

## SPECIFICATION OF HIGH SPEED 3-AXIS VERTICAL MACHINING CENTER

### PROPOSED USE OF THE MACHINE:

- The proposed 3-axis CNC vertical machining center must be capable of machining various materials like hardened steel (hardness > 45 HRc), metal matrix composites, aluminium alloys, titanium alloys, nickel alloys (hardness > 20 HRc) at high speeds with high precision in a research laboratory environment. Machine should have a rigid base with minimal overhangs and good vibration damping characteristics. It should be able to handle fast accelerations/decelerations while providing good contouring accuracy.

### TECHNICAL SPECIFICATION:

#### (A) STANDARD MACHINE

1	Machine capacity	(a) Table size: At least 800 mm x 450 mm (b) X-travel of up to 600 - 1200 mm (c) Y-travel of up to 400 - 1000 mm (d) Z-travel of up to 400 - 1000 mm
2	Axes feed drive	(a) High precision, high stiffness, automatically lubricated, pre-loaded ball screw drive for all 3 axes with almost zero backlash error (b) Drive should be protected from coolant/chips/debris (c) Active cooling of all feed drives to maintain uniform temperature and reduce thermal effects (d) All 3 axes should be directly driven by digital servo motors (e) Linear scale encoder closed-loop feedback for all 3 axes (with scale spacing of no more than 20 micrometer and of sub-micrometer resolution from a reputed manufacturer); linear encoder should be well protected from coolant/chips/debris (f) Z-axis braking in case of power failure (g) Feed traverse rates in the range of 30 – 60 m/min for all 3 axes (h) Positional resolution of less than 1 micrometer and positional accuracy of less than 5 micrometers for all 3 axes, over the entire travel length (to be shown using laser interferometer calibration certificate)
3	Guideways	(a) All axes guideways to be adequately protected from coolant/chips/debris using telescoping covers (also see optional item 51) (b) Guideways to be lubricated automatically

4	Spindle	<ul style="list-style-type: none"> <li>(a) Integral spindle motor</li> <li>(b) Max speed of 18,000 rpm or higher</li> <li>(c) Power: Minimum 35 kW / 25 kW (S6/S1)</li> <li>(d) Torque: Minimum 120 Nm / 80 Nm (S6/S1); torque should not go below 10 Nm at the highest rated spindle speed; S6/S1 torque should be available up to a speed of 2,600 rpm. S6/S1 power should be available from 2,600 rpm to highest rated spindle speed</li> <li>(e) Spindle taper: HSK-63 (other options can be provided) – should be in-built without any adapter</li> <li>(f) Digital drive with feedback using rotary encoder</li> <li>(g) Active cooling of the spindle is required to maintain uniform temperature and reduce thermal effects</li> <li>(h) Spindle should have high accuracy bearings with spindle run-out less than 2 micrometers</li> <li>(i) Maintenance free lubrication of bearings should be used in the spindle</li> <li>(j) Hydraulic clamping for tool holder</li> <li>(k) Taper cleaning during tool changes</li> <li>(l) Radial and axial stiffness values to be provided and they should be sufficient to perform high speed machining of hard materials</li> </ul>
5	Tool setting probe	<ul style="list-style-type: none"> <li>(a) Automatic tool setting probe in the machine and tool length/diameter compensation integrated in the machine+controller (probe should be made by a reputed manufacturer)</li> </ul>
6	Coolant	<ul style="list-style-type: none"> <li>(a) Through the spindle coolant delivery is required</li> <li>(b) Minimum 3 nozzle coolant delivery points around the spindle at a pressure of at least 20 bars at a flow rate of not less than 20 litres/min</li> <li>(c) Easily accessible coolant tank with capacity of at least 200 litres</li> <li>(d) Chip/debris separation/filtration so that coolant can be reused</li> <li>(e) Coolant and pneumatic air spray nozzles to be supplied for manual use near the machine door (see optional items 52 and 53)</li> </ul>
7	CNC controller	<ul style="list-style-type: none"> <li>(a) Non-proprietary standard controller (e.g. latest versions of Fanuc, Siemens, Heidenhain etc.) with easy to procure post-processors for standard CAM softwares that will be used for programming; open architecture based controller is preferred</li> <li>(b) Should be capable of 3 axes switchable simultaneous control</li> <li>(c) Machine should have in-built MTCONNECT compatibility</li> </ul>
8	Wired/wireless	<ul style="list-style-type: none"> <li>(a) Machine should have wired/wireless hand-held</li> </ul>

	pendant control	<p>pendant control for manual movement of axes</p> <p>(b) For fine and manual adjustment of axes pendant should have the following selectable ranges: 1 mm, 0.1 mm, 0.01 mm and 0.001 mm</p>
9	Controller features	<p>(a) Standard ISO code programming with canned cycles</p> <p>(b) Program memory should be at least 20 GB; RAM should be at least 2 GB; Hard disk drive should be at least 60 GB.</p> <p>(c) Block processing time should be <math>\leq 0.5</math> ms</p> <p>(d) Resolution and display step: 0.1 micrometer linear axes</p> <p>(e) Linear interpolation in 3 axes; circular interpolation in 2 axes; helical interpolation</p> <p>(f) Axis feedback controller position, speed, current cycle time <math>\leq 200</math> microseconds</p> <p>(g) Number of axes, axis range and spindle speed should be compatible with the machine</p> <p>(h) Error compensation – pitch error, backlash and others</p> <p>(i) RS 232 interface + 3 USB (1 front and 2 elsewhere)</p> <p>(j) Tool Radius and length off set and tool wear compensation.</p> <p>(k) Absolute &amp; incremental programming.</p> <p>(l) Background editing and programming.</p> <p>(m) Program repetition, Coordinate transformation, Rotation, Mirror, Scale, Copy programming</p> <p>(n) Display of remaining cycle during execution of repetitive cycle/subroutine</p> <p>(o) Multi program storage with program identification.</p> <p>(p) Number of work offsets: 4 minimum</p> <p>(q) Battery for buffering data in case of power loss</p> <p>(r) Graphical simulation &amp; display of tool paths</p> <p>(s) Conversational programming &amp; macro programming</p> <p>(t) POWER on/off switch, Cycle start, emergency stop, feedhold, single block, optional stop, block skip, dry run, spindle override, feed rate override, coolant switch, spindle rotation direction, manual spindle orientation, tool change, reference position M-S-T lock, machine lock, manual absolute, Z-axis neglect, MDI model, AUTO mode, MEMORY mode, DNC mode, EDIT mode, MANUAL mode, HOME mode, HANDLE mode, JOG mode, RAPID mode, Memory acces, Lube light, Error light</p>
10	Display features	<p>(a) IP65 Protection for the display panels</p> <p>(b) <math>\geq 12</math> inch color monitor with key board &amp; display in English language.</p> <p>(c) Machine position</p> <p>(d) Program under execution.</p> <p>(e) Block No.</p>

		<ul style="list-style-type: none"> <li>(f) Active command block.</li> <li>(g) Spindle speed &amp; feed rate-actual &amp; program value.</li> <li>(h) Spindle load display.</li> <li>(i) Absolute position.</li> <li>(j) Distance to go.</li> <li>(k) Tool No. Off set No.</li> <li>(l) Error message if any.</li> <li>(m) Mode of operation.</li> <li>(n) Tool under execution.</li> <li>(o) Relative position.</li> <li>(p) Part program &amp; tool file library.</li> <li>(q) Tool data.</li> <li>(r) Work Zero.</li> <li>(s) Spindle running time display.</li> </ul>
11	Calibration	<ul style="list-style-type: none"> <li>(a) Machine to be calibrated in metric system based on JIS standard.</li> <li>(b) Appropriate test charts to be supplied along with machine</li> </ul>
12	Standard accessories	<ul style="list-style-type: none"> <li>(a) All standard accessories required for normal machine operation should be included in the quotation</li> </ul>
13	Chip collection	<ul style="list-style-type: none"> <li>(a) Chip collection tray after separation from coolant should be provided at a suitable accessible location (also see optional item 54)</li> </ul>
14	Power supply / Air pressure	<ul style="list-style-type: none"> <li>(a) Machine should be operable using the following 3-phase AC power supply: 400 V (10% variation) , 50 Hz (5% variation)</li> <li>(b) Adequate protection against power line disturbances with ultra-isolation transformer</li> <li>(c) Machine should be operable using: Standard shop air pressure of 6-8 bar</li> </ul>
15	Automatic tool changed (ATC)	<ul style="list-style-type: none"> <li>(a) Minimum: 20 tools</li> <li>(b) Tool diameters: up to 80 mm</li> <li>(c) Max. tool length (excluding taper portion of the tool holder): 300 mm</li> </ul>
16	Documentation	<ul style="list-style-type: none"> <li>(a) Complete set of machine documentation must be provided in one printed copy as well as in CD-ROM</li> </ul>
17	Working conditions	<ul style="list-style-type: none"> <li>(a) The machine's performance and its accessories should be tropicalized – i.e. must be suitable for an annual ambient temperature variation of 15 – 40 °C, and relative humidity in the range of 60 – 100%.</li> </ul>
18	Warranty	<ul style="list-style-type: none"> <li>(a) Entire machine inclusive of all systems / accessories should be warranted for 36 months from the date of installation / commissioning against all the design,</li> </ul>

		material or manufacturing defects.
19	Ergonomics and safety	<ul style="list-style-type: none"> <li>(a) Ergonomic accessibility to the work table in the machine</li> <li>(b) Automatic Open/close door with door safety switch</li> <li>(c) Working area of the machine should have fully-covered safety enclosure to protect operator from coolant splashes and flying debris/objects.</li> <li>(d) Machine should have front/side covered windows for adequate visibility to the machining process</li> <li>(e) The machine must be provided with all safety features necessary to protect the machine, control and the operator while in operation from possible damage / injury.</li> <li>(f) Automatic machine shutoff with warning in the event of lubrication and coolant failure, spindle off and axis over travel.</li> </ul>
20	Supplier capability	<ul style="list-style-type: none"> <li>(a) Bidder should provide at least five of installations and commissioning of similar machines in a related industries/institutions in India where it is being used.</li> <li>(b) Bidders should be direct manufacturer with subsidiary office or certified agent in India.</li> <li>(c) Bidder should have solid service support and provide service network in India; all machine parts should be preferably serviceable preferable in India.</li> </ul>
21	Installation and commissioning	<ul style="list-style-type: none"> <li>(a) Foundation kit like vibro mounts, bolts etc, required for foundation to be supplied.</li> <li>(b) Detailed installation layout drawing to be supplied along with the quotation.</li> <li>(c) Requirements like Air conditioning, dust free atmosphere and flooring to be specified.</li> <li>(d) The installation &amp; Commissioning will be done by supplier's Engineers at IIT site within the stipulated time (to be specified by the supplier) from the receipt of the machine at IIT Madras site.</li> <li>(e) The supplier should provide calibration/traceability certificate of the equipment as per National institute of Standards &amp; Technology (NIST)/National Physical Laboratory (NPL) UK / United Kingdom Accreditation System (UKAS) preferably.</li> <li>(f) The supplier must have supplied similar equipment to other national academic institutions or national research laboratories in India (list to be provided).</li> </ul>
22	Training	<ul style="list-style-type: none"> <li>(a) During the period of erection &amp; commissioning, the supplier should train the personnel required for operation and maintenance of the machine. These personnel will be associated with the supplier's rep.</li> </ul>

		<p>during the erection and commissioning period and they should be trained to operate and maintain the machine independently.</p> <p>(b) Training shall be imparted to the personnel who will be deputed for pre-dispatch inspection on operation, maintenance, fault finding/remedies, programming etc.</p> <p>(c) During pre-dispatch inspection, training shall be imparted to at least 2 (two) persons.</p> <p>(d) Firm shall impart on-site training to the staff in following disciplines i.e. maintenance of the mechanical, hydraulic, electrical and electronic parts/functions of the machine including the assembly, fitting of various components and trouble shooting. The maintenance training shall be exhaustive in content and cover all practical difficulties likely to be encountered.</p>
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(B) OPTIONAL ITEMS TO QUOTE:

51	Guideways/axes drive protection	(a) Protection of guideways and axes drives should extend to the debris/chips from the use of abrasive polishing tools in the machine
52	High pressure flood coolant	<p>(a) High pressure coolant up to 70 bars (or higher) at a flow rate of not less than 80 litres/min</p> <p>(b) The high pressure pump system should be operable using M-codes in the controller</p> <p>(c) Machine should be capable of handling such high pressure coolant sprays</p>
53	Minimum quantity lubrication (MQL)	<p>(a) It should be provided with M-codes for minimum lubrication external "ON" and "OFF".</p> <p>(b) It should have provision to machine under Minimum Quantity Lubrication with the following specification</p> <p>(c) Capacity: 1 - 3 litres</p> <p>(d) Outlet ports: 3</p> <p>(e) Compressed air ports (bars): Min 2, Max 10</p> <p>(f) Air consumption (NI/min): 15 - 300</p> <p>(g) Oil quantity (ml/h): 1 - 500</p> <p>(h) Mounting position: Vertical</p> <p>(i) Type of lubricant: Aqueous: Water, peroxides; Hydrocarbons: Alcohols, Vegetable oils, Esters, Glycols; Gases: Air (O2/N2, ), CO2, N2</p> <p>(j) Other specifications such as metal housing, internal lubrication, external lubrication, visual filling level indicator, flow sensor, pressure monitoring should be standard</p>

54	Chip conveyor	(a) Chip/swarf conveyor with controllable chip transport to the side/back of the machine to be provided
55	Tool holder kit	(b) Suitable tool holders for drilling, milling, boring, reaming
56	CAD/CAM software	(c) CAD/CAM software with needed post-processors that can be used for programming the quoted machine