailed specifications should be provided. The CNC controller should be either **Sinumerik 810T GA3** (J82 option) **or Fanuc 0i – TD** with TFT monitor and standard Machine Control Panel (MCP) for turning operations.
- C.2 AC Servo drives and Servo Motors for RH Ram of suitable rating for Cross (X) and Longitudinal (Z) feeds should be provided. The AC Servo drives & motors should either be **Simodrive 611U with 1FK7 motors** or **Fanuc α i series servo drives & motors.**
- C.3 AC servo motor (of suitable rating) with matching drive for the cross & longitudinal feeds of the conventional LH ram. The servo motor & drive should be either **Simodrive 611U with 1FK7 motor** or **Fanuc α i / β i series servo drive & motor.**
- C.4 Isolation transformer of adequate rating for all the feed drives.
- C.5 Electrical cabinet(s) incorporating the table drive (existing) & new feed drives, CNC & PLC accessories and other switchgear should be provided.
- C.6 Operator Pendant/Desktop incorporating the CNC Operator Panel, MCP and selector switches should be provided.

- C.7 Two hand held pendants are to be provided – one for the CNC Right hand Ram and the other for the conventional Left head ram.
- C.8 Linear scales of suitable length should be provided for X & Z Axis for the CNC RH Ram and cross & longitudinal feeds for the conventional LH Ram. Additionally a DRO should be provided for the LH Ram. The scales & DRO should be of Heidenhain (Germany) make.
- C.9 Backlash free ball-screw & ball-nut of reputed make for Axes X & Z of the RH Ram. The make of the ball-screws are to be specified in the technical bid.
- C.10 A Centralized Lubrication system (Cenlub/Vogel Make preferable) to be provided for the complete Machine.
- C.11 Hydraulic balancing system for CNC Ram to be provided with suitable Power pack of Rexroth/Vickers makes. The balancing system should be automatically controlled & monitored through PLC.
- C.12 Flexible coupling for connecting the table motor to the table gear box.
- C.13 All the Mechanical & Electrical items and fittings required for the reconditioning & retrofitting work
- C.14 Documents consisting of
- ❖ Electrical circuit diagram – 3 sets.
 - ❖ PLC printout in ladder form with symbols & comments in English – 3 sets.
 - ❖ O&M manuals (hard copy) for CNC, PLC, Drives & Measuring systems – 3 sets.
 - ❖ Programming manual (hard copy) for CNC system – 3 sets.
 - ❖ Machine data (NC, PLC, Setting & Alarm texts), Drives data & PLC program (soft copy) – 3 sets.
 - ❖ O&M manual for ball screws & ball nuts – 3 sets.
 - ❖ O&M manual for Lubrication system & Balancing system – 3 sets.
 - ❖ Details of all mechanical modifications & fittings with drawings – 3 sets.

D SCOPE OF WORK:

D.1 Mechanical reconditioning:

The machine should be reconditioned & modified to the suit the fitment of CNC system on the right hand RAM for **positioning accuracies & repeatability better than 0.02mm/m & 0.01mm/m respectively** when checked as per VDI/DGQ 3441/ ISO 230-2.

Emphasis is to be given on the following works while doing the reconditioning:

- ❖ The mechanical accuracies of the slides & other accessories are to be restored. Turcite lining is to be provided on the machine slide for the RH RAM.
- ❖ Present lead-screw arrangements are to be replaced by backlash-free ball-screw arrangements of reputed make for RH RAM.
- ❖ Installation of the replacement feed motor for Cross (X) and Longitudinal (Z) feeds of the conventional LH and CNC RH ram.
- ❖ Installation of the linear scales for Cross and Longitudinal feeds of the LH & RH ram.
- ❖ Installation of dynamic balancing system (counterbalance) with the suitable hydraulic power pack for the retrofitted Ram.
- ❖ Installation of centralized automatic lubrication system of adequate capacity (CENLUB/Vogel make preferable).
- ❖ Restoration of the mechanical rigidity of the RH Ram so as to withstand the cutting forces while taking the intermittent cuts & machining of hardened material.

- ❖ Adjustments/Levelling of columns & Cross-rail to achieve the desired accuracies as per OEM specifications.
- ❖ Replacement of the existing fixed coupling of the table motor to the table gear box with a suitable flexible coupling.
- ❖ Table gear box should be checked & rectifications (if any) should be carried out.
- ❖ The level and run-out of the table should be checked and rectification (if any) should be carried out accordingly.
- ❖ The RH Ram should have the capacity to take a depth of cut of 10mm at feed rate of 0.6mm/rev with latest generation of coated carbide tool.
- ❖ A relevant test piece is to be machined for proving out of machining accuracy of the machine with all operations on full capacity.

D.2 CNC Retrofit:

- ❖ Installation of new electrical cabinet(s).
- ❖ Installation of new operator pendant/desk.
- ❖ Interfacing & commissioning of the CNC, PLC, Position feedback, Table & Feed drives systems
- ❖ Prove-out of the main functions (axes & table).
- ❖ Prove-out of the auxiliary functions (Coolant, Cross-rail .etc.).
- ❖ Prove-out of the alarms and message prompts.
- ❖ Prove-out of the machining of 2 components with part program in automatic mode.

E CNC FEATURES:

The CNC controller should be offered with following features:

- E.1** 2 axes continuous path control system for Turning operations.
- E.2** Mode selection through a mode selector switch/keys
- E.3** TFT/LCD monitor for display.
- E.4** Graphic simulation.
- E.5** Display of NC & PLC Alarms.
- E.6** Full Alphanumeric key board for input of part programs.
- E.7** RS 232 C port for serial communication.
- E.8** Minimum 128 kB memory for program storage.
- E.9** Facility to store up to 99 subroute lines & 999 part programmes.
- E.10** Background editing of programs.
- E.11** Part program renaming & copying facility.
- E.12** Block search with calculations in automatic mode.
- E.13** Facility to store 2 zero offsets & 2 additive zero-offsets.
- E.14** It should be possible to store 64 tool offsets.
- E.15** Resolution of 0.001 mm, accuracy should be as per VDI3441.
- E.16** Backlash & pitch error compensation facility.
- E.17** Software limits through machine parameters.
- E.18** Automatic tool offset loading facility.

F OPERATIONAL FEATURES

- F.1** The stand alone pendent /control desk with the CNC operator panel should have the following operational features either on the MCP or provided additionally.
 - ❖ Axes selection keys X & Z.

- ❖ Directional keys + & - for axis movement in jog.
- ❖ Rapid traverse key.
- ❖ Rotary table ON / OFF.
- ❖ Rotary table rotation direction CW/CCW.
- ❖ Emergency stop.
- ❖ Reset facility.
- ❖ Single block switch/key
- ❖ Dry run switch/key
- ❖ Oil pump ON push-button/key.
- ❖ Main motor ON push-button/key.
- ❖ Cross rail up/down push-button/key.
- ❖ Coolant ON / OFF push-button/key.
- ❖ Indicators for main motor ON, Oil pump ON, cross slide locked/unlocked, Table ON.
- ❖ RPM meter & current meter for table.

F.2 The Hand Pendant for conventional LH Ram should have the control for:

- ❖ Table rotation CW/CCW.
- ❖ Table inch CW/CCW.
- ❖ Feed ON/OFF.
- ❖ Feed direction.
- ❖ Axis selection.
- ❖ Potentiometers for Feed movement & table rotation.
- ❖ Screw cutting ON/OFF.
- ❖ Swiveling motor anticlockwise.
- ❖ Swiveling motor clockwise.
- ❖ Emergency Pushbutton.

F.3 The Hand Pendant for CNC RH Ram should have the following:

- ❖ Manual Pulse Generator (Hand-wheel) with step selection for 1,10,100,1000 microns.
- ❖ Axis selection.
- ❖ MPG selection.
- ❖ Table inch CW/CCW.
- ❖ Emergency Pushbutton

F.4 Feed & Table range:

- ❖ X & Z Axis: 02 - 3000mm/min for RH RAM.
- ❖ Table speed: 0.807 - 17 RPM.

F.5 Monitoring:

- ❖ Any abnormality on the machine should be indicated by indicating lamps, PLC alarms & message prompts.
- ❖ PLC alarms & messages should include the device number and/or the operand.

F.6 Safety Features should include

- ❖ Fuses & Overloads of appropriate ratings for all primary & auxiliary circuits.
- ❖ Limit switches & sensors to avoid over-travel & collision of any part of the machine.
- ❖ Float & pressure switches to ensure proper functioning of hydrostatic & lubrication systems.

G PROGRAMMING FEATURES:

- G.1 ISO code (G&M mode type) programming.
- G.2 Absolute/incremental programming.
- G.3 Decimal point programming.
- G.4 Linear & circular interpolation on both axes.
- G.5 Programmable dwell.
- G.6 Scaling factor.
- G.7 Storage of user defined subroutine independent of the main program.
- G.8 Variable parametric programming with mathematical functions including trigonometric & logic functions.
- G.9 Arc-programming with radius & end-point.
- G.10 Conditional & unconditional jump.
- G.11 Programmable tool offset.
- G.12 Programmable zero offset.
- G.13 Two Programmable additive zero offset.
- G.14 Subroutine nesting up to 3 levels.
- G.15 Programmable skip.
- G.16 Facility of inclusion of message in the part programme.
- G.17 Corner rounding & chamfering.
- G.18 Diameter programming.
- G.19 Canned cycles for:
 - ❖ Axis parallel routing, with option of semi finishing cut parallel to contour.
 - ❖ Counter parallel roughing.
 - ❖ Diameter grooving.
 - ❖ Face grooving.
- G.20 Tool nose radius compensation. (TNRC)
- G.21 Coolant on/off should be programmable.
- G.22 Programming of primary & auxiliary functions through M, S, T codes.

H MEASURING SYSTEM:

- H.1 Suitable linear measuring system of Heidenhain make should be provided for cross & longitudinal feeds of both LH & RH rams.
- H.2 The linear scales must have accuracies no lesser than $5\mu\text{m}$ per meter and should be suitable for resolutions of $1\mu\text{m}$ (0.001mm) for CNC system as well as DRO display.
- H.3 The DRO for the conventional LH ram should be of Heidenhain make with display step of $5\mu\text{m}$ and facilities for reference points and presets.

I FEED SYSTEM:

At present, the cross and longitudinal feeds to both the rams are through separate motors with clutches and gear boxes assembly.

- I.1 For the proposed CNC RH ram, the AC servo motors for X & Z axes should be coupled directly or indirectly (through belt pulley arrangement) so as to provide a rapid feedrate of 3000 mm/min and at the same time generate sufficient torque for the required cutting force.

- I.2 Suitable backlash-free ball screws and box nuts arrangement for X & Z are to be installed for the RH ram. Necessary refurbishments to be carried out to minimise drags/plays and ensure jerk-free movement of the axes.
- I.3 For the conventional LH ram, AC servo motor for the cross & longitudinal feed is to be fitted with the existing feed system for horizontal & vertical movements.

J ELECTRICAL SYSTEM:

- J.1 Electrical panel(s) along with switch gear, relay, contactors, overloads, fuses, MCB's should be suitably positioned and all compartments should be illuminated for ease of maintenance and proper air conditioning ensured for the cooling of the devices.
- J.2 The switchgear (MCBs, Overloads, Contactors, Relays etc) should be of any one of the following makes: **Siemens, Schneider, Fuji, Mitsubishi or ABB.**
- J.3 Electrical Cabinet & Operator Panel both of should be of **Rittal** make with proper air conditioning and vermin proof.
- J.4 The existing Table Motor (Siemens make 3 Φ , 132 kW), Table Drive (Siemens Simovert Master Drives Order No: 6SE7032-6TG20) along with braking module and resistance box will only be retained and should be interfaced with the new CNC system and switchgear. All relevant documents of Table drive system will be provided.
- J.5 Provisions for incorporating the existing Table Drive along with the braking module should be made in the new electrical cabinet. The braking resistance box can be placed suitably on the top of the electrical cabinet.
- J.6 The operator's pendant/control desk, handheld pendants should be suitably positioned for ease of operation & maintenance.
- J.7 All the panels, Junction boxes, devices should have nomenclatures and individual wires ferruled as per the electrical schematics.
- J.8 Existing AC motors for cross slide movement, cross slide locking, head swivelling, table gear change, pendant up/down movement should be retained & rewired.
- J.9 The wiring of the entire machine should be replaced by new ones of adequate capacity and reputed make.
- J.10 The left hand Ram wiring has to be suitably modified so that the left Hand Ram can be controlled through PLC (Relay logic of LH Ram to be removed) and selection of LH Ram should be possible from the Main control Desk.
- J.11 Provision should be made to operate the Table from the LH pendant in inch & continuous mode at different speeds.
- J.12 220VAC, 5A plug points should be provided in the Electrical Cabinet(s) and on the Operator Panel.

K GENERAL OPERATING CONDITIONS:

- K.1 1. Temperature: 5⁰ to 50⁰ C
- K.2 Humidity: 0 - 95% RH
- K.3 Power Supply: 415V +/-10%, 50 Hz +/- 3%, 3 Phase, 3wire without neutral.

L MISCELLANEOUS:

- L.1** A spares list for the supplied items should be provided.
- L.2** The geometrical accuracy of the machine shall be checked as per the Dr. Schlingers test chart. Positional accuracy (better than **0.02mm/m**) & repeatability (better than **0.01mm/m**) of the machine are to be checked as per VDI3441. All these tests should be performed by the supplier at BHEL works.
- L.3** Sufficient lighting should be provided on the machine. It should be well guarded from the chips & coolant.
- L.4** Supplier should provide details of test piece to be machined by them to check the machine accuracy at BHEL works.

M COMPLETION:

- M.1** Upon completion of the scope of supply and scope of work, **successful machining of BHEL components** shall constitute the FINAL HAND-OVER of the machine and completion of the job.

N PERIOD OF RETROFIT:

- N.1** **Four (4) months maximum** (from the date of release of machine), from supply of materials, transportation (if required), erection, commissioning and final hand-over.

O TRAINING:

The supplier should provide

- O.1** Two weeks training in the areas in operation and programming at supplier's work.
- O.2** One week training in the operation & maintenance aspects of CNC controller at OEM's works/training centre.

P GUARANTEE:

- P.1** Vendor shall stand guarantee for smooth functioning of the machine, including all the items and parts employed in retrofitting, for a period of **one year** from the date of FINAL HAND-OVER of the machine.

Q OFFER:

- Q.1** The total offer should be submitted in the following manner.
 - ❖ Techno-commercial bid.
 - ❖ Price bid.
- Q.2** The Techno-commercial & price bids should be submitted separately. The price bid will be opened after finalization of Techno-commercial bids.
- Q.3** The Techno-commercial bid should contain the technical details & the commercial terms & conditions.
- Q.4** The price bid should contain the only total price along with the price break-up for all the major items. The price bid containing any terms & conditions are liable to be rejected.

R QUALIFYING CRITERIA:

R.1 The parties meeting any of the following criteria would only be considered:

- ❖ Any party who is presently manufacturing (OEM) Vertical Boring Machines of table diameter 1000mm or more.
- ❖ Any party who have reconditioned, retrofitted or previously manufactured vertical boring machine of table diameter 1000mm or more. The party must submit “Performance Certificate(s)” of the machine(s) from the end user along with the offer and arrange for visit of BHEL team for verification at the end user’s works.

NOTE:

Bidders are strongly advised to study the machine and its documents before submitting the bids