ME 6320

Micro Manufacturing Technology

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Department of Mechanical Engineering
Indian Institute of Technology Madras
Chennai – 600 036

Course Content

Unit I: Introduction to Mechanical Micro Machining: Principle Micro Machining techniques, micro turning, micro milling, micro drilling, micro grinding, micro Tool geometry and tool materials, cutting forces and measurement, micro tool and tooling management.

Unit II: Components of micro manufacturing systems: Micro linear stage, rotary stage, air spindle, air bearings, magnetic bearings, servo motors and micro actuators, micro positioning systems, Micro robots, micro grippers, micro parts handling systems - selection criteria

Unit III: Non conventional micro machining technique: Micro EDM, Ion Beam machining, Laser micro machining, Laser Assisted Mechanical Micro Machining, Abrasive micro machining, Electron beam machining – process mechanics, capabilities and Applications

Unit IV: Micro forming: Micro forming processes- ultra fine punching, imprinting, extrusion, incremental forming, micro forming of sheet metals, micro-deep drawing.

Unit V: Micro/Nano Measurement systems: Micro sensors, laser measurement systems, capacitance sensors, micro optical sensors, feedback sensors, 2D and 3D surface profiling.

Text Books and References

10. Text Books:

1. Joseph Mc Geough, Micromaching of Engineering Materials, Marcel Dekker Inc, New York, 2002.
2. Yi Qin, Micro-Manufacturing Engineering and Technology, Elsevier Inc., Oxford, UK,2010.

11. References:

1. V. K. Jain, Introduction to Micromachining, Narosa Publishing House Pvt Ltd, New Delhi, 2010.
2. J. Paulo Davim and Mark J. Jackson, Nano and Micromachining, John Wiley & Sons, London, UK., 2013.
3. P.C. Pandey and H. S. Shan, Modern Machining Processes, Tata McGraw Hill, New Delhi, 2009.
4. Richard S. Muller, Microsensors, New York: IEEE Press, 1991.
5. Frank Vollertsen, Micro Metal Forming, Springer-Verlag, Berlin Heidelberg, Germany, 2013.

Evaluation

Total Marks : 100

- Mid Sem – 20 Marks
- Assignment/ Seminar/ mini project/modeling – 30 Marks
- End Sem – 50 Marks

Total (GLS) - 100 Marks

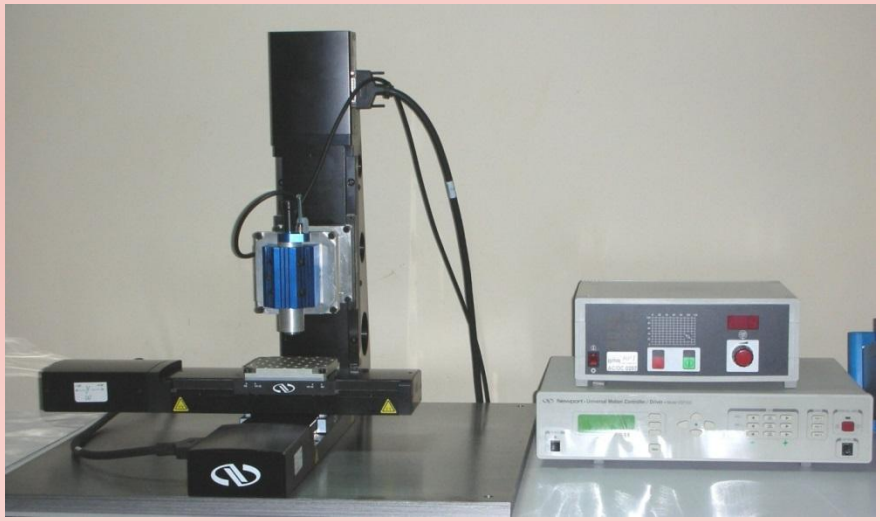
Facilities Available

- **KERN Evo – Ultra Precision High speed Micro Machining Center**

Micro machining Facility

Technical specifications:

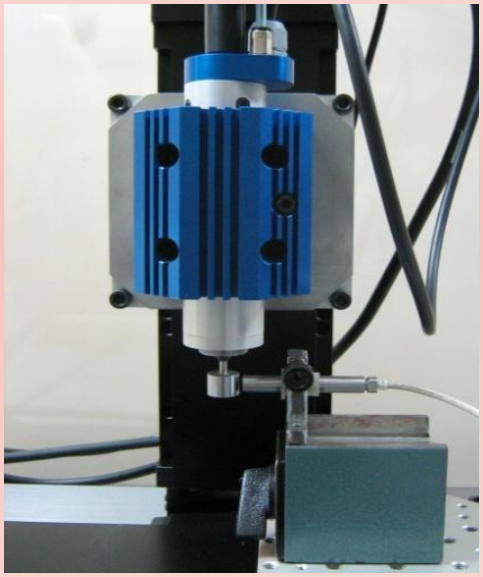
Sl. No	Specifications	Data
1	Manufacturer	Newport Corporation, USA
2	Total travel Range	150 mm (X and Y) 100 mm (Z)
3	**Resolution**	**0.1 µm**
4	**Maximum Speed**	**100 mm/s**
5	On Axis Accuracy	2 µm
6	Uni-directional Repeatability	0.2 µm
7	Reversal Value (Hysteresis)	0.1 µm
8	Weight	4.8 kg



Micro Machine Tool Components

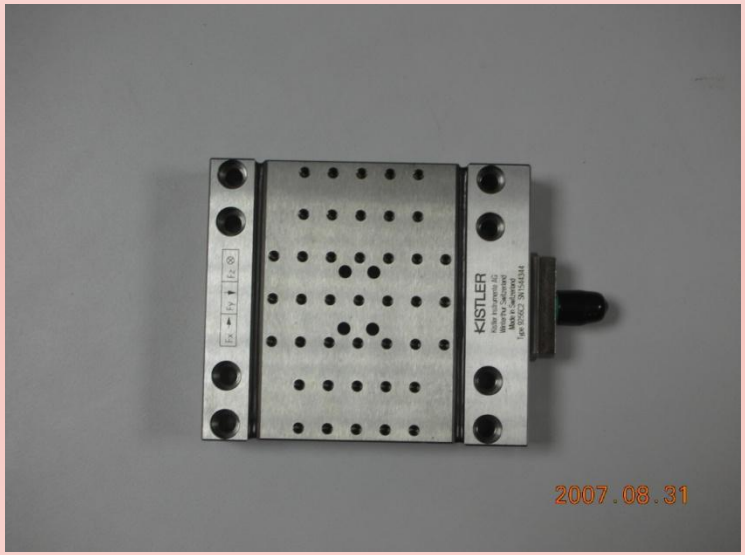
Micro tools (0.04, 0.1, 0.2, 0.5 and 1.0 mm

High Speed Spindle



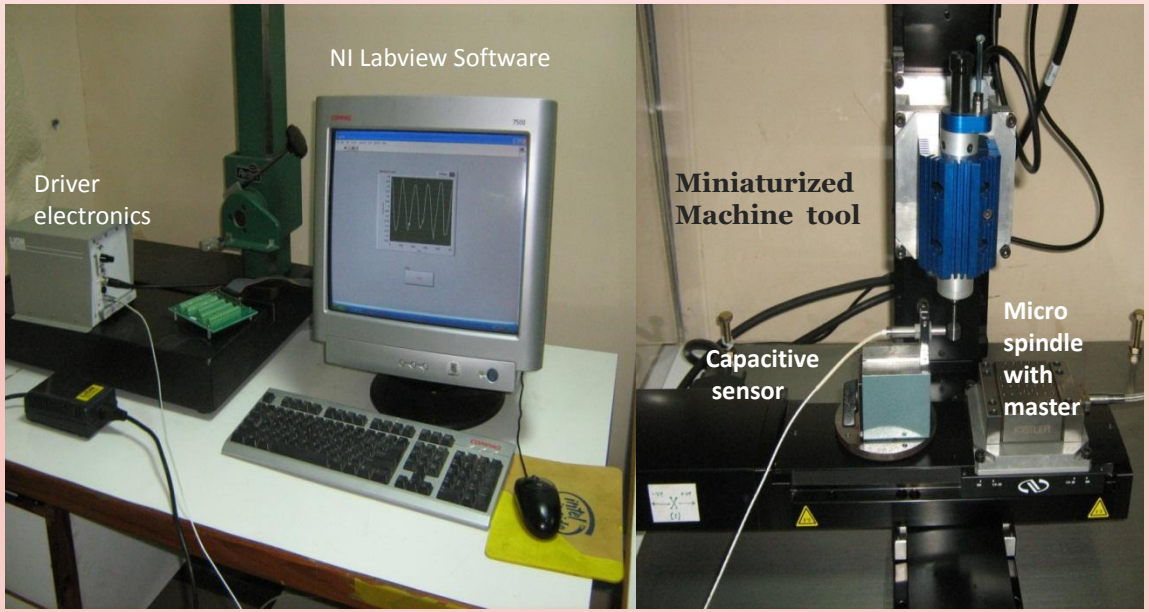
Linear Drives

Micro Force Dynamometer

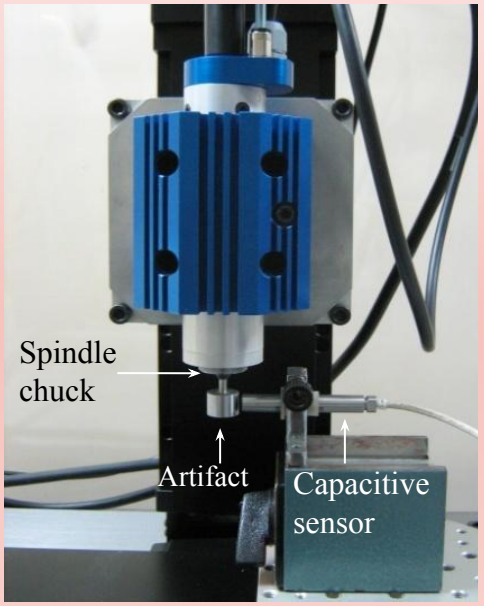


Minimum force measured: 0.002 Newton

Spindle Measurement



Experimental setup



Close-up view

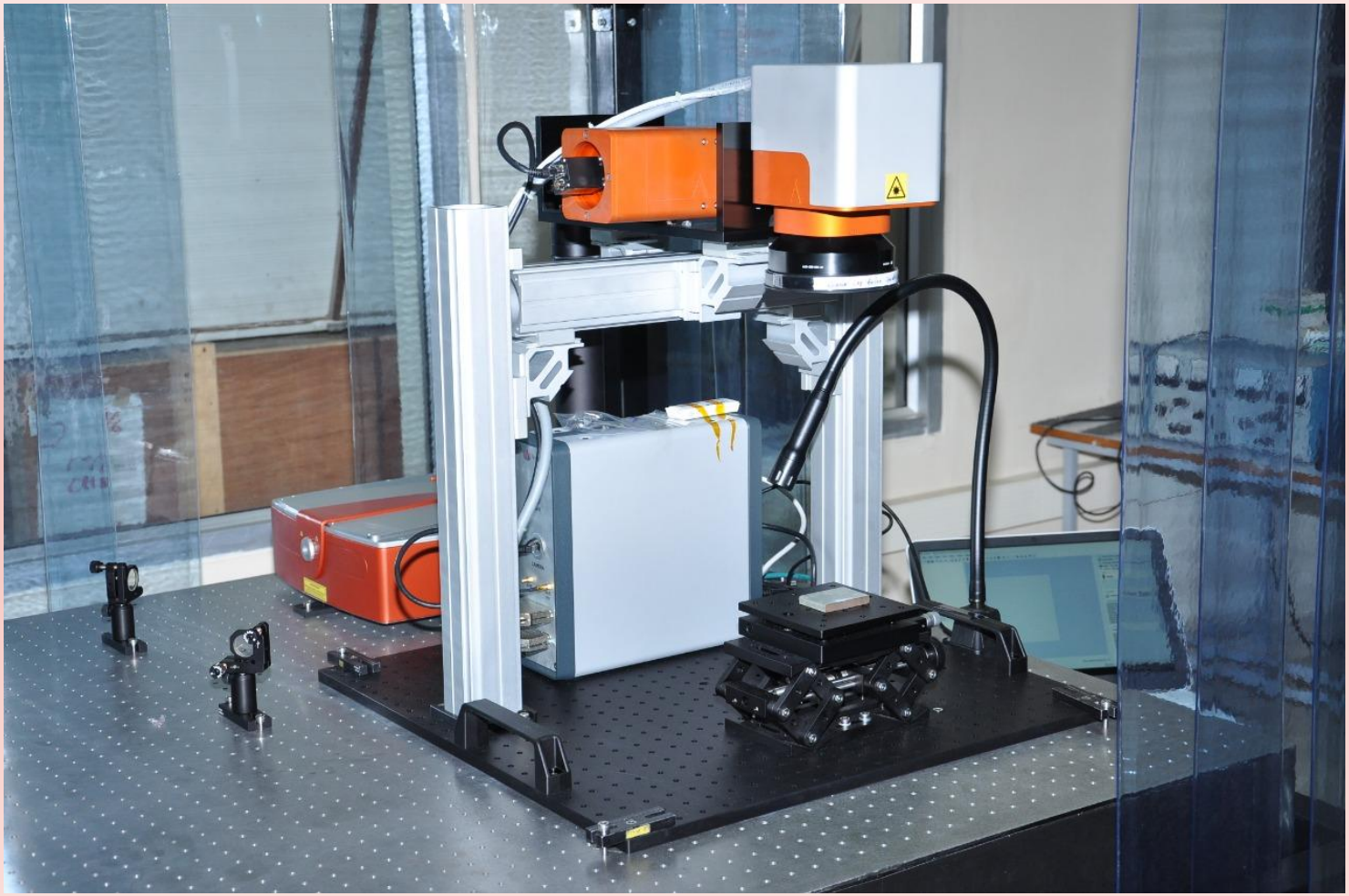
Wire EDM

Sl. No	Specifications	Data
1	Controllable Axes	4 (X,Y & U,V)
2	Axis Limits	250 (X) x 350 (Y) x 200 (Z) mm, U/V: ± 15mm
3	Resolution	0.001 mm
4	Cutting Speed (Dry Run)	80 mm/min
5	Wire Electrode Dia.	0.25mm, 0.2 mm
6	Wire Feed Rate	80mm/min
7	Main Table Feed Rate	0-10 m/min
8	Dielectric Medium	Distilled Water
9	Manufacturer	Electronica, India

Micro EDM

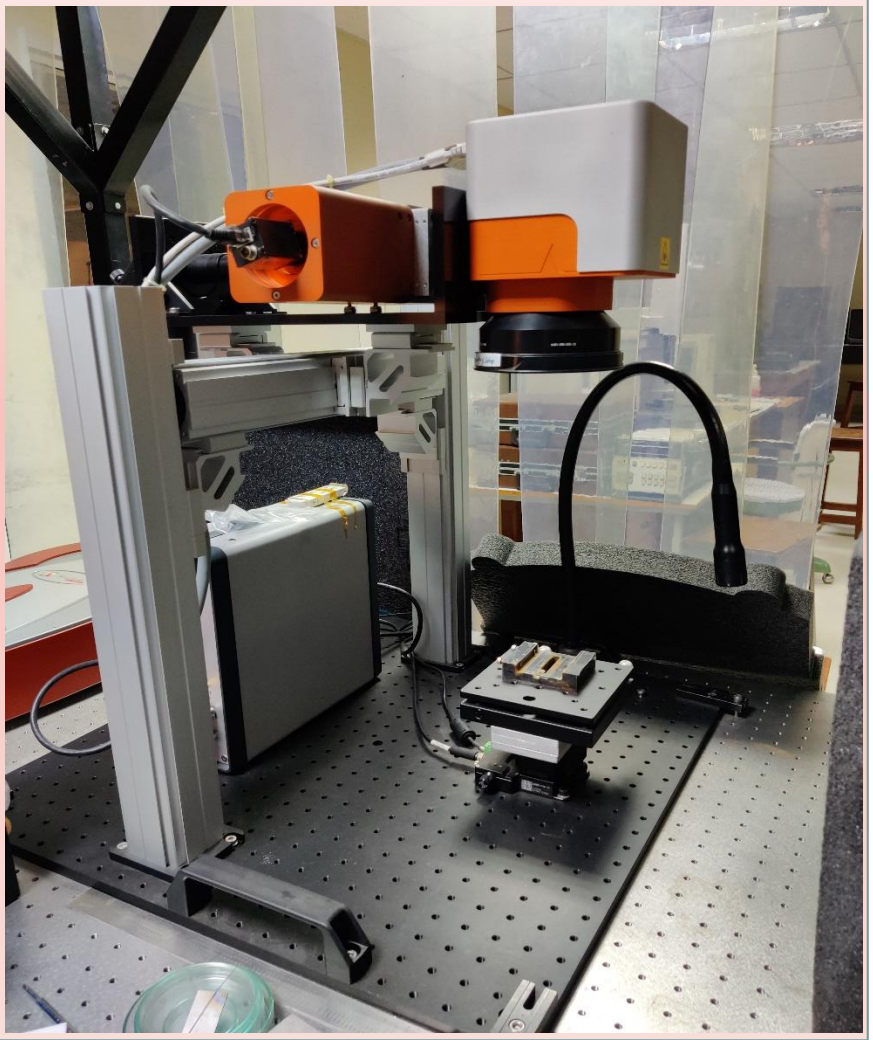
Sl. No	Specifications	Data
1	Pulse generator	Voltage: 80-120 V Capacitance:1-400 picofarad Selectable @6 level Invertible polarity
2	Resolution	0.001 mm
3	spindle Speed	0-3000 rpm
4	Electrode Dia.	0.3,0.5, 1mm
5	Min incremental movement	1 μm
6	Linear Stage	155 mm
7	Dielectric Medium	Distilled Water
8	Manufacturer	Indigenous

Ultra Short Pulse LASER

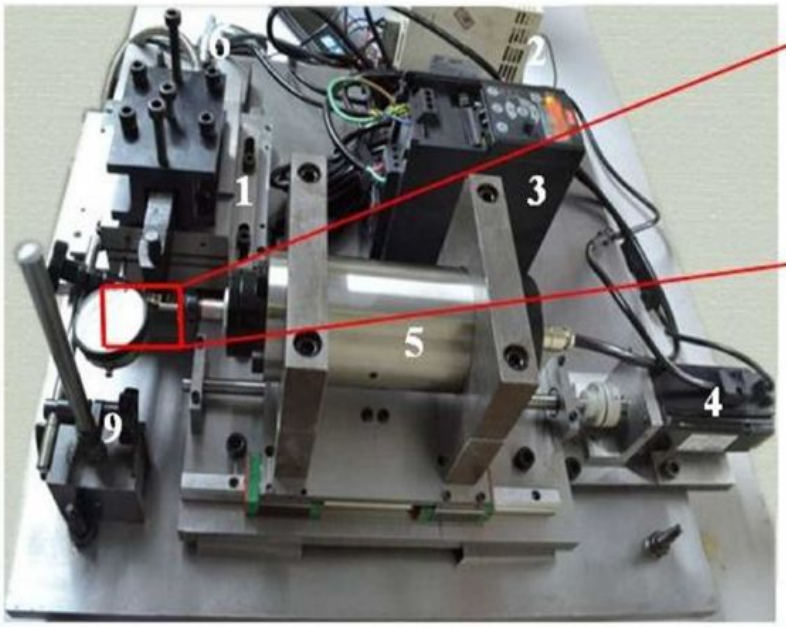


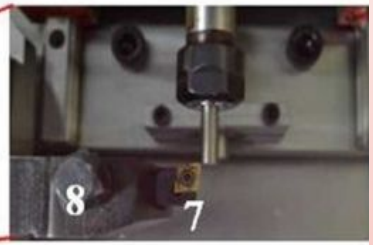
Ultra Short Pulse LASER

Sl. No	Specifications	Data
1	Energy per pulse	>40 µJ
2	Average Power	> 20 W
3	Center Wavelength	1030+/- 5nm
4	Bandwidth FWHM	<10 nm
5	Pulse Duration	< 400nm
6	Pulse to pulse stability (RMS)	<1%
7	Polarization Ratio	> 100:1
8	Beam Ellipticity	<13%
9	Pointing Stability	<100 µrad



Micro Turning Machine



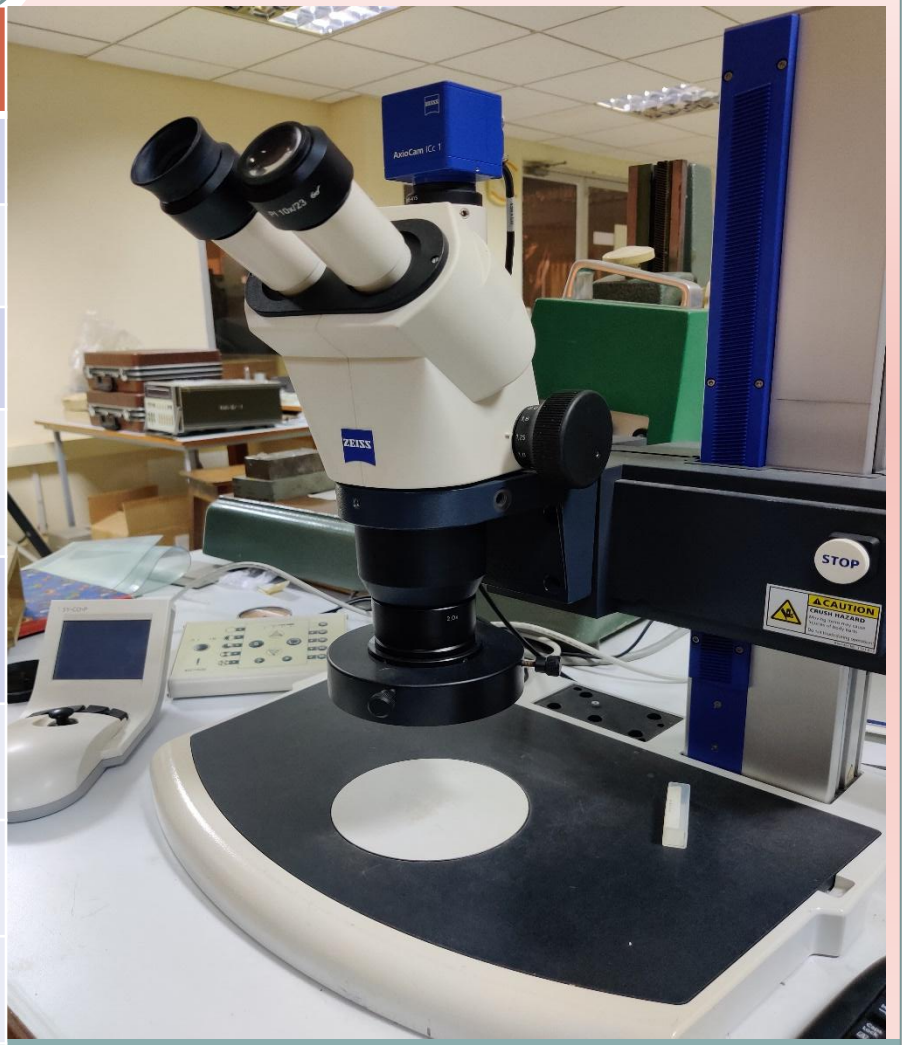


1. Piezoelectric Dynamometer
2. Encoder drive
3. Variable frequency drive
4. Servo motor with encoder
5. Spindle with inbuilt motor
6. Micrometer
7. Coated carbide tool
8. Tool holder
9. Dial gauge

Sl. No	Specifications	Data
1	Machine Base	600 x 600 x 20 mm
2	**Max Spindle Speed**	**24000 rpm**
3	**Force Measurement**	**Piezo electric dynamometer (9257b)**
4	Z axis Control	Servo motor (3000 rpm max, 0.1 rpm min)
5	X- Axis control	0-25 mm
6	Manufacturer	Research Scholar

Stereo Microscope

Sl. No	Specifications	Data
1	Magnification range	6.3x – 50x
2	Design Principle	Two Zoom Systems, Tilted By The Stereo Angle
3	Free Working Distance	92 mm
4	Maximum Object Field Diameter	36.8 mm
5	Accessible Magnification Range	1.9 x - 250 x
6	Microscope Manual Zoom	8:1
7	Quality of Zoom Optics	Distortion Free, Excellent Contrast, Apochromatic Corrected
8	Manufacturer	Oberkochen, Germany



Metallurgical Microscope

Sl. No	Specifications	Data
1	Observational Body	Binocular, Monocular
2	Tube Factor	1 X
3	Accuracy	0.001 mm
4	Lamp	Low Voltage, Quartz Iodine Lamp
5	Stage Movement	0.1 mm
6	Stage Accuracy	0.1 mm
7	Rotating Accuracy	0.1°
8	Make	REICHERT WIEN, Germany

Inverted Metallurgical Microscope

Sl. No	Specifications	Data
1	Observation Method	Reflected: Brightfield, darkfield, simple polarized, differential interference contrast and MIX Transmitted: Brightfield, simple polarized
2	Optics	UIS2 optics
3	Reflected/Transmitted	LED light source
4	Stage	Maximum stroke 50 × 50 mm
5	Weight	25 kg approx (microscope only: 20 kg)
6	Tubes	Widefield (FN 22)

Co-ordinate Measuring Machine (CMM)

Multi sensor (Contact and Non- Contact type)

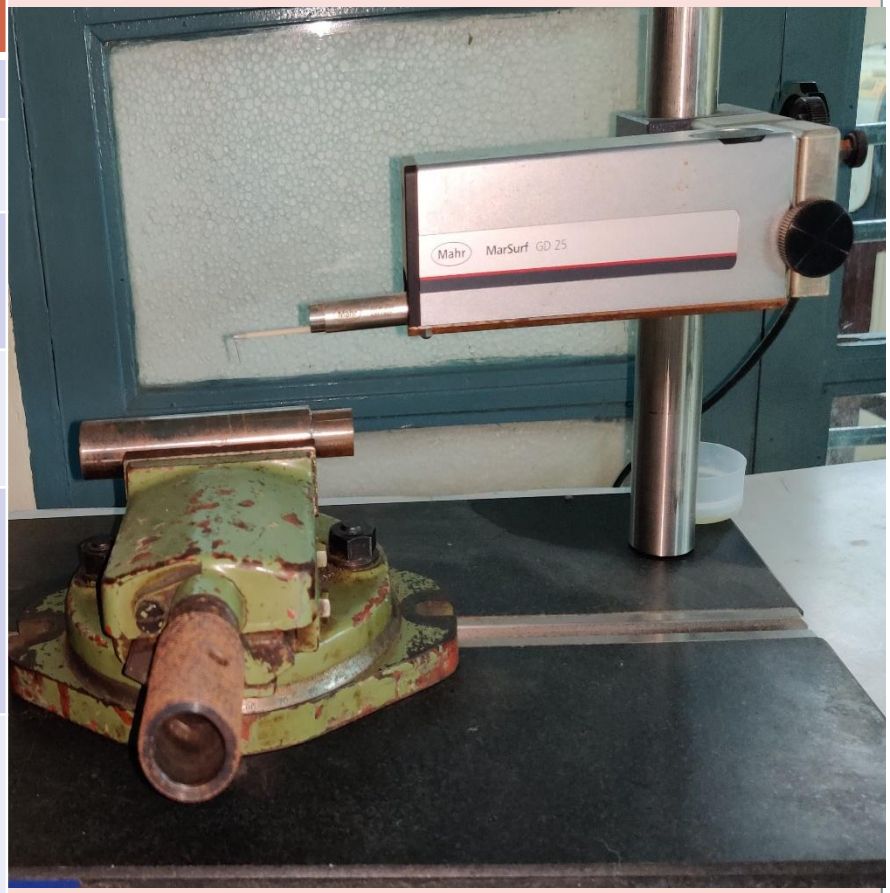
Sl. No	Specifications	Data
1	Camera	ZEISS Discovery.V12
2	Measuring volume	500x400x300 mm^3
3	Field of view	(min) 16.1x12.0 mm^2
		(max) 1.3x1.0 mm^2
4	Length measurement error MPE(E)	1.4µm+L/250 µm (1D)
		1.6µm+L/250 µm (2D)
		1.9µm+L/250 µm (3D)
5	Software	ZEISS CALYPSO
6	Manufacturer	ZEISS, Germany

CMM Contact Type

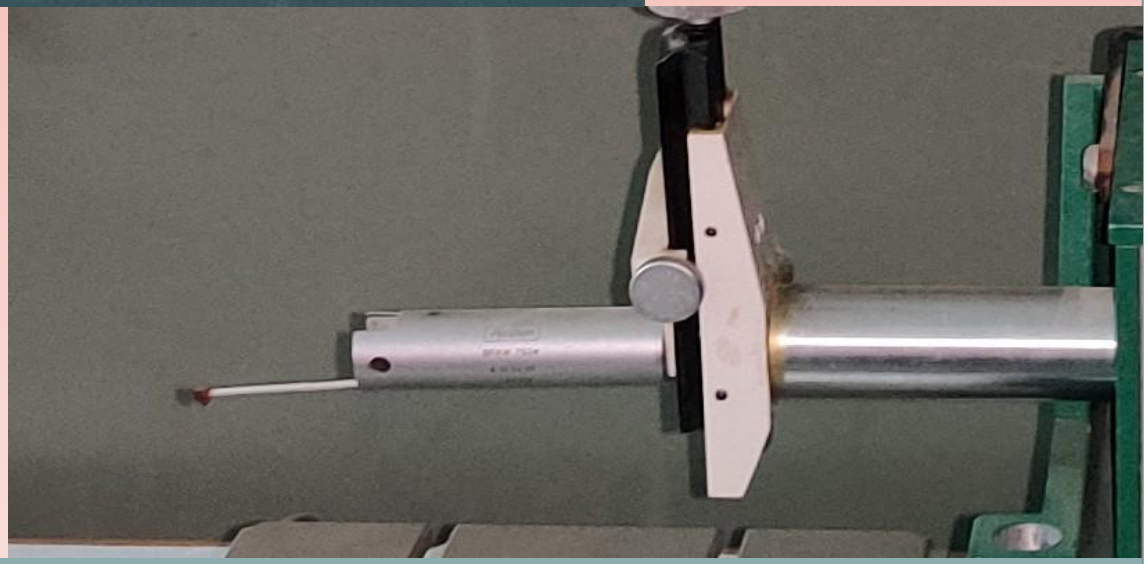
Sl. No	Specifications	Data
1	Manufacturer	HELMEL Inc, USA
2	Construction	Bridge Type
3	Measuring Range	X: 304.8 mm Y: 304.8 mm Z: 254.0 mm
4	Resolution	X: 0.00635 mm Y: 0.00152 mm Z: 0.00229 mm
5	Repeatability	0.002032 mm
6	Working Principle	Moire Fringe

Surface Measurement Instrument

Sl. No	Specifications	Data
1	Measuring principle	Stylus method
2	Probe	R probe, MFW 250 B
3	Measuring range	MFW 250: ±25 µm, ±250 µm, (up to ±750 µm);
4	Traversing lengths	Automatic; 0.56 mm; 1.75 mm; 5.6 mm; 17.5 mm, 56 mm,
5	Number n of sampling length according to ISO/JIS	1 to 50 (default: 5)
6	Surface parameters	Over 100 surface parameters for R, P and W profiles according to current ISO/JIS or MOTIF standards (ISO 12085)
7	Manufacturer	Mahr, Germany



Different probes for Perthometer



PERTHOMETER - 1

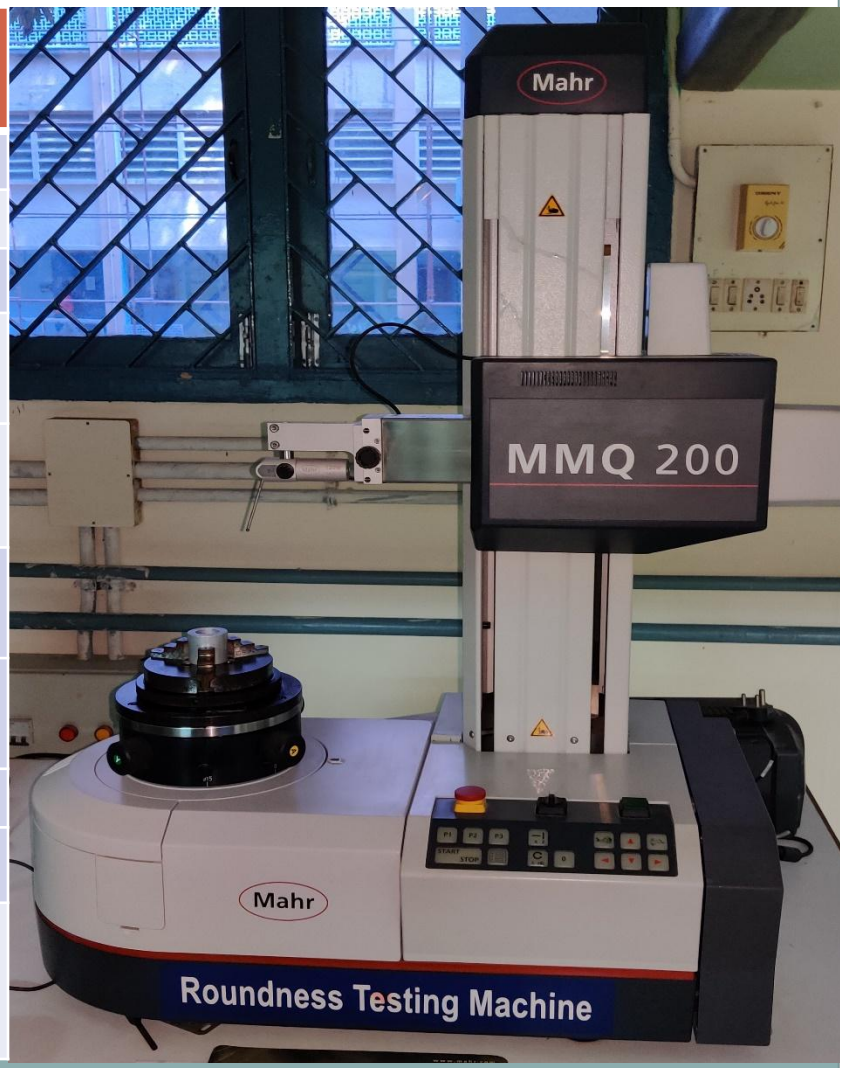
Sl. No	Specifications	Data
1	Measuring Range	0.0012…..125 µm
2	Tracing lengths	0.48,1.5,4.8,15 & 48 mm
3	Reverse Speed	1.5 mm/s
4	Tracing Speed	0.5-0.01 mm/s ±1%
5	Bearing area Curve	50mm
6	Cut-off wavelengths	0.08, 0.25, 0.8, 2.8 & 8 mm
7	Angle Setting	±1°
8	Dimensions	410 x 200 x 200 mm
9	Make	Mahr GMBH, Germany

PERTHOMETER - 2

Sl. No	Specifications	Data
1	Measuring Range	150 µm
2	Tracing lengths	01.75, 5.60, 17.50 mm
3	Reverse Speed	1.2 mm/s
4	Tracing Speed	0.5 mm/s
5	Skid pressure	0.3N(Standard Position) 0.15N (Upside Down Position)
6	Cut-off lengths	0.25, 0.8, 2.5 mm
7	Stylus radius	2 µm
8	stylus Force	0.7 mN
9	Make	Mahr, Germany

Form Testing Machine

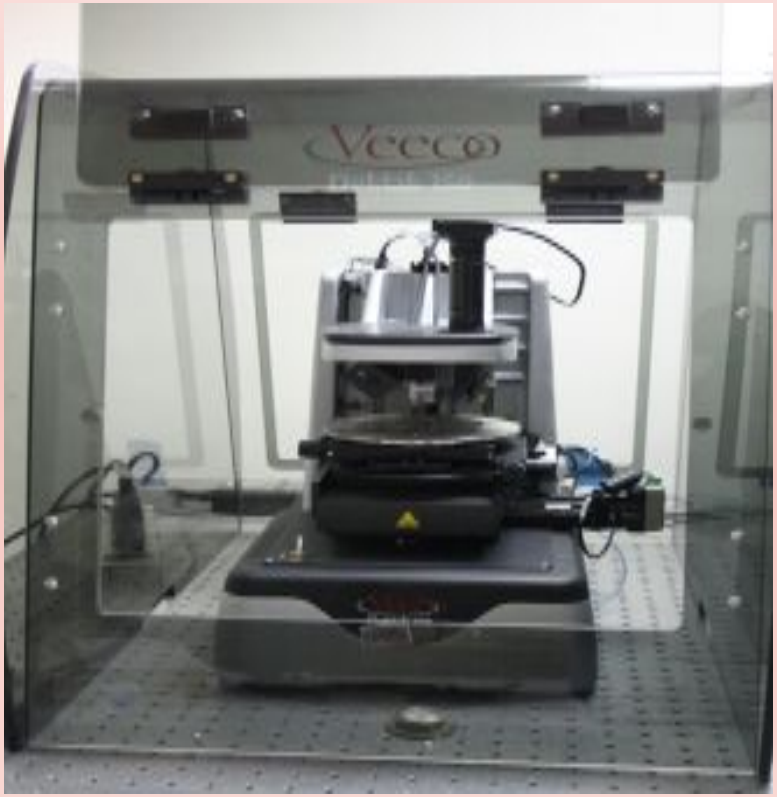
Sl. No	Specifications	Data
1	Centering and tilting table	manual
2	Speed (rpm) 50 Hz / 60 Hz	0.2-15
3	Measuring path, motorized Z (mm)	250
4	Straightness deviation / total measuring path (µm), Z axis	0.3
5	Parallelism deviation Z-/C axis in tracing direction, measuring path (µm)	0.5
6	Roundness deviation (µm+µm/mm measuring height)	0,03 + 0,0006
7	Axial runout deviation (µm+µm/mm measuring radius)	0,04 + 0,0006
8	Measuring speed (mm/s), Z axis	0.5-30
9	Positioning speed (mm/s), Z axis	0,5-100
10	Manufacturer	Mahr, Germany



Tool Makers Microscope

Sl. No	Specifications	Data
1	Measuring Range	50mm X 50mm X 70mm
2	Linear Accuracy	3 + L/200 µm
3	Objective Lens	Standard: 2X Optional: 3X, 4X, 5X
4	Measuring Range or Travel	50mm X 50mm for micrometers and 100mm X 100mm for D.R.O.
5	Repeatability	±2 µm
6	Resolution	15µm / 1µm / 0.5µm
7	Focusing Range	100mm
8	Measurement Method	Micrometer/ D.R.O. / Software
9	Make	Sipcon Instrument Industries, India

3D Profilers



3D Contact Profiler

3D Non-Contact Profiler

Optical 3-D Profilometer

Sl. No	Specifications	Data
1	Manufacturer	Veeco Instruments Inc., USA
2	Measurement Technique	Optical Phase- shifting & white light vertical Scanning Interferometry
3	Measurement capability	3D, Non contact
4	Objectives	20X, 50X, Manual Turret
5	Measurement Array	Max. 736 x 480
6	Light Source	Tungsten halogen lamp
7	Stages	Automated in ±x/y (±50.8mm)
8	Vertical Measurement range Vertical Resolution	0.1nm to 1nm < 1A° Ra
9	RMS Repeatability Scan Speed	< 0.01nm Up to 7.2 µm/s

Thank You

References :

- 1. Groover.M.P and Zimmers.E.W, CAD/CAM: Computer Aided Design and Manufacuture, Prentice-Hall, 1984.
- 2. Warnecke.H.J and Steinhilper.R, Ed., Flexible Manufacturing Systems, IFS Pubs.,Bedford, 1985.
- 3. Bigneil V, Dooner M, Hughes J, Chris Pym and Sheila Stone, Manufacturing Systems: Context, Applications and Techniques, Basil Blackwell University Limited, Oxford, 1985
- 4. Warnecky H.J. and Steinhilper R, Flexible Manufacturing Systems, International Trends in Manufacturing Technology, Springer Verlag, 1985.
- 5. Mcguigan.K, Ed., Flexible Manufacturing, IFS Pubs., Bedford, 1988. 6. Paul Ranky, The Design and Operation of FMS, IFS Pubs. 1988.