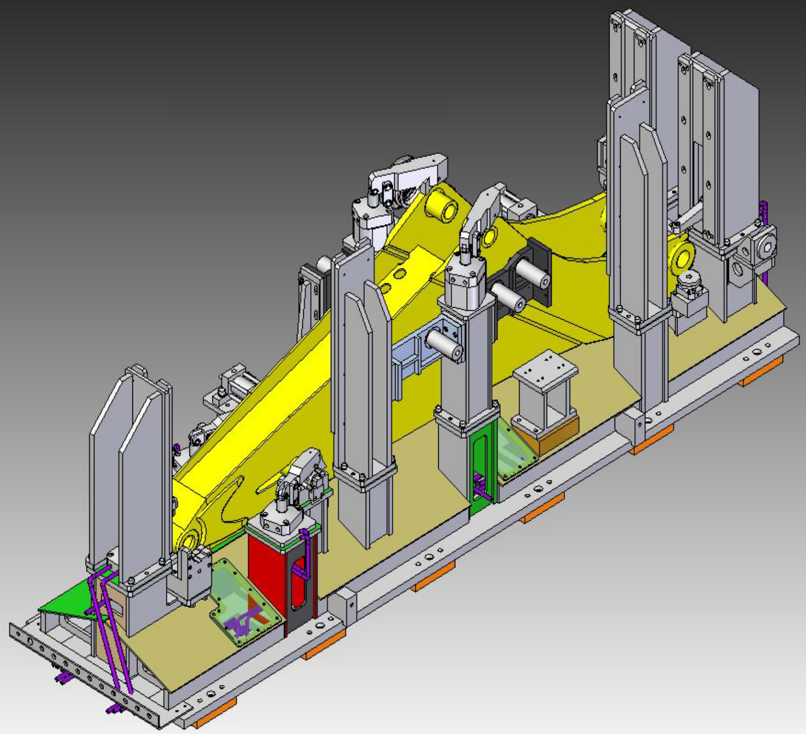
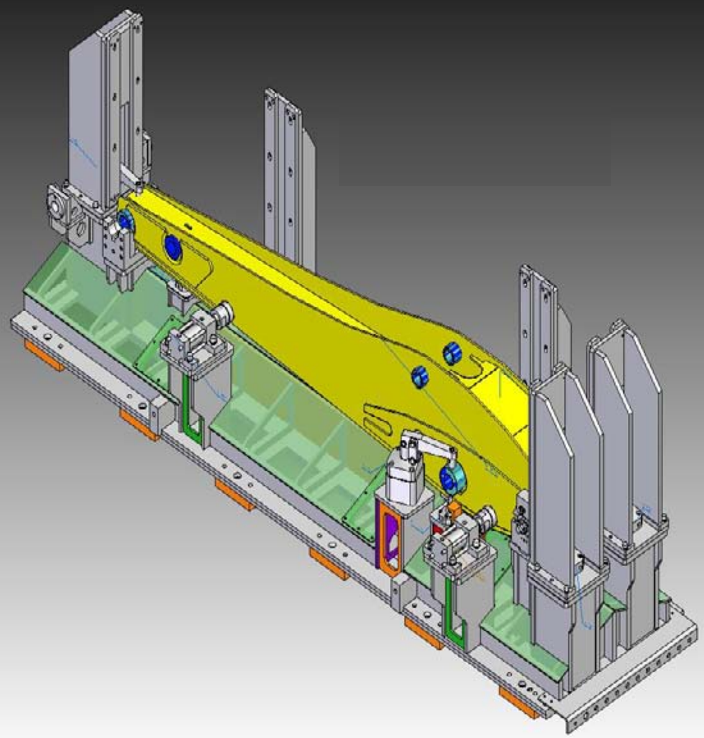




Design of Workholding Fixtures

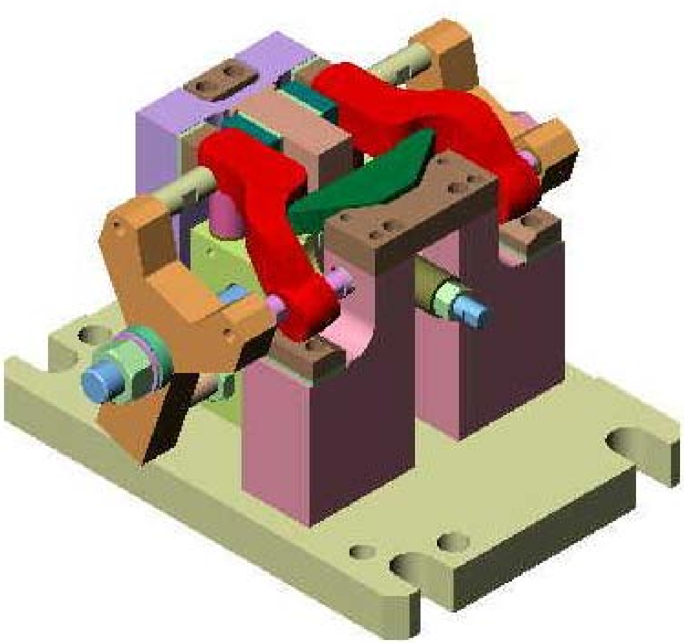
Indian Machine Tool Manufacturers' Association

Agenda

- Key Factors & Technical Features of Workholding Fixtures
- Various Types of Workholding Fixtures
- Basics of Fixture Design
- Design of basic elements
- Elements for Hydraulic, Pneumatic Fixtures
- Case Studies
- Workholding Fixtures for Turning
- Safety Features/ Cost Controls

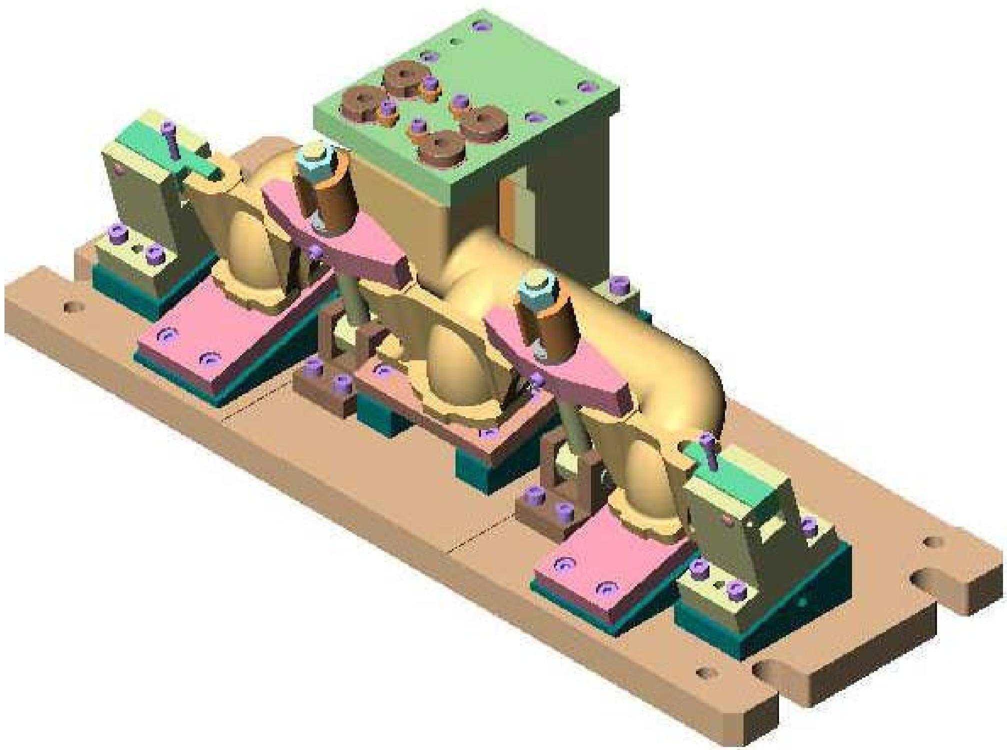
What is a Fixture?

- A fixture is a work holding device which holds and positions the work piece but does not locates / guides the cutting tool.



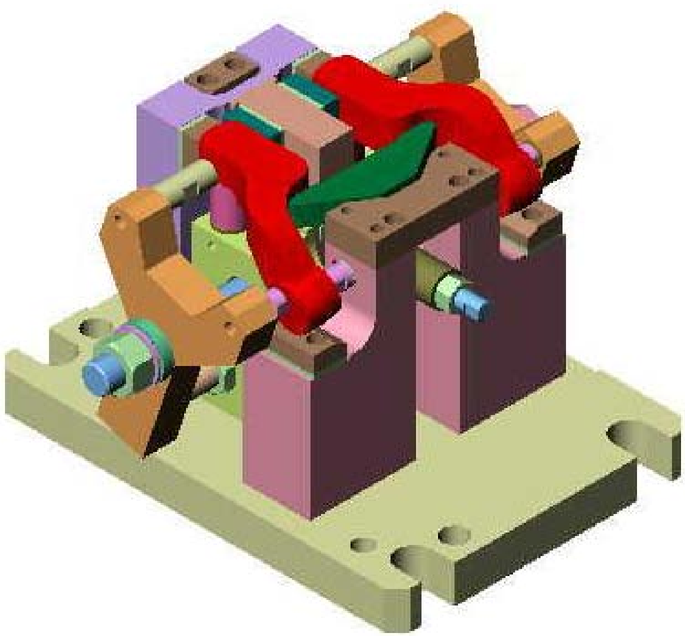
What is a Jig?

- A Jig is a device which holds and positions the work piece, locates & guides the cutting tool relative to the work piece.



Fixture !!!

- Fixture is an Equipment used for Locating and firmly Holding the Work Piece in the predetermined Position during Machining Operations



Why is a Fixture required?

- To hold the Component and to take care of the Cutting Load
- To avoid distortion of the Component during machining
- To accurately position/ locate the component w.r.t. defined references,
- To get the desired accuracies on the component consistently

Why is a Fixture required? (Contd.)

- To ensure correct loading of the component each time

Getting Repeatable accuracies on Parts

High productivity and reduced Machine Idle Time

Reduced cost of operation/Component

Key Points for consideration while designing the fixture

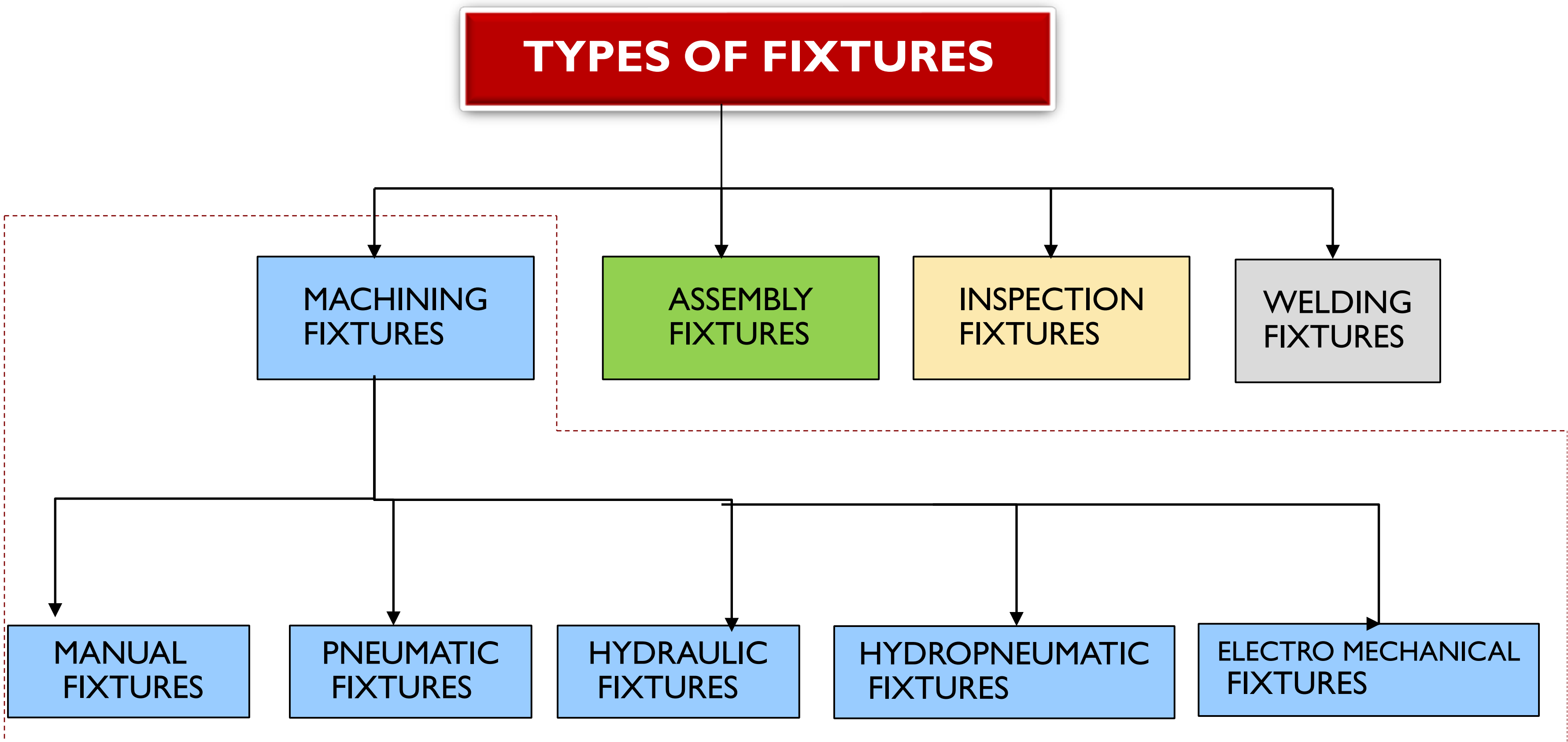
- Study of the component drawing i.e. Forging / Casting/ Machining
- Study of component material and its properties like hardness, etc.
- Study of the Rigidity behavior of the component
- Study of complete machining process
- Study of the relation of the reference dimensions and tolerances
- Study for Averaging of machining allowances. (Qualifying operation)
- Type of operation to be performed
- To decide the number of set ups required

Key Points for consideration while designing the fixture (contd.)

- Machine type & configuration for which fixture is to be designed e.g. General Purpose Machines like VMC, HMC, Turning, Milling, Gear Cutting, etc. and SPMs
- Quality Parameters to be achieved i.e. Relations, Tolerances and Form Accuracies
- Component Inspection method
- Tooling (types of Tools used for required operation) & Tool layout
- Cutting forces acting on the component during operation
- Cycle time required for the operation
- Budget for Fixtures
- Selection of Resting, Location & clamping point

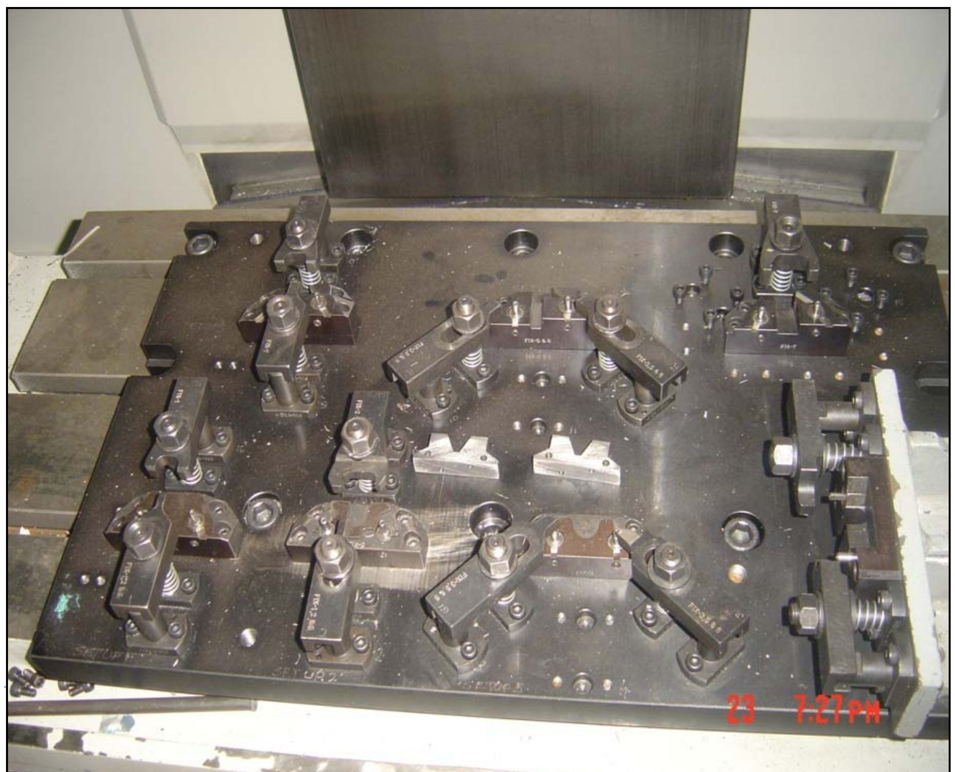
Key Points for consideration while designing the fixture (Contd.)

- Type of Loading – Manual, Gantry, Robot
- Sequence of clamping
- Safety Features
- Operator fatigue
- Component Seat checking
- Component Ejection
- Piping (External/ Internal)
- Chip Disposal
- Type of clamping source - Manual , Pneumatic, Hydraulic, Electro-mechnical
- Fool-proofing (Poka-yoke)


TYPES OF FIXTURES
MACHINING FIXTURES
ASSEMBLY FIXTURES
INSPECTION FIXTURES
WELDING FIXTURES
MANUAL FIXTURES
PNEUMATIC FIXTURES
HYDRAULIC FIXTURES
HYDROPNEUMATIC FIXTURES
ELECTRO MECHANICAL FIXTURES

Manual Fixtures

- The Component is clamped manually by positioning clamping Levers and tightening by using Hand Tools such as Spanners, Allen Keys, etc. Torque Wrenches are recommended to get uniform Clamping Forces



Manual Fixtures

Pros

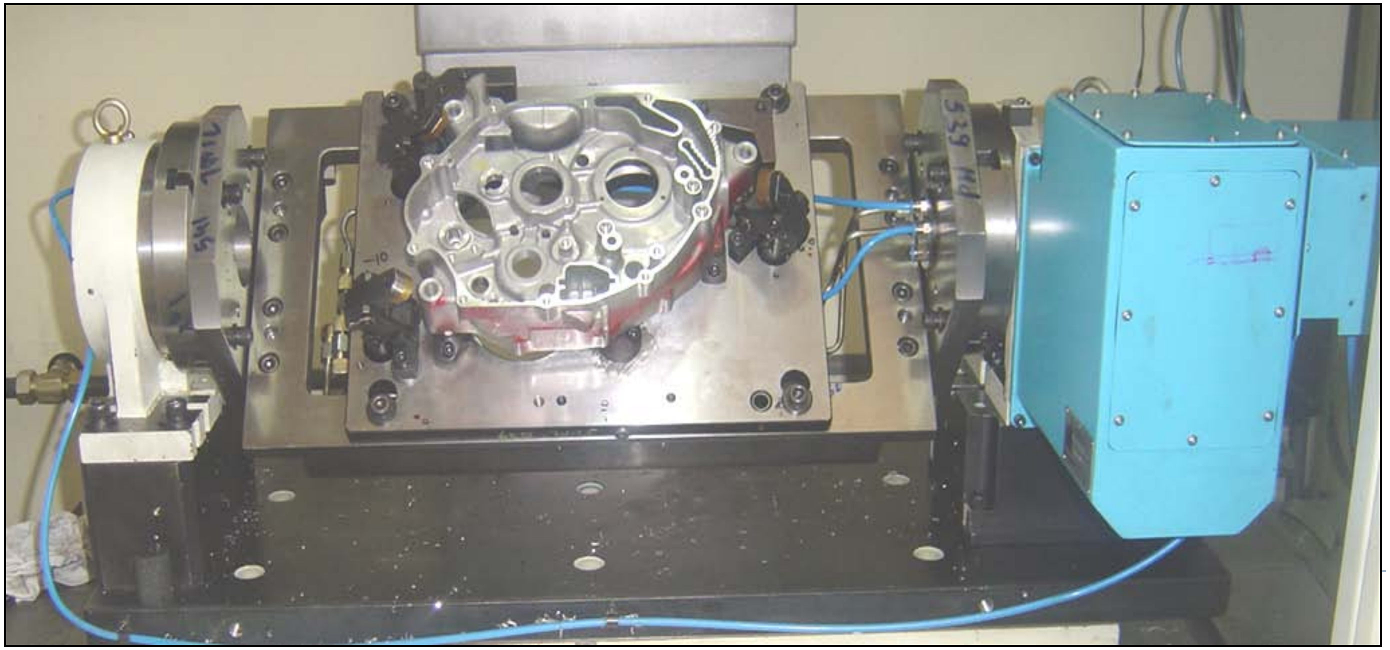
- Simple and Cheap
- No Maintenance
- Easier to modify
- Quicker delivery

Cons

- Loading Time is more
- Operator Fatigue
- Operator needs to be more vigilant
- Less Suitable for machining cells

Pneumatic Fixtures

- Compressed air is used as fluid for power transmission. The air is pressurised upto 4 to 5 bar to energise it.
- Although very rapid in operation, air operated clamping devices are vulnerable to variation in Clamping Forces.



Pneumatic Fixtures

Pros

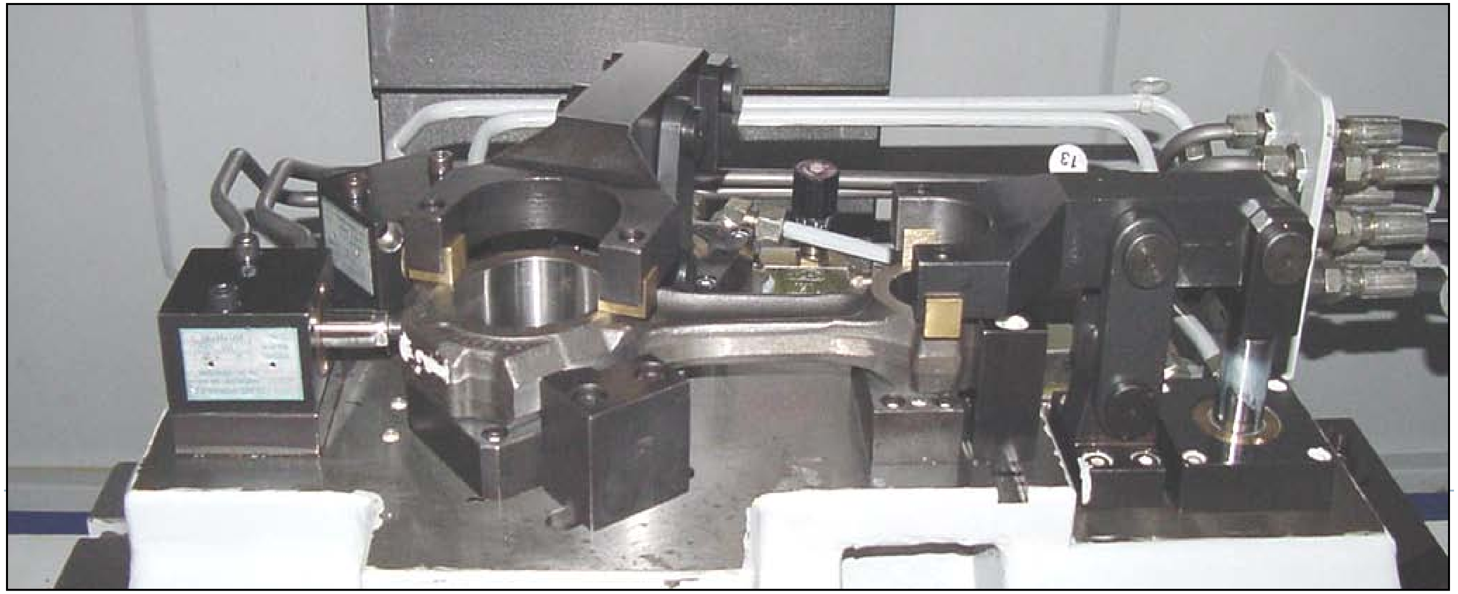
- Cheap Elements
- Less Component Distortion
  - Ideal for Al

Cons

- Low Clamping Forces.
- Noisy and erratic operation
- Palletised version not possible

Hydraulic Fixtures

- Unlike air, hydraulic oil is almost incompressible, consequently variations in Cutting Forces does not affect clamping.
- Operating pressure of hydraulic System for Fixture clamping ranges from 10 to 250 bar. Hydraulic operation generally requires substantial investment for hydraulic power pack and cylinders



Hydraulic Fixtures

Pros

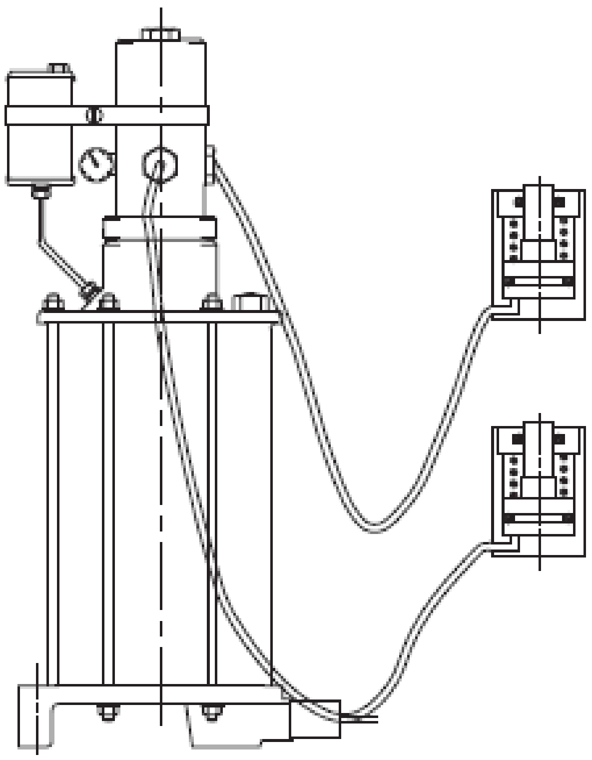
- Low Operator Fatigue
- Clamping Consistency
- High Clamping Forces
- Suitable for Machining Cells
- Quick Component Loading

Cons

- Expensive
- Longer delivery
- Top loading is not always possible

Hydropneumatic Fixtures

- The concept involves - installation of the air to hydraulic booster which is used to convert low pressure, for operating a hydraulic cylinder.
- The booster operates from regular shop line pressure without pumps or high pressure valving.



Hydropneumatic Fixtures

Manual | Hydraulic | Pneumatic | HydroP. | ElectroM

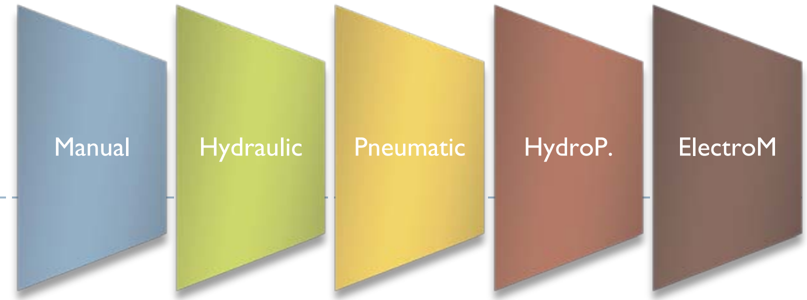
Pros

- Cheaper than Hydraulic - Palletized
- All Advantages of Hydraulic Clamping

Cons

- Little Noisy and erratic operation
- Local Alternatives not available

Electro Mechanical Fixtures



- The concept involves - installation of electro mechanical actuator (GMT or Berg) which is available for clamping at various torques

Electro Mechanical Fixtures

Manual | Hydraulic | Pneumatic | HydroP. | ElectroM

Pros

- Cheaper in case where Hydraulics or Pneumatics is not available
- Widely used in general purpose machines
- Used in palletized machines

Cons

- Not suitable for differential clamping system

Selection criteria for the type of clamping system

Criteria	Pneumatic	Hydraulic	Hydropneumatic*
Cost	Lowest	High	Low
Clamping force	Light - 2 to 3 kN max. Higher forces if no space constraints	Medium and heavy - above 5 kN	Medium and heavy - from 5 kN to 100 kN
Clamping Cylinder Size	Bulky for even medium clamping force (Op.Pr. 5 bar)	Compact (For SPM Op.Pr. 30 to 70 bar)	Most Compact for heavy forces (Op.Pr. 150 to 200 bar)
Clamping Stroke	Wide range - from short to very long	Wide range - from short to very long	Short stroke - 50 mm max.
Clamping Speed	Very fast	Fast	Fast
Impact while clamping	Present	Not Present	Not Present
Reliability	Low - as can be overpowered due to the compressibility of air	Most safe - due to the check valve and incompressibilty of oil	Safe - as factor of safety for force selection can be more

Selection criteria for the type of clamping system (Contd.)

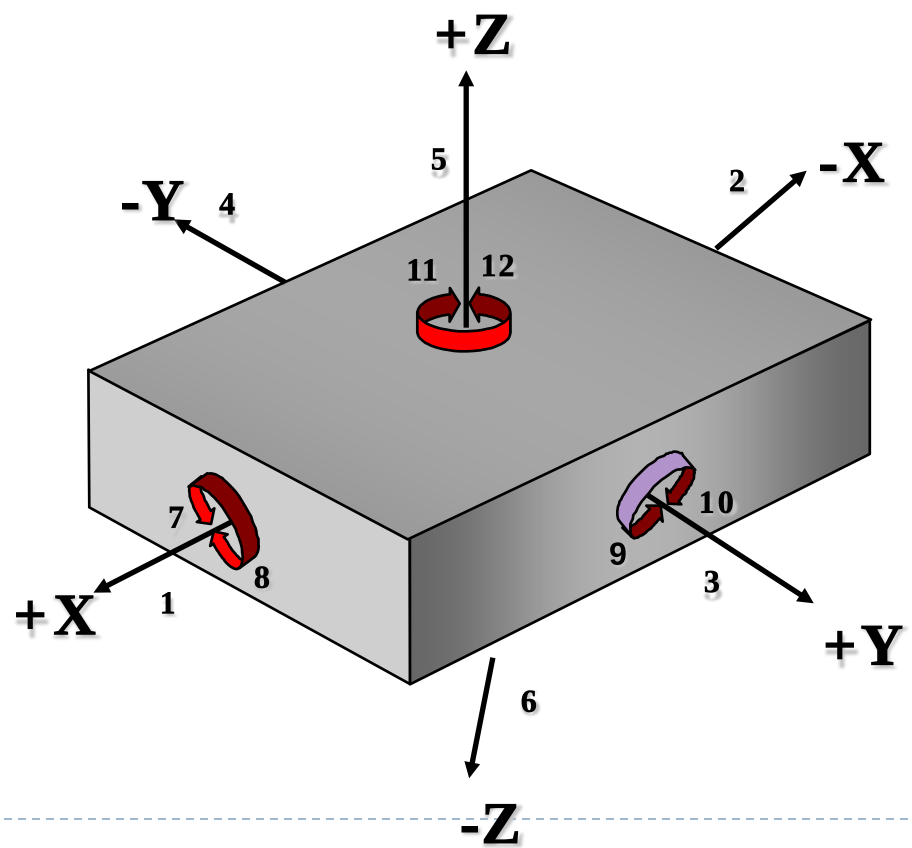
Criteria	Pneumatic	Hydraulic	Hydropneumatic*
Sequencing	Possible	Possible	Difficult
Piping & Circuit	Complicated	Complicated	Simple
Oil heating problem	Not Present	Present	Not Present
Return stroke speed and power	Fast due to double acting cylinder, but with low power	Fast, with power and positive due to double acting cylinder	Slugish due to spring return cylinders
No.of clamping points	No limit	No limit	Limited, 3 to 5 per intensifier
Other applications	Material handling, Valve actuation, Door movement	Feed cylinders, Earth moving equip., Cutting, Hole punching, Deep drawing	Pressing assembly, Rivetting, Crimping, Cutting,

Basics of Fixture Design

Basics of Fixture Design

12 Degrees Of Freedom

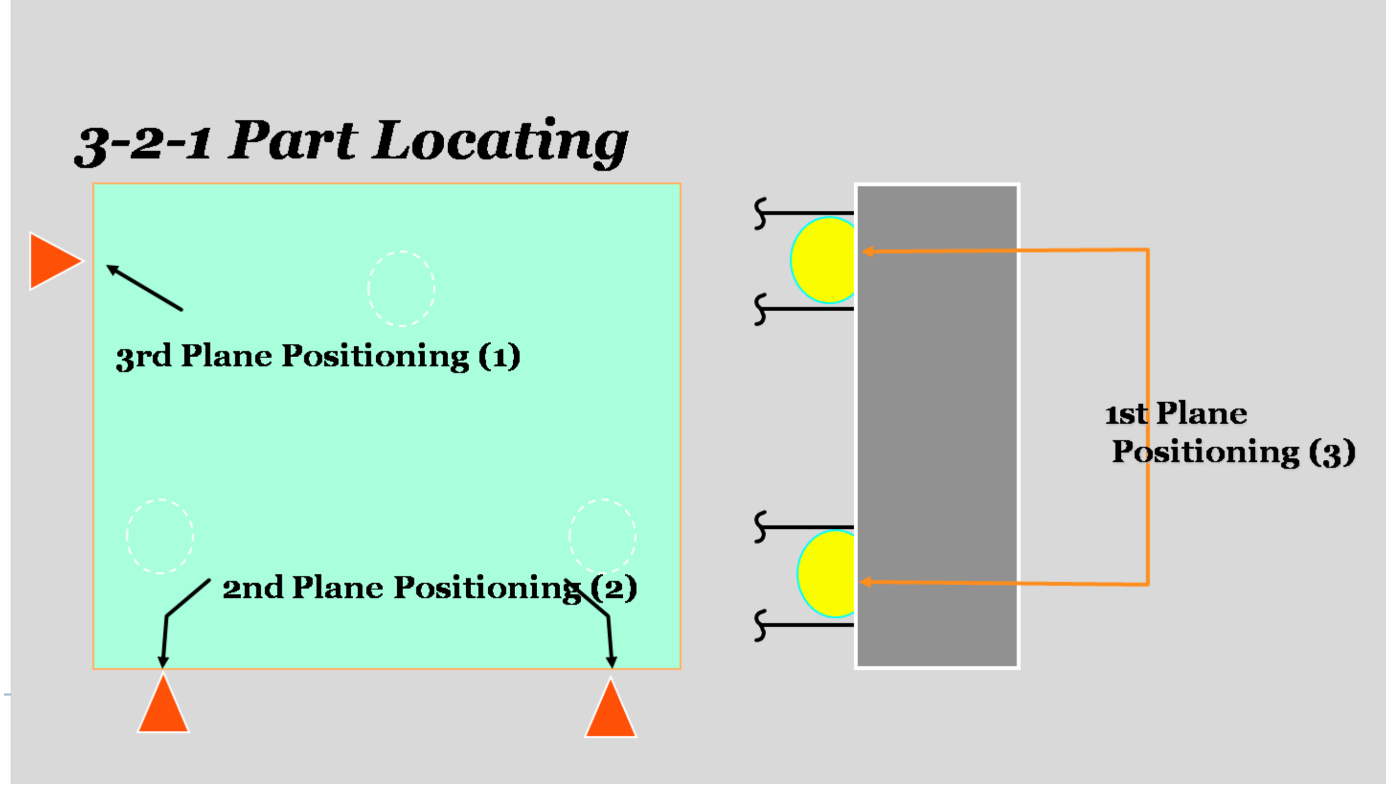
(1) X+
(2) X-
(3) Y+
(4) Y-
(5) Z+
(6) Z-
(7) XCCW
(8) XCW
(9) YCCW
(10) YCW
(11) ZCW
(12) ZCCW



Basics of Fixture Design

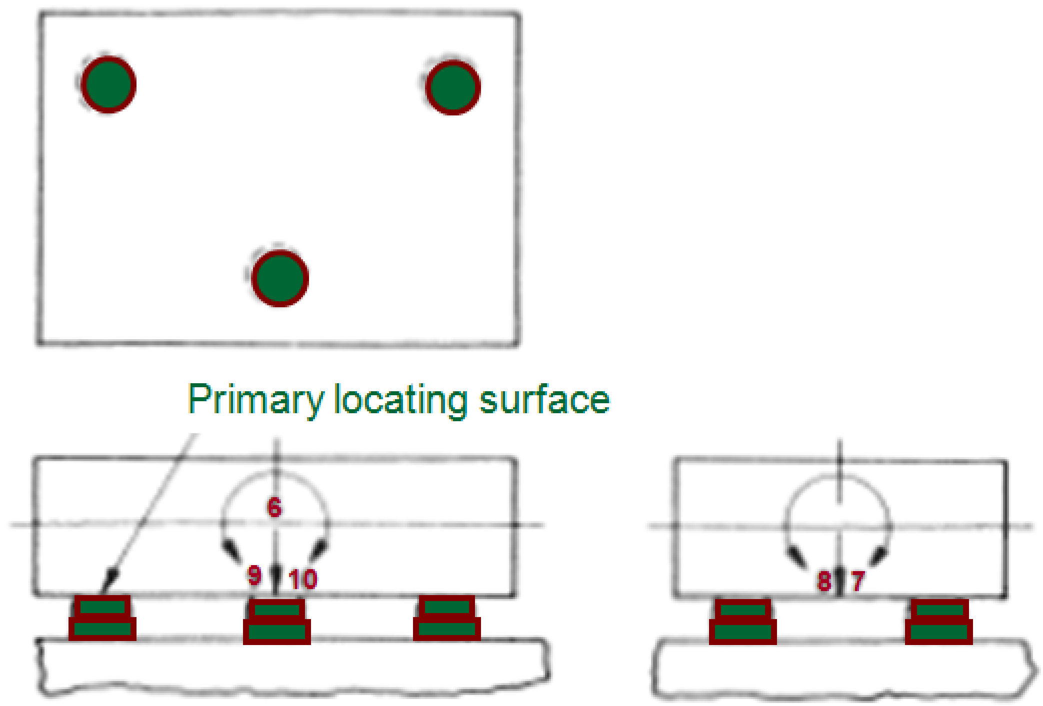
- Resting - stability
- Locating - w.r.t datum
- Orienting - w.r.t secondary datum
- Clamping - ensuring above not disturbed

3-2-1 principle



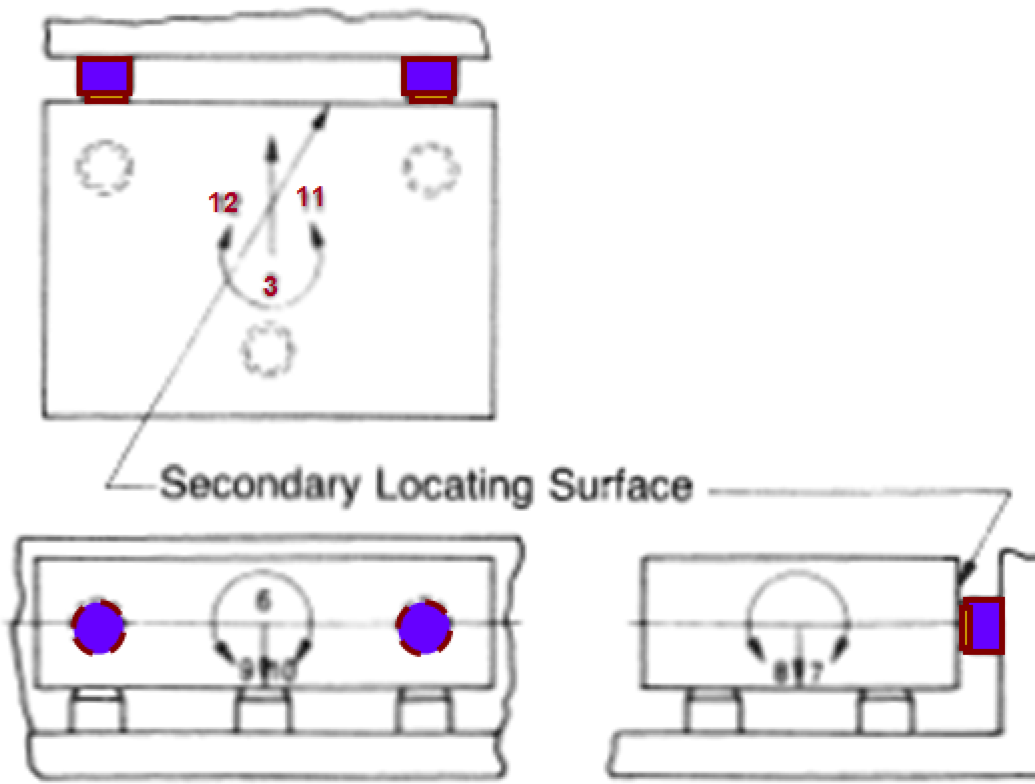
Six-point locational method
or **3-2-1 method**

- Three locators, or supports, are placed under the workpiece (positioned on the primary locating surface, restricting five degrees of freedom). This restricts axial movement downward, along the -z axis (#6) and rotationally about the x (#7 and #8) and y (#9 and #10) axes.



3-2-1 or Six Point Locational method

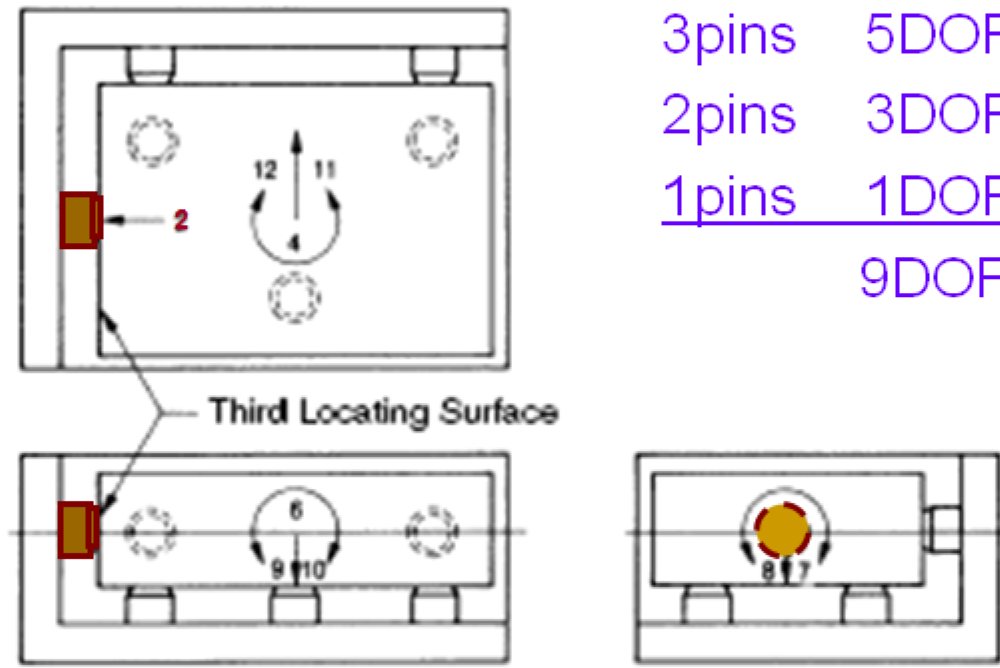
- The next two locators are normally placed on the secondary locating surface, restricting an additional three degrees of freedom by arresting the <u>axial movement</u> along the <u>+y axis</u> (#3) and the <u>rotational movement about the z</u> (#11 and #12) axis.



3-2-1 or Six Point Locational method

- The final locator, is positioned at the end of the part. It restricts the axial movement in one direction along the -x axis (restricting one more degree of freedom). Together, these six locators restrict a total of nine degrees of freedom.

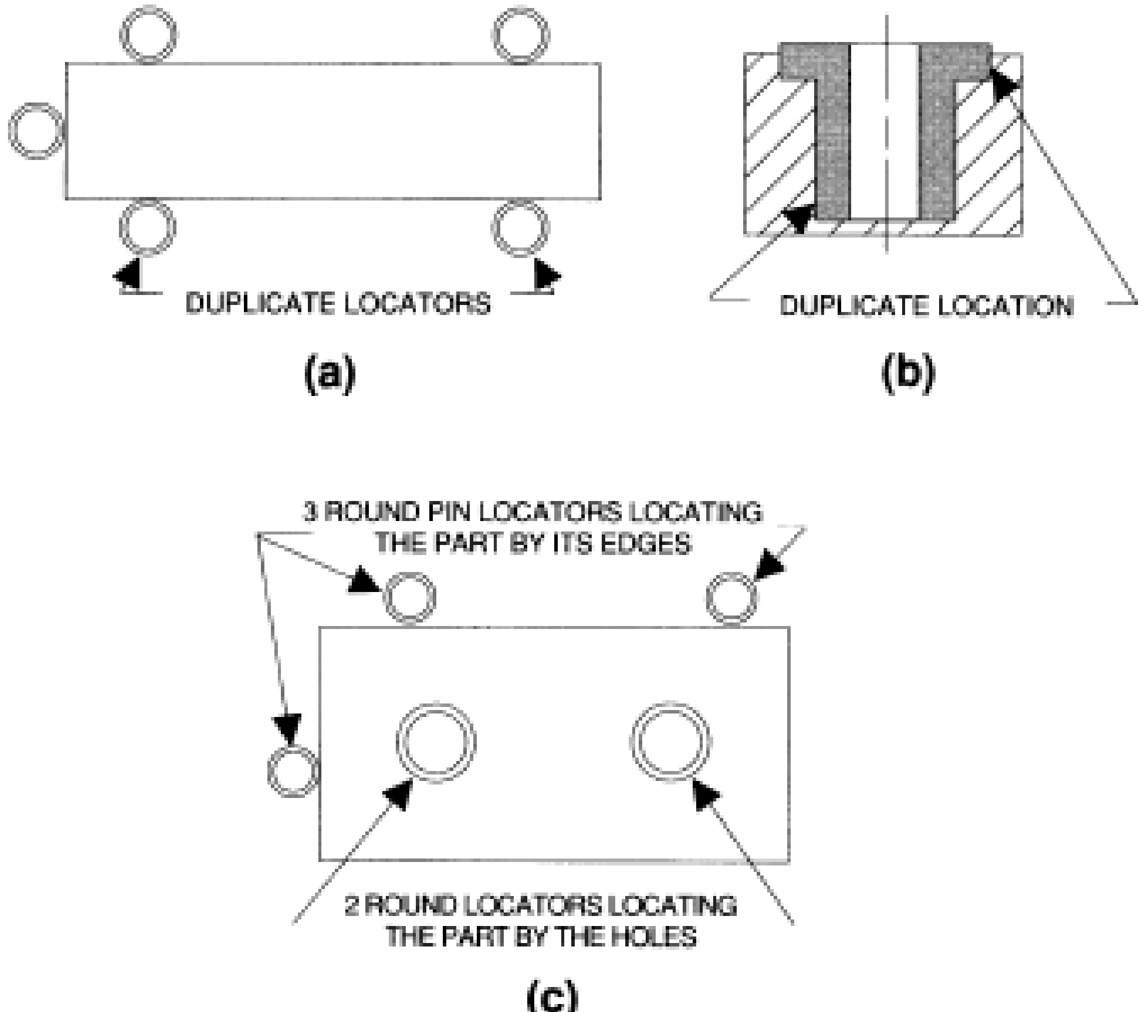
Pins	restricted
3pins	5DOF
2pins	3DOF
1pins	1DOF
	9DOF

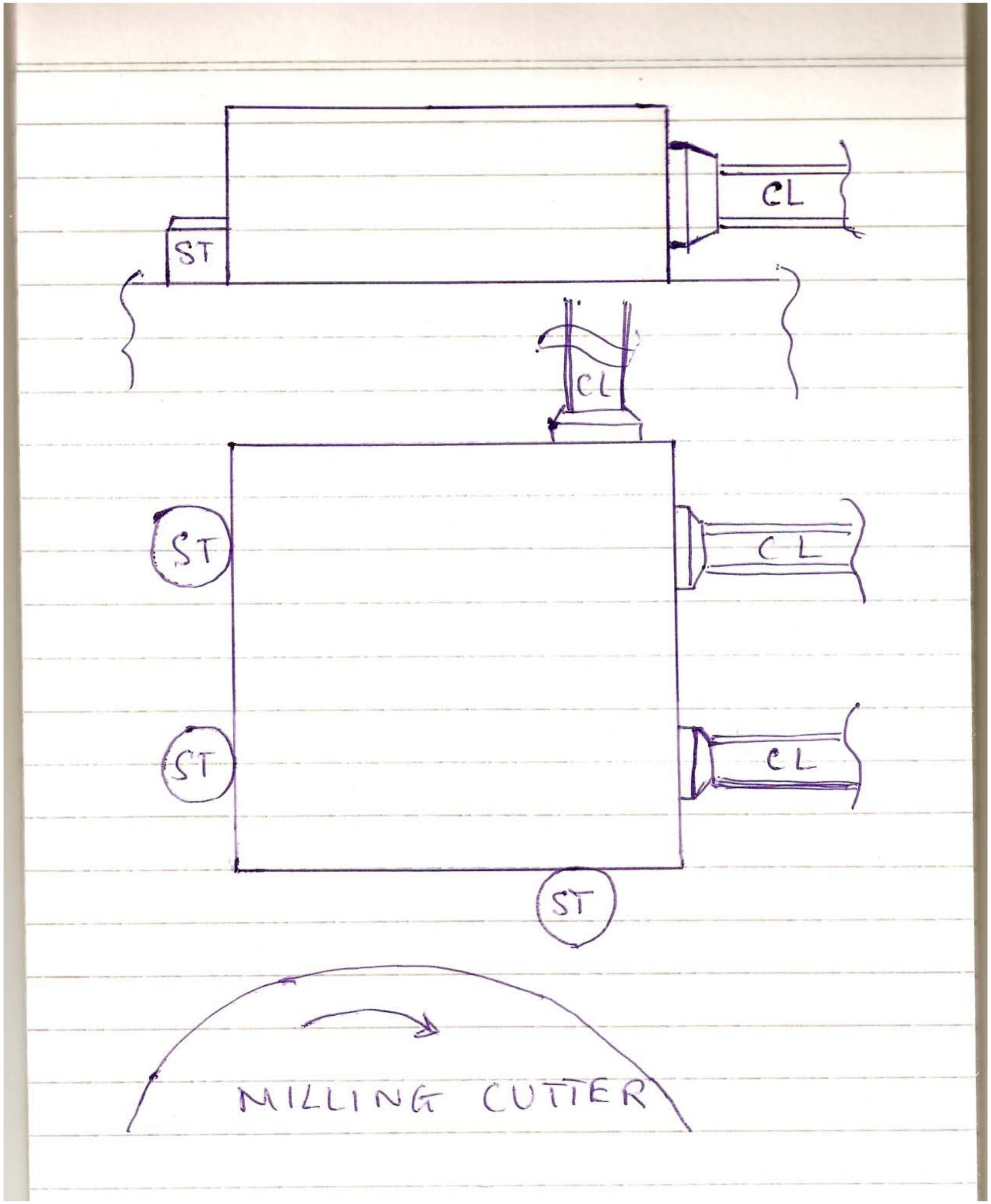


- The remaining three degrees of freedom (#1, #4, and #5) will be restricted by the clamps.

LOCATING ISSUES

LOCATING ISSUES





ST
CL
CL
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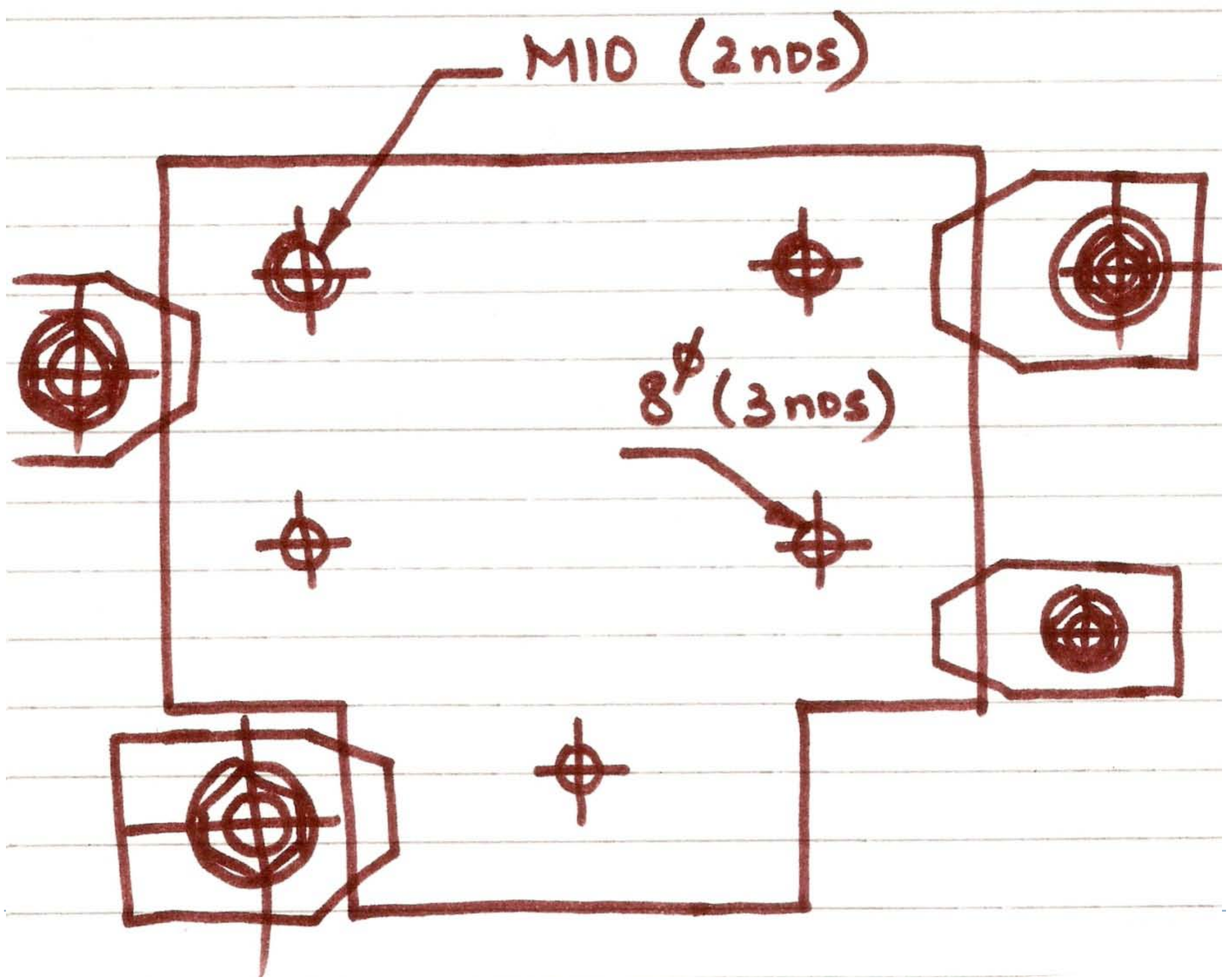
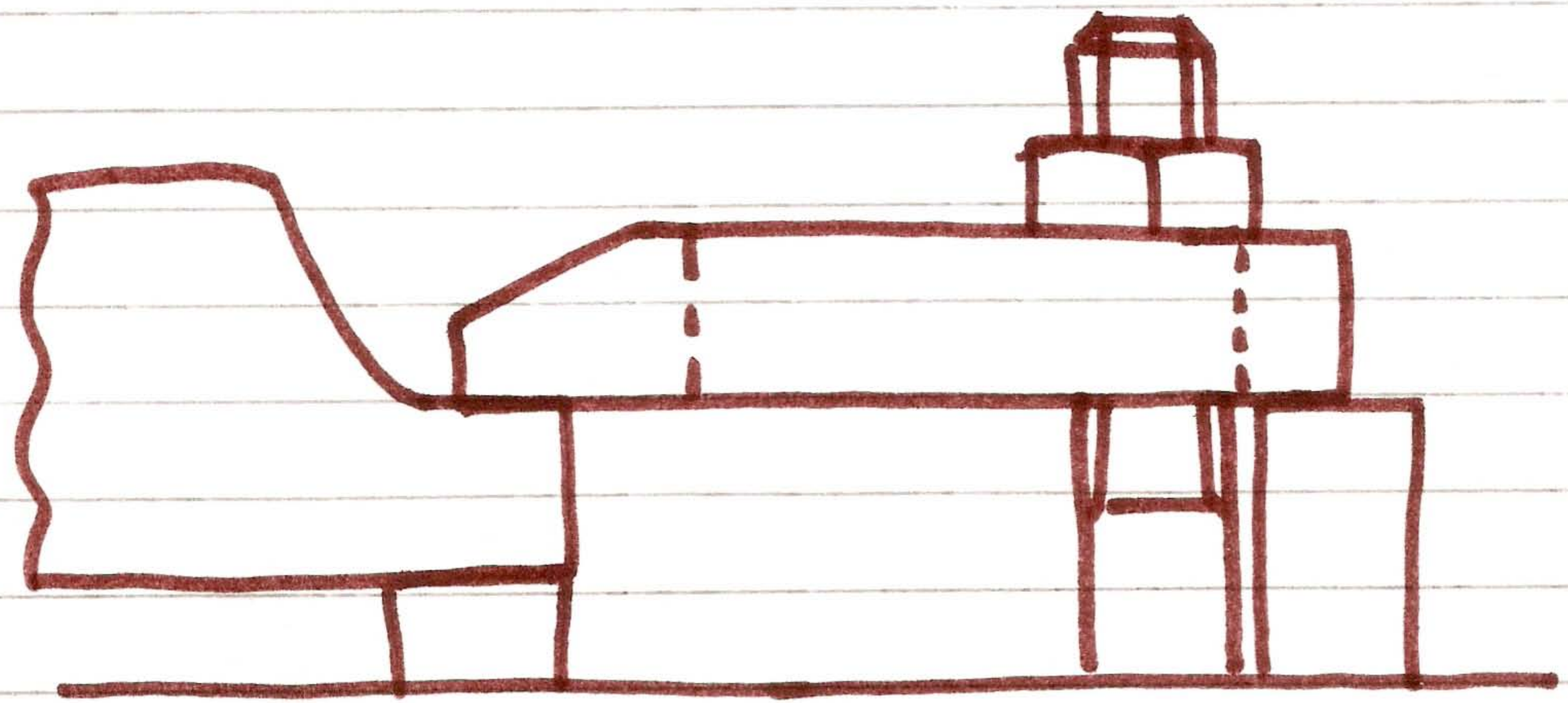
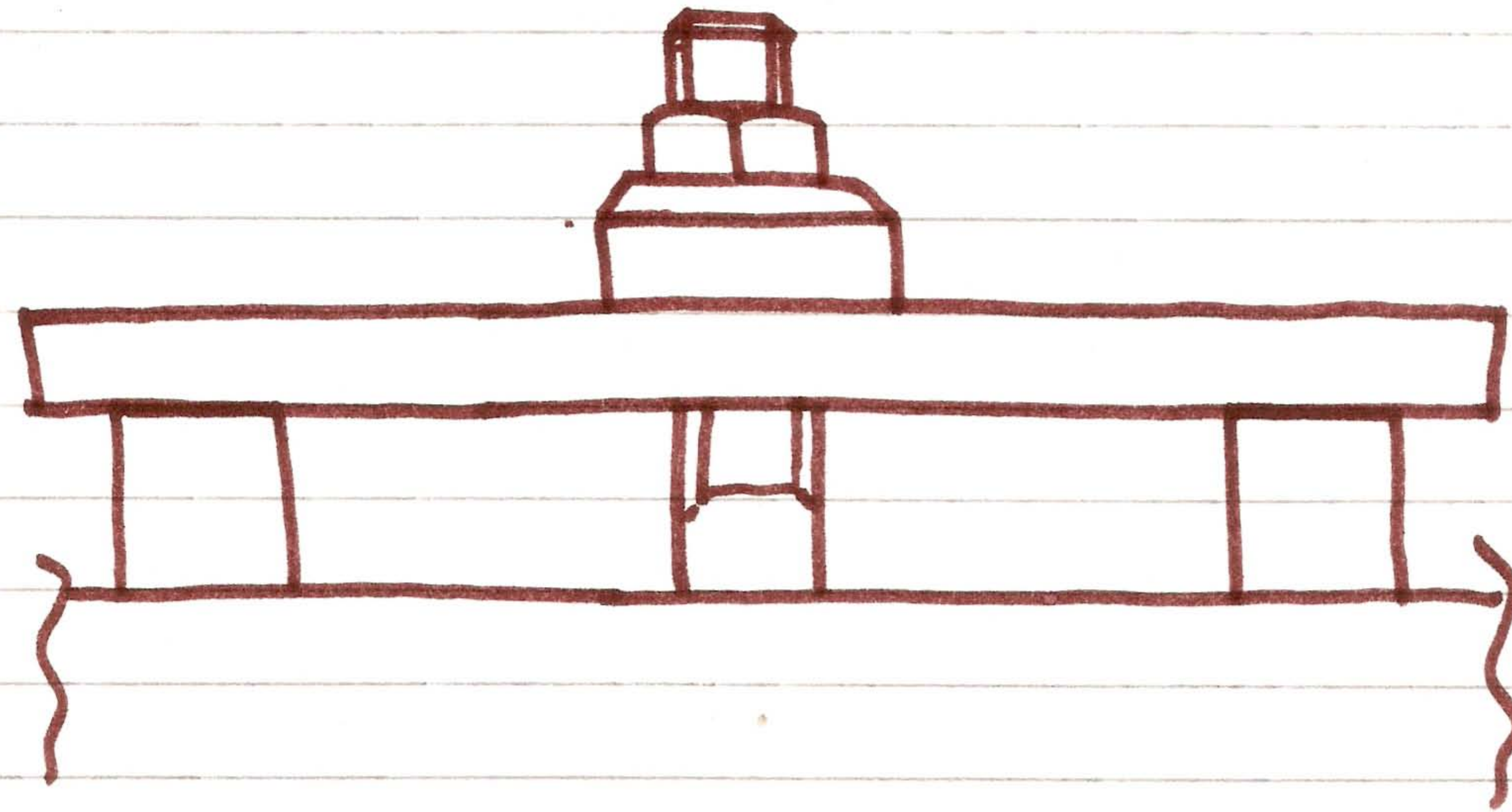
MILLING CUTTER

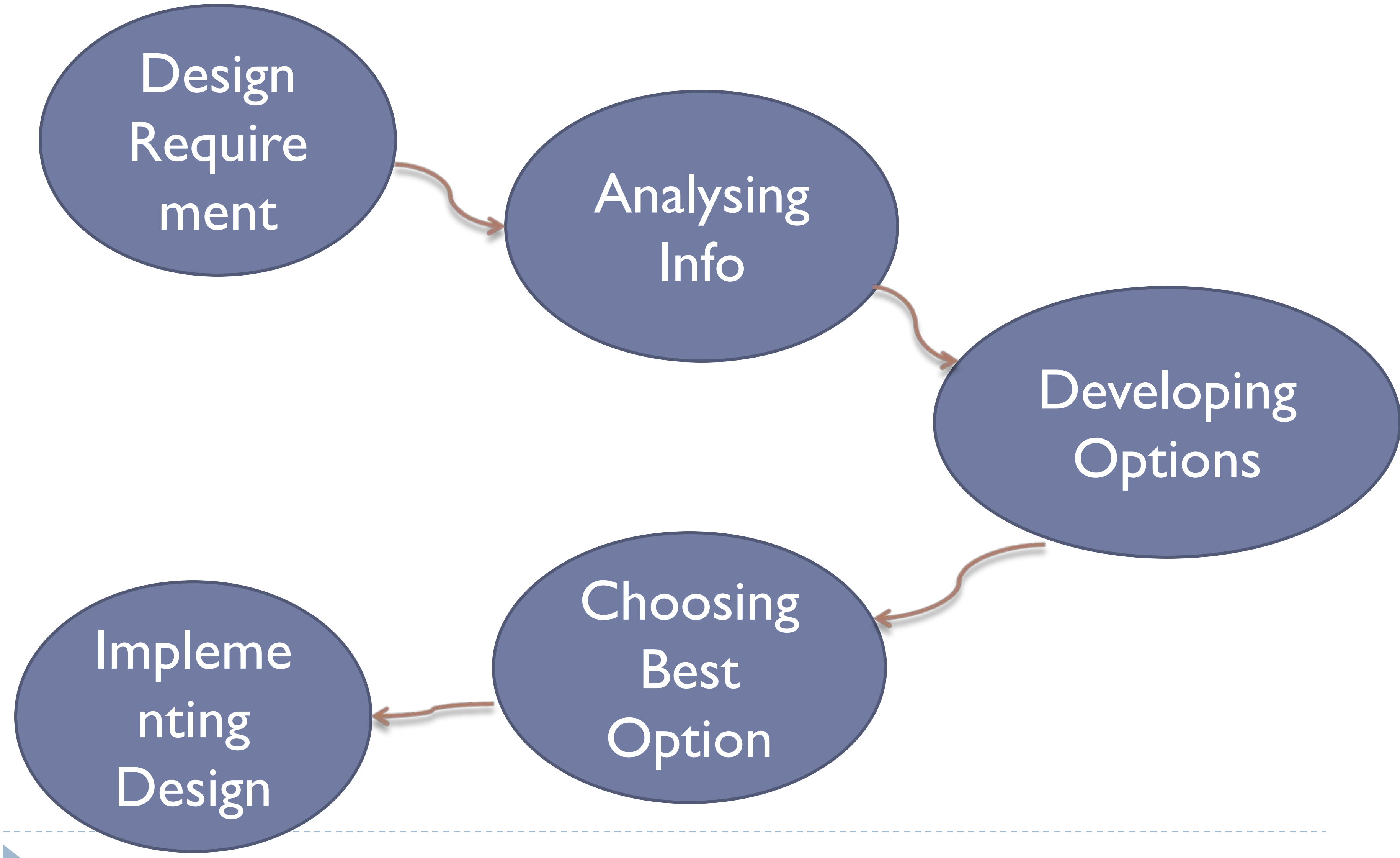
Clamping arrangement on a Radial Drill





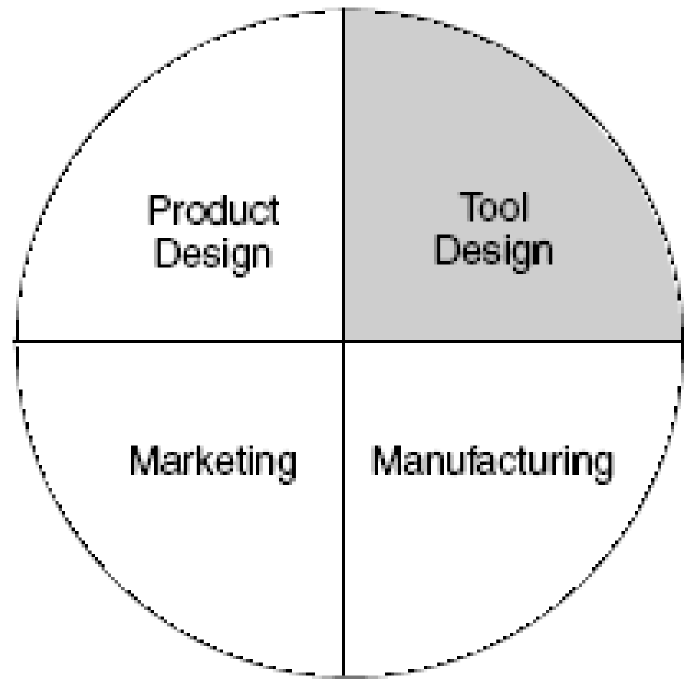


Fixture Design Process



DEFINING REQUIREMENTS

- The first step in the tool-design process should be to clearly state the problem to be solved, or needs to be met.



GATHERING AND ANALYZING INFORMATION

- Main sources of information are part print, process sheet, and machine specification.
- Four categories of design considerations need to be taken into account at this time: work piece, manufacturing operations, equipment, and personnel.

CONSIDERATIONS- WORKPIECE

- Size (Large, Small)
- Shape (Rectangular, Square, Cylindrical, other)
- Required Accuracy (Tolerances, Machining allowances)
- Material Type (Steel, St'nless steel, Aluminium, non ferrous etc)
- Material Condition (Cold rolled, Hot rolled, Cast, Forged etc)
- Locating Points (Machn'd or Unmachn'd surfaces, Holes, slots)

CONSIDERATIONS- WORKPIECE

- Locating Stability (Rigid, Fragile)
- Clamping Surfaces (Machined or Unmachined, supported or unsupported, Avoiding part damage)
- Production Quantity (Limited vs Mass Production, One Time vs Recurring production, Product lifetime, Projected future increases)
- Pending part-design revisions.

CONSIDERATIONS - OPERATIONS

- Types of Operations (Machining, Assembly, others)
- Number of Separate Operations (Similar vs Different, Sequential vs Simultaneous)
- Sequence (Primary operations, Secondary operations, Heat treating, ageing)
- Inspection Requirements

CONSIDERATIONS - EQUIPMENT

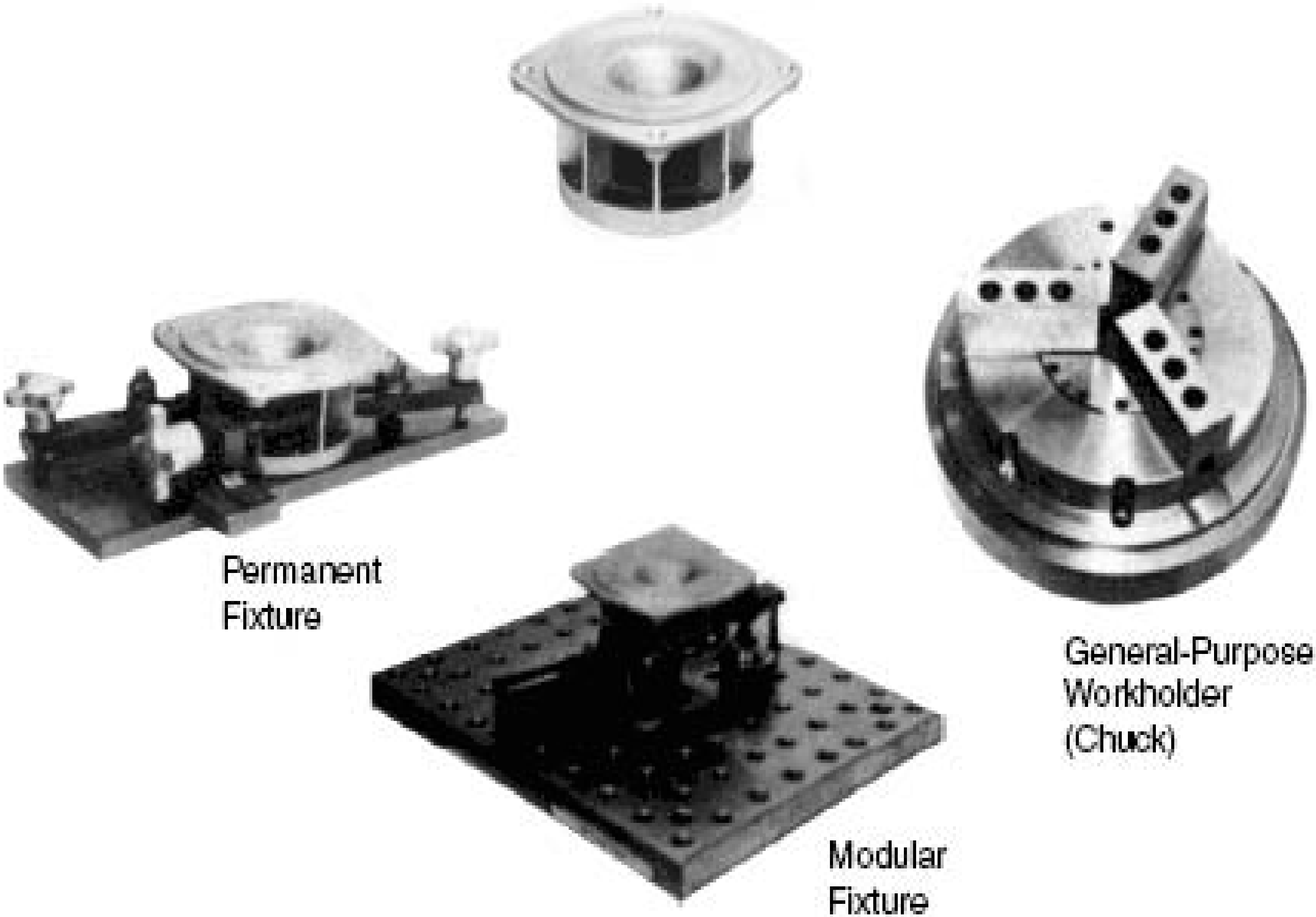
- Machine Tools (Horsepower, Size limitations, Weight limitations Others)
- Cutting Tools
- Special Machinery
- Assembly Equipment and Tools
- Inspection Equipment and Tools
- Equipment Availability and Scheduling
- Plant Space Required

CONSIDERATIONS - PERSONNEL

- Safety Equipment (Machine, operator, plant)
- Safety Regulations and Work Rules
- Economy of Motion (Unloading, Loading, Clamping)
- Operator Fatigue
- Power Equipment Available
- Possible Automation

DEVELOPING SEVERAL OPTIONS

- The third phase of the tool-design process requires the most creativity.
- Usually starts with at least three options: permanent, modular, and general-purpose workholding



Permanent Fixture
Modular Fixture
General-Purpose Workholder (Chuck)

CHOOSING THE BEST OPTION

- The fourth phase of the tool-design process is a cost/benefit analysis of different tooling options.
- Some benefits, such as greater operator comfort & safety, difficult to express in Rupees but still important. Other factors, such as tooling durability, difficult to estimate. Life Time Cost analysis sometimes more art than science.

Guidelines for Economical Design

- Use Standard Tooling Components
- Use Pre finished Materials
- Eliminate Unneeded Finishing Operations
- Keep Tolerances As Liberal As Possible
- Simplify Tooling Operation

IMPLEMENTING THE DESIGN

- The final phase of the tool-design process consists of turning the chosen design approach into reality. Final details are decided, final drawings are made, and the tooling is built and tested.

Building and Testing the Work holder

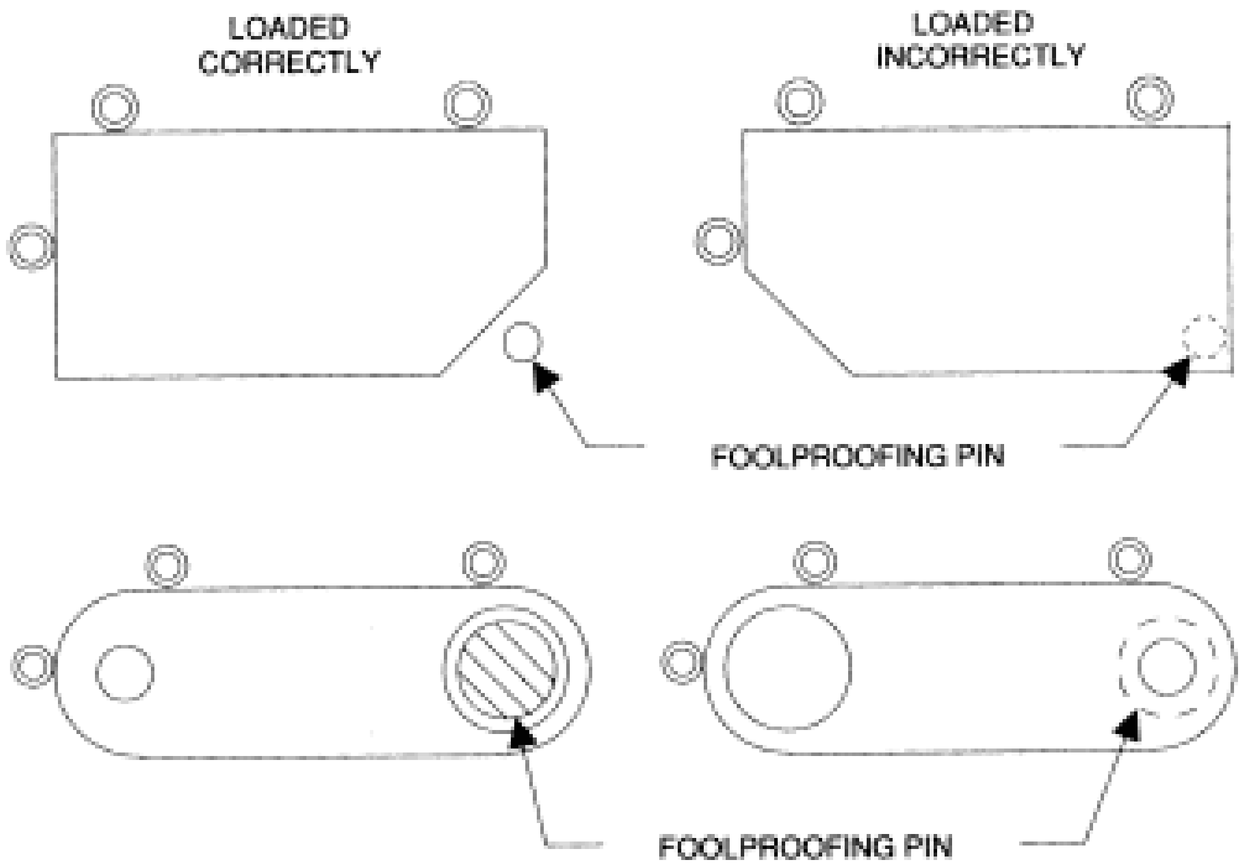
- Designer should ensure the tool room knows exactly what must be done when making the tool.
- After the tool is completed and inspected, the last step is tool tryout.
- When the tool proves itself in this phase, it is ready for production.

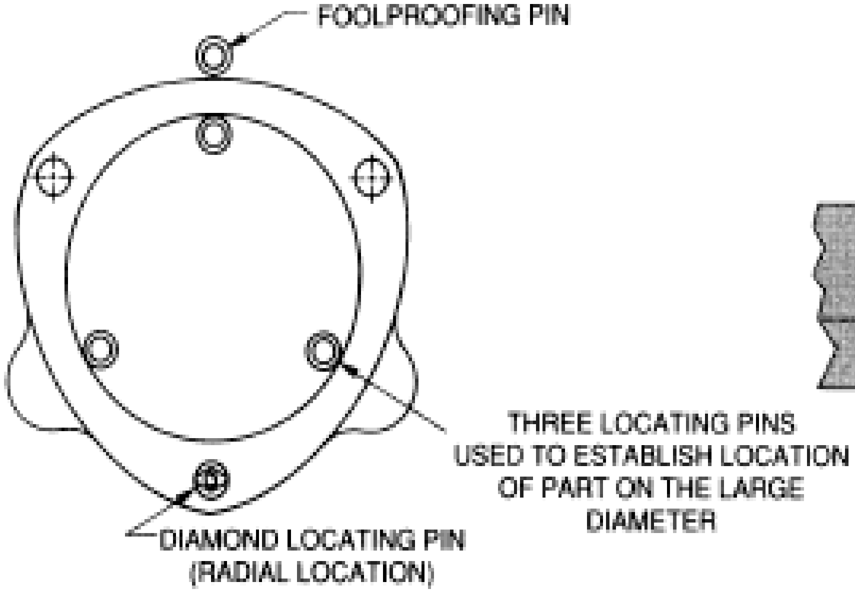
Three Stages of Poka Yoke

- Signal or warning
- Physical barrier
- Total prevention

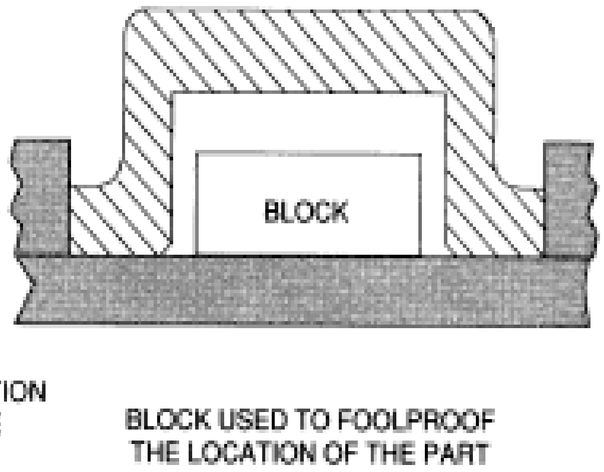
Poke Yoke or Mistake Proofing

- Fool proofing prevents improper loading of a work piece.





(a)



(b)

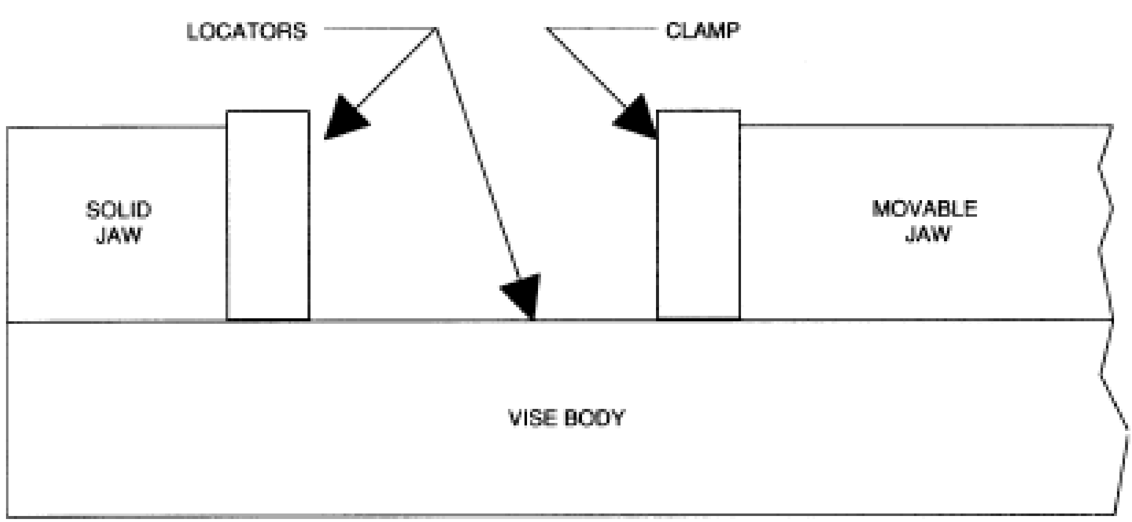
Simple pins or blocks are often used to foolproof the location

CLAMPING GUIDELINES

- Locating the work piece is the first basic function of a jig or fixture.
- Once located, the work piece must also be held to prevent movement during the operational cycle against the cutting forces. This is fundamentally done by the locators and not the clamps.
- Clamps are primararily used for holding the work piece against the locators.
- To perform properly, both the clamping devices and their location on the work holder must be carefully selected.

Factors in Selecting Clamps

- Clamps serve two primary functions. First, they must hold the work piece against its locators. Second, the clamps must prevent movement of the work piece. The locators, not the clamps, should resist the primary cutting forces generated by the operation.

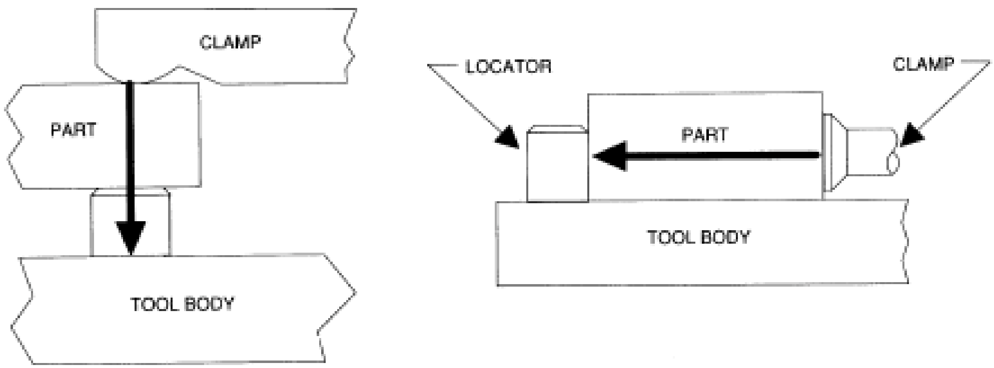


Factors in Selecting Clamps

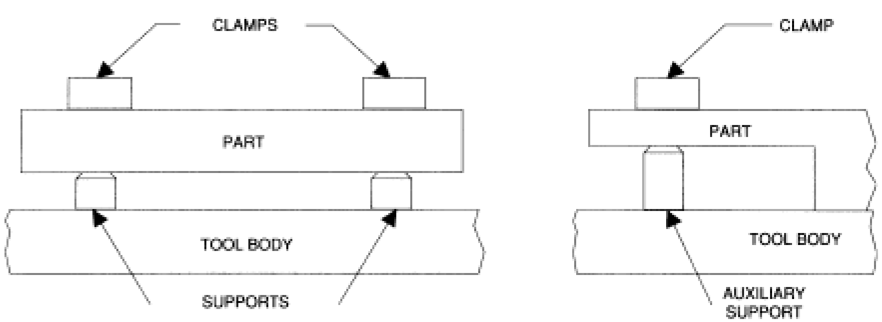
- Holding Securely Under Vibration, Loading, and Stress
- Preventing Damage to the Work piece
- Improving Load/Unload Speed

Positioning the Clamps

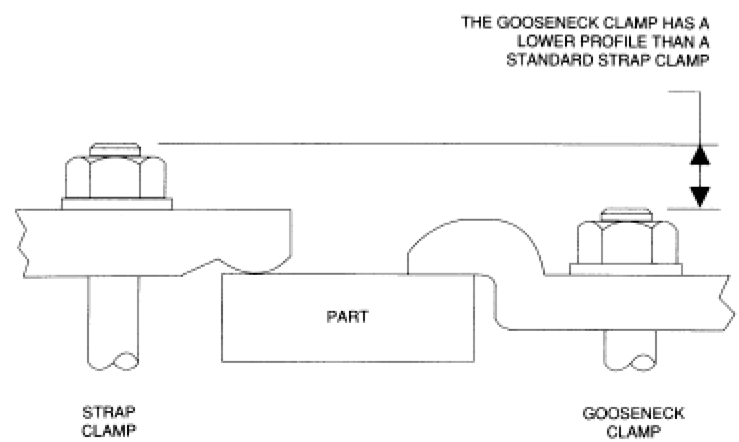
- The position of clamps on the work holder is just as important to the overall operation of the tool as the position of the locators. The selected clamps must hold the part against the locators without deforming the work piece

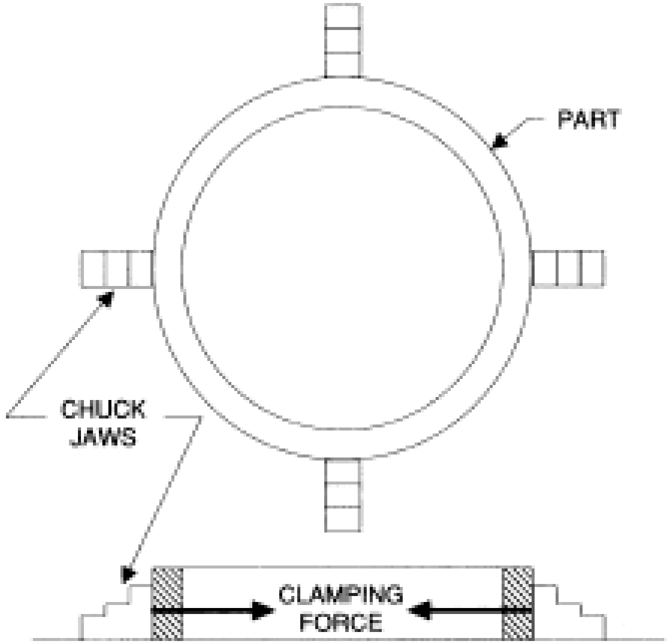

CLAMP
PART
TOOL BODY
LOCATOR
CLAMP
PART
TOOL BODY

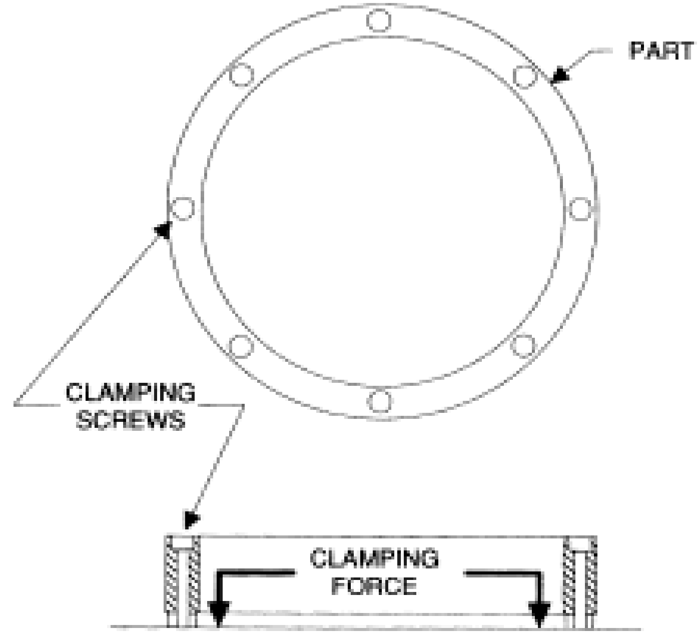
(a) (b)

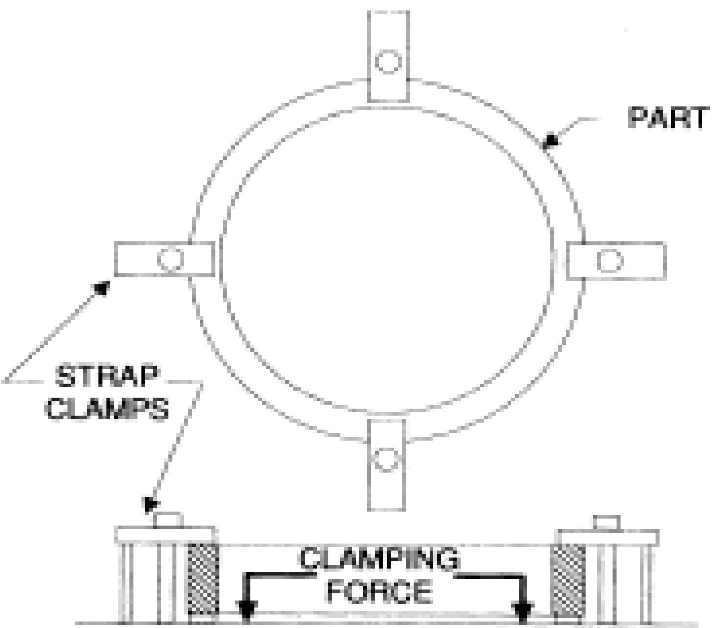

CLAMPS
PART
TOOL BODY
SUPPORTS
CLAMP
PART
TOOL BODY
AUXILIARY SUPPORT

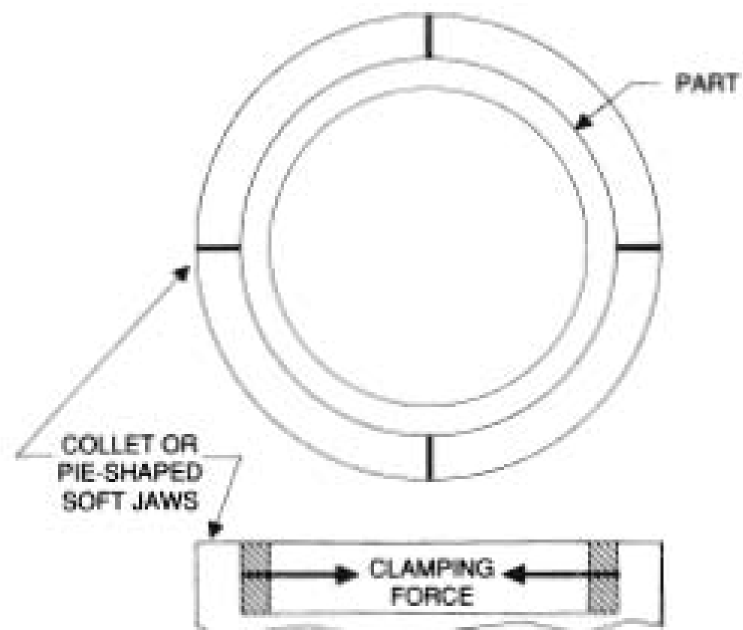
(a) (b)


THE GOOSENECK CLAMP HAS A LOWER PROFILE THAN A STANDARD STRAP CLAMP
PART
STRAP CLAMP
GOOSENECK CLAMP


PART
CHUCK JAWS
CLAMPING FORCE


PART
CLAMPING SCREWS
CLAMPING FORCE


PART
STRAP CLAMPS
CLAMPING FORCE


PART
COLLET OR PIE-SHAPED SOFT JAWS
CLAMPING FORCE

Fixture Design Checkpoints

- Is process clear? Are machining operations clear and the setups required?
- Is production rate and time available for loading/ unloading clear?
- What is the lead time available?
- What machine are we going to use?
- What are the critical dimensions on the drawing?
- What are the geometrical tolerances to be maintained?

Fixture Design Checkpoints

- What are the reference surfaces in the part drawing?
- What is critical variable in this component – material, shape, cycle time, etc?
- What are the locating surfaces on the component?
- What are the clamping surfaces?
- Is clamping force directed towards the rest pads?
- What about ease of operation of the fixture?

Fixture Design Checkpoints

- Will chips accumulate on rest surfaces?
- Is fixture easy to clean before loading of next part?
- What is the direction of cutting force?
- Is machining force directed towards rest pads or the clamp?
- Is the rule of 3 – 2- 1 followed? Are all degrees of freedom arrested?

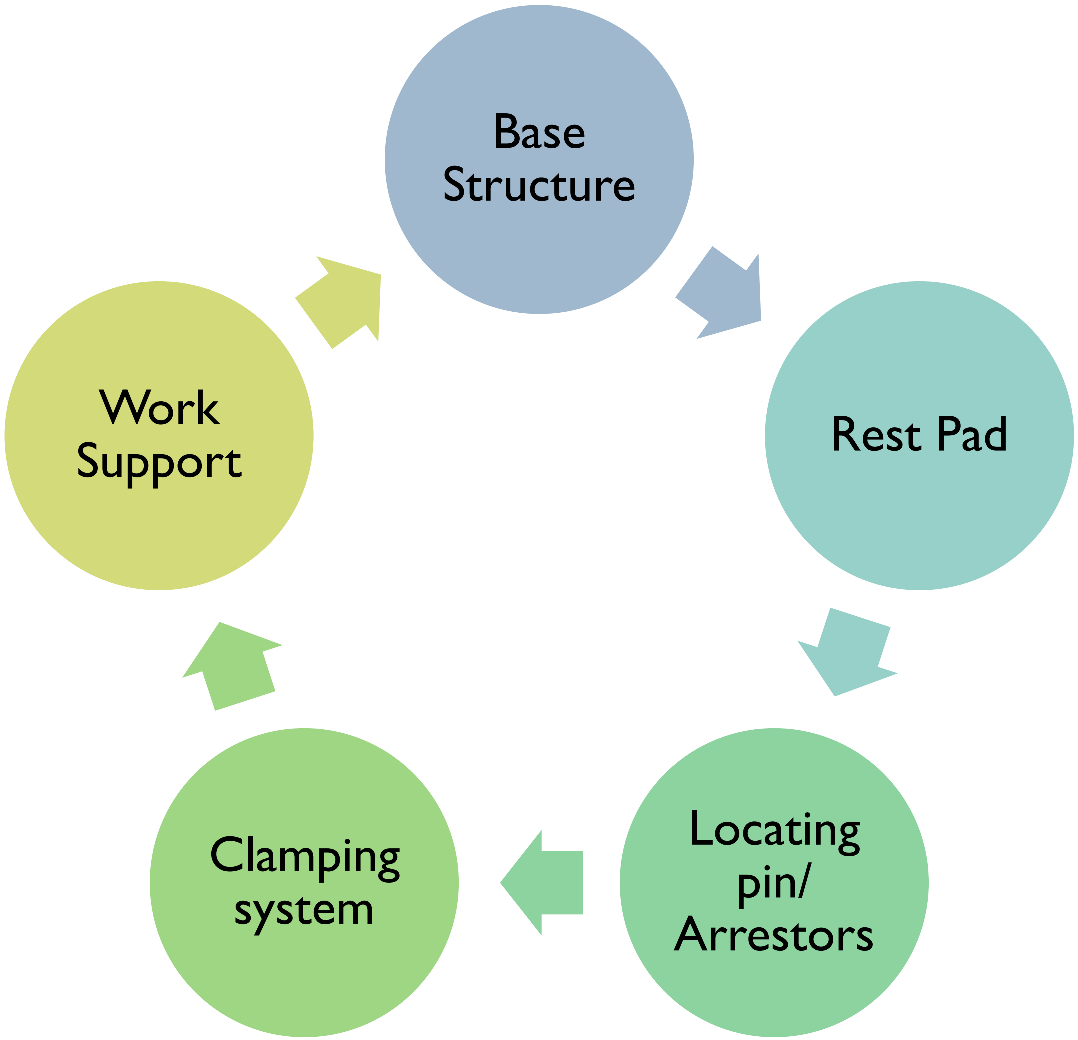
Fixture Design Checkpoints

- Is there likelihood of component being distorted due to clamping pressure?
- What is the effect of raw part variation on clamping, resting or location?
- Will the clamps withstand the machining force?
- Are we over clamping?
- In case of forging or casting how do we do averaging/ targeting?

Fixture Design Checkpoints

- In case of heavy or large jobs, how do we ensure quick and safe lifting?
- How do we inspect the component and assure its quality? Does my fixture design have any role to play in this?
- Have I ensured fool proofing so that part is not wrongly loaded or prevent a wrong part being loaded?

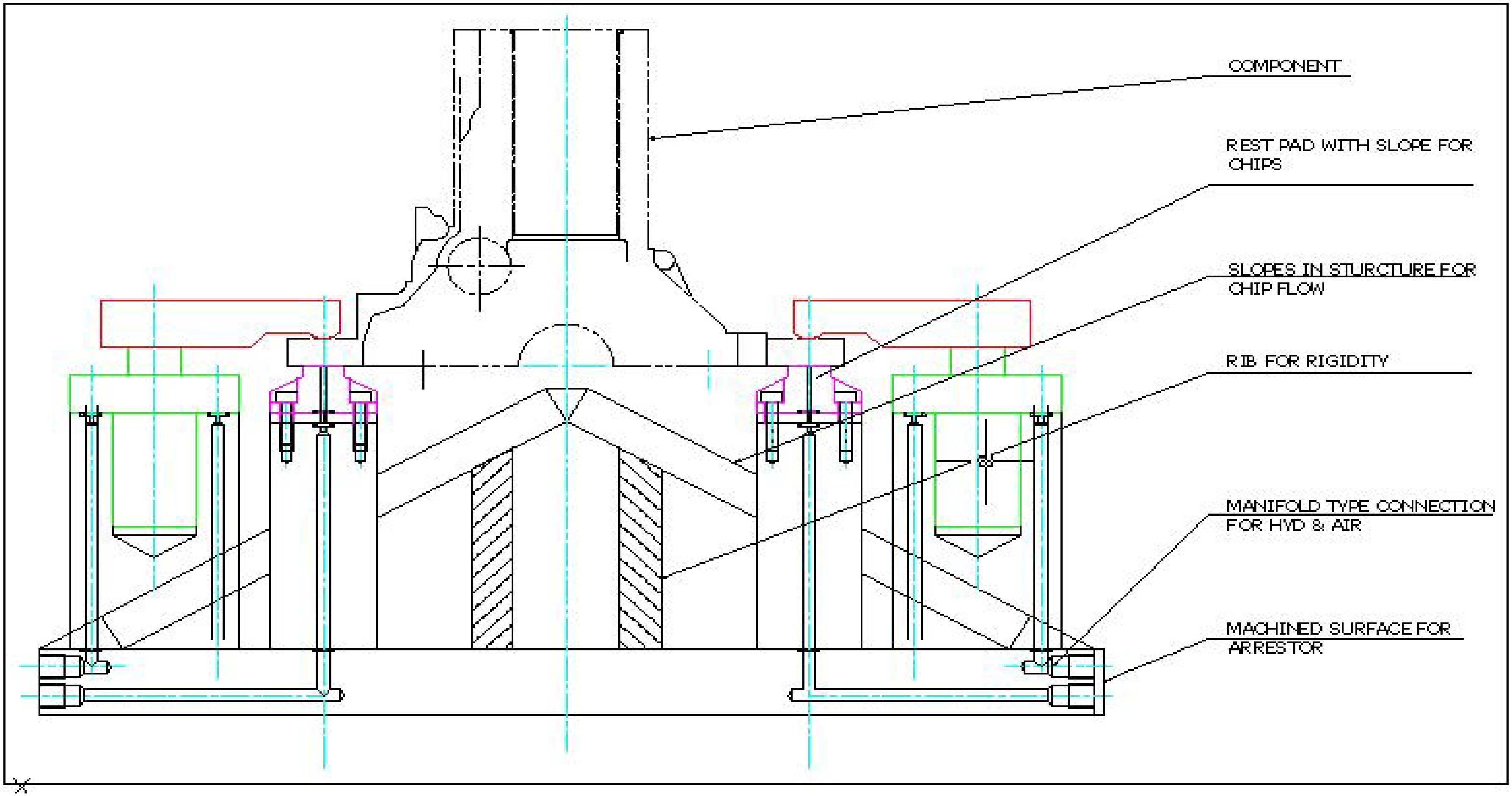
Basic Elements of the Fixture



Base Stucture

- Can be welded / cast , & should be suitably ribbed for high rigidity so as to avoid any distortion due to cutting forces during operation.
- Proper slopes to be provided on the base structure such that chips should not accumulate.
- Should be stress relieved to avoid any distortion over a period of time.
- Reference machining/ Geometrical accuracies to be maintained to check the alignment on the machine.
- Internal piping to be preferred to avoid chip accumulation.
- Reference hole to be generated on base structure for programming purpose.
- Side arrestors to be provided for positioning & quick change of fixture.

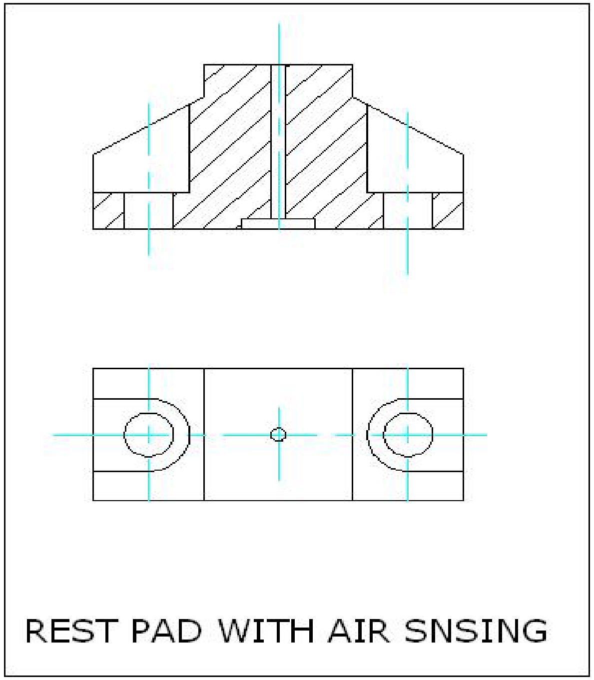
Base Stucture

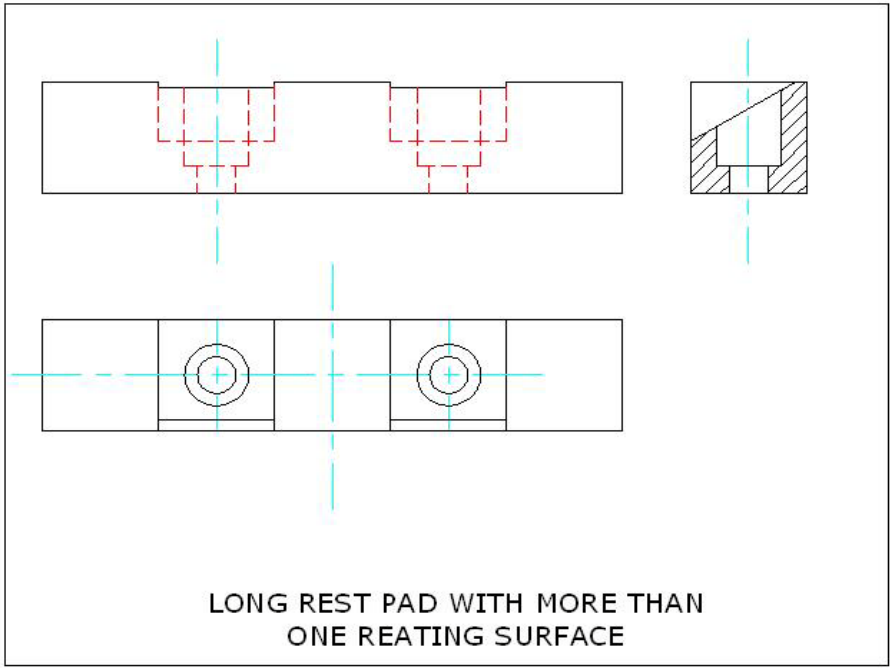


Rest Pad

- Minimum three rest pads to be provided to form a plane.
- Auxiliary rest pads to be provided (keeping 5 to 10 microns below the resting surface) to avoid the distortion of the component.
- For roughing operations, the rest pads should be relieved to avoid chip accumulation on resting surface.
- Slopes to be provided on rest pad to avoid the chip accumulation.
- For finishing operation, resting area should be maximum of 15 dia.
- Air sensing & cleaning hole to be provided for confirmation of component resting properly.
- Spacer below the rest pad to be provided to maintain geometrical & dimensional accuracies.
- Rest pad material should be hardened & ground.

Rest Pad


REST PAD WITH AIR SNSING

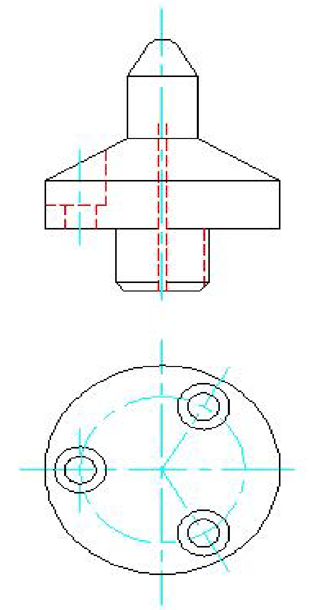

LONG REST PAD WITH MORE THAN
ONE REATING SURFACE

Locating Pin/ Arrestor & Rough Locators

- Locating pin should be hardened & ground.
- Locating pin to be fixed or retractable type depending upon size & weight of the component.
- Size & tolerance of round / diamond Locating pin to be determined on the basis of part hole dimension & center distance tolerance and accuracies to be achieved.
- Orientation of round and diamond pin to be maintained.
- Bullet head or good lead chamfer to be provided for easy loading of the Component.
- Locating pin with Flange type or cyl. Location to be designed and fixed directly or from the other side. Side clamping should be avoided.
- Pin Breakage detection by air sensing can be provided.
- For higher accuracies,hydraulic operated (collar type) locating pins to be provided.
- Slopes to be provided to avoid the chip accumulation.

Locating Pin/ Arrestor & Rough Locators

- Slopes to be provided to avoid the chip accumulation.
- Groove/ flat to be provided on the pin for air escapement.
- Rough locator to be provide for easy loading & unloading of the component.
- Fool-proofing to be provided to make sure that the component is loaded properly.
- Arrestor if required to be provided.

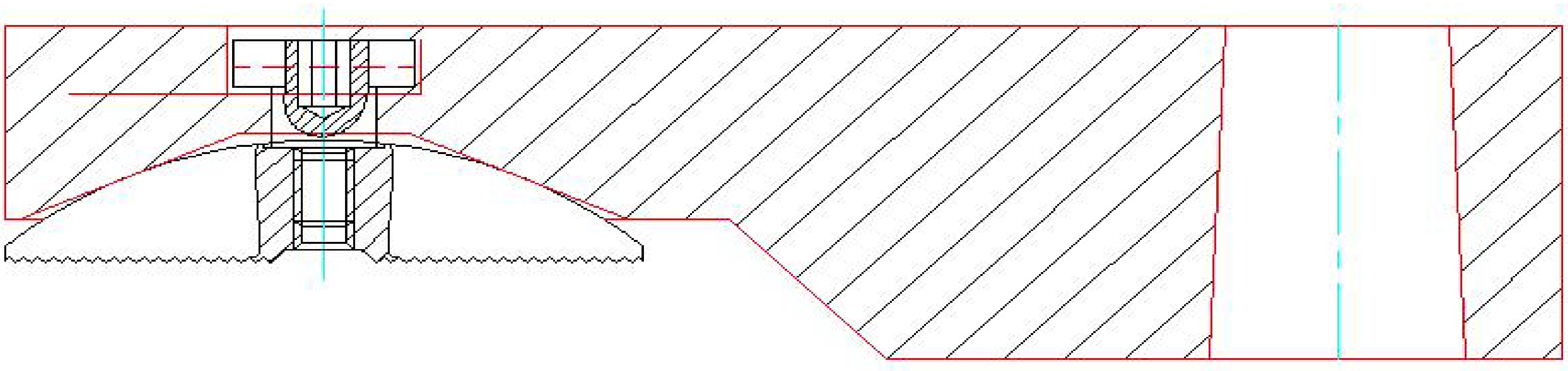


FLANGED TYPE CYL LOCATING
PIN WITH PIN BREAKAGE
SENSOR HOLE

Clamping Systems

- Clamping should be against rest pad.
- Clamp should be rigid enough to take care of cutting forces generated during operation.
- For clamping on rough cast/ forged surface, serrated, hardened pad should be used.
- For clamping on machined surface, soft pad should be used.
- Material of the Clamp should be toughened.
- Clamping point should be replaceable type.
- Clamping force should be adjustable so as to avoid distortion of the component.
- Hinge type clamps should be lubricated by self lubricated bushes or external lubrication.
- Swing type/ Toggle type/ Direct actuation cylinders to be used considering the clamping point /ease of loading.
- For hydraulic fixtures, clamping confirmation to be taken by pressure switch & limit switch.

Clamping Systems



SERRATED CLAMP WITH FLOAT

Work Supports

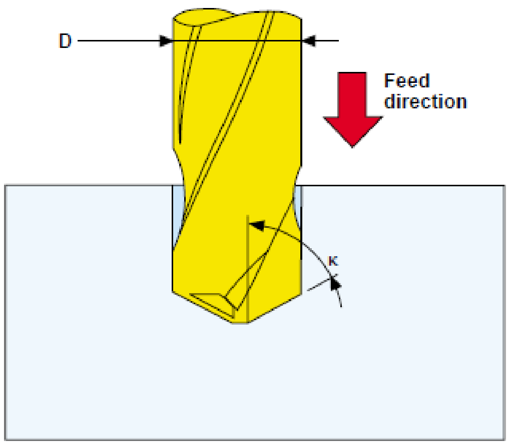
- Can be manual/ Hydraulic/ Pneumatic depending on the type of the fixture.
- For thin section component, pneumatic fixture with pneumatic work support is preferred.
- Clamping can be provided directly above the work support.

CALCULATION FOR CUTTING FORCES IN DRILLING

Calculating The Power Demand

$$P_c = \frac{Q}{396{,}000 \cdot \eta} \cdot k_c$$

P_c = Power HP
Q = Metal removal rate in^3/min
η = Efficiency
k_c = Cutting force per inch^2 (Lbf/inch^2)



CALCULATION FOR CUTTING FORCES IN DRILLING (Contd.)

Calculating Metal Removal Rate, Q

Multiply the feed speed v_f with the cross-section area of the cut A_T in the feed direction.

Example: For a drill

$$A_T = \frac{\pi \cdot D^2}{4} \qquad Q = v_f \cdot A_T$$

Calculating Cutting Force Per inch², k_c

$$k_c = \frac{1 - .01 \cdot \gamma_o}{\left(\frac{h_D}{.04}\right)^{m_c}} \cdot k_{c1.1}$$

k_c = Cutting force/inch² N/mm² (Lbf/inch²)
γ_o = Effective rake angle (for cutter + insert)
h_D = Nominal chip thickness inch
m_c = Exponent (see page 297)
$k_{c1.1}$ = Cutting force for .040 inch chip thickness Lbf/inch²

$$h_D = f_z \cdot \sin \kappa$$

h_D = Nominal chip thickness inch
f_z = Feed per tooth inch/tooth
κ = Cutting edge angle for drilling/plunging

Effective rake angle, m_c-factor and $k_{c1.1}$-value

Effective rake angle value can be found on the insert pages.
Add the value of the actual cutter.

The m_c-exponent and the $k_{c1.1}$-value for each material group can be found on page 297.

CALCULATION FOR CUTTING FORCES IN DRILLING (Contd.)

Example

Calculate power demand for a drill mill used in a drilling operation: 216.19, Ø 1.57 inch
Insert: XCMC120408T-MD11, T25M.

Material group = 3
Feed per tooth f_z = .0055 inch/tooth
Cutting speed v_c = 509 ft/min

Calculate RPM and feed speed

See formula on page 289

$$n = \frac{509 \cdot 12}{\pi \cdot 1.57} = 1233 \text{ RPM}$$

K-value for drilling = 1 (see page 228)

$v_f = 1 \cdot .0055 \cdot 1233 = 6.8$ inch/min

Calculate metal removal rate, Q

$$Q = \frac{6.8 \cdot \pi \cdot (1.57)^2}{4} = 13.16 \text{ in}^3\text{/min}$$

Calculate cutting force per inch² k_c

See page 297 material group 3

$k_{c1.1}$-value = 218,000 Lbf/inch²
m_c-exponent = 0.25
Cutting edge angle $\kappa \cong 90°$

Rake angle for cutter = –5° page 228
Rake angle for insert = 0° page 259
Effective rake angle γ_o = –5°

Average chip thickness $h_D = .0055 \cdot \sin 90° = .0055$ inch

$$\text{Cutting force per inch}^2\ k_c = \frac{1-0.01 \cdot (-5)}{\left(\frac{.0055}{.04}\right)^{.25}} \cdot 218{,}000 = 375{,}898 \text{ Lbs/inch}^2$$

Calculate Power, P_c

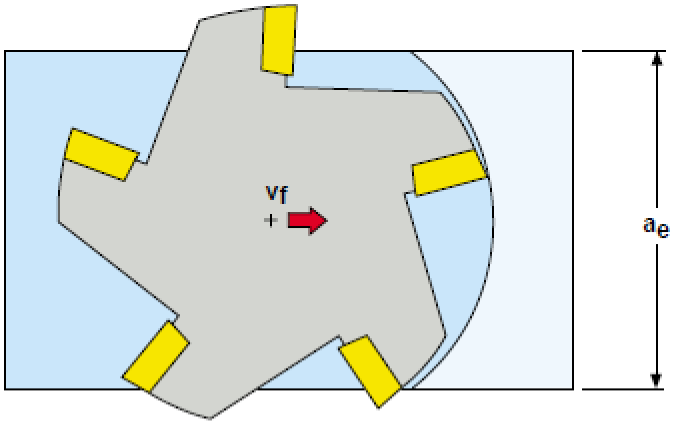
Efficiency η = 80%

$$\text{Power } P_c = \frac{13.16}{396{,}000 \cdot 0.80} \cdot 375{,}898 = 15.61 \text{ HP}$$

CALCULATION FOR CUTTING FORCES IN MILLING

Calculating The Power Demand

$$P_c = \frac{Q}{396{,}000 \cdot \eta} \cdot k_c$$



P_c = Power HP
a_p = Depth of cut inch
a_e = Width of cut inch

v_f = Feed speed in/min
η = Efficiency
k_c = Cutting force per inch^2 (Lbf/inch^2)

CALCULATION FOR CUTTING FORCES IN MILLING (Contd.)

Calculating Average Chip Thickness, h_m, and Cutting Force Per inch^2, k_c

Use the formula below or use the table on page 282–283.

For a_e/D > 30%

$$h_m = \frac{360 \cdot f_z \cdot a_e}{\pi \cdot D \cdot \omega_e} \cdot \sin \kappa$$

For a_e/D < 30%

$$h_m = f_z \cdot \sqrt{\frac{a_e}{D}} \cdot \sin \kappa$$

$$k_c = \frac{1 - .01 \cdot \gamma_o}{\left(\frac{h_m}{.04}\right)^{m_c}} \cdot k_{c1.1}$$

h_m = Average chip thickness inch
f_z = Feed per tooth inch/tooth
a_e = Width of cut inch
D = Cutter diameter inch
ω_e = Engagement angle (see table below)
κ = Cutting edge angle°

k_c = Cutting force/in² Lbf/inch²
γ_o = Effective rake angle (Rake angle of cutter (γ_o) + rake angle of insert)
h_m = Average chip thickness inch
m_c = Exponent (see page 297)
$k_{c1.1}$ = Cutting force for .04 inch chip thickness Lbf/inch²

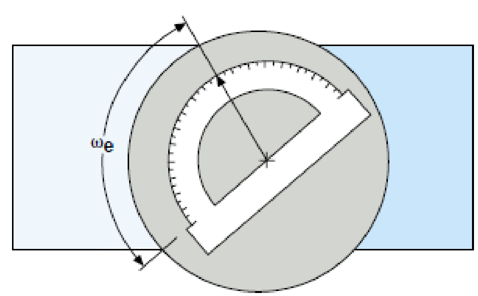
Engagement Angle

Engagement a_e/D	Engagement Angle ω_e
Cutter Position: Center	
75%	97°
100%	180°
Cutter position: off center	
5%	26°
10%	37°
25%	60°

Effective Rake Angle, m_c-Factor and $k_{c1.1}$-Value

Effective rake angle value can be found on the insert pages. Add the value of the actual cutter.

The m_c-exponent and the $k_{c1.1}$-value for each material group can be found on page 297.



Engagement angle can be read from a simple drawing using a graduated arc.

CALCULATION FOR CUTTING FORCES IN MILLING (Contd.)

Example

Calculate power demand for a face milling cutter:

220.13, Ø 6.30, $z = 7$
Insert: SEKR42AFTN-ME13 T25M.

Material group = 3
Depth of cut a_p = .197 inch
Width of cut a_e = 4.72 inch
Cutter position = center
Feed per tooth f_z = .0083 inch/tooth
Cutting speed v_c = 705 ft/min

Calculate RPM and Feed Speed

See formula on page 277

$$n = \frac{705 \cdot 12}{\pi \cdot 6.30} = 428 \text{ RPM}$$

$$v_f = 7 \cdot .0083 \cdot 428 = 24.8 \text{ in/min}$$

Calculate Average Chip Thickness, h_m

$a_e/D = 4.72/6.30 = 75\%$ Engagement angle $\omega_e = 97°$ (see table above)

Average chip thickness $$h_m = \frac{360 \cdot .0083 \cdot 4.72}{\pi \cdot 6.30 \cdot 97} \cdot \sin 45° = .0052 \text{ inch}$$

Calculate Cutting Force Per mm² k_c

See page 309 Material Group 3		Rake angle for cutter	= 12° (page 42)
$k_{c1.1}$-value	= 218,000 Lbf/in²	Rake angle for insert	= 24° (page 253)
m_c-exponent	= 0.25	Effective rake angle γ_o	= 36°

Cutting force per inch² $$k_c = \frac{1-0.01 \cdot 36}{\left(\frac{.0052}{.04}\right)^{.25}} \cdot 218{,}000 = 232{,}354 \text{ Lbs/inch}^2$$

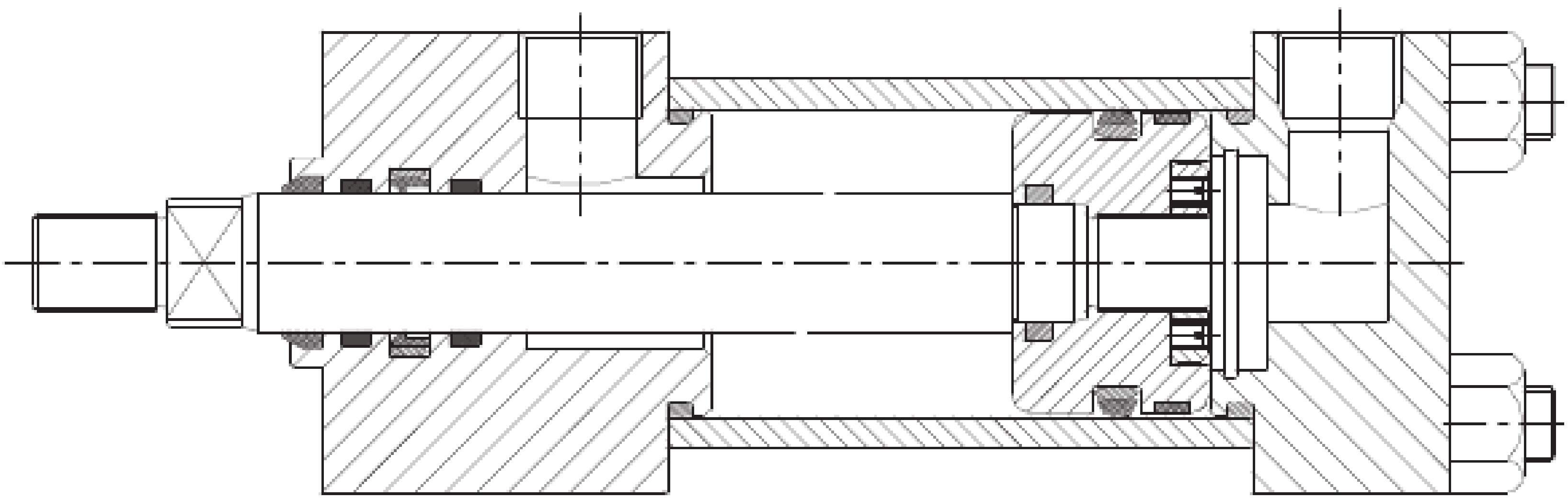
Calculate Power, P_c

Efficiency $\eta = 80\%$

$$\text{Power } P_c = \frac{23.06}{396{,}000 \cdot 0.80} \cdot 232{,}354 = 16.9 \text{ HP}$$

Hydraulic Cylinder (Cross Section)

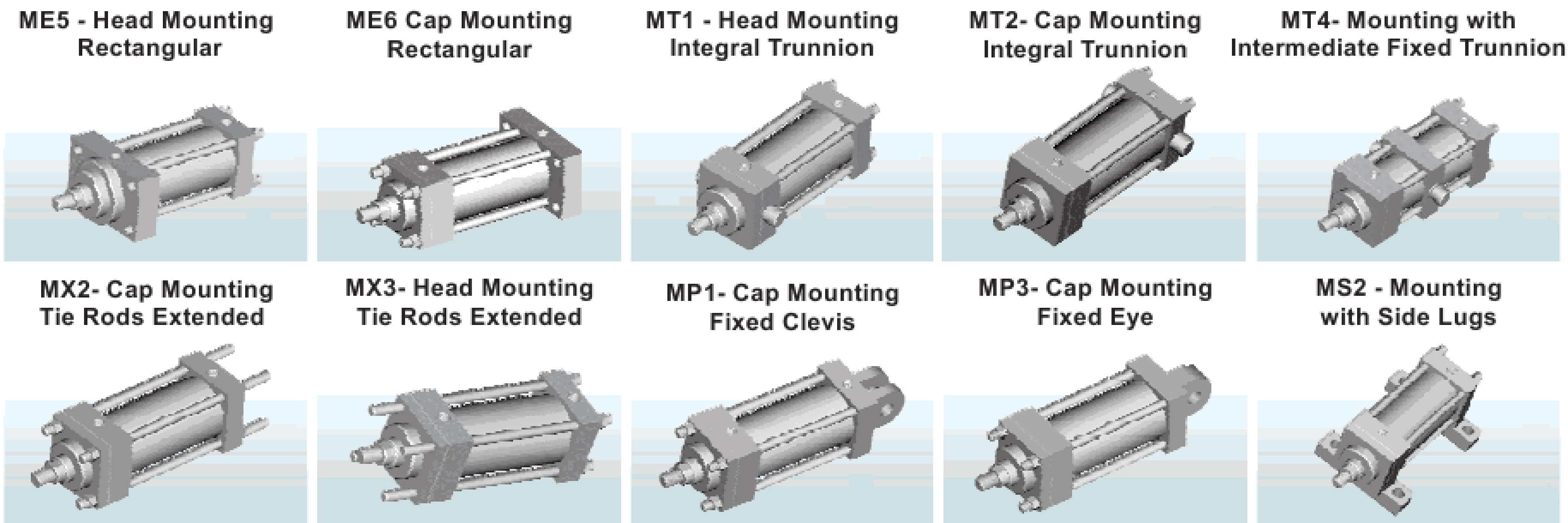
CROSS SECTION



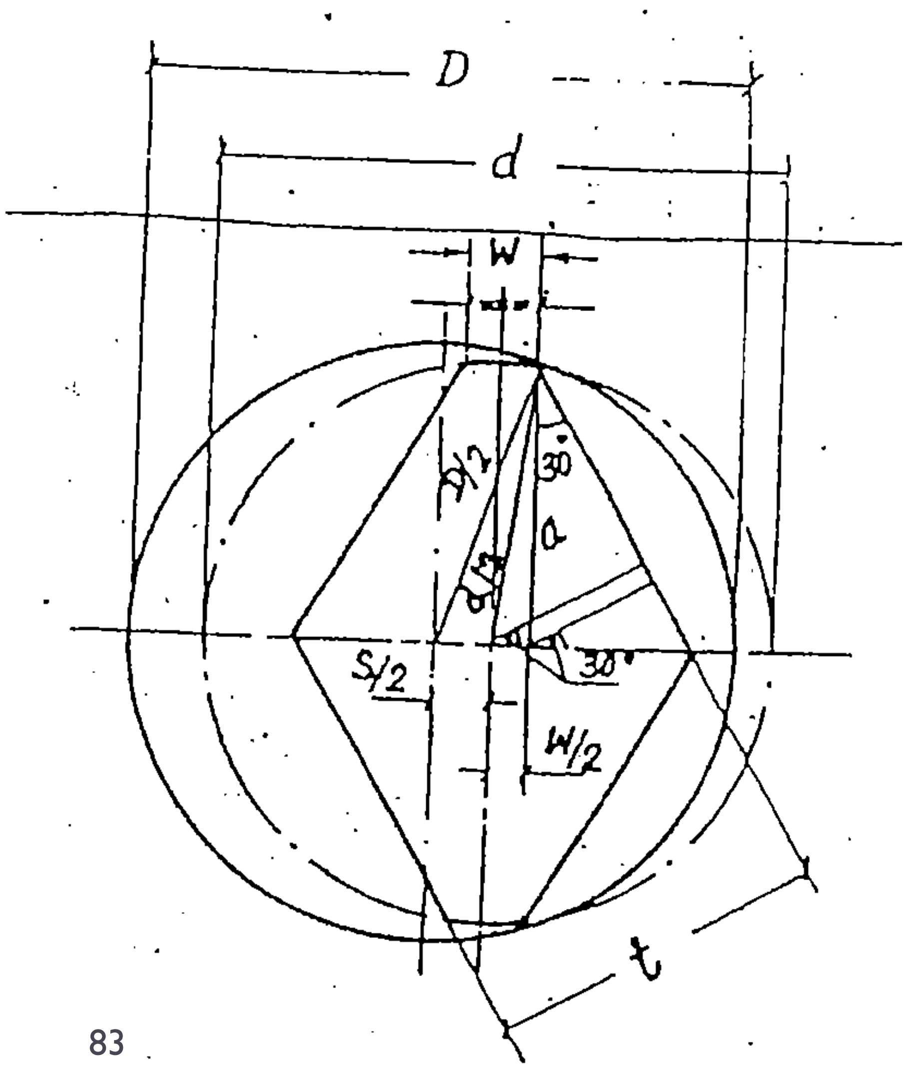
Calculation of Forces due to Cylinders

- Force = Pressure (P) X Area
  - Force in Kgs
  - Pressure in Kg/cm^2
  - Area in cm^2
- Cylinder Bore Dia (D1) mm
- Piston Rod Dia (D2) mm
- Area on Piston Side A1(cm^2)= $\Pi \times D1^2 / 4 \times 100$
- Area on Rod Side A2(cm^2)= $\Pi \times (D1-D2)^2 / 4 \times 100$
- Force on Piston Side = A1*P1
- Force on Rod Side = A2*P2
  - P1 & P2 are pressure acting on Piston & Rod Side

Hydraulic Cylinders (types)



CALCULATIONS FOR DESIGN OF DIAMOND PIN



- D : minimum diameter of the hole
- d : maximum diameter of the pin
- S : sum of tolerances on Center Distance
- t : thickness of diamond
- W : width of land on diamond

CALCULATIONS FOR DESIGN OF DIAMOND PIN (Contd.)

To calculate 'd'

$$a^2 = (D/2)^2 - (W/2 + S/2)^2 \text{, also,} \quad -(1)$$

$$a^2 = (d/2)^2 - (W/2)^2 \quad -(2)$$

$$\text{or} \quad (d/2)^2 = a^2 + (W/2)^2 \quad -(3)$$

substituting (1) in (3)

$$(d/2)^2 = (D/2)^2 - (W/2 + S/2)^2 + (W/2)^2$$

$$\text{or} \quad d^2 = D^2 - [(W+S)^2 - W^2]$$

$$= D^2 - [W^2 + 2WS + S^2 - W^2]$$

$$d^2 = D^2 - 2S(W + S/2)$$

$$d = \sqrt{D^2 - 2S(W + S/2)}$$

To calculate 't'

$$t/2 = W/2 \cos 30° + a \sin 30°$$

$$= W/2 \cdot \frac{\sqrt{3}}{2} + a \cdot 1/2$$

$$\text{or} \quad t/2 = 0.866\, W/2 + 1/2 \frac{\sqrt{d^2 - W^2}}{2}$$

$$t = 0.866\, W + \frac{\sqrt{d^2 - W^2}}{2}$$

CALCULATIONS FOR DESIGN OF DIAMOND PIN (Contd.)

Example :

Data :

Hole $\phi\, 30\, H7\, (30^{+0.021}_{+0.000})$, Hence $D = 30$

* Sum of tolerances on c.d.

S= 0,1

* Width of land of diamond pin = 4 mm

Note :

* Usually assumed value of $W = 1/8\, d_{nom}$ but always $W > 0,8\ mm = 1/32$

CALCULATIONS FOR DESIGN OF DIAMOND PIN (Contd.)

Working:

$D = 30 ; W = 4 ; S = 0.1$

$$d = \sqrt{D^2 - 2S(W + S/2)}$$

$$= \sqrt{(30.00)^2 - 2.0.1(4 + 0.1/2)}$$

$$= \sqrt{900 - 0.81} = \sqrt{899.19} = \underline{29.986}$$

tolerance on 'd' can be 'h5'

So, $\boxed{d = 29.986_{h5}}$

$$t = 0.866W + \frac{\sqrt{d^2 - W^2}}{2} = 0.866.4 + \frac{\sqrt{(29.986)^2 - 4^2}}{2}$$

$$= 3.464 + \frac{\sqrt{(883.19)}}{2} = 3.464 + 14.856 =$$

$$= 18.32$$

Elements for Pneumatic Fixtures

Energy Conversion

- COMPRESSOR
- SINGLE ACTNG CYLINDER
- DOUBLE ACTING CYLINDER
- PRESSURE INTENSIFIER
- AIR LINK CLAMP
- AIR SWING CLAMP

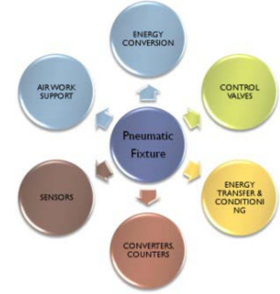
Control Valves

- DIRECTION CONTROL VALVE
- CHECK VALVE
- FLOW CONTROL VALVE
- SEQUENCE VALVE
- REGULATOR

Energy Transfer & Conditioning

- SWIVEL CONNECTION ROTARY DISTRIBUTOR
- SILENCER
- VESSEL (AIR RESERVIOR)
- PRESSURE GAUGE
- FILTER
- REGULATOR
- LUBRICATOR

Types of Controls



- MANUAL CONTROL – BY PUSH BUTTON OR LEVER OR BY PEDAL
- MECHANICAL ACTUATION – ROLLER
- PNEUMATIC ACTUATION – BY APPICATION OF PRESSURE
- ELECTRICAL ACTUATION – BY SOLENOID

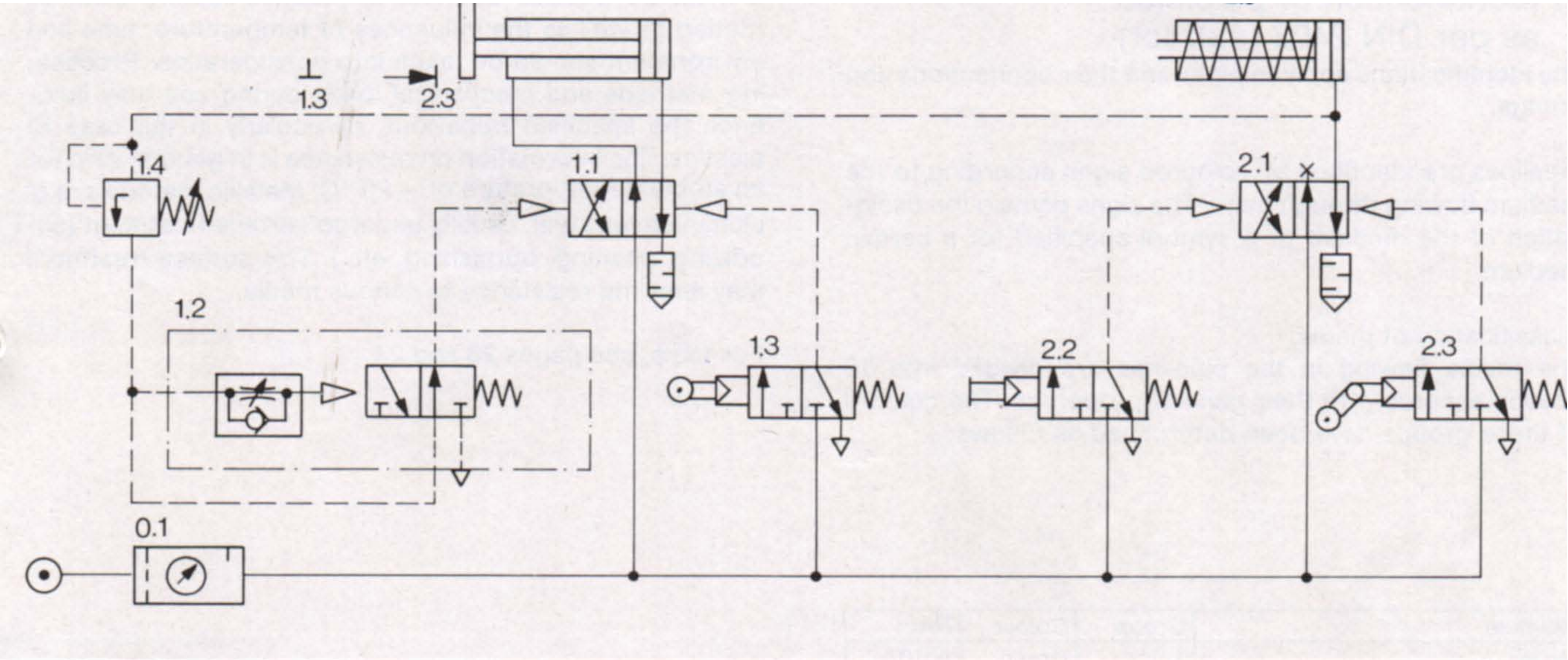
Sensors

- REED TYPE PROXIMITY SWITCH
- ELECTRICAL LIMIT SWITCH
- PNEUMATIC PRESSURE SWITCH
- PROXY SWITCH

Air Work Support

- TO PREVENT CHATTERING DURING MACHINING OF THIN WORK PIECES
- COMPACTNESS RESULTS IN SPACE SAVING
- STRONG SUPPORT FORCE BY PNEUMATIC SYSTEM
- CAN BE USED IN THE COMBINATION WITH PNEUMATIC CLAMP

Circuit Diagram with various Pneumatic Elements

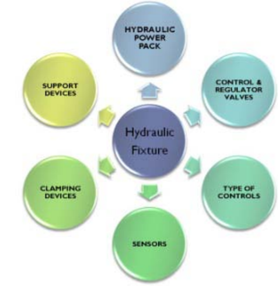


Sources of Supply for Pneumatic Elements

- FESTO INDIA
- SMC PNEUMATICS
- JANATICS
- IPH
- KOSMEK JAPAN
- ROEMHELD

Elements for Hydraulic Fixtures

Hydraulic Power Pack

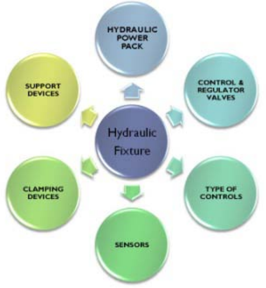


- OIL RESERVIOR / OIL SUMP
- POWER SOURCE i.e. HYD. PUMP-MOTOR COMBINATION
- OIL FILTER
- AIR OIL COOLER
- PRESSURE GAUGE
- AIR BREATHER
- ACCUMULATOR
- OIL LEVEL INDICATOR

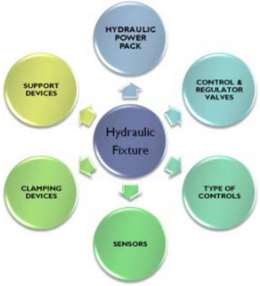
Control & Regulator Valves

- DIRECTION CONTROL VALVE
- CHECK VALVE
- FLOW CONTROL VALVE
- SEQUENCE VALVE
- PRESSURE REGULATOR

Types of Controls



- MANUAL CONTROL – BY PUSH BUTTON OR LEVER OR BY PEDAL
- ELECTRICAL ACTUATION – BY SOLENOID



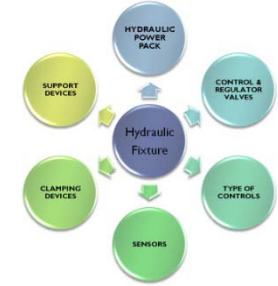
Sensors

- ELECTRICAL LIMIT SWITCH
- PRESSURE SWITCH
- PROXY SWITCH

Support Devices

- WORK SUPPORT – FLANGE / THREADED
- DATUM CYLINDER – FOR POSITIONING TOMBSTONE/ JIG PLATE / WORKPIECE
- AUTO COUPLER
- SEAT CHECK
- ROTARY DISTRIBUTOR

Clamping Devices



- THREADED BODY CYLINDER
- BLOCK CYLINDER – SINGLE / DOUBLE ACTING
- SINGLE ACTING CYLINDER – FLANGE MOUNTING
- DOUBLE ACTING CYLINDER – WITH / WITHOUT CUSHIONING - FLANGE MOUNTING
- TOGGLE TYPE CLAMPING CYLINDER -TOP FLANGE / BOTTOM FLANGE
- SWING CYLINDER - TOP FLANGE / BOTTOM FLANGE
- HOLLOW PISTON CYLINDER
- BALL LOCK CLAMP

Sources of Supply for Hydraulic elements to be used in Fixtures

- KOSMEK JAPAN
- ROEMHELD
- AMF GERMANY
- QUICKLOCK
- HY-POWER
- IPH

Sources of Supply for Seal Kits

- VAKO
- SEAL JET
- SIMRIT
- BUSAK & LUKEN
- SPARAGE BOMBAY

Selection Criteria of various elements of Hydraulic/ Pneumatic Fixture systems

- ☑ HYD. TANK
- ☑ HYD PUMP
- ☑ MOTOR FOR HYD PUMP
- ☑ AIR OIL COOLER
- ☑ CHILLER
- ☑ FILTER / HOSE / PIPING / PRESSURE GAUGE
- ☑ CHECK VALVE / PRESSURE REDUCING VALVE
- ☑ DIRECTION CONTROL VALVE / FLOW CONTROL VALVE
- ☑ ACCUMULATOR
- ☑ PRESSURE SWITCH
- ☑ CYLINDERS (ACTUATORS) / WORK SUPPORTS

Parameters to be listed after Final Fixture Design

- Number of cylinders in use for
  - Location
  - Clamping
  - Work supports
- Size of each cylinders in use
- Clamping Pressure / cylinder
- Speed of each cylinder
- No. of cylinders in actuation at a time.
- Clamping Sequence

Selection Criteria of various elements of Hydraulic/ Pneumatic Fixture systems

- ☑ HYD. TANK
- ☑ HYD PUMP
- ☑ MOTOR FOR H
- ☑ AIR OIL CO
- ☑ CHILLER
- ☑ FILTER / HO
- ☑ CHECK VAL
- ☑ DIRECTION
- ☑ ACCUMULAT
- ☑ PRESSURE SWITCH
- ☑ CYLINDERS (ACTUATORS) / WORK SUPPORTS

- Hyd. Tank capacity should be 3 times pump capacity if chiller is used.
- Hyd. Tank capacity should be 5 times pump capacity if chiller is not used.

Selection Criteria of various elements of Hydraulic/ Pneumatic Fixture systems

- ☑ HYD. TANK
- ☑ HYD PUMP
- ☑ MOTOR FOR HYD PUMP

Size Selection

- ☑ AIR OIL COOLER
- ☑ CHIL
- ☑ FILTE
- ☑ CHE
- ☑ DIRE
- ☑ ACC
- ☑ PRES
- ☑ CYLI

- Flow requirement from the Hyd. Pump =

  1.2 x Area of cylinder x Speed x No. of cylinders in actuation.

- Tank capacity (with out chiller) = 4 to 5 Times the pump flow requirement.
- Max. rise in Temp. allowed 60°C or 25° above ambient which ever is lower.
- If chiller is used Tank capacity can be 3 times the flow requirement.
- Select standard variable displacement Piston Pump / vane pump on the basis of flow requirements.
- Electric motor selection on the basis of pump flow and maximum clamping pressure
- Motor (KW) = (Flow (Lt/min.) x Pr (Kg /cm2)) / 612 x efficiency of motor

Selection Criteria of various elements of Hydraulic/ Pneumatic Fixture systems

- ☑ HYD. TANK
- ☑ HYD PUMP
- ☑ MOTOR FOR HYD PUMP
- ☑ AIR OIL COOLER
- ☑ CHILLER
- ☑ FILTER
- ☑ CHECK
- ☑ DIRECT
- ☑ ACCUM
- ☑ PRESSU
- ☑ CYLINDE

•Air Oil cooler to be used in drain line of the pump.

•Chiller size to be selected on the basis of the pump motor power rating, ambient temp and tank capacity.

Selection Criteria of various elements of Hydraulic/ Pneumatic Fixture systems

- ☑ HYD.TANK
- ☑ HYD PUMP
- ☑ MOTOR FOR HYD PUMP
- ☑ AIR OIL COOLER
- ☑ CHILLER
- ☑ FILTER / HOSE / PIPING / PRESSURE GAUGE
- ☑ CHECK
- ☑ DIRECT
- ☑ ACCUN
- ☑ PRESSU
- ☑ CYLINI

•FILTER of 25 micron to be provided in suction return line

•Hose to be provided with check valve after pump so as to avoid the transmission of vibration and to hold the oil in the pipe line.

•Standards size of piping to be used (12 to 18 Dia) so has to have a free flow.

•Glycerine filled Pressure Gauge of required range to be provided with factor of safety.

Selection Criteria of various elements of Hydraulic/ Pneumatic Fixture systems

- ☑ HYD. TANK
- ☑ HYD PUMP
- ☑ MOTOR FOR HYD PUMP
- ☑ AIR OIL COOLER
- ☑ CHILLER
- ☑ FILTER / HOSE / PIPING / PRESSURE GAUGE
- ☑ CHECK VALVE / PRESSURE REDUCING VALVE
- ☑ DIRECTION
- ☑ ACCUMUL
- ☑ PRESSURE
- ☑ CYLINDER

•Check Valve - to hold the pressure in pipe line.

•Pressure Reducing Valve - to maintain required reduced pressure.

•Direction Control Valve - determines direction of flow of fluid in the actuator.

•Flow Control Valve - controls volume of flow of fluid to attain desired speed

Selection Criteria of various elements of Hydraulic/ Pneumatic Fixture systems

- ☑ HYD.TANK
- ☑ HYD PUM
- ☑ MOTOR
- ☑ AIR OIL
- ☑ CHILLE
- ☑ FILTER
- ☑ CHECK
- ☑ DIRECTIO
- ☑ ACCUMULATOR
- ☑ PRESSURE SWITCH
- ☑ CYLINDERS (ACTUATORS) / WORK SUPPORTS

•Accumulator – To be used to maintain pressure in the system in case of non availability of live hydraulic

•Selection of Accumulator is based on leakages across cylinders / piping & fittings

Selection Criteria of various elements of Hydraulic/ Pneumatic Fixture systems

- ☑ HYD.TANK
- ☑ HYD PUM
- ☑ MOTOR
- ☑ AIR OIL
- ☑ CHILLE
- ☑ FILTER
- ☑ CHECK
- ☑ DIRECTIO
- ☑ ACCUMULATOR
- ☑ PRESSURE SWITCH
- ☑ CYLINDERS (ACTUATORS) / WORK SUPPORTS

•Pressure switch is provided to get feed back signal for control systems.

•It gets actuated when the line pressure reaches the set value, so that further sequence in the cycle can continue.

Selection Criteria of various elements of Hydraulic/ Pneumatic Fixture systems

- ☑ HYD.TANK
- ☑ HYD PUMP
- ☑ MOTOR
- ☑ AIR OIL
- ☑ CHILLE
- ☑ FILTER
- ☑ CHECK
- ☑ DIRECT
- ☑ ACCUMULATOR
- ☑ PRESSURE SWITCH
- ☑ CYLINDERS (ACTUATORS) / WORK SUPPORTS

•Cylinders (Actuators) are provide to create clamping force for holding the component in fixture.

•Size, No. of Cylinders and actuating pressure are selected based on clamping force required to perform the desire operation.

•Types and size of work supports is selected depending upon clamp force against the work support.

Case Study of Fixtures

- MANUAL FIXTUERS
- HYDRAULIC FIXTURES
- PNUEMATIC FIXTURES

Case Study of Fixtures

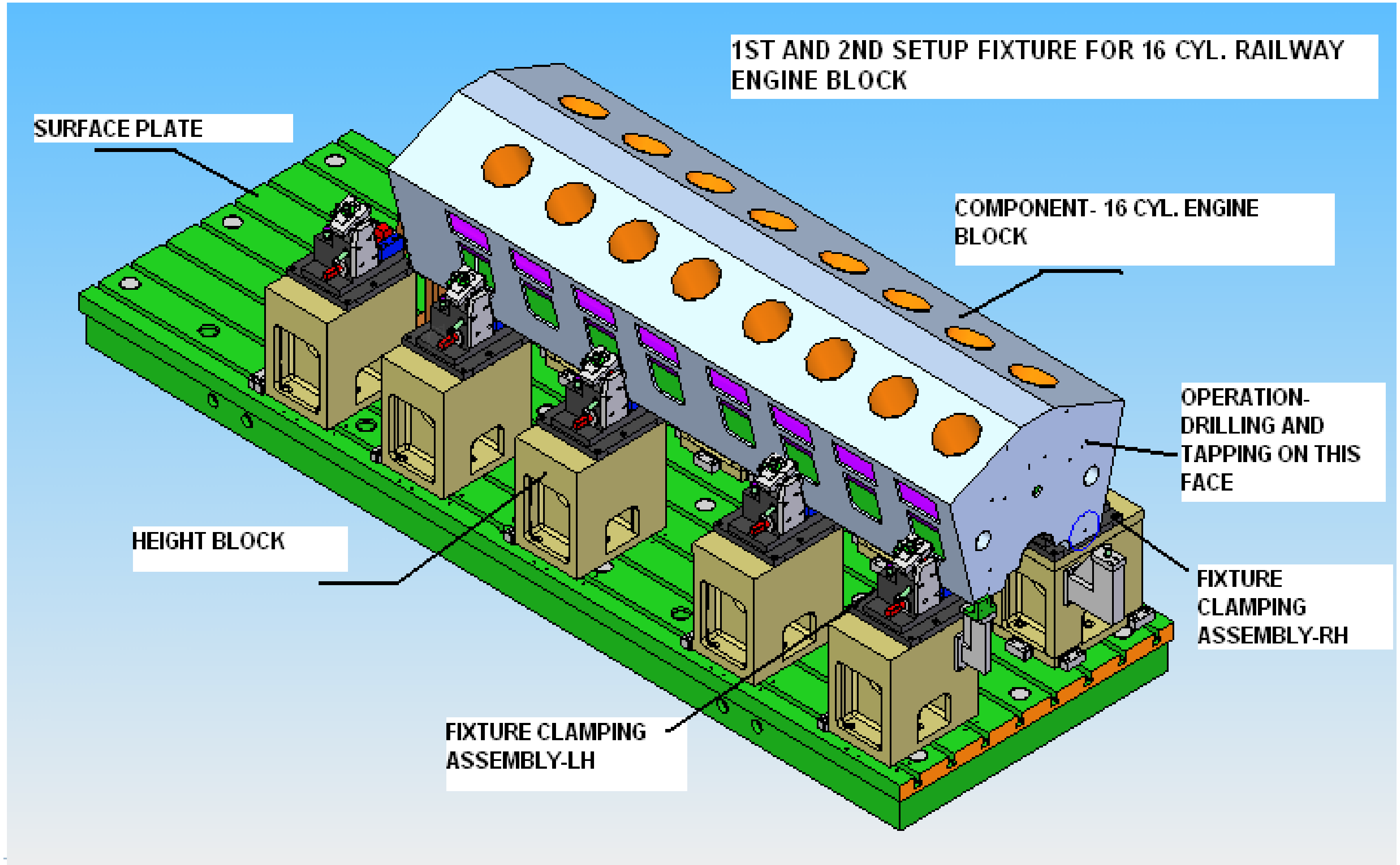
- MANUAL FIXTUERS

- HYDRAULIC FIXTURES

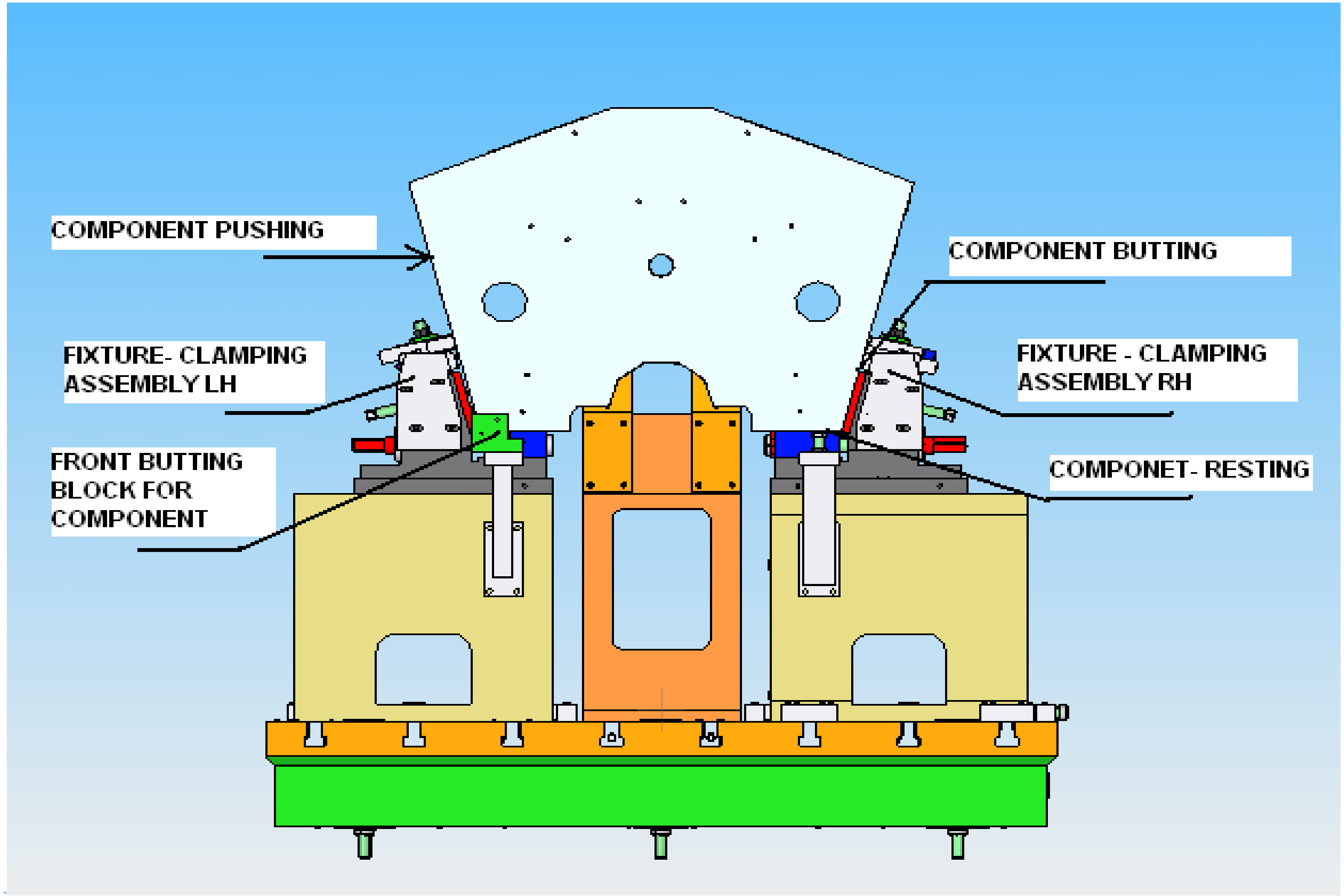
- PNUEMATIC FIXTURES

MANUAL FIXTURE

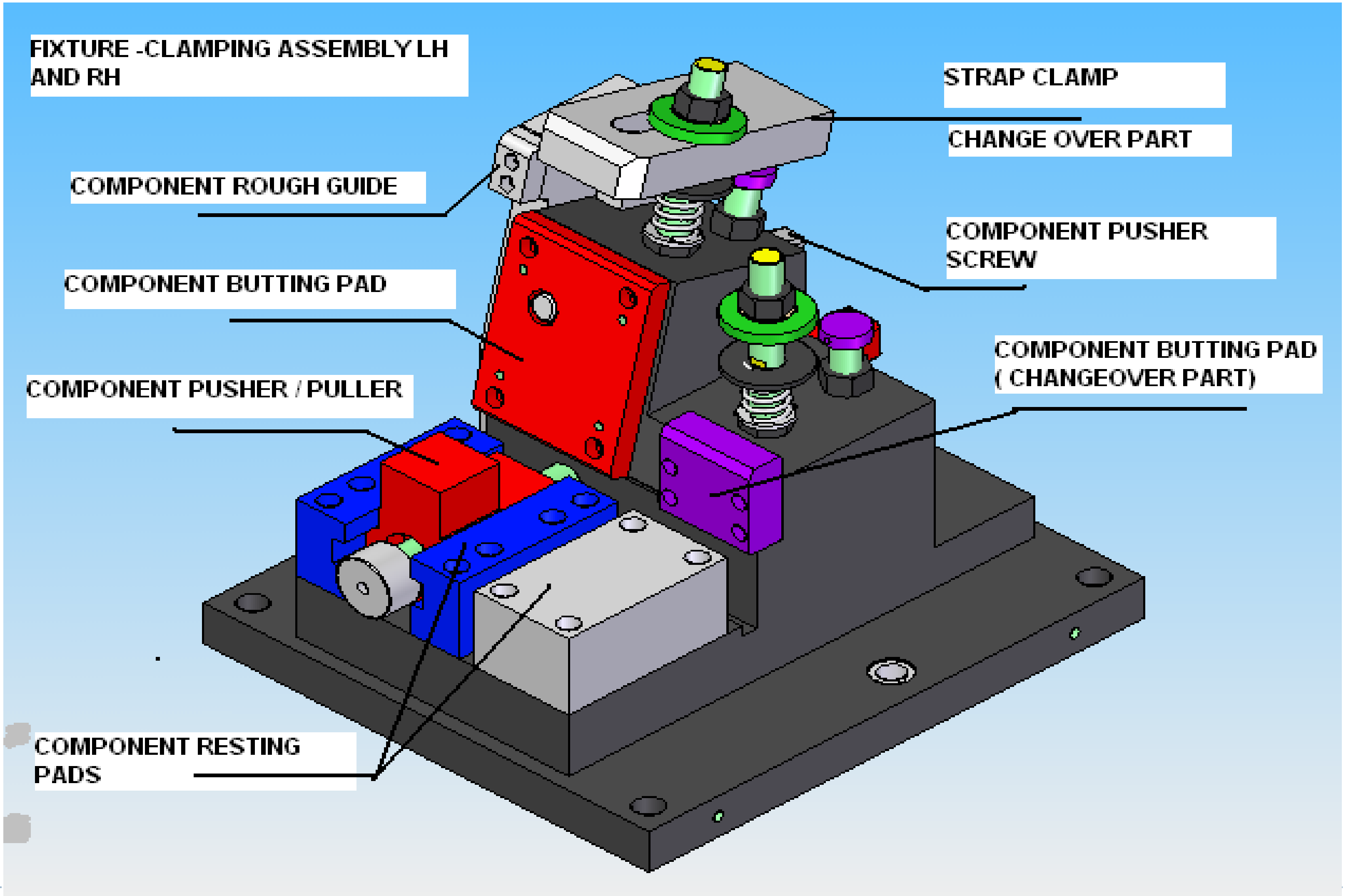
COMPONENT-12/ 16/20 CYLINDER ENGINE BLOCK
OPEARTION- MILLING/DRILLING/BORING/TAPPING
MACHINE- HORZ.MACHINING CENTER



Fixture Front view

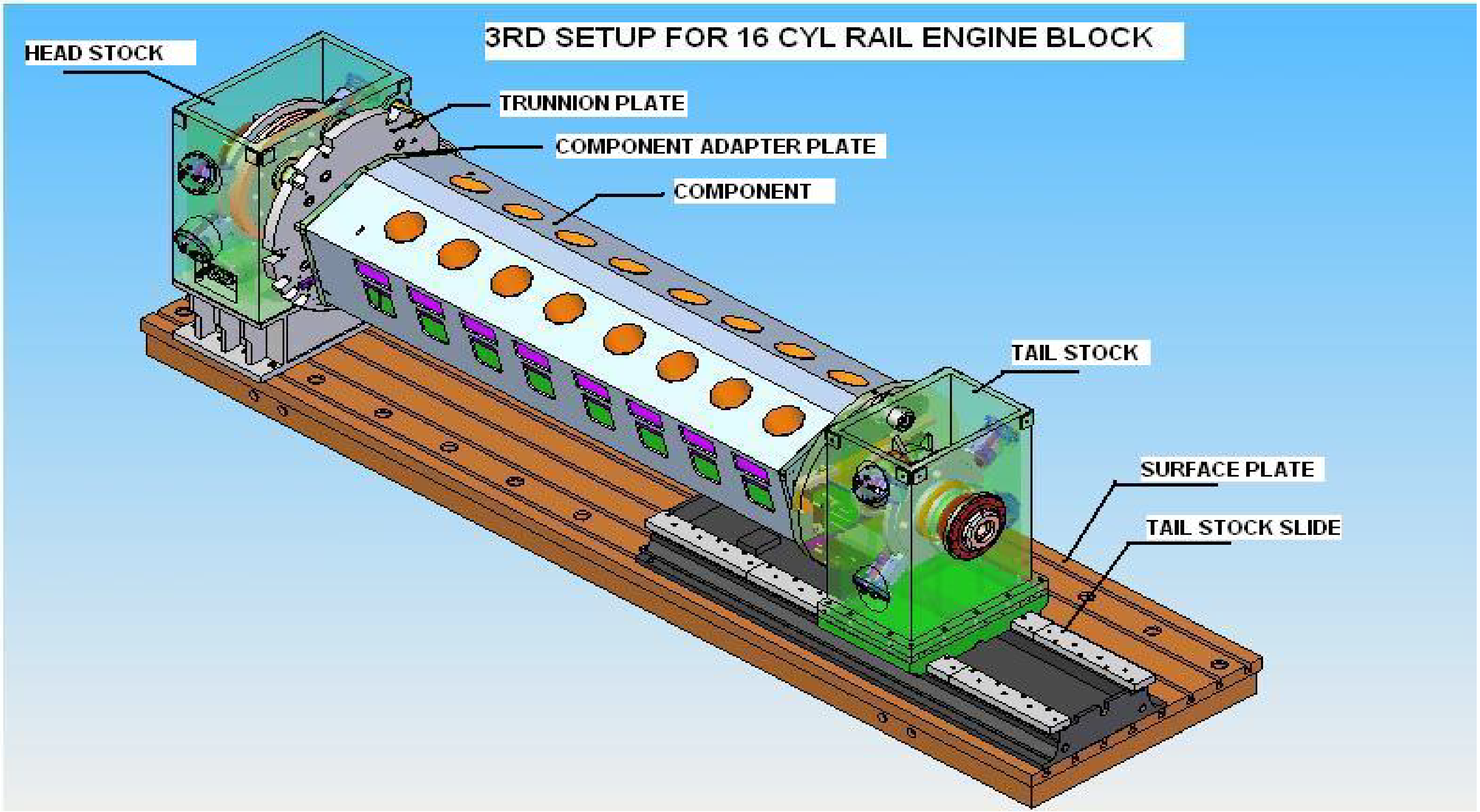


MODULAR FIXTURE CLAMPING ASSEMBLY LH & RH

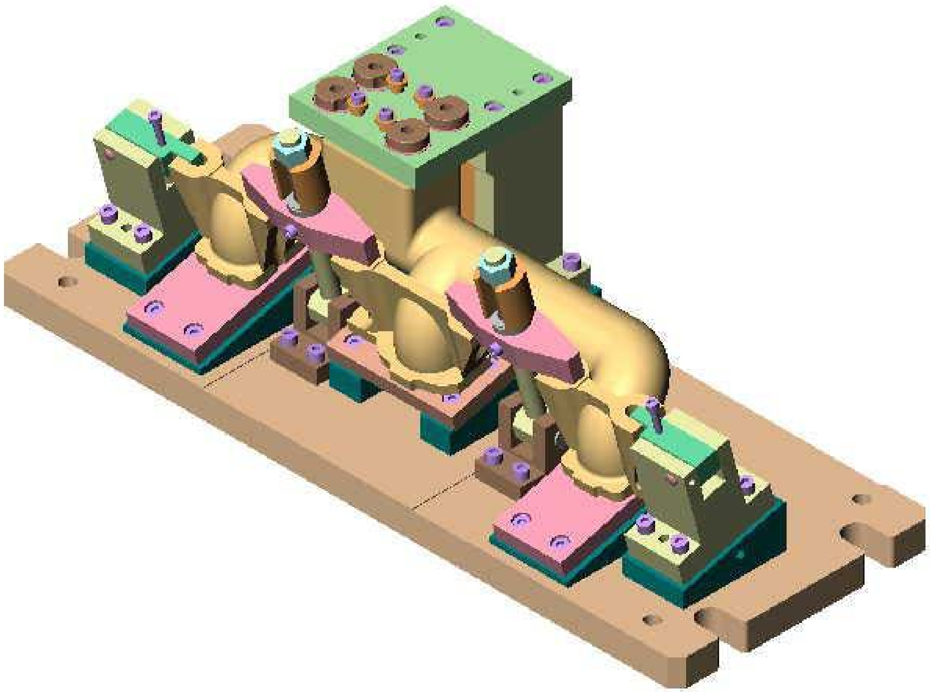


MANUAL FIXTURE

SETUP 3RD –OPERATION FOR 16 CYLINDER RAILWAY ENGINE BLOCK

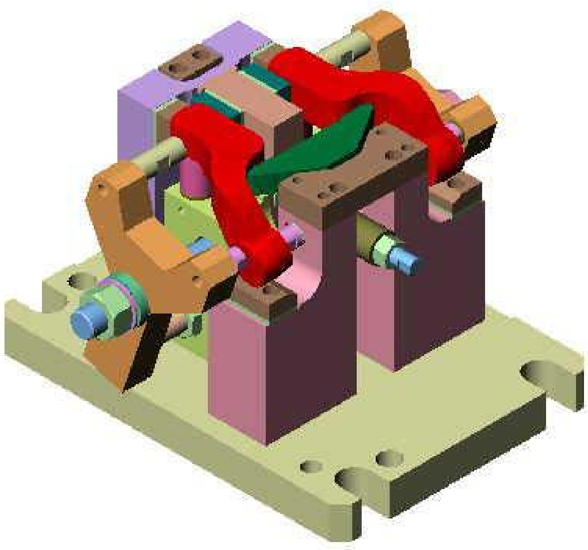


Manual Clamping for Exhaust Manifold

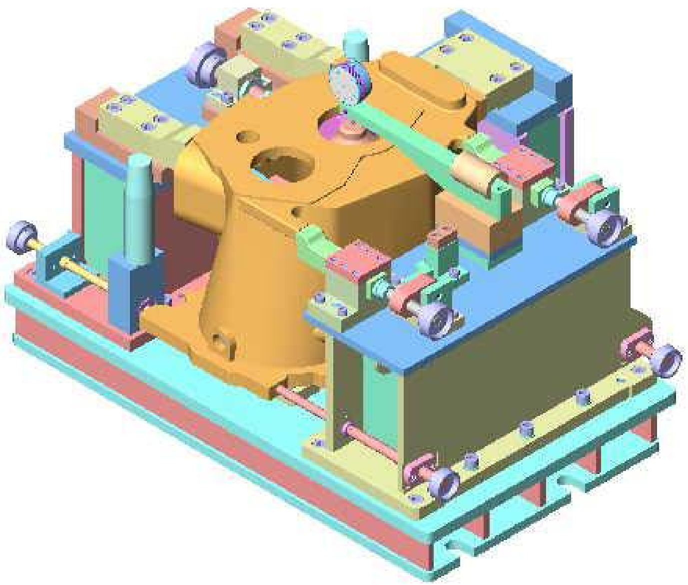


Inspection Fixture (manual)

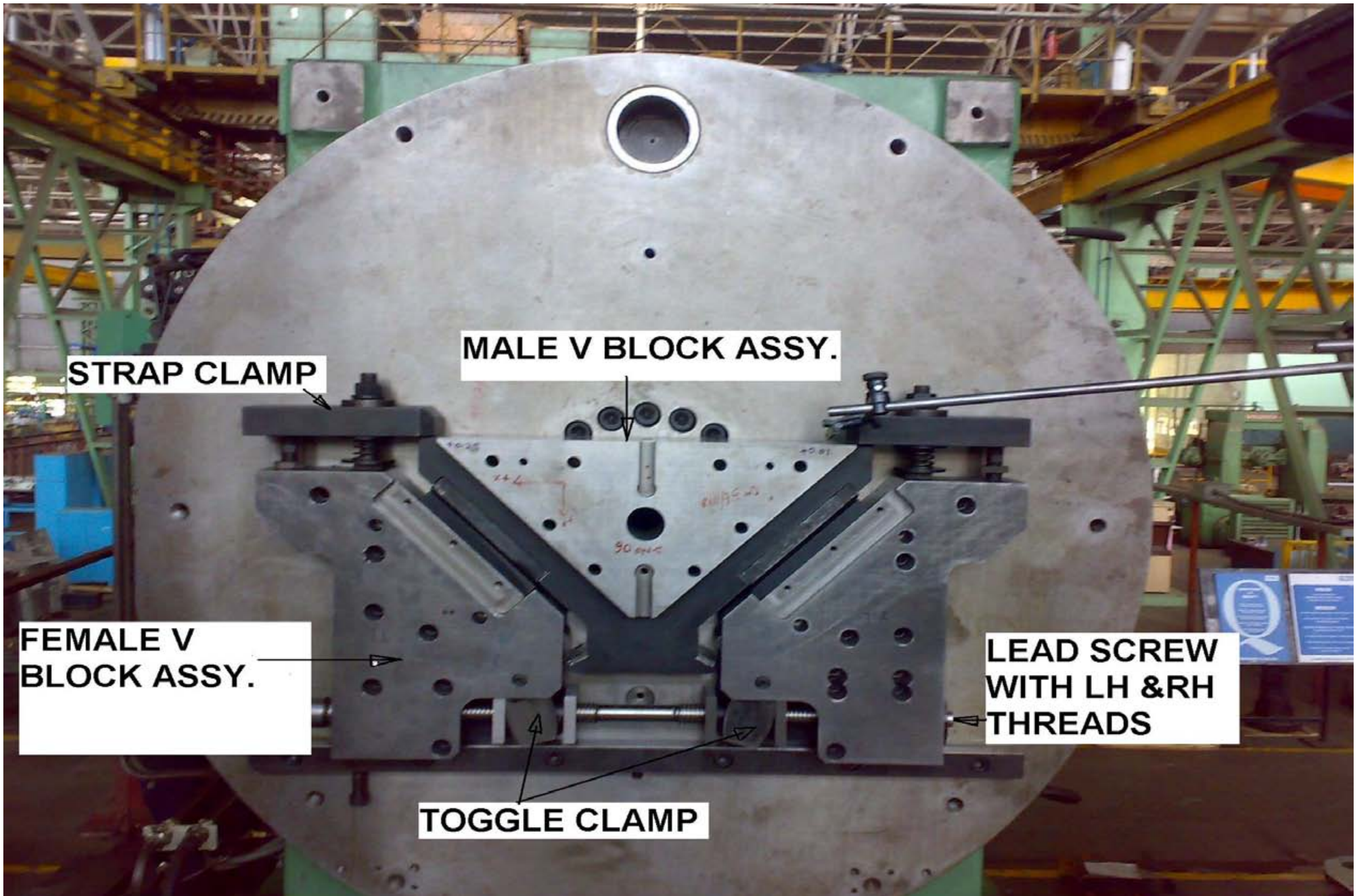
Milling Fixture for Lever (manual)



Manual Fixture for Gearbox Housing



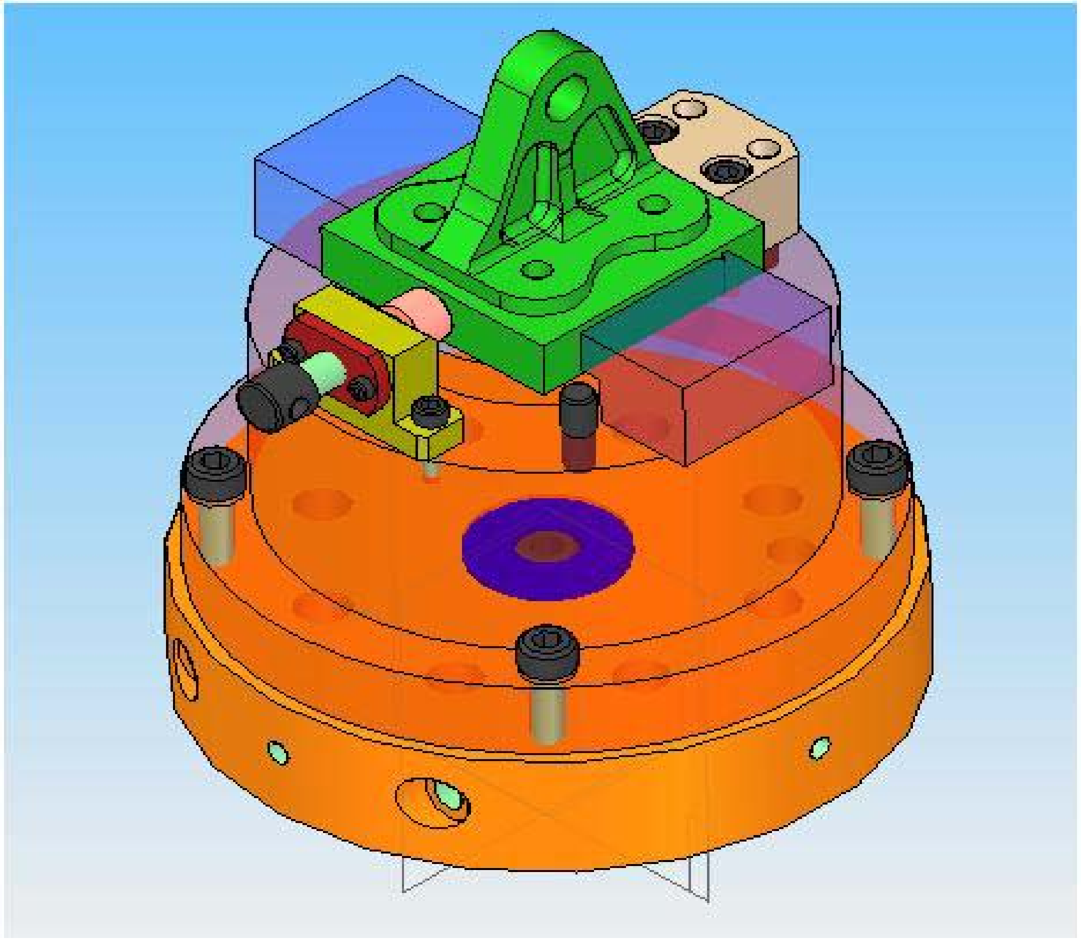
3rd SETUP TRUNION FIXTURE



3rd SETUP TRUNION FIXTURE

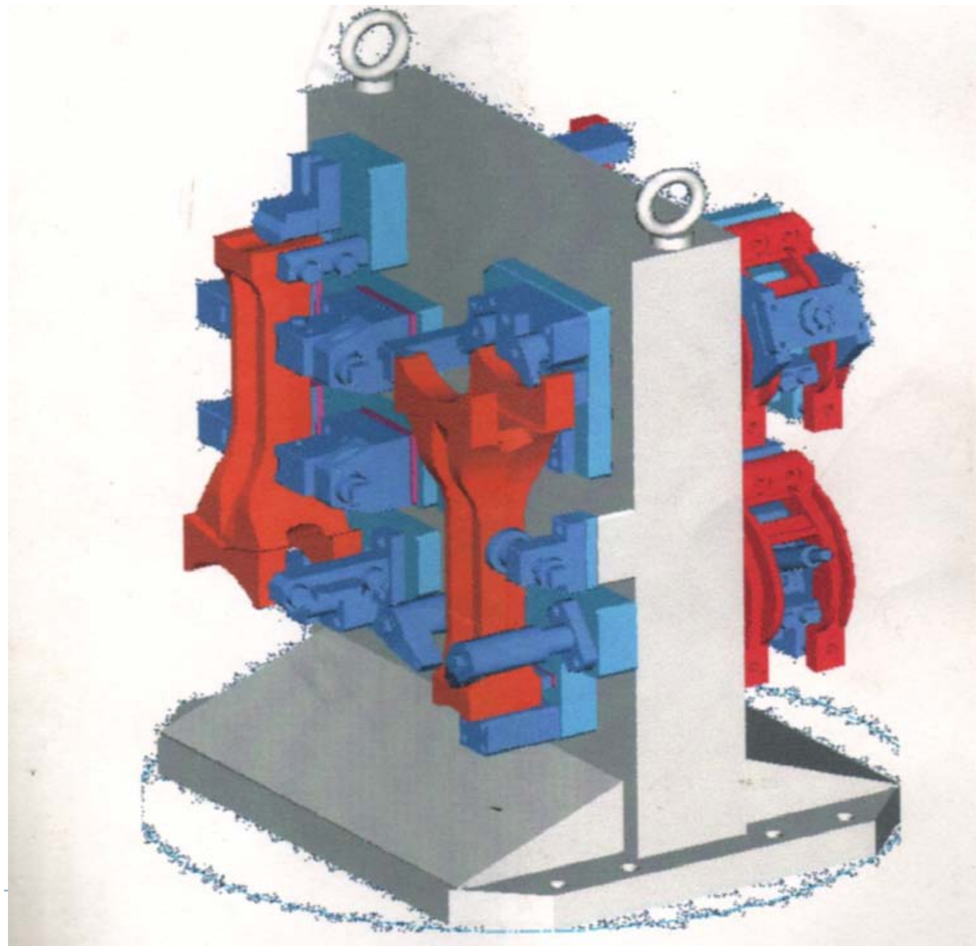
FIXTURE FOR AEROSAPCE COMPONENT-

STANCHSION FITTING
MACHINE- VMC
OPERATION- DRILLING/MILLING/BORING



Modular Fixture Systems

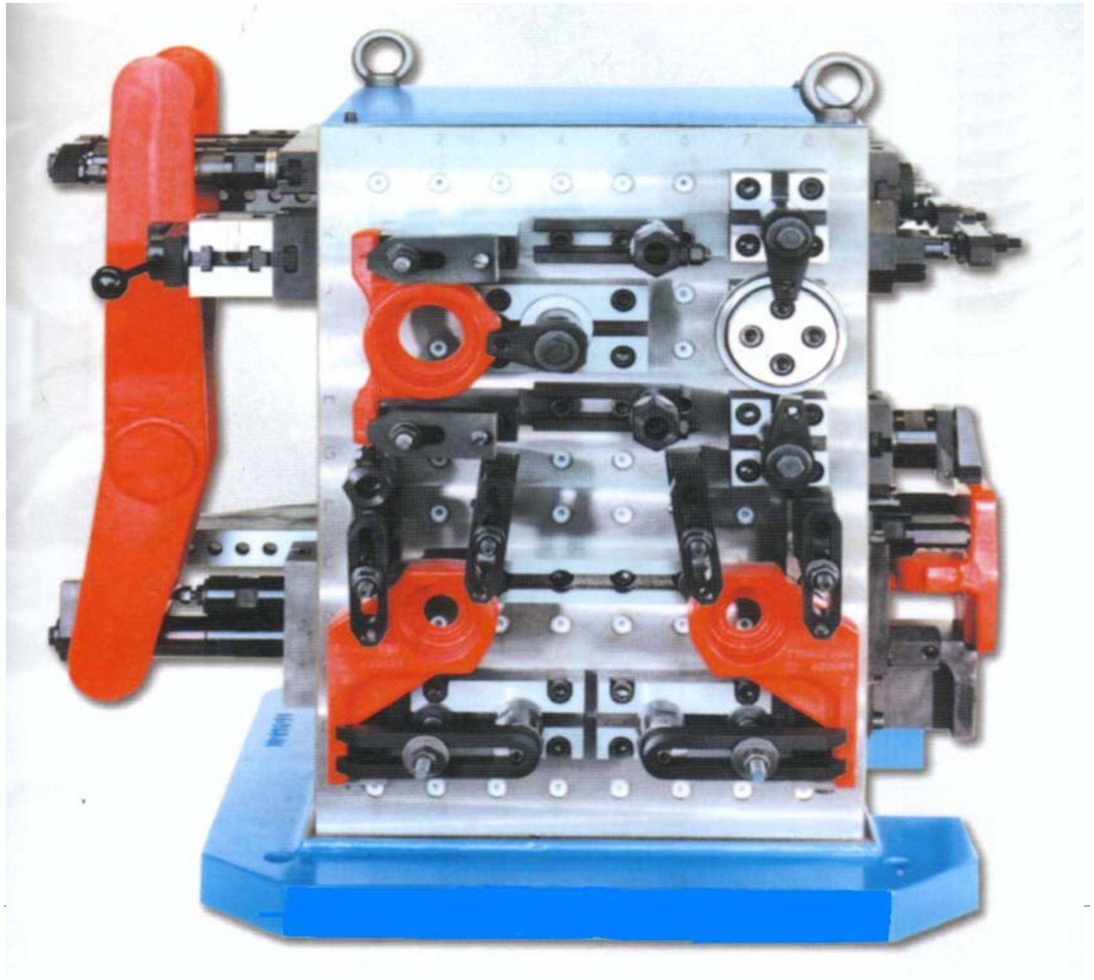
COMPONENT- CONNECTING ROD
MACHINE – HMC
OPERATIONS- MILLING/DRILLING



Modular Fixture Systems

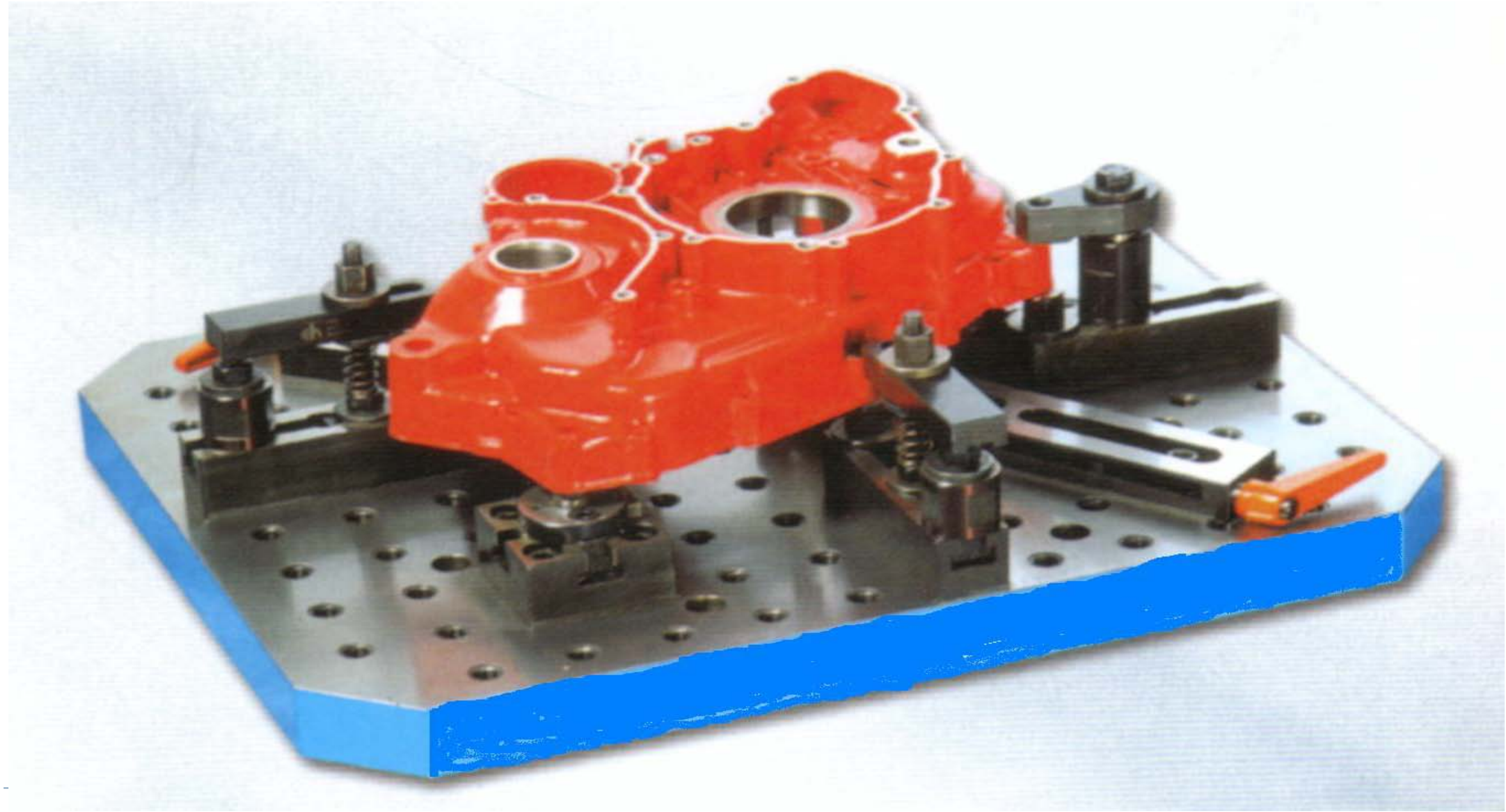
OPERATIONS- MILLING/DRILLING/BORING

MACHINE- HMC



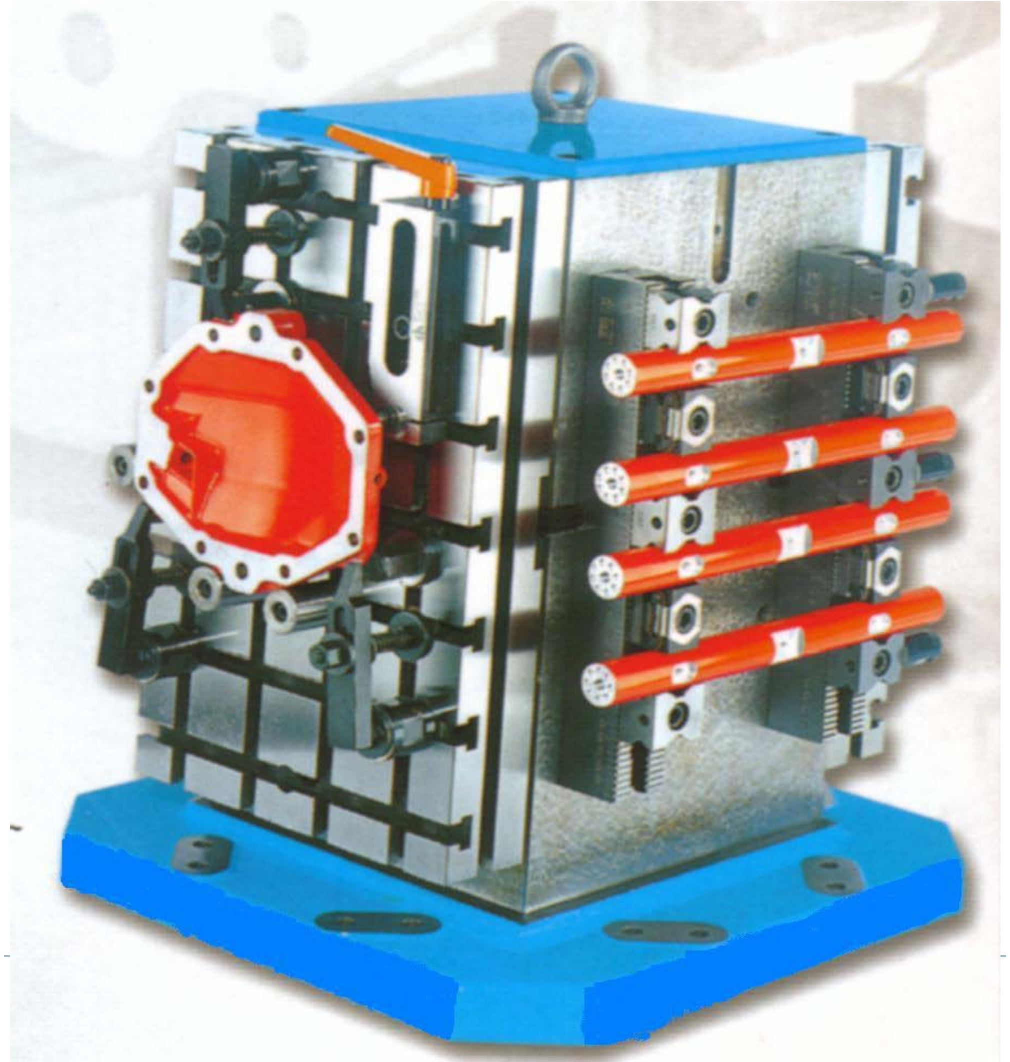
Modular Fixture Systems

COMPONENT- TRANSMMISION HOUSING
OPERATIONS- MILLING/DRILLING/BORING
MACHINE- VMC



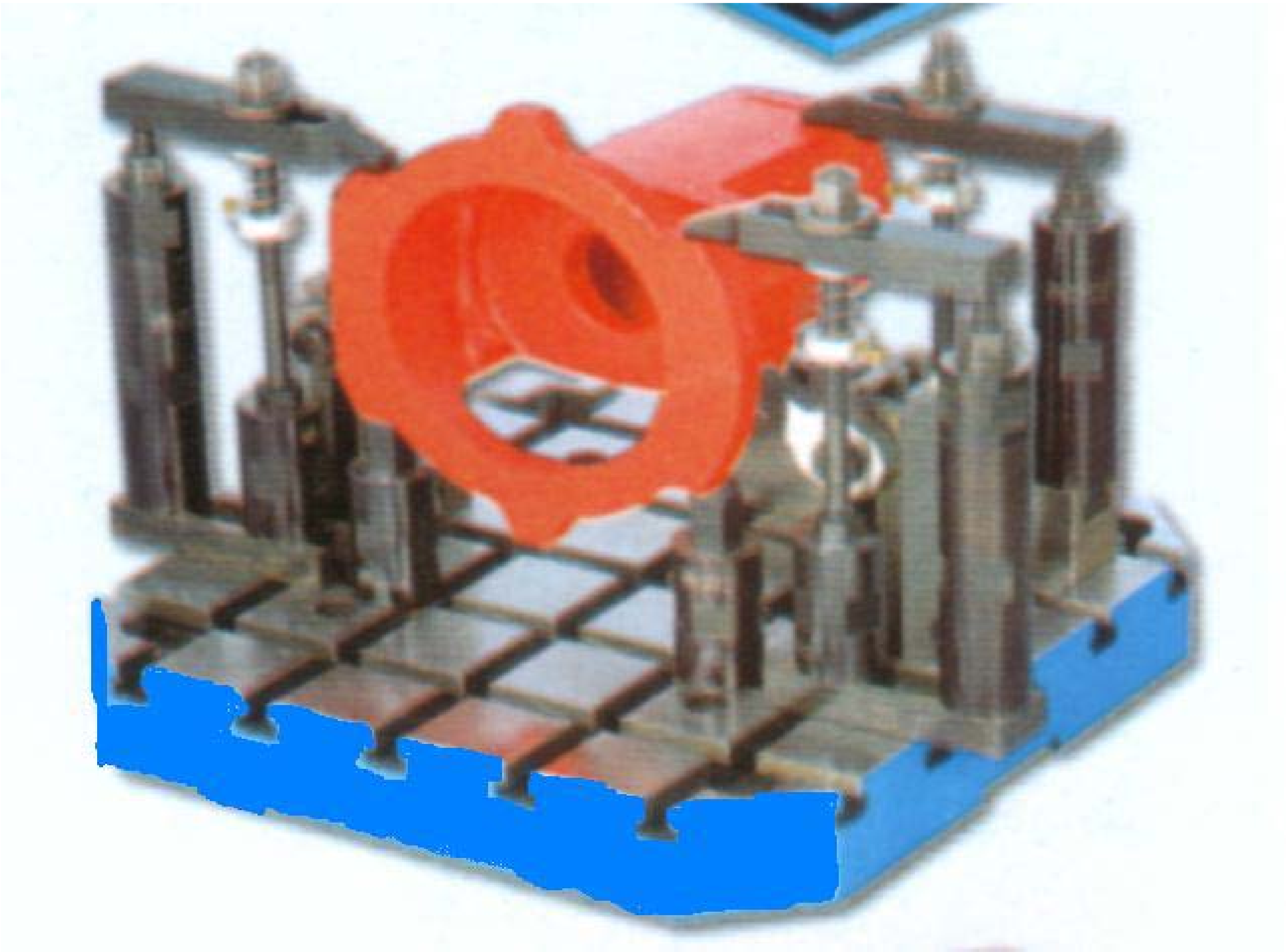
Modular Fixture Systems

OPERATIONS- MILLING/DRILLING/BORING/TAPPING
MACHINE- HMC



Modular Fixture Systems

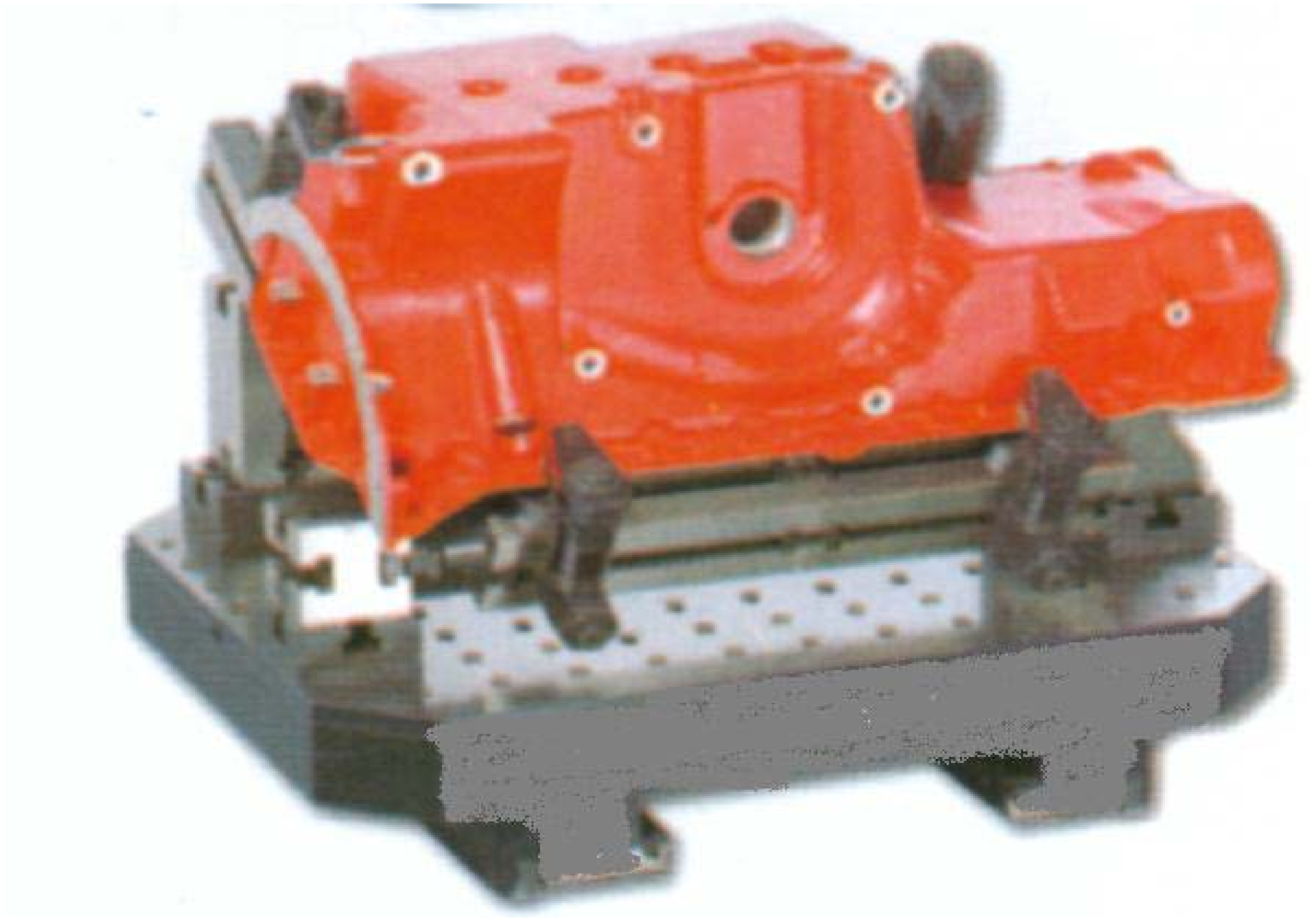
COMPONENT- TRUMPET HOUSING
OPERATIONS- MILLING/DRILLING/BORING
MACHINE- HMC



Modular Fixture Systems

OPERATIONS- MILLING/DRILLING/BORING

MACHINE- HMC



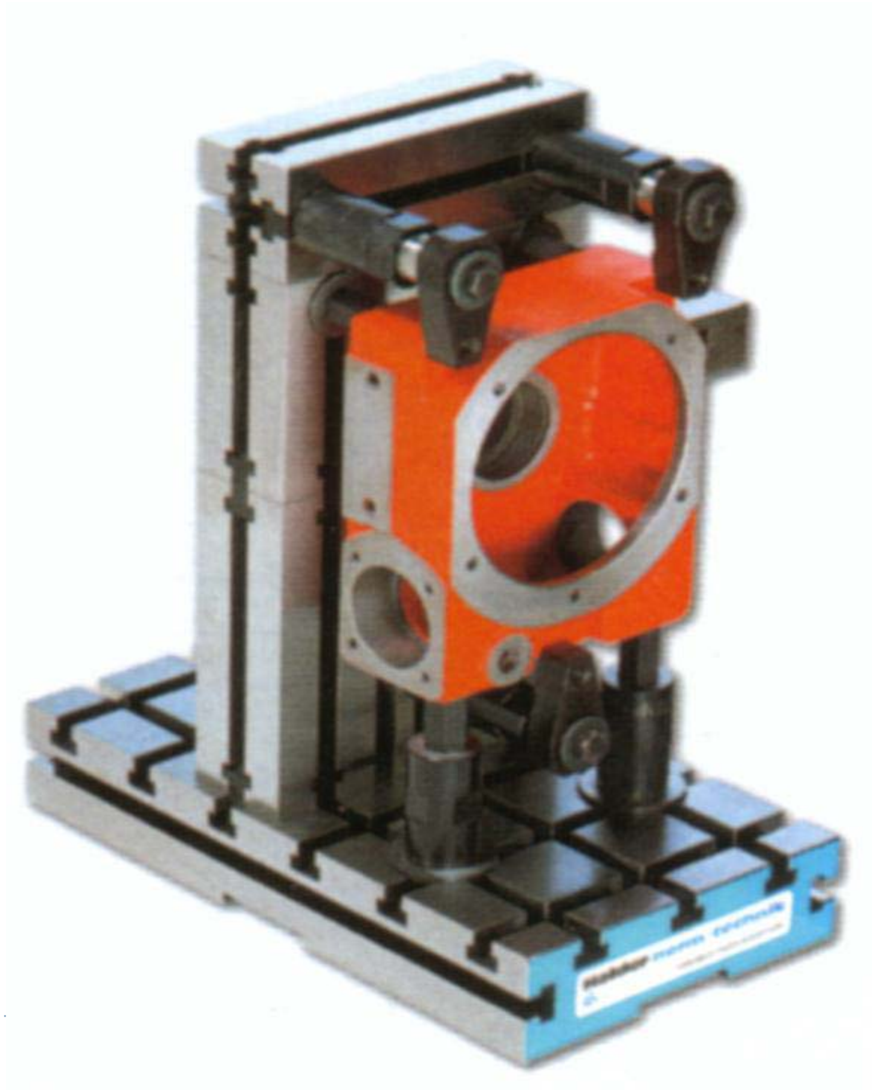
Modular Fixture Systems

COMPONENT- EXHAUST MANIFOULD
OPERATIONS- MILLING/DRILLING/BORING
MACHINE- VMC

Modular Fixture Systems

OPERATIONS- MILLING/DRILLING/BORING

MACHINE- HMC



Modular Fixture Systems

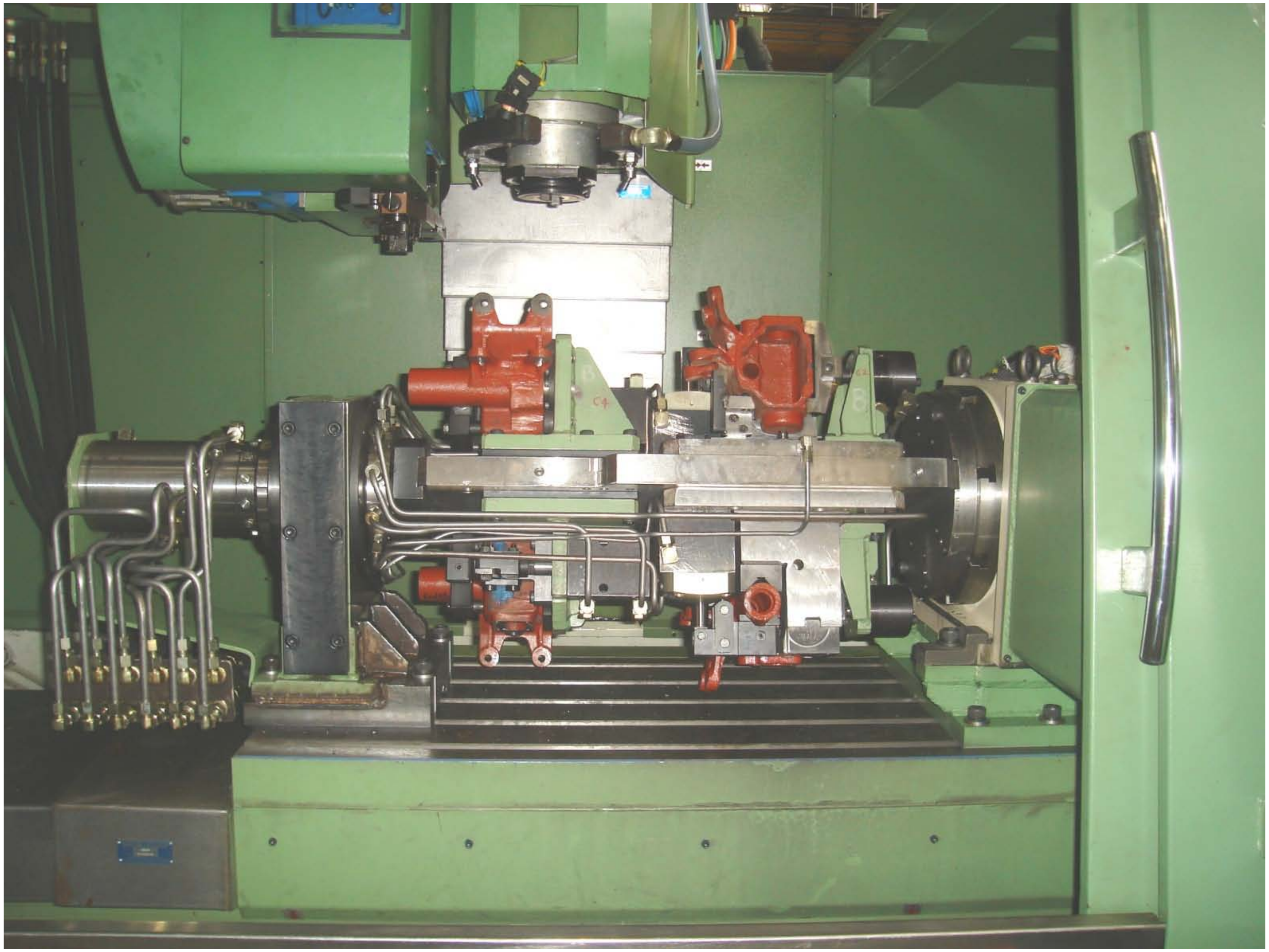
OPERATIONS- MILLING/DRILLING/BORING

MACHINE- VMC

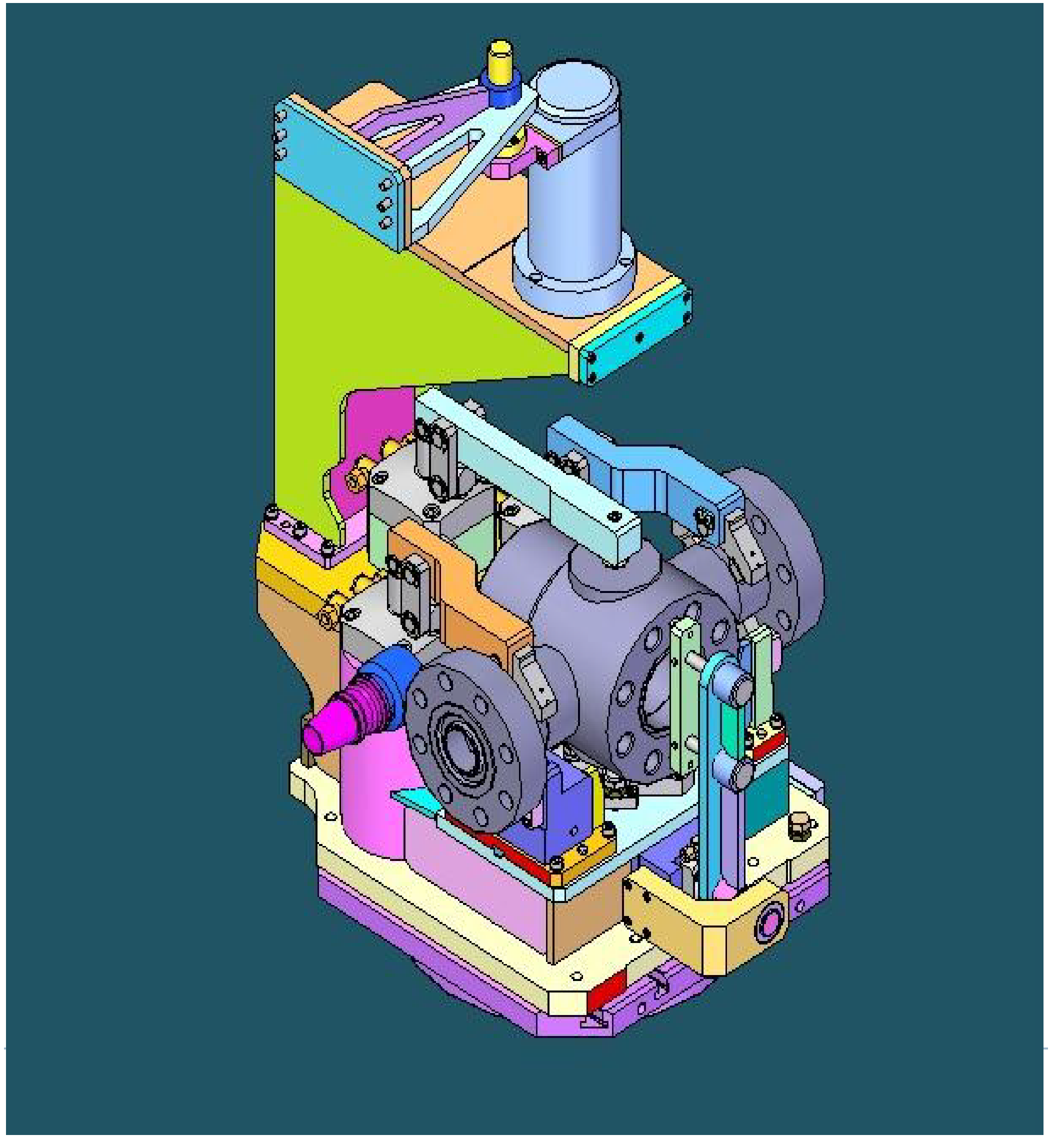
Case Study of Fixtures

- MANUAL FIXTUERS
- HYDRAULIC FIXTURES
- PNUEMATIC FIXTURES

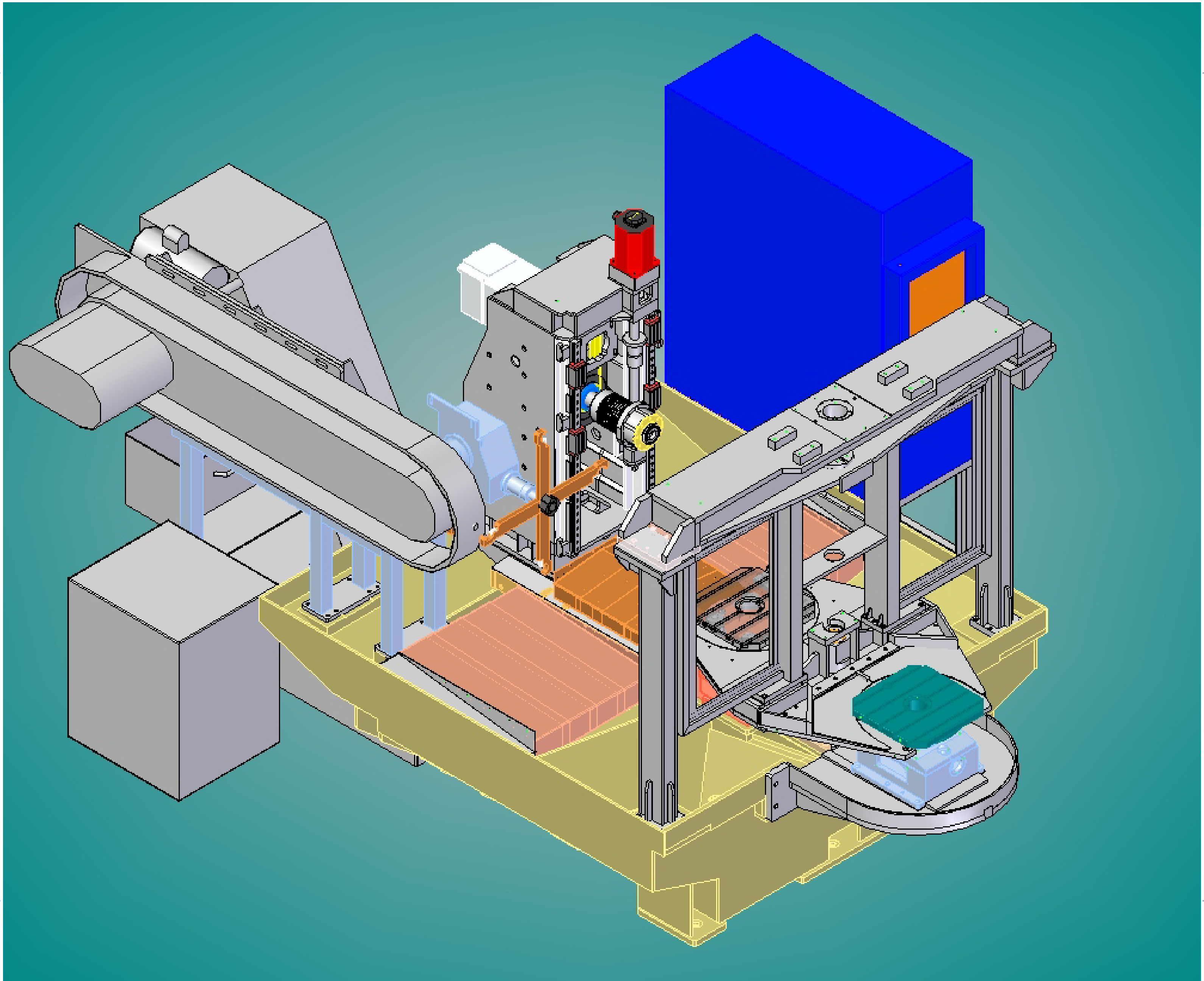
Hydraulic Fixture for Steering Housing



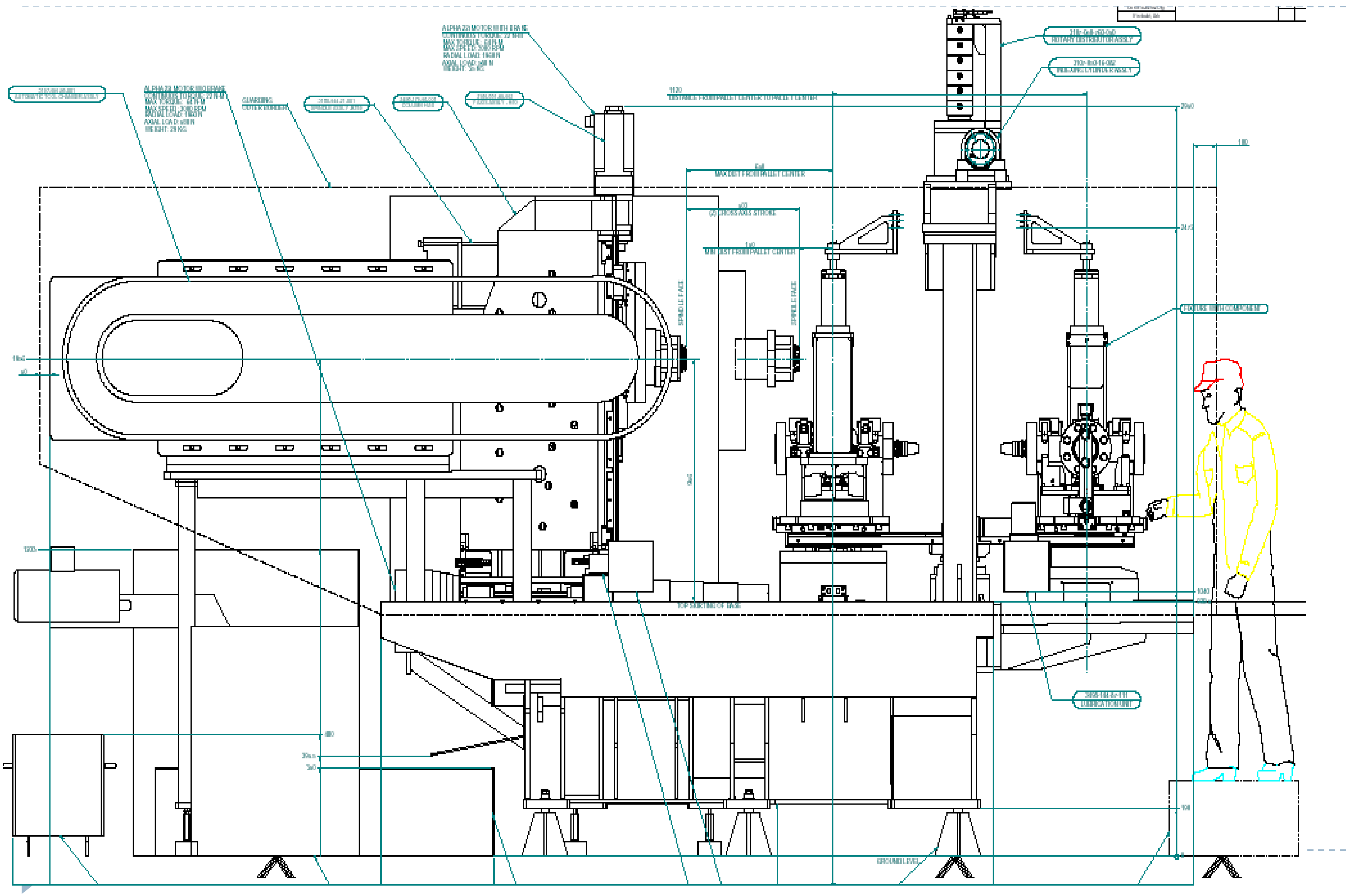
CUSTOMER- HILTON FORGE
COMPONENT- VALVE BODY
MACHINE- HMC
OPERATIONS- DRILLING/BORING/TAPPING



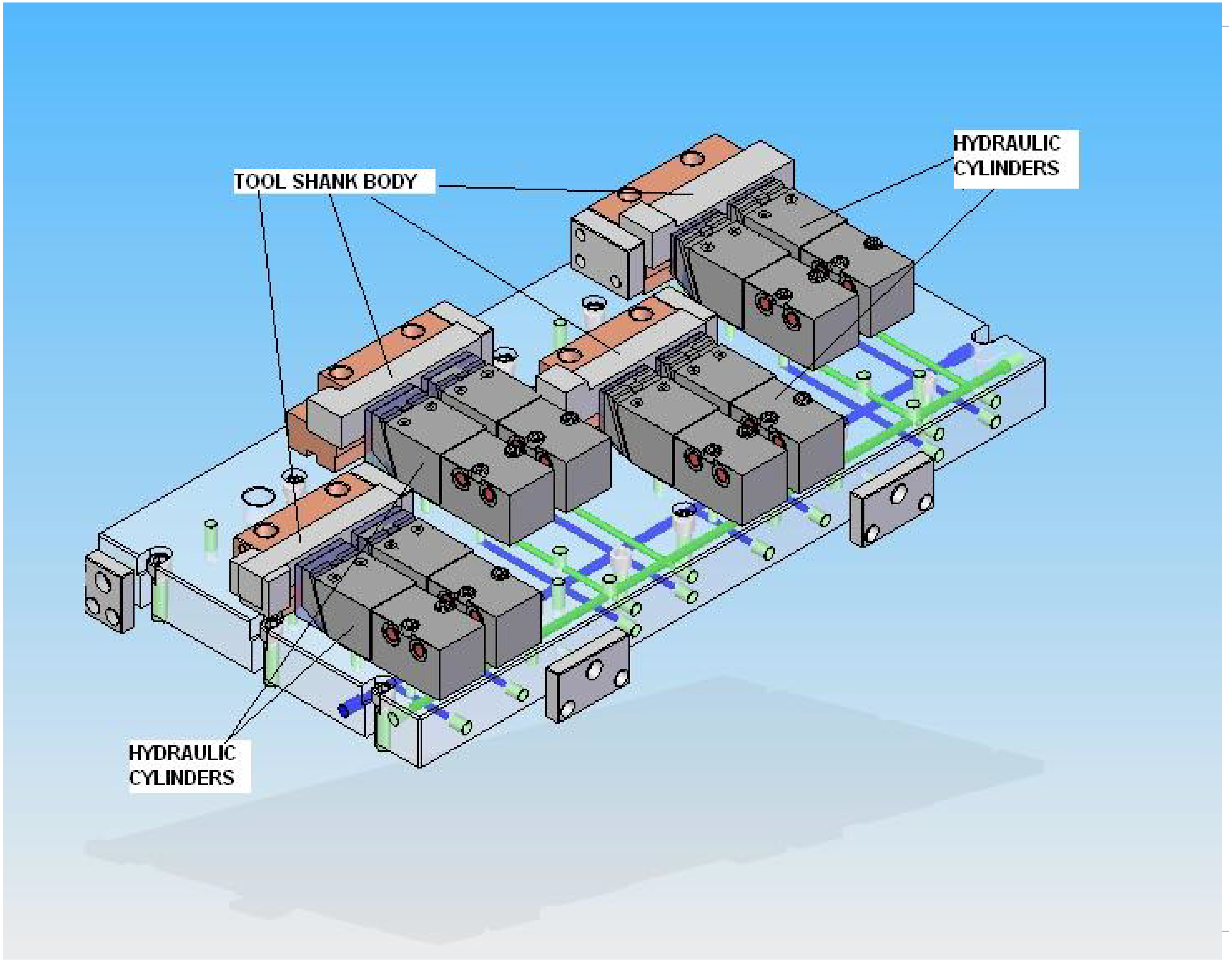
MACHINE LAYOUT - H50
CUSTOMER- HILTON FORGE



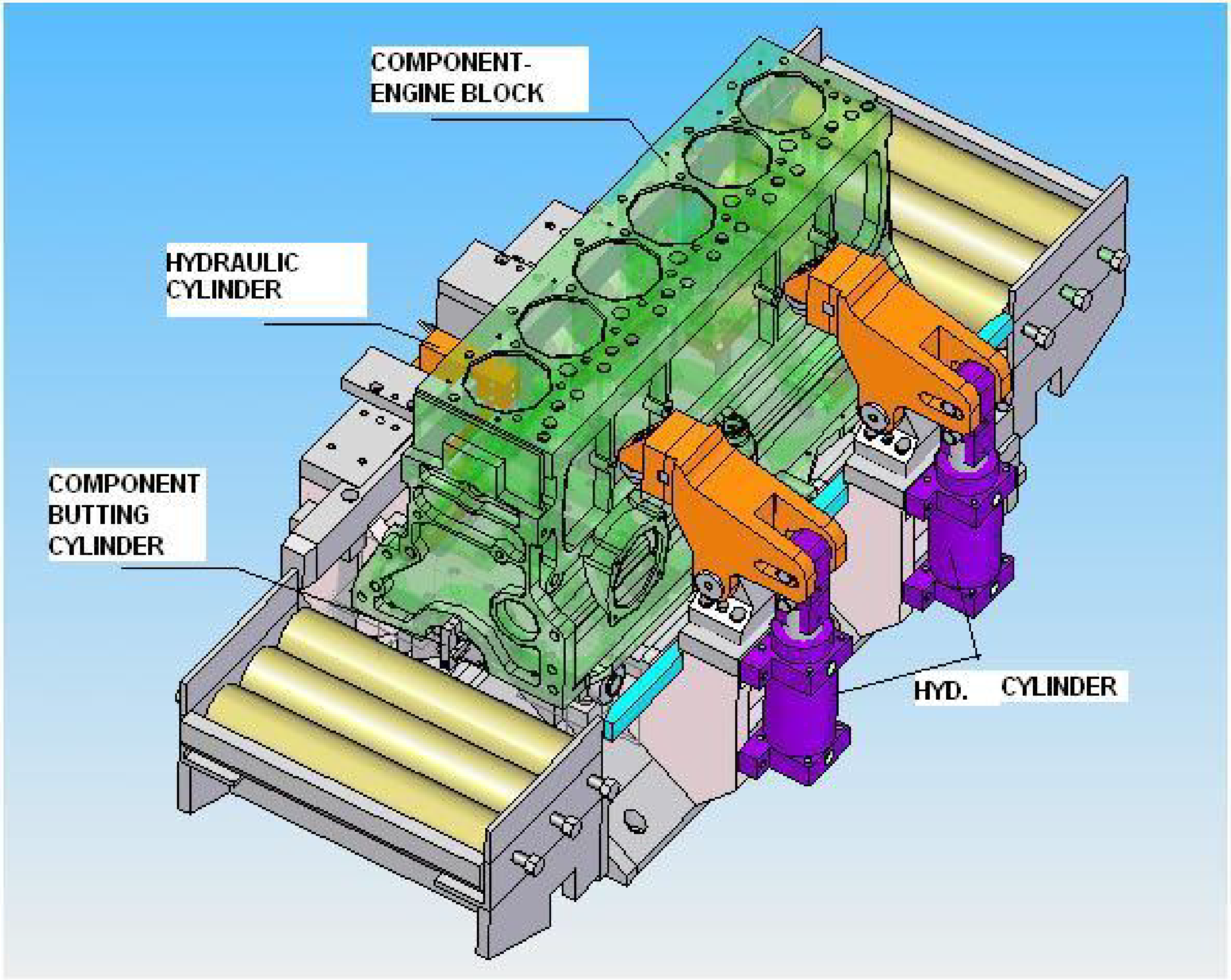
MACHINE LAYOUT - H50
CUSTOMER- HILTON FORGE
LEFT HAND SIDE VIEW



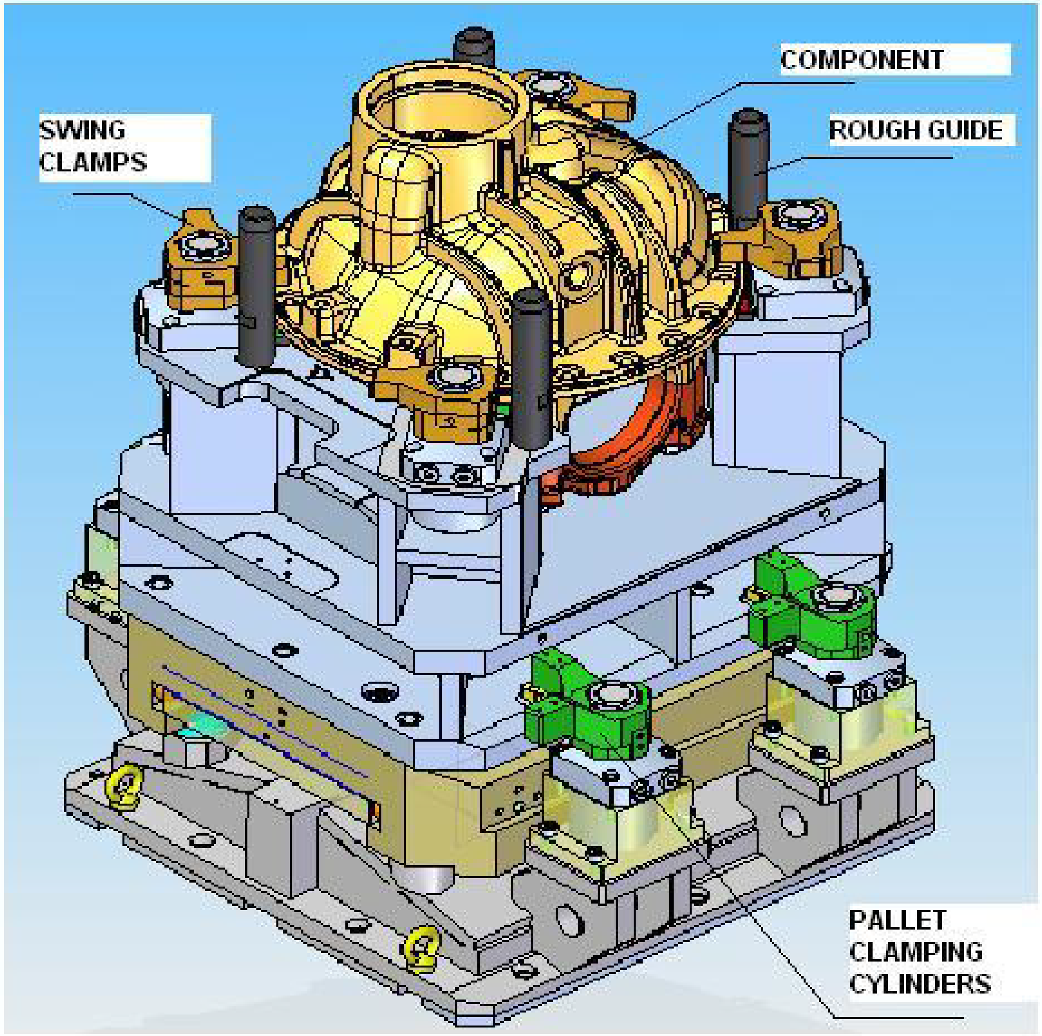
CUSTOMER- SANDVIK
COMPONENT- TOOL SHANK BODY
OPERATION- MILLING



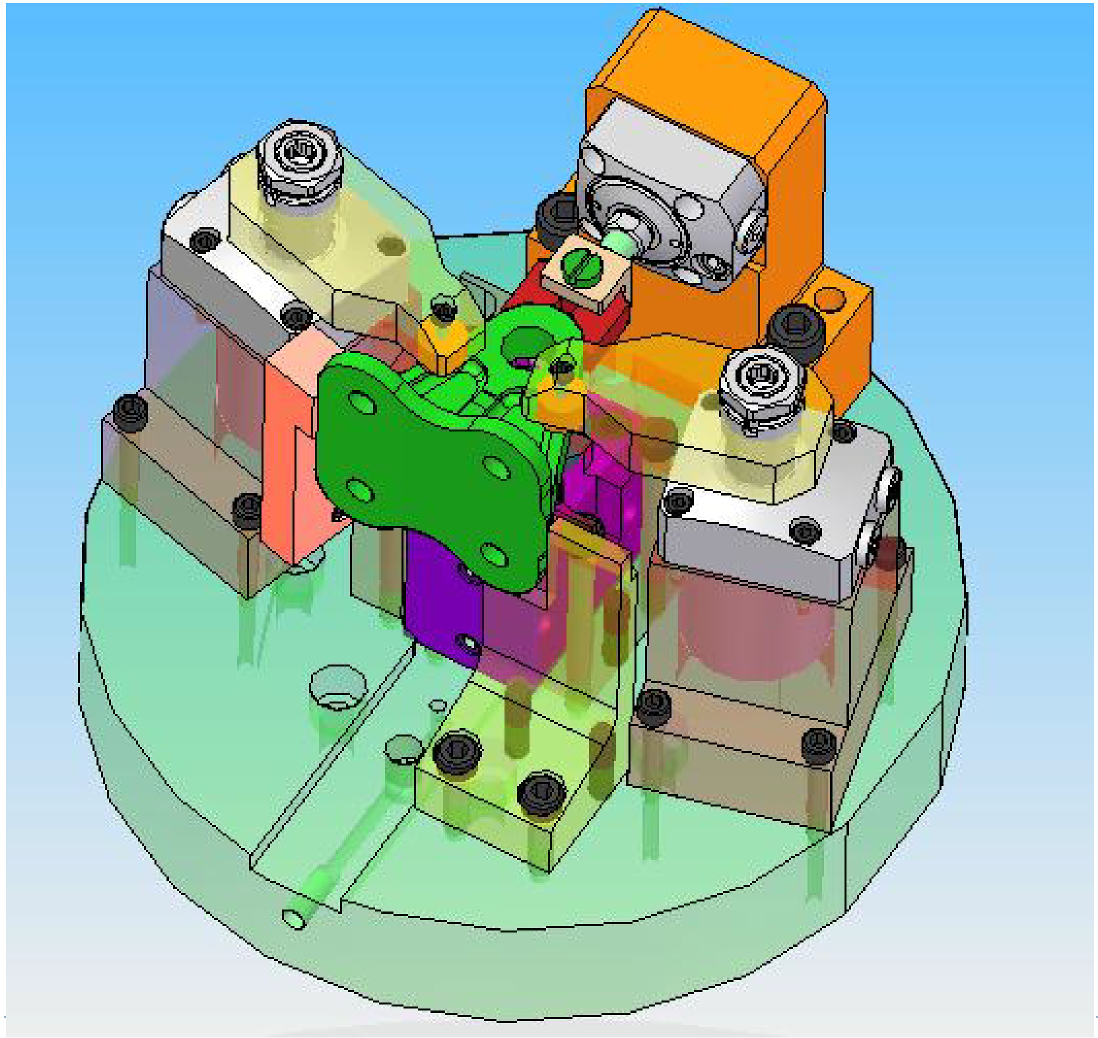
CUSTOMER- TATA MOTORS
COMPONENT- ENGINE BLOCK
OPERATION- HEAD FACE MILLING



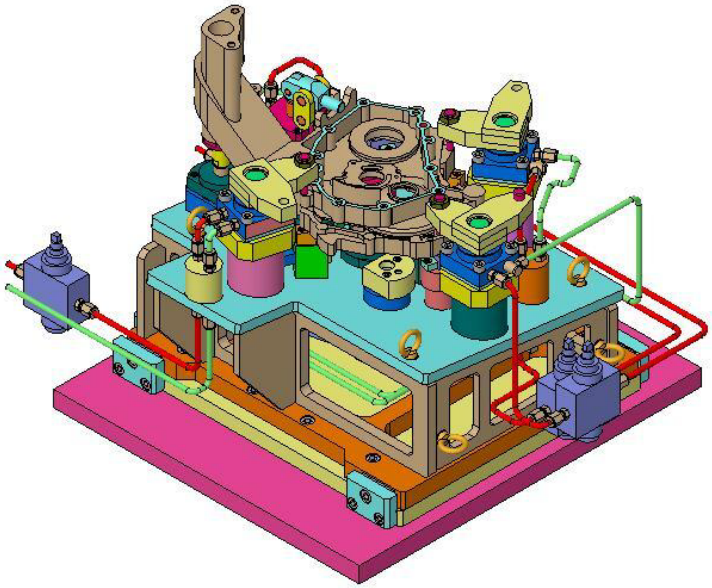
CUSTOMER-HEAVY AXIAL TATA MOTORS
MACHINE- HMC
COMPONENT-CARRIER HOUSING
OPERATION- 3WAY BORING



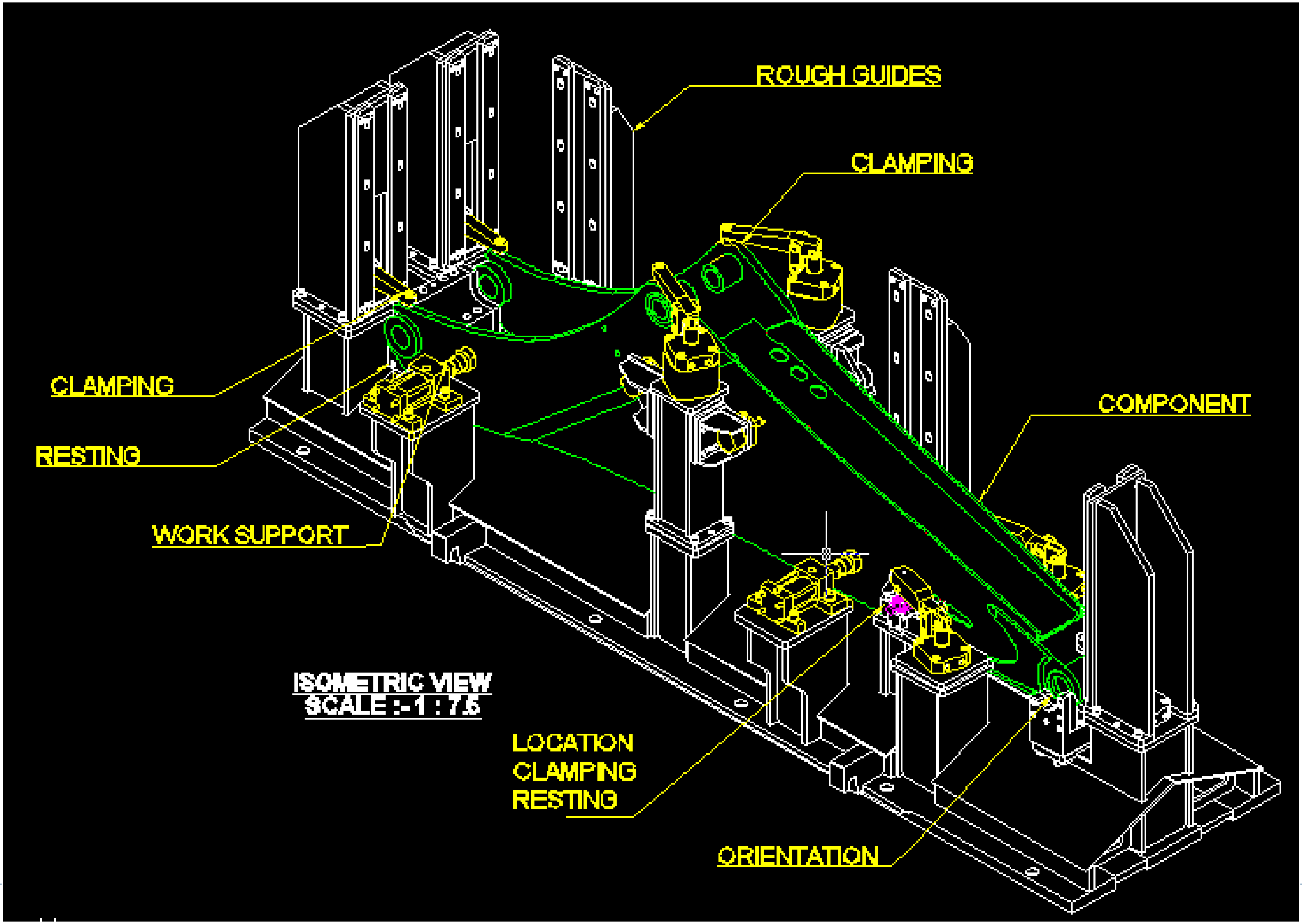
FIXTURE FOR AEROSPACE
COMPONENT- STANCHSION FITTING
MACHINE- VMC
OPERATION- DRILLING/MILLING/BORING



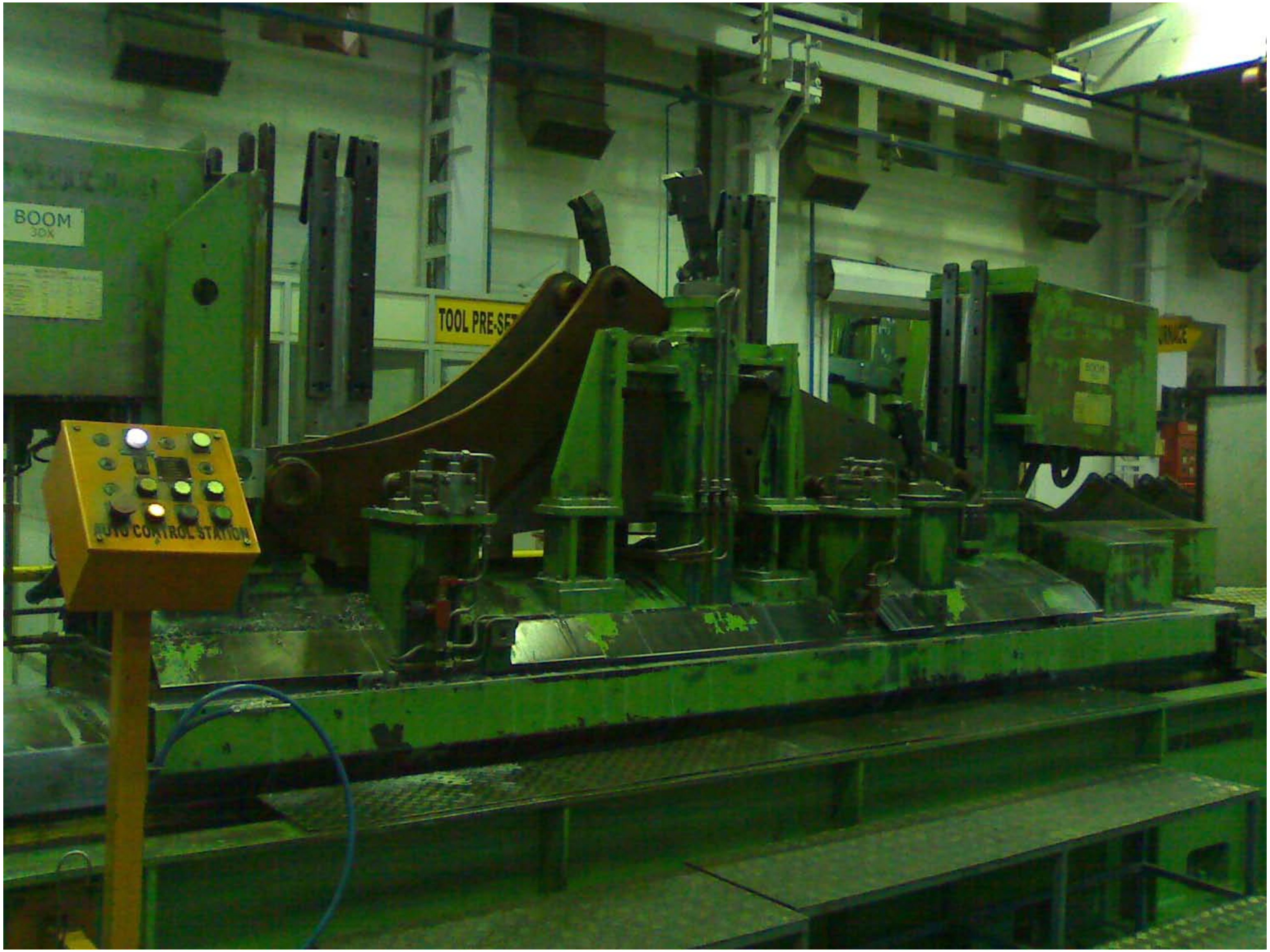
Hydraulic Fixture for Crank Case



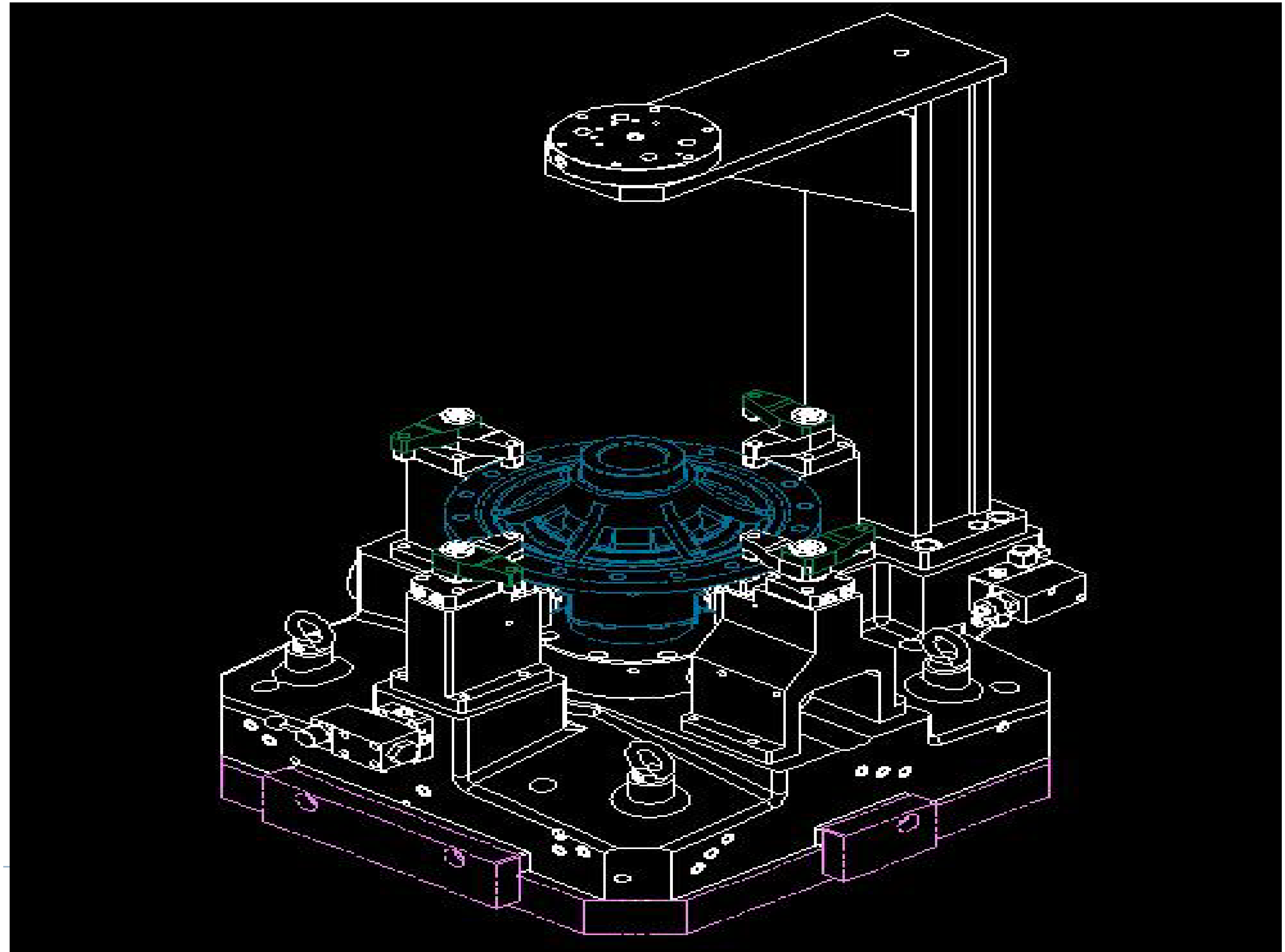
CUSTOMER- JCB
MACHINE- 2 WAY HMC
COMPONENT- DIPPER
OPERATION- ROUGH & FINISH BORING



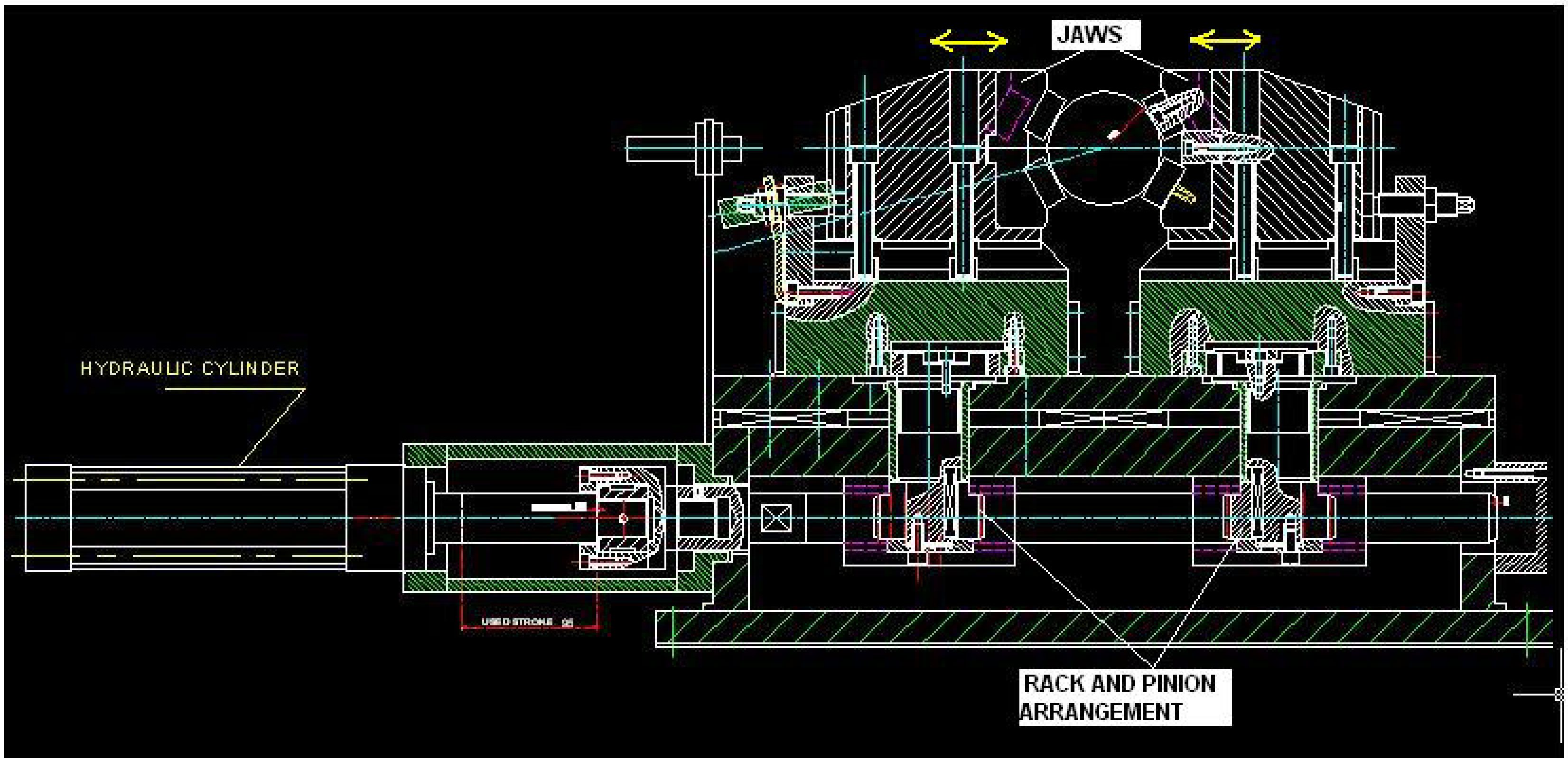
ACTUAL PHOTO OF FIXTURE- DIPPER JCB INDIA LTD



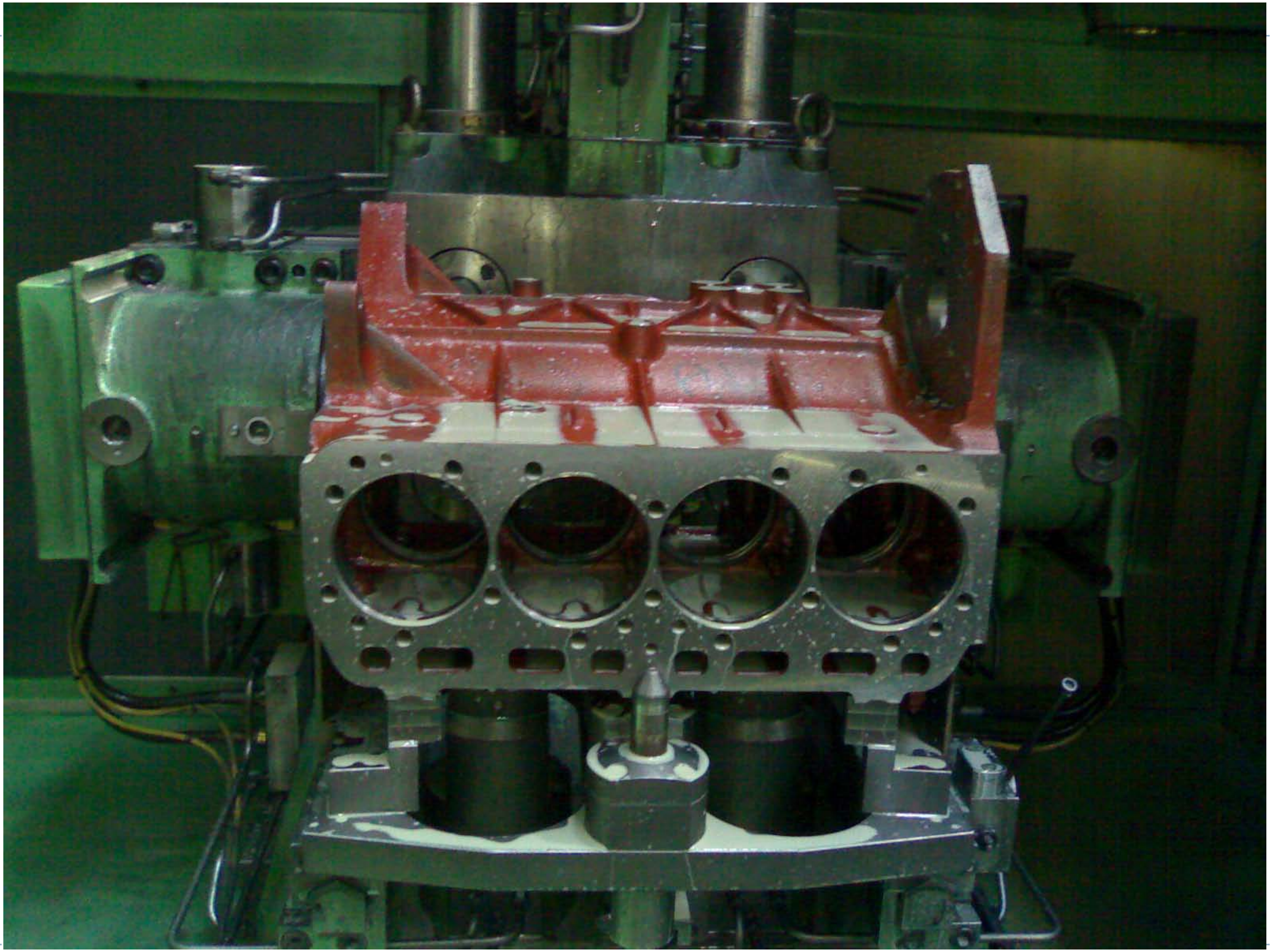
CUSTOMER- TML
MACHINE- HMC
COMPONENT- DIFFERENTIAL CASE COVER
OPERATION- ROUGH & FINISH BORING



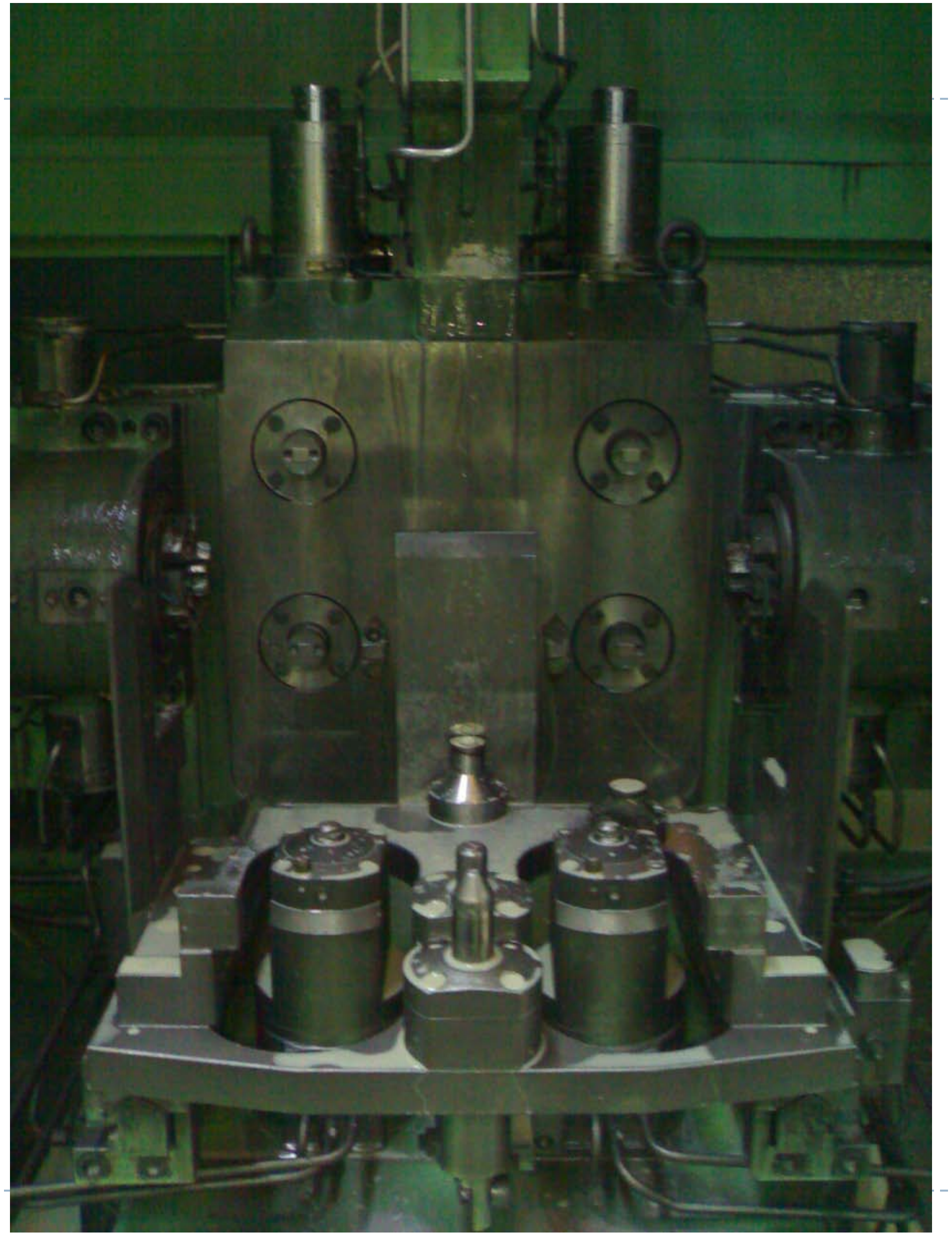
CUSTOMER- TATA MOTOR
MACHINE-HMC
COMPONENT- NANO CRANKSHAFT
OPERATION- FACEING AND CENTRING



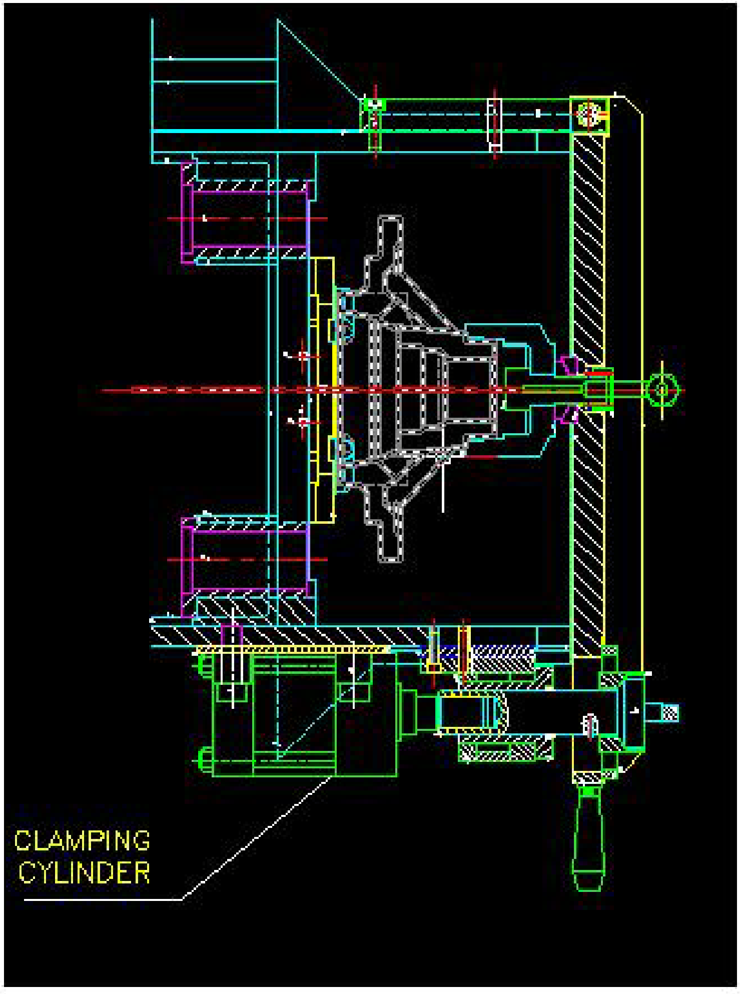
FIXTURE FOR- CYLINDER BLOCK
MACHINE – HMC
OPERATIONS- FINISH MILLING AND BARREL BORING



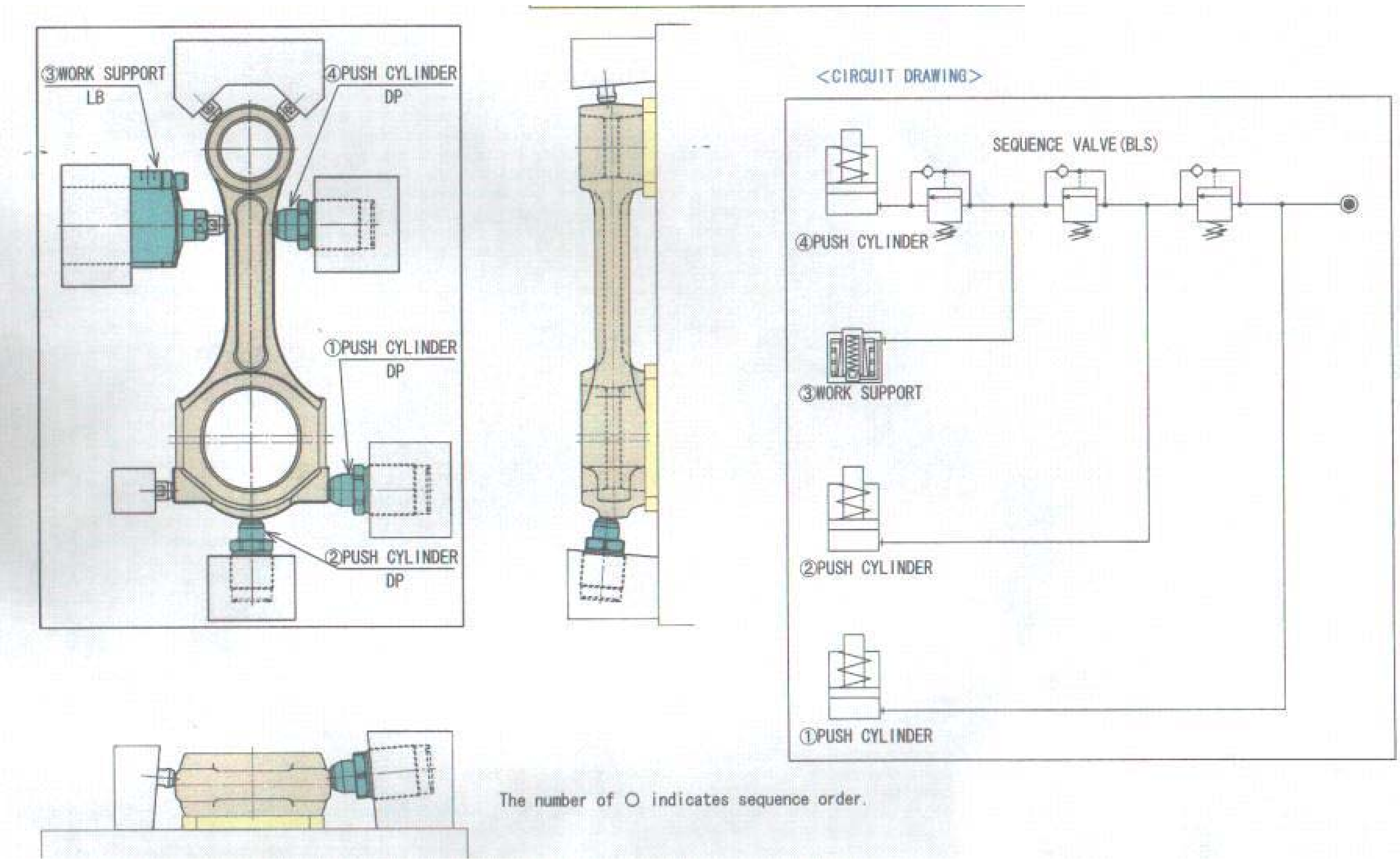
FIXTURE FOR CYLINDER BLOCK



CUSTOMER- HEAVY AXIAL TATA MOTORS
COMPONENT- DIFFERENTIAL HOUSING
OPERATION- SPHERICAL TURNING



CONNECTING ROD FIXTURE 1

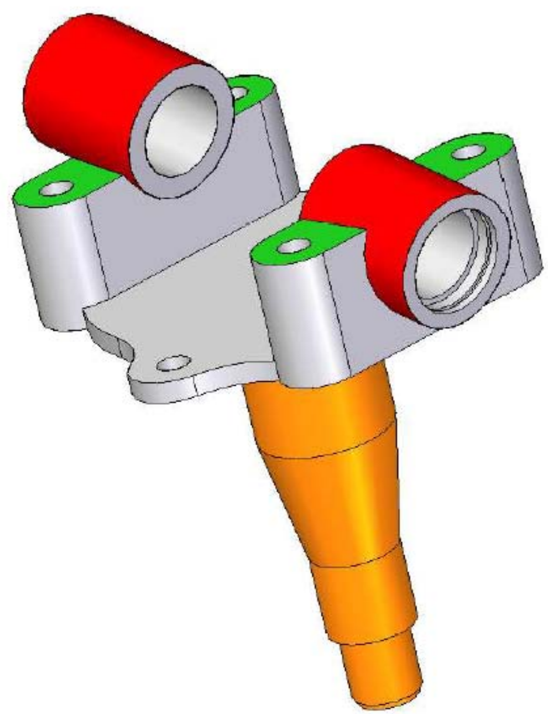


The number of ○ indicates sequence order.

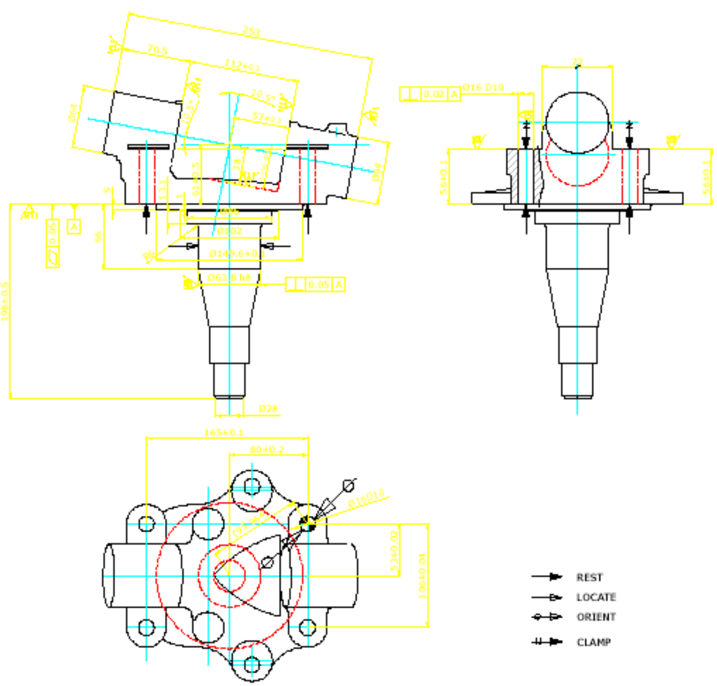
COMPONENT

STUB

AXLE



PRE MACHINED CONDITION OF COMPONENT

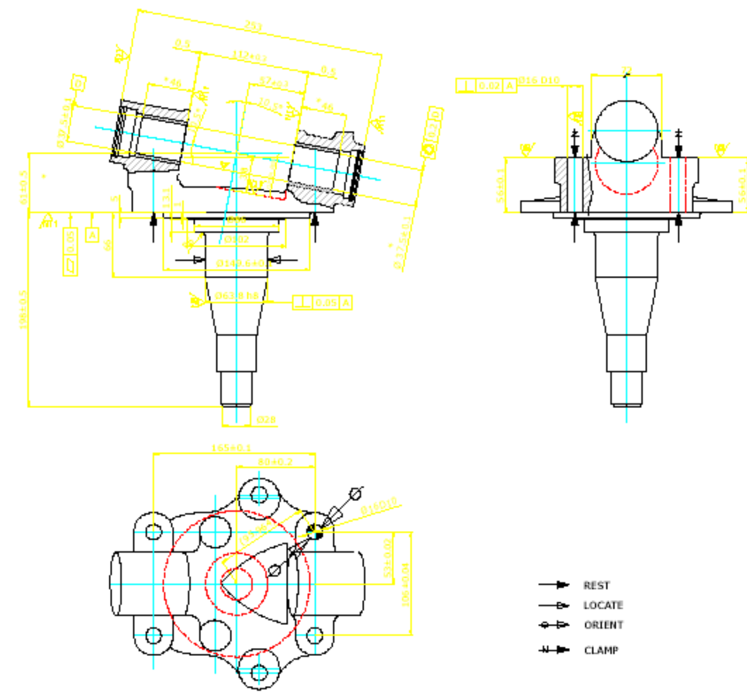


SET UP - I

COMPONENT : STUB AXLE
COMPONENT NO : 2575
MATERIAL : 42 Cr4 Mo2, SS 4027 T 14, 90-105

OPERATIONS TO BE DONE IN SET UP -I (PARENT BORING)

1. U DRILLING 42Ø FROM SOLID GPL = 200
2. SEMIFINISH 43.7Ø & 50 DIA (DIIFERNCE BETWEEN TWO INSERTS IS 63 mm) GPL = 200
3. GROOVING 53 ØH12 WITH 60° Chamfer GPL = 135
4. CHAMFERING 1.5 X30° FOR 50Ø ONLY ON ONE SIDE GPL = 125
5. FINISH BORING OF 44ØJs9 FROM 43.7Ø±0.1 GPL = 200



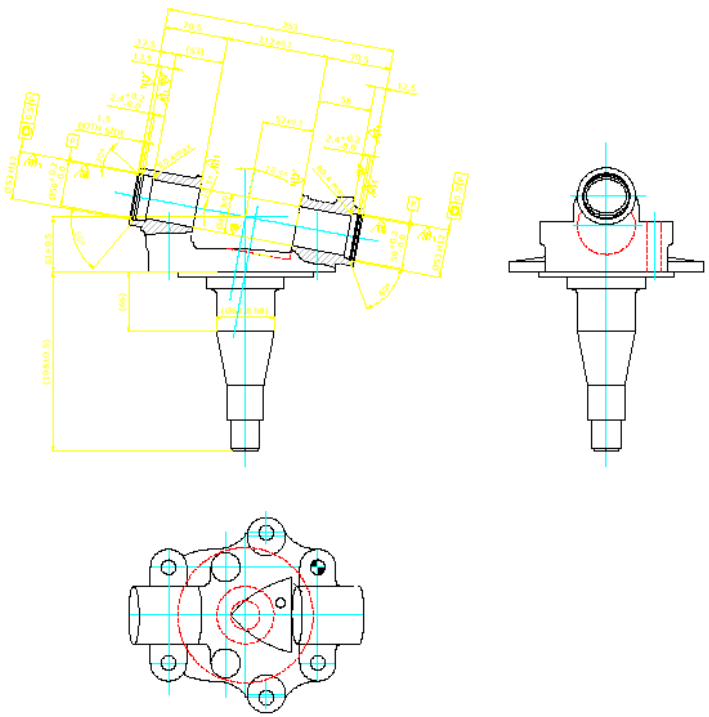
SET UP - II

COMPONENT : STUB AXLE WITH BUSH
BUSH DIMENSIONS
BUSH MATERAIL : ALBZ10REF6S or ALBZF6

OPERATIONS TO BE DONE IN SET UP -II (BUSH BORING)

1. FINISH BUSH BORING 38.25ØF8 FROM 37.5Ø±0.1 GPL = 200 (BY INDEXING)
   ALTERNATE BUSH BORING 38.25ØF8 FROM 37.5±0.1 GPL = 300 (FROM ONE SIDE)
2. FINISH GAP MILLING 113 +0.3 (250 Ø Cutter) GPL = 220

POST MACHINED CONDITION OF COMPONENT

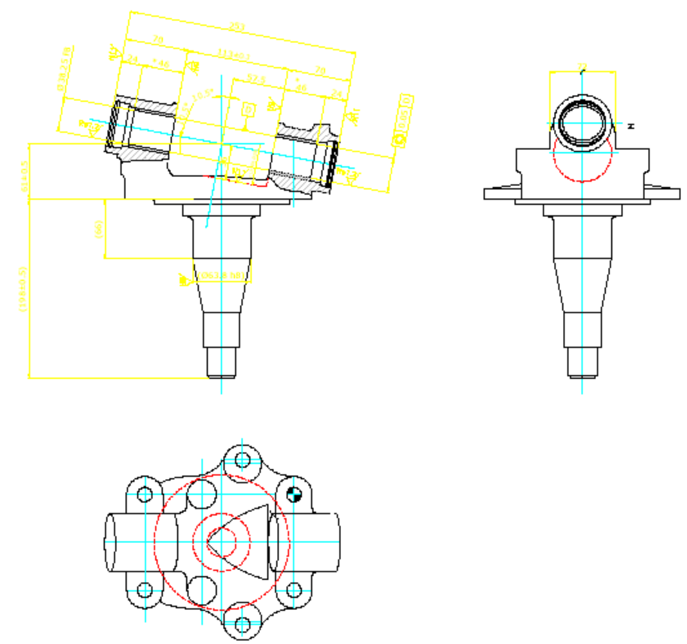


SET UP - I

COMPONENT : STUB AXLE
COMPONENT NO : 2575
MATERIAL : 42 Cr4 Mo2, SS 4027 T 14, 90-105

OPERATIONS TO BE DONE IN SET UP -I (PARENT BORING)

1. U DRILLING 42Ø FROM SOLID GPL = 200
2. SEMIFINISH 43.7Ø & 50 DIA (DIFFERNCE BETWEEN TWO INSERTS IS 63mm) GPL = 200
3. GROOVING 53 ØH12 WITH 60° Chamfer GPL = 135
4. CHAMFERING 1.5 X30° FOR 50Ø GPL = 125
5. FINISH BORING OF 44Ø Js9 FROM 43.7 DIA GPL = 200



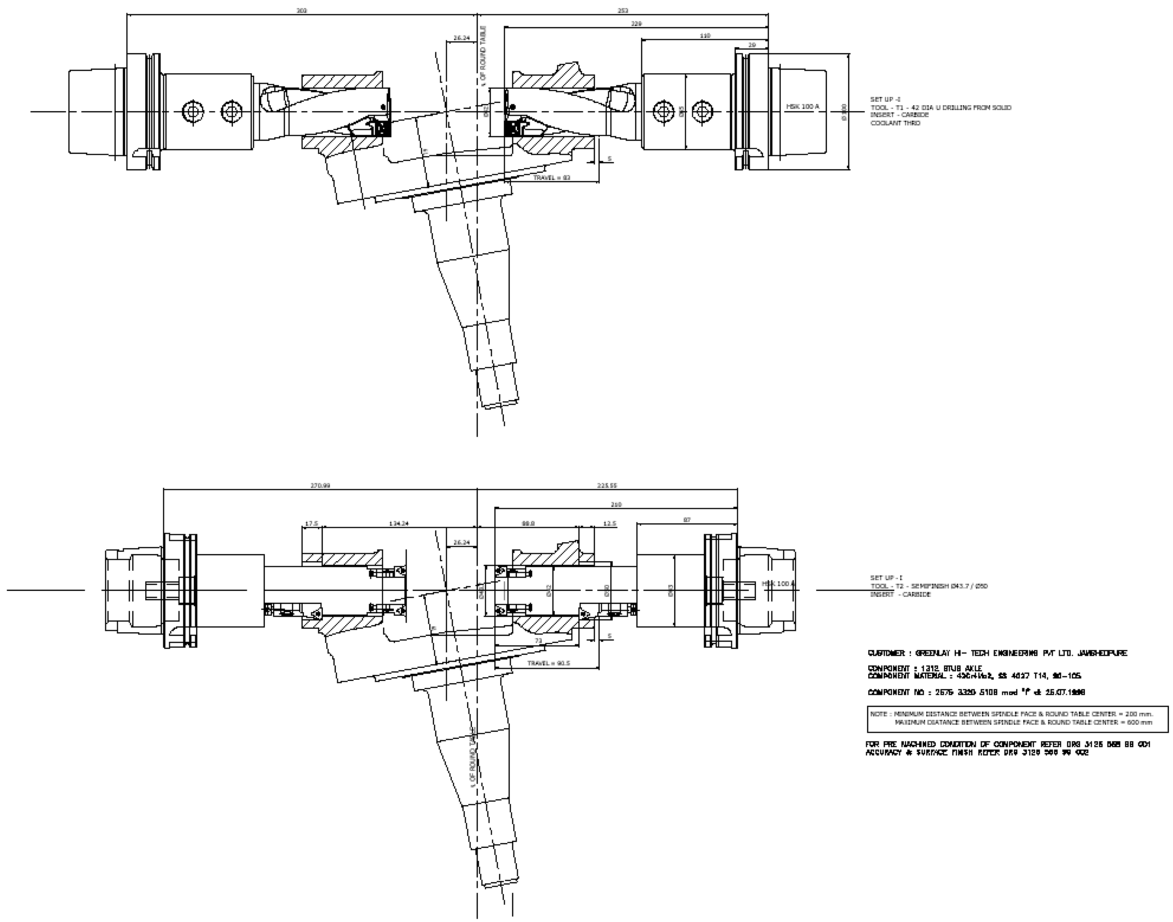
SET UP - II

COMPONENT : STUB AXLE WITH BUSH
BUSH DIMENSIONS
BUSH MATERAIL : ALBZ10REF6S or ALBZF6

OPERATIONS TO BE DONE IN SET UP -II (BUSH BORING)

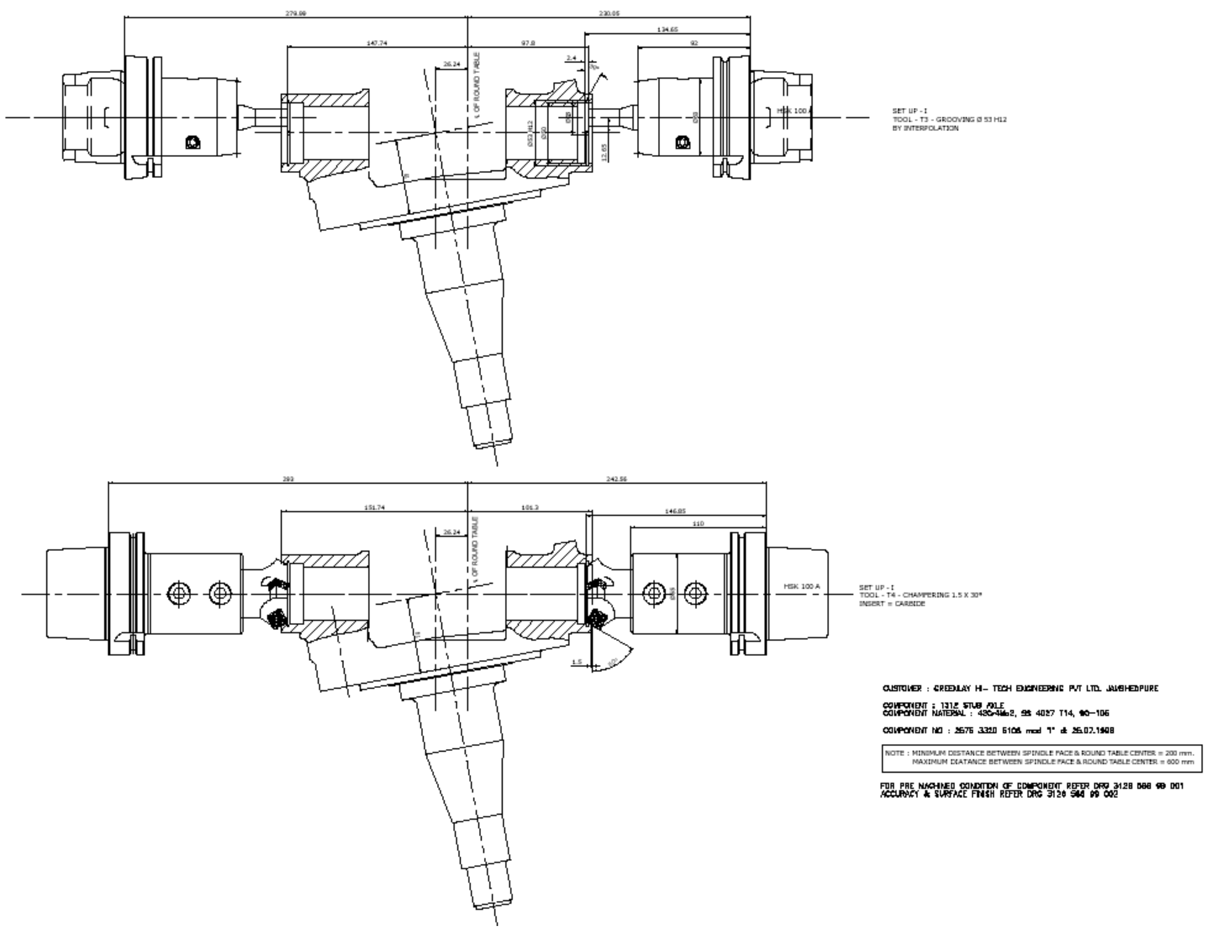
1. FINISH BUSH BORING 38.25ØF8 GPL = 200 (BY INDEXING)
   ALTERNATE BUSH BORING 38.25ØF8 GPL = 300 (FROM ONE SIDE)
2. FINISH GAP MILLING 113 +0.3 (250 Ø Cutter) = 220

TOOL LAYOUT



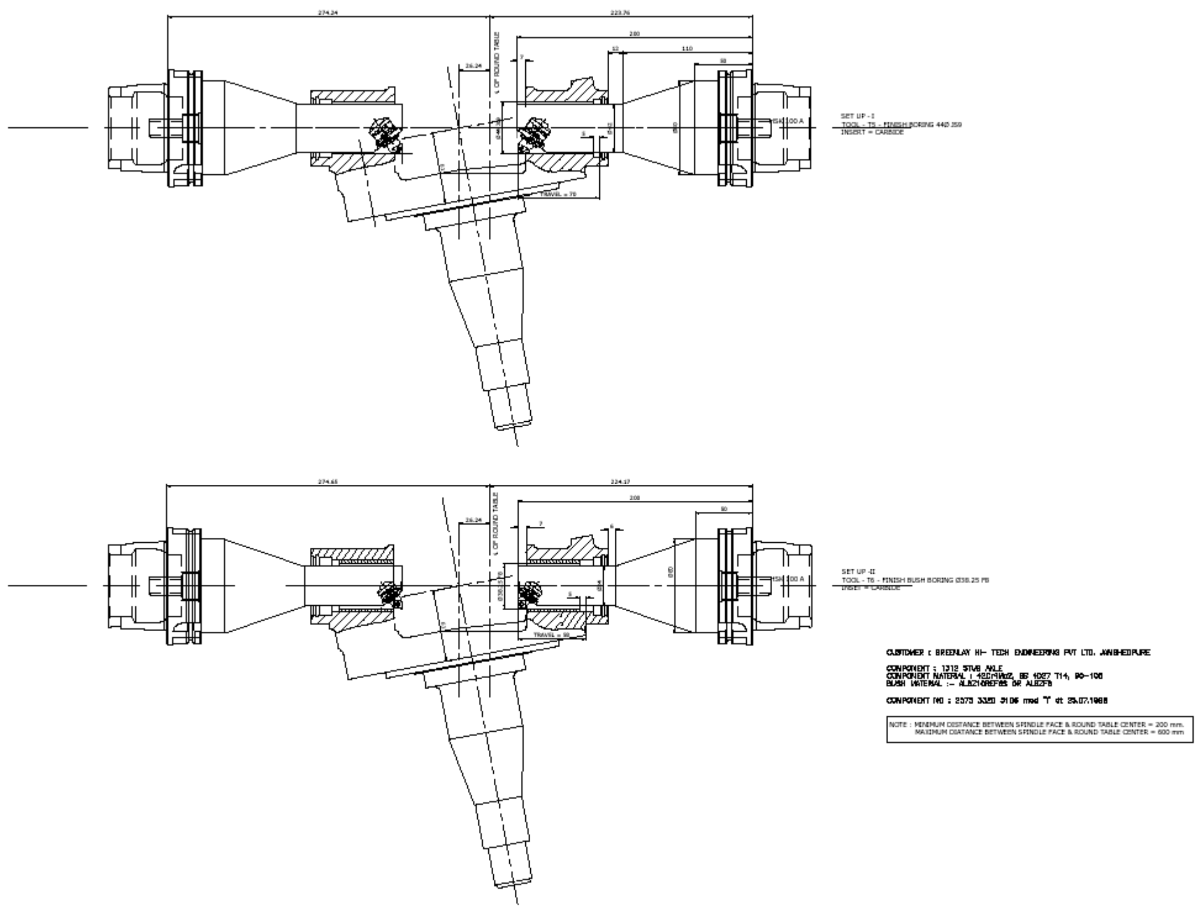
SET UP - I
TOOL - T1 - 42 DIA U DRILLING FROM SOLID
INSERT - CARBIDE
COOLANT THRO
TRAVEL = 83
HSK 100 A
SET UP - I
TOOL - T2 - SEMIFINISH Ø43.7 / Ø50
INSERT - CARBIDE
TRAVEL = 90.5
CUSTOMER : GREENLAY HI- TECH ENGINEERING PVT LTD. JAMSHEDPURE
COMPONENT : 1312 STUB AXLE
NOTE : MINIMUM DISTANCE BETWEEN SPINDLE FACE & ROUND TABLE CENTER = 200 mm.
MAXIMUM DIATANCE BETWEEN SPINDLE FACE & ROUND TABLE CENTER = 600 mm

TOOL LAYOUT

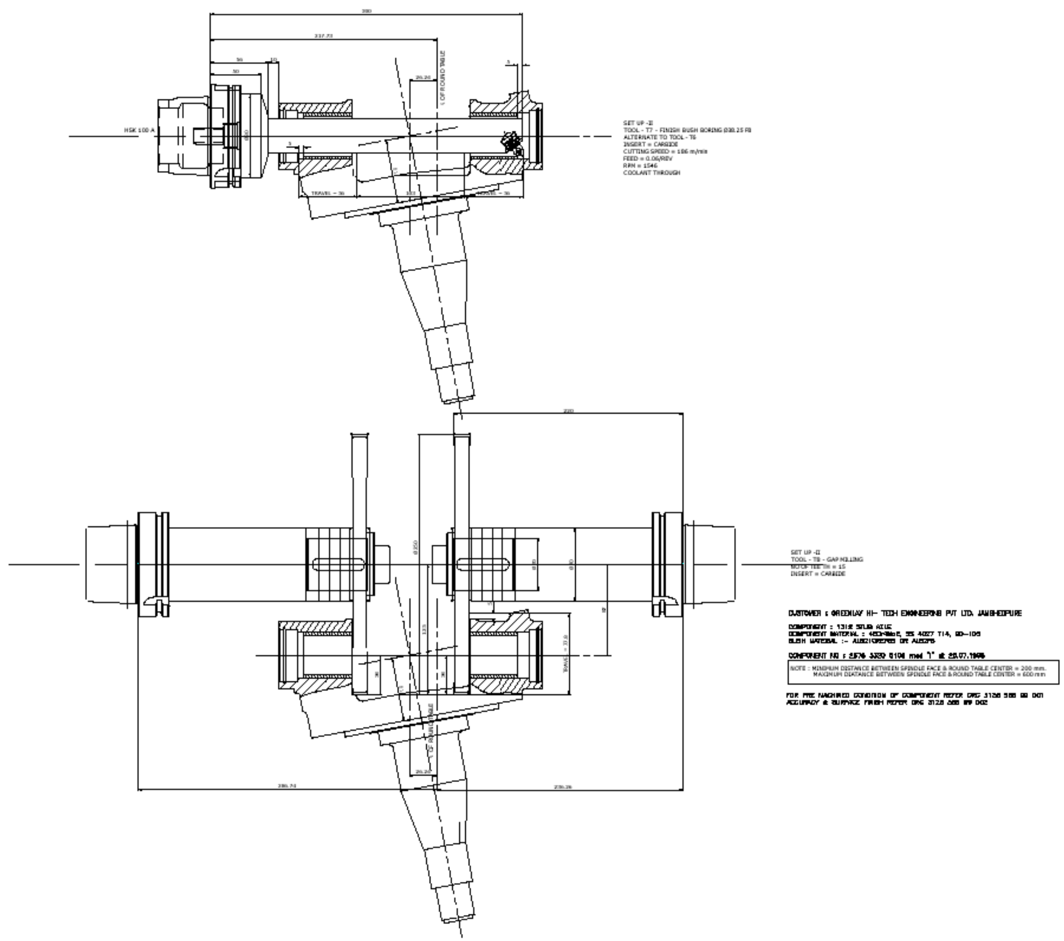


HSK 100 A
SET UP - I
TOOL - T3 - GROOVING Ø 53 H12
BY INTERPOLATION
SET UP - I
TOOL - T4 - CHAMFERING 1.5 X 30°
INSERT = CARBIDE
CUSTOMER : GREENLAY HI- TECH ENGINEERING PVT LTD. JAMSHEDPURE
COMPONENT : 1312 STUB AXLE
NOTE : MINIMUM DISTANCE BETWEEN SPINDLE FACE & ROUND TABLE CENTER = 200 mm.
MAXIMUM DIATANCE BETWEEN SPINDLE FACE & ROUND TABLE CENTER = 600 mm

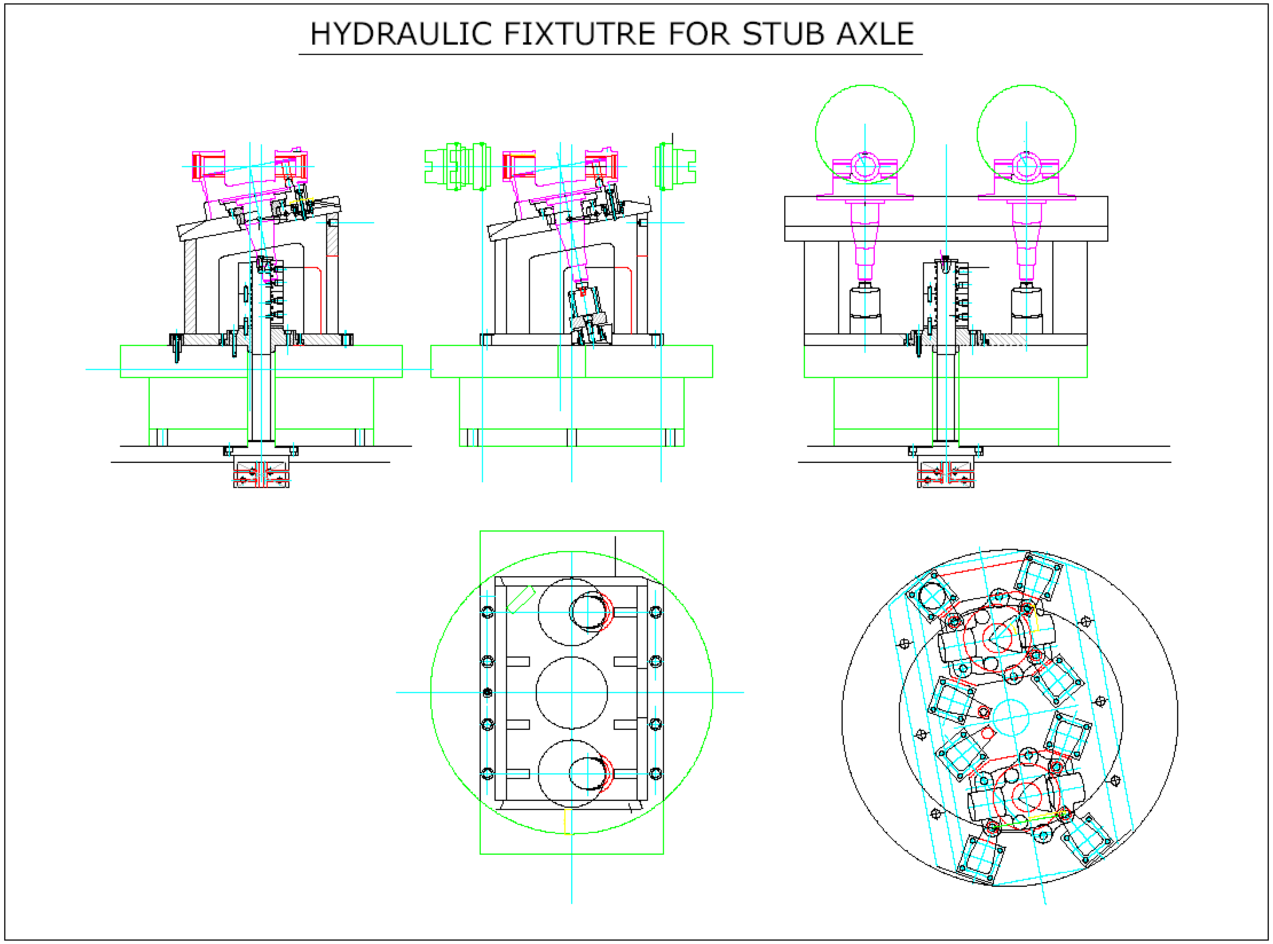
TOOL LAYOUT


274.24
223.76
280
12
110
88
26.24
℄ OF ROUND TABLE
TRAVEL = 70
SET UP - I
TOOL - T5 - FINISH BORING 44Ø J59
INSERT = CARBIDE
274.65
224.17
208
90
26.24
℄ OF ROUND TABLE
TRAVEL = 50
SET UP -II
TOOL - T6 - FINISH BUSH BORING Ø38.25 F8
CUSTOMER : BREENLAY HI- TECH ENGINEERING PVT LTD. JAMSHEDPURE
COMPONENT : 1312 STUB AXLE
NOTE : MINIMUM DISTANCE BETWEEN SPINDLE FACE & ROUND TABLE CENTER = 200 mm.
MAXIMUM DISTANCE BETWEEN SPINDLE FACE & ROUND TABLE CENTER = 600 mm

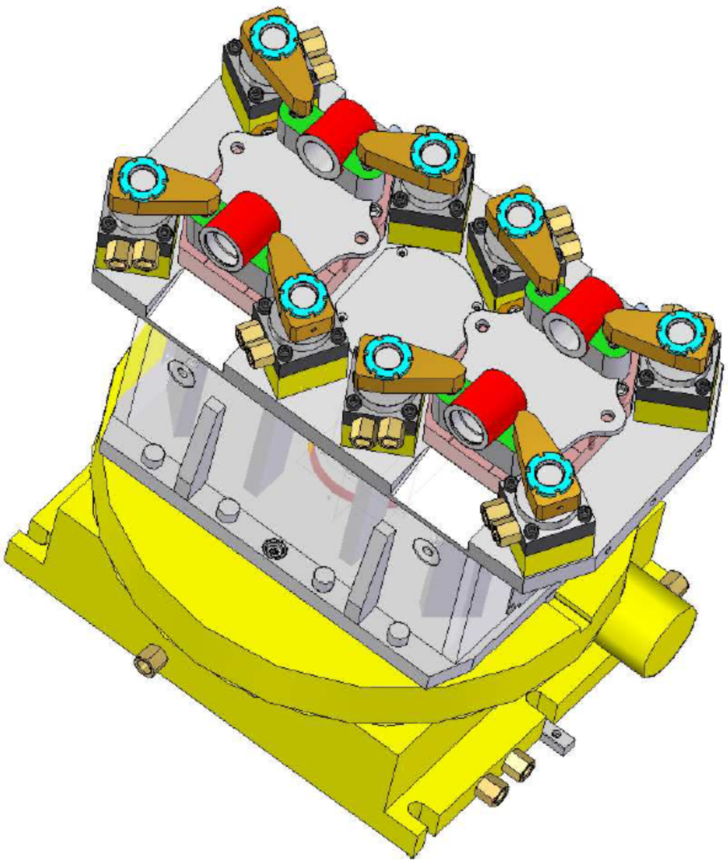
TOOL LAYOUT


SET UP -II
TOOL - T7 - FINISH BUSH BORING Ø38.25 F8
ALTERNATE TO TOOL - T6
INSERT = CARBIDE
CUTTING SPEED = 186 m/min
FEED = 0.06/REV
RPM = 1546
COOLANT THROUGH
SET UP -II
TOOL - T8 - GAP MILLING
INSERT = CARBIDE
NOTE : MINIMUM DISTANCE BETWEEN SPINDLE FACE & ROUND TABLE CENTER = 200 mm.
MAXIMUM DISTANCE BETWEEN SPINDLE FACE & ROUND TABLE CENTER = 600 mm

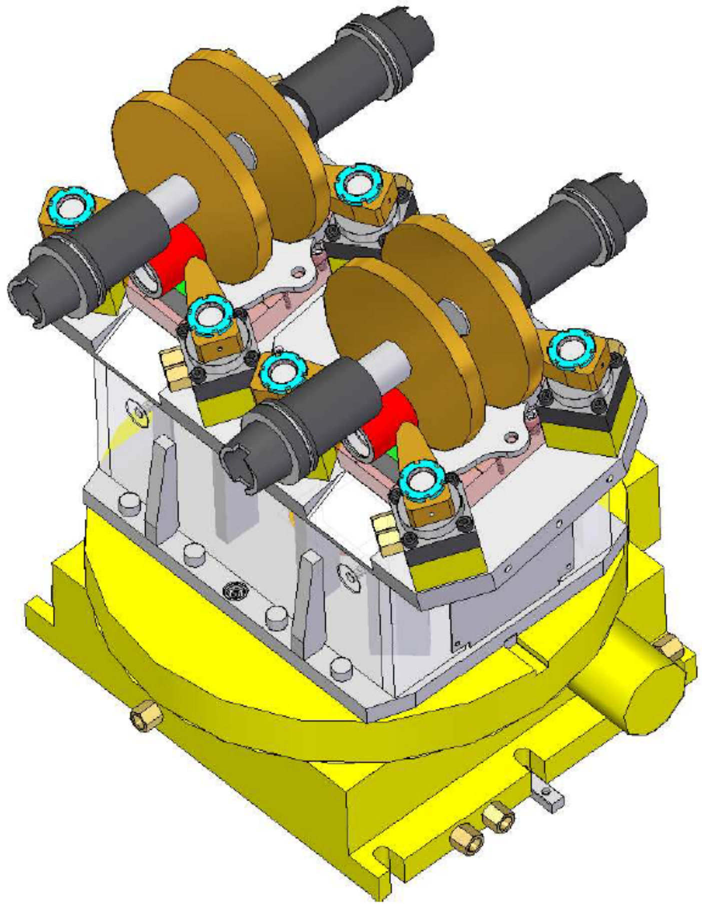
FIXTURE FOR STUB AXLE



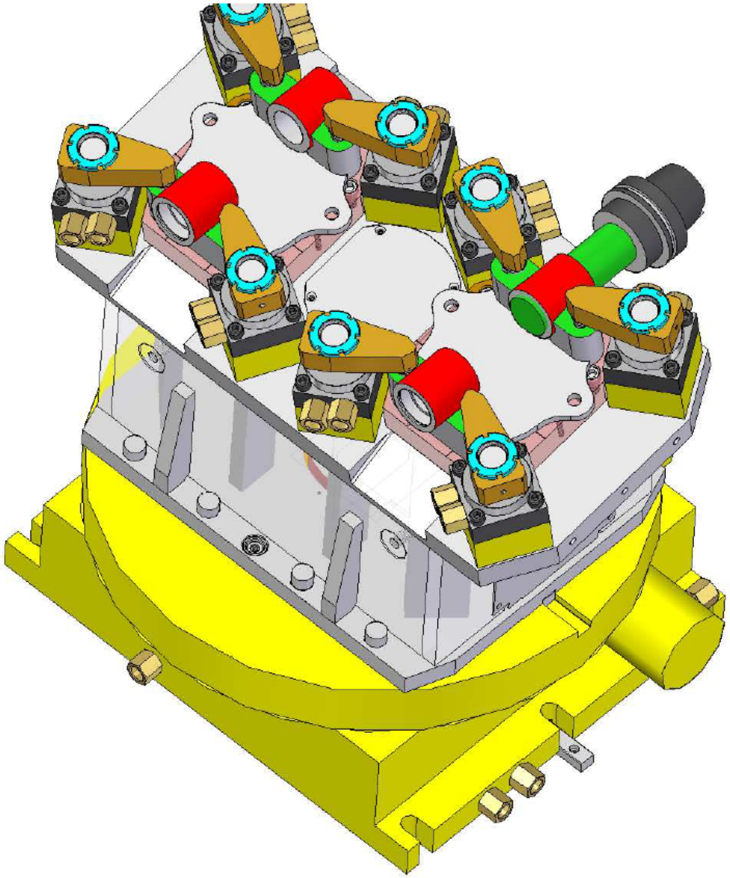
3D OVERVIEW



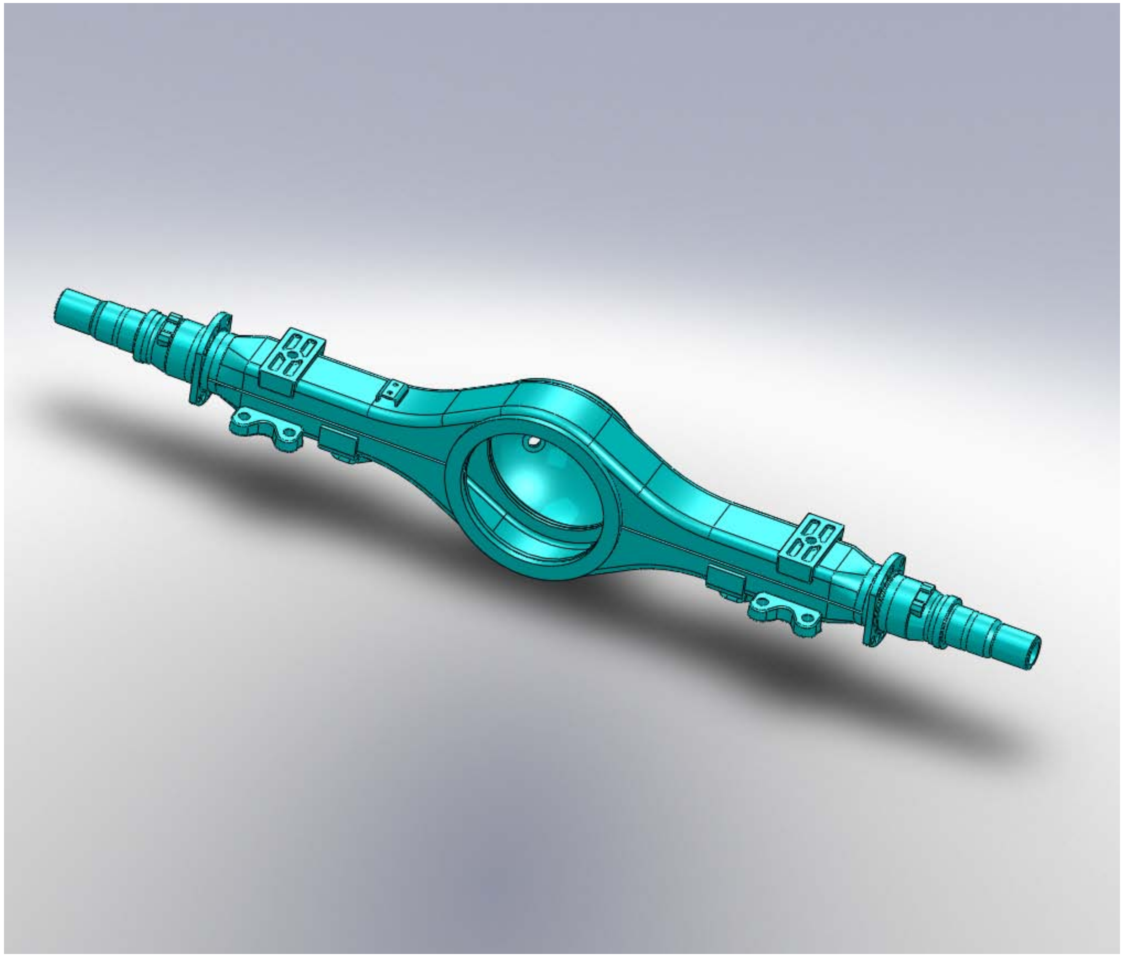
FIXTURE WITH TOOLS (GAP MILLING)



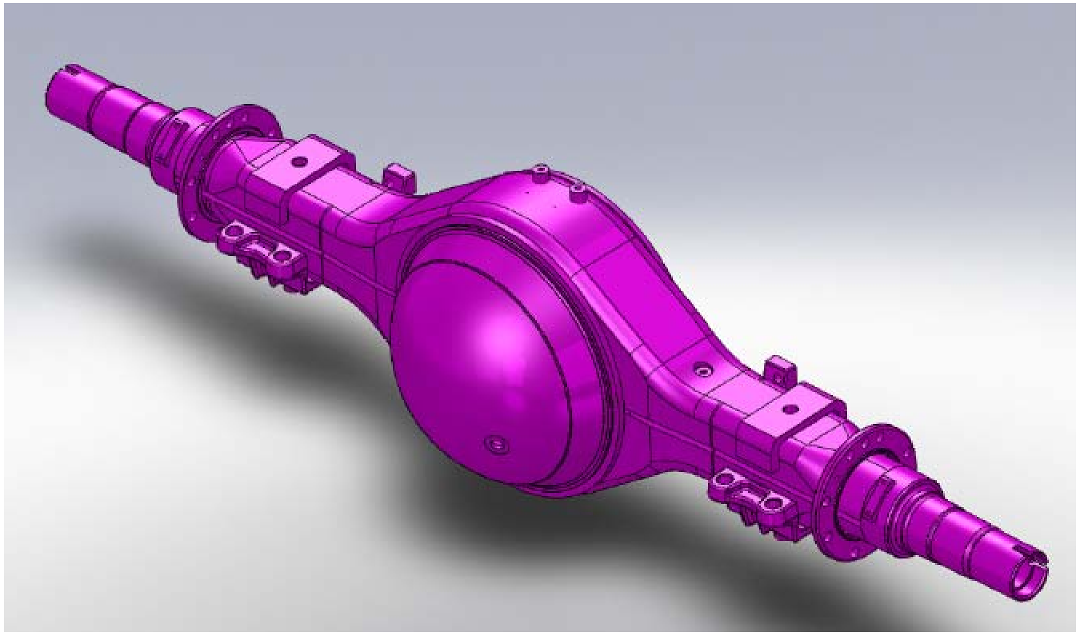
FIXTURE WITH TOOL (U-DRILLING)



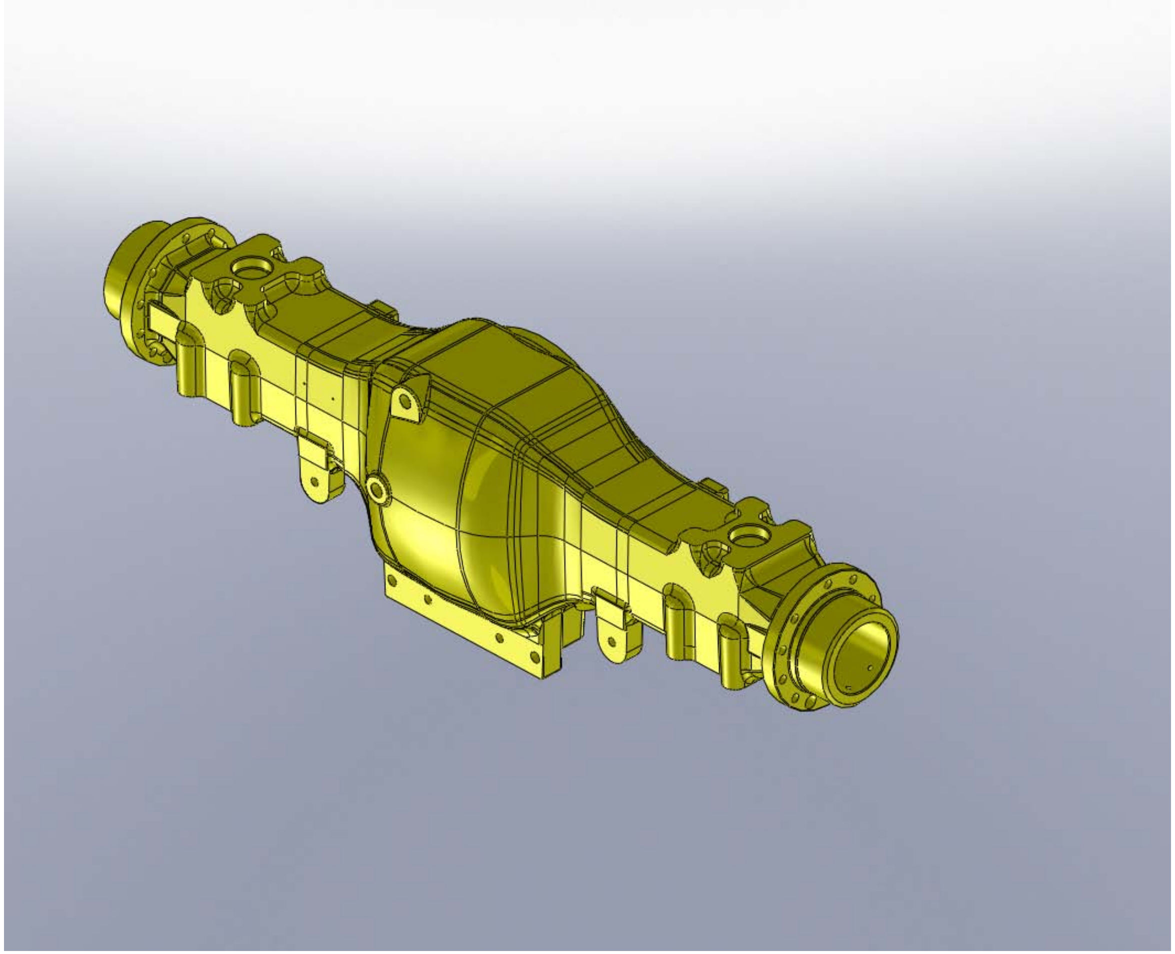
FIXTURE FOR BANJAO BEAMS



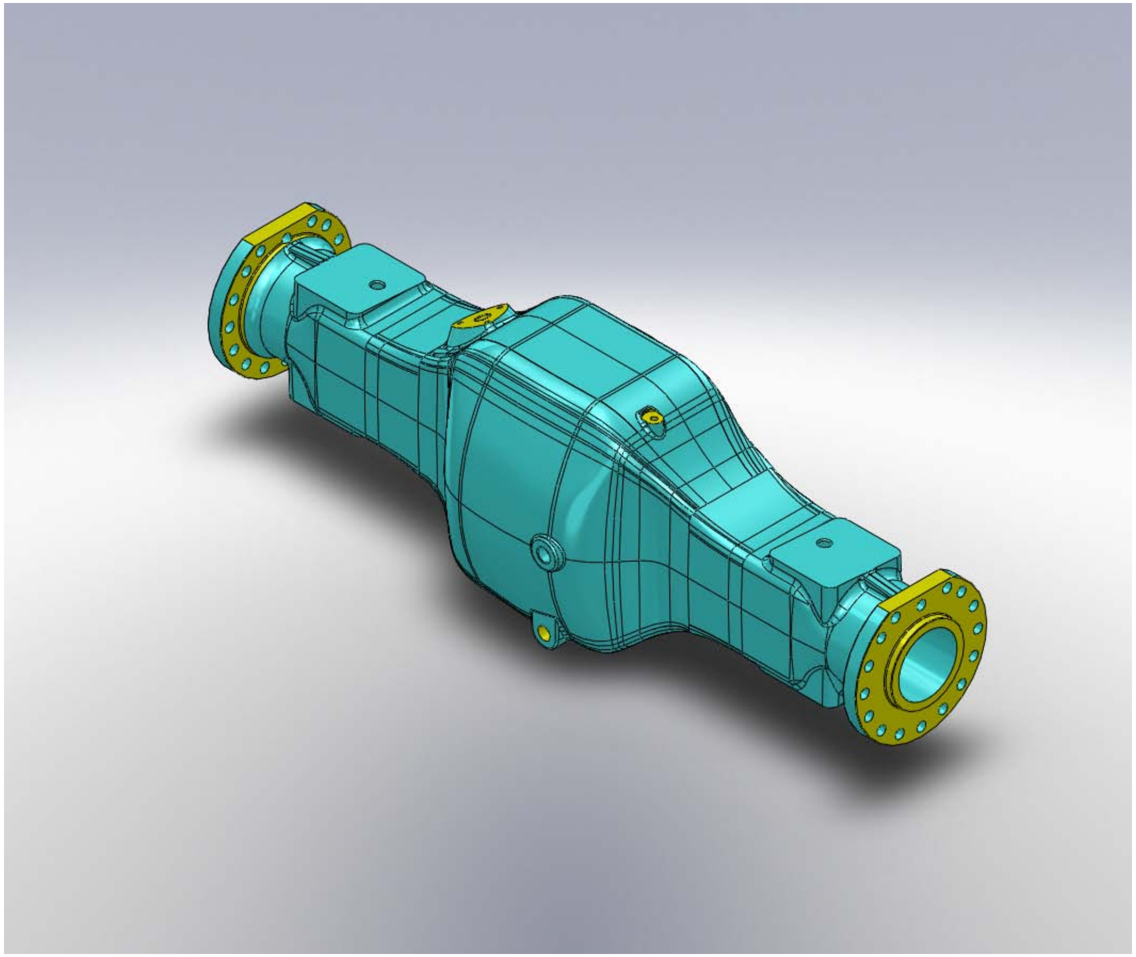
COMPONENT



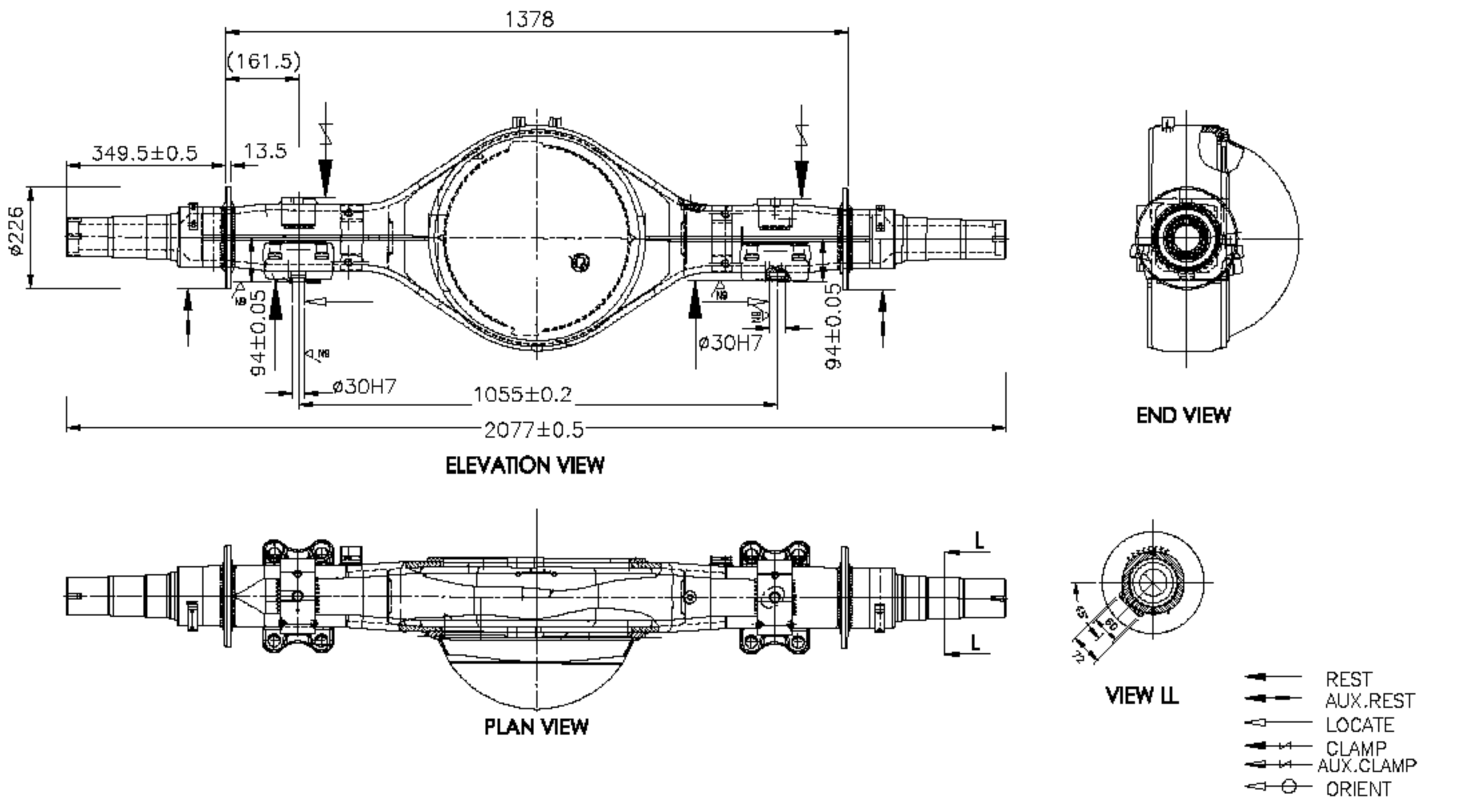
COMPONENT



COMPONENT

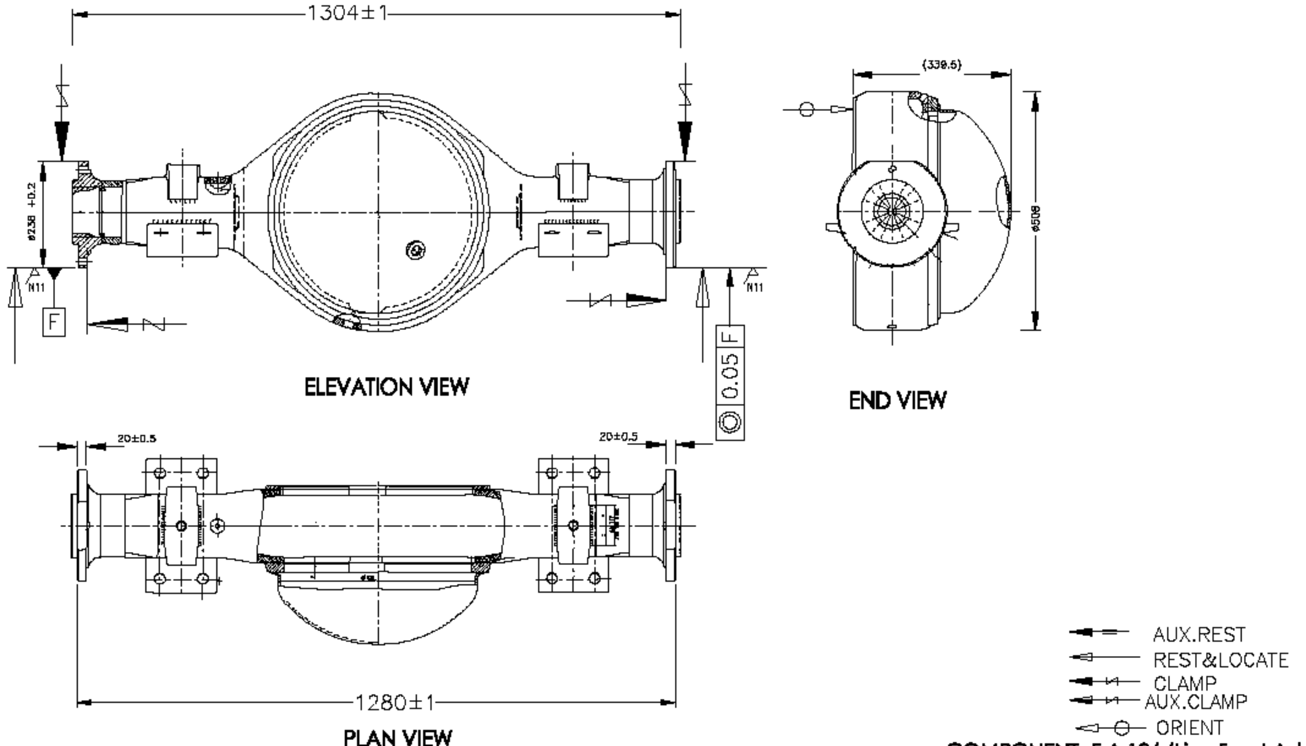


PREMACHINED CONDITION OF COMPONENT



COMPONENT -R A 109RR
DRAWING NO. :- 273235100431
MATERIAL : Fe540B/ Fe590B

PREMACHINED CONDITION OF COMPONENT

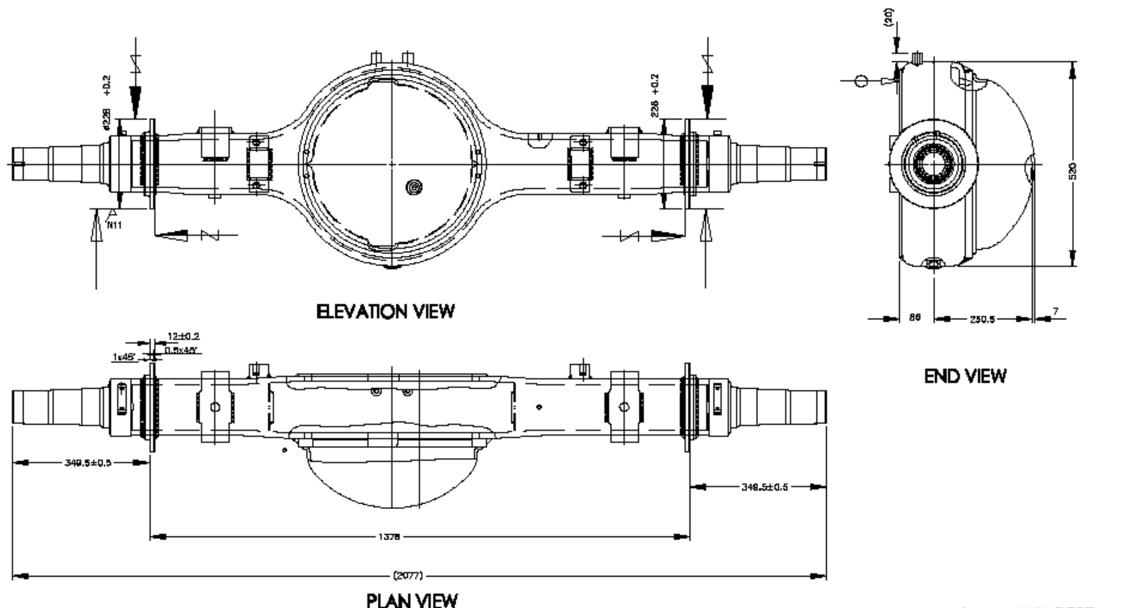


COMPONENT -F A 106 (Live Front Axle)
DRAWING NO. :- 273733150109

COMPONENT PRE MACHINED CONDITION DIMENSION MATRIX FOR BANJO BEAM

Sr No.	Comp Discription	Model No.	Drg No.	Comp. Length	Flange OD	Dist Between Flanges	Flange Position from End	Flange Thickness
1	FRT Axle Beam	FA207	5802 3315 01 02	1304	Ø238 +0.2	1280	12	20±0.5

PREMACHINED CONDITION OF COMPONENT



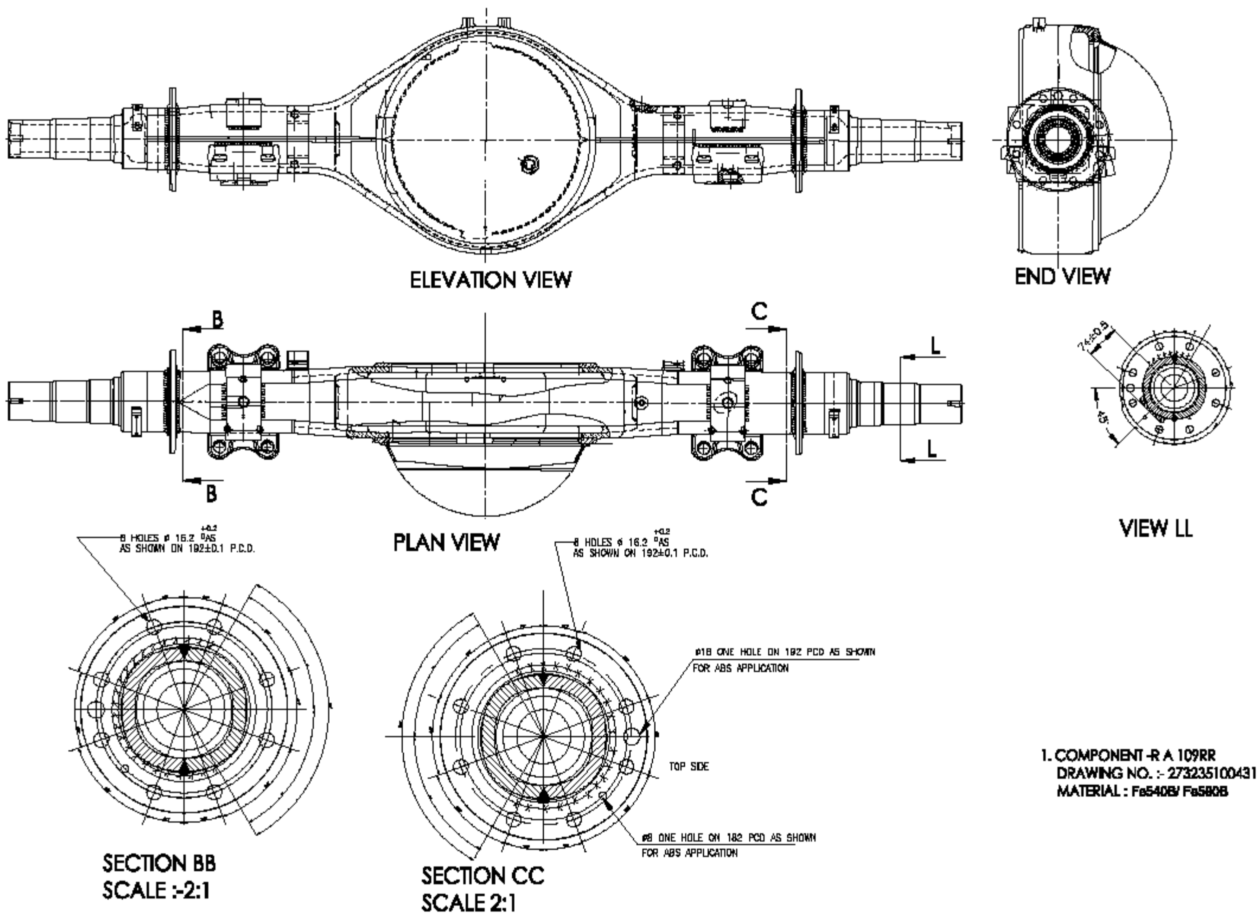
COMPONENT PRE MACHINED CONDITION DIMENSION MATRIX FOR BANJO BEAM (LOCATION ON FLANGE OD)

Sr No.	Comp Discription	Model No.	Drg No.	Comp. Length	Flange OD	Dist Between Flanges	Flange Position from End	Flange Thickness
1	R A Beam	RA1068	5817 3510 01 02	1854±0.5	Ø 170±0.3	1320	267±0.5	11
2	Y1-7.5T R A BEAM	7.5 T-Y1	2661 3510 01 65	1862	Ø 170±0.3	1312	275±0.5	11 -0.5

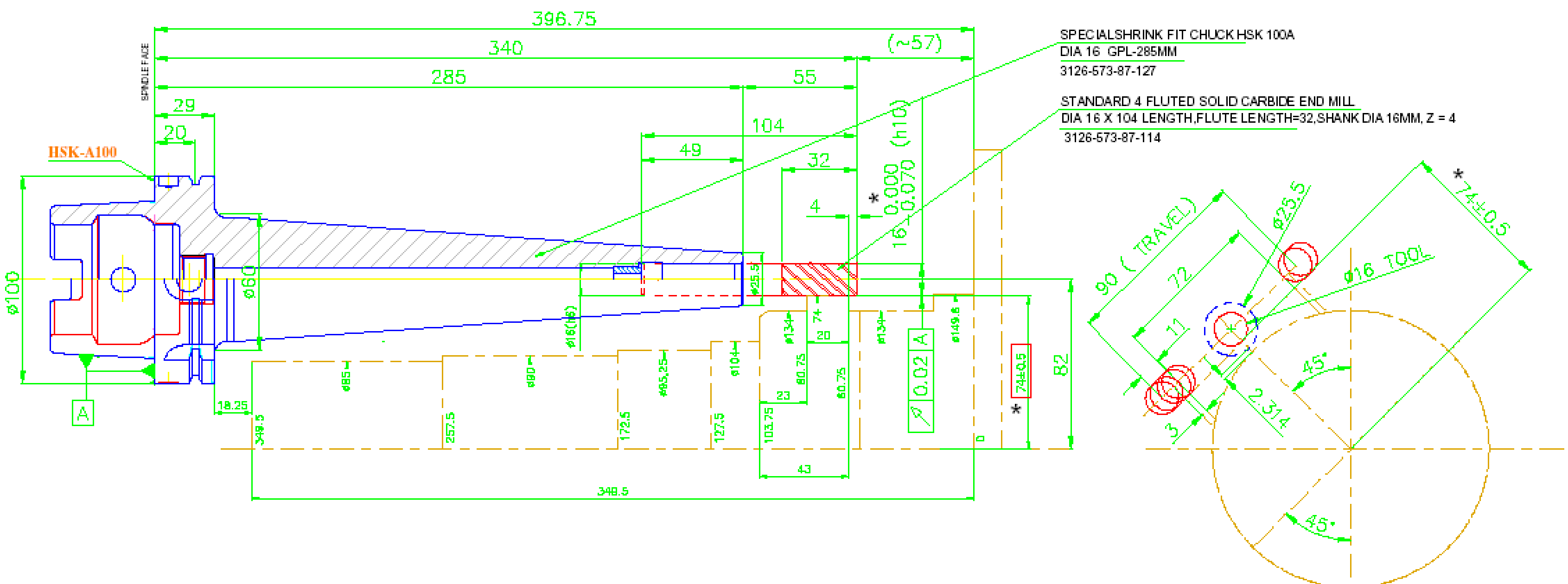
AUX.REST
REST&LOCATE
CLAMP
AUX.CLAMP
ORIENT

COMPONENT -R A 109SRT
DRAWING NO. :- 581035100402

POST MACHINED CONDITION OF COMPONENT



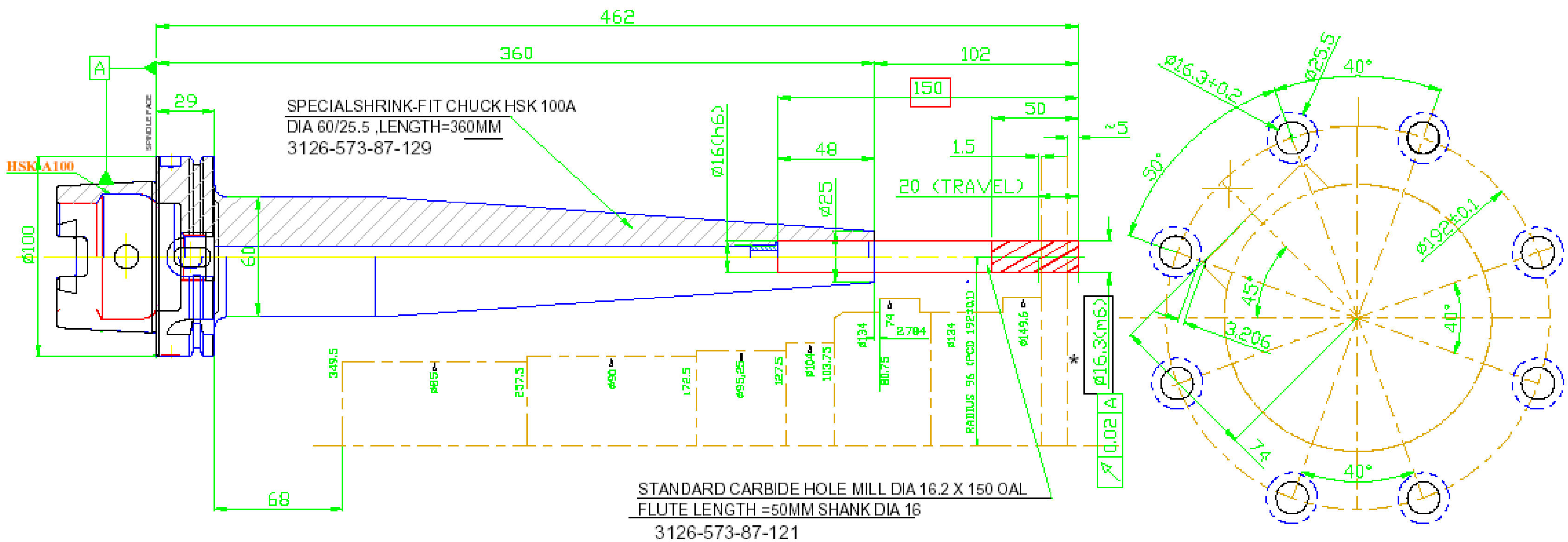
TOOL LAYOUT



T1	74+/−0.5	76	2	EXTERNAL	CARBIDE	80	1592	0.04	0.18	255	90	21.1	2	42
TOOL NO	FINAL DIMN. mm	M/C DIMN mm	M/C ALLOW. mm	COOLANT	TOOL MATL.	CUTTING SPPED m/min	RPM N	TOOTH	REV	MIN	TRAVEL mm	PURE CUTTING TIME SEC	NO OF STRIKES/ HOLES	TOTAL CUTTING TIME SEC
								FEED RATE mm/PER						

OPERATION : END MILLING OF BRACKET
TOOL NO : T1
COMPONENT : - BANJO BEAM RA 109 RR
COMPONENT NO : - 2732 3510 0431
MATERIAL :- Fe 540 B / Fe 590 B

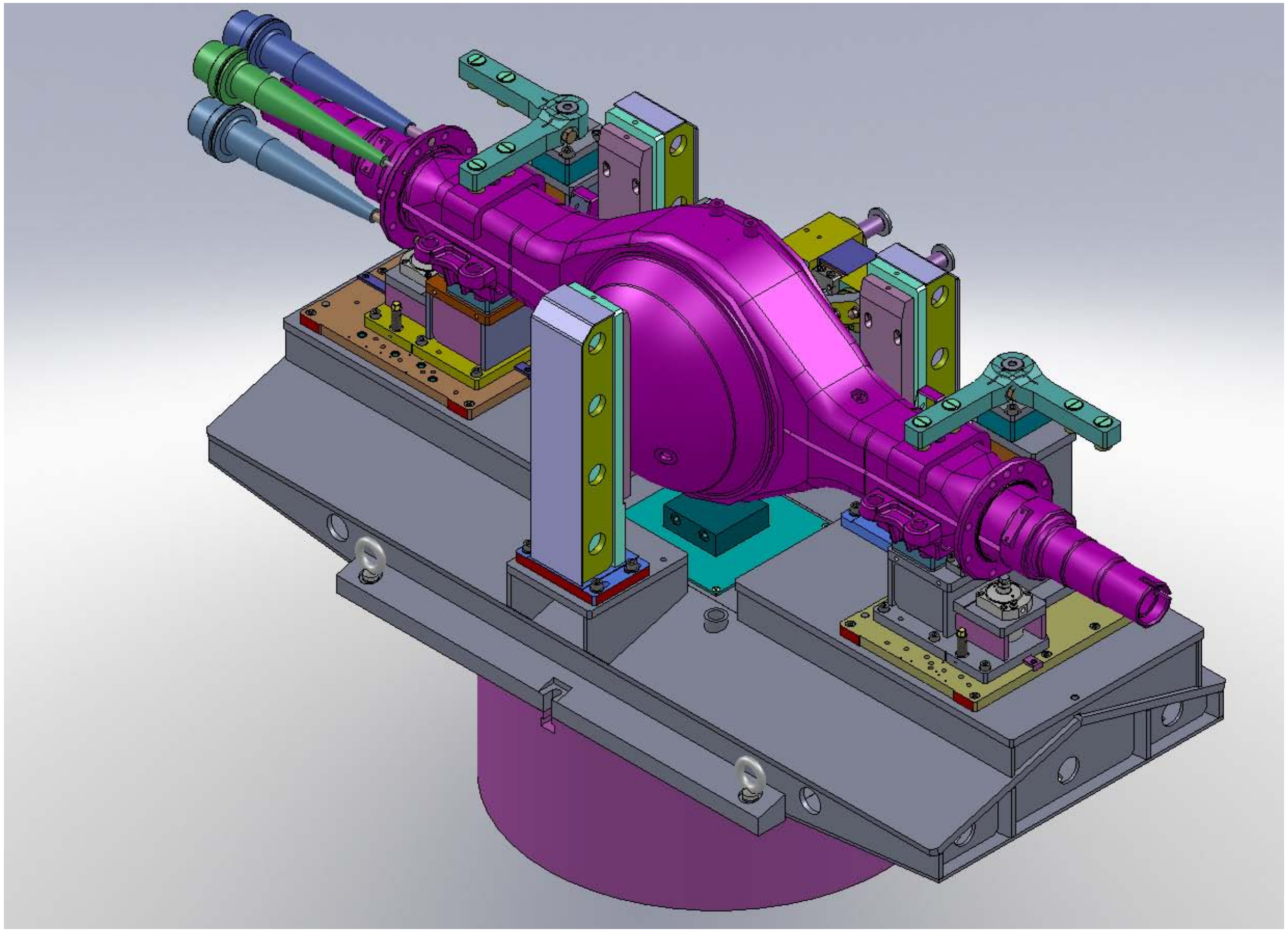
TOOL LAYOUT



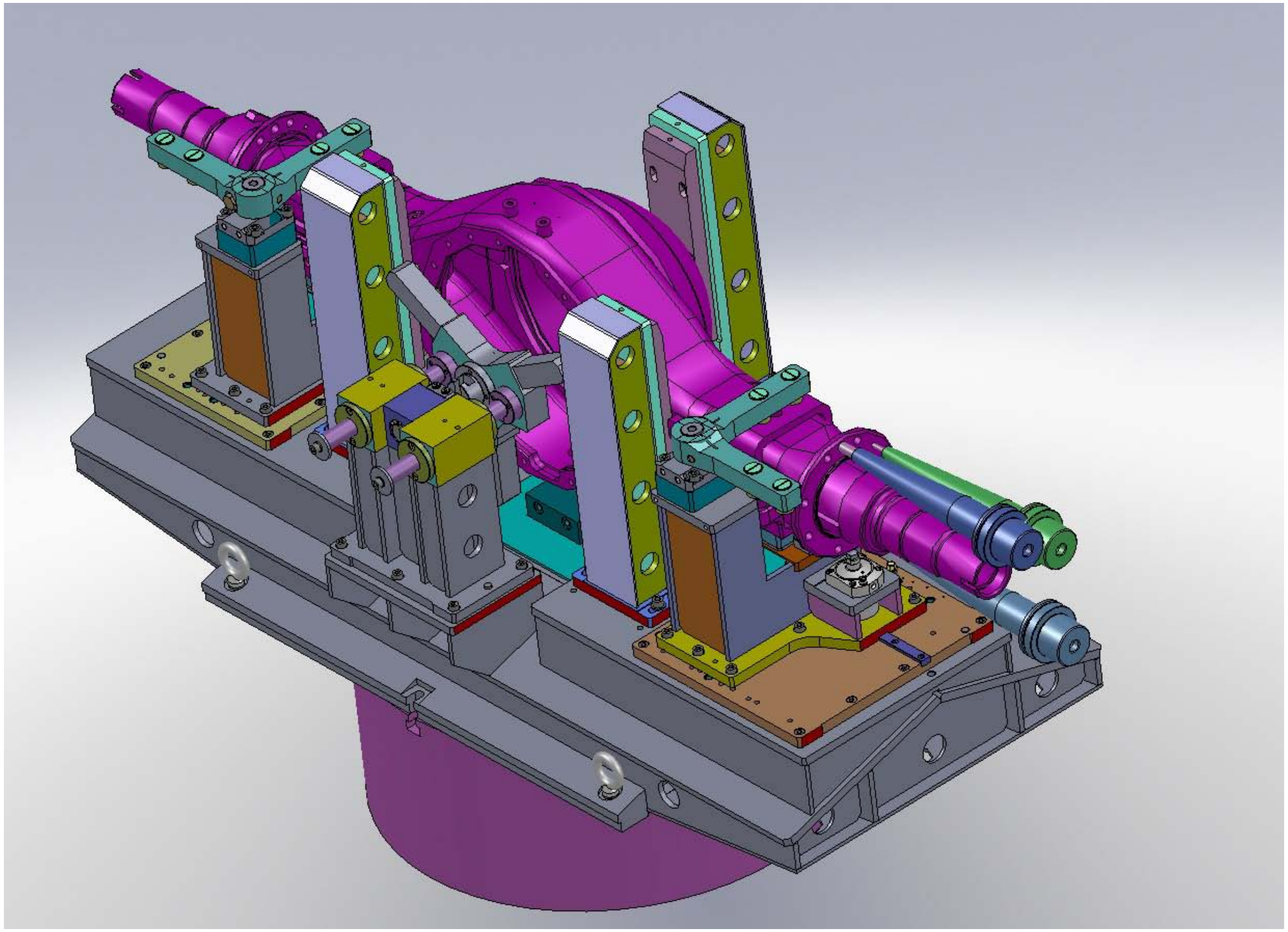
T5	16.2	---	SOLID	EXTERNAL	CARBIDE	40	785	0.053	0.16	126	20	9.5	8X2	152
TOOL NO	FINAL DIMN. mm	M/C DIMN mm	M/C ALLOW. mm	COOLANT	TOOL MATL.	CUTTING SPPED m/min	RPM N	TOOTH	REV	MIN	TRAVEL mm	PURE CUTTING TIME SEC	NO OF STRIKES	TOTAL CUTTING TIME SEC
								FEED RATE mm/PER						

OPERATION : HOLE MILL DIA 16.3 +0.2
TOOL NO : T5
COMPONENT : - BANJO BEAM RA 109 RR
COMPONENT NO : - 2732 3510 0431
MATERIAL :- Fe 540 B / Fe 590 B

FIXTURE



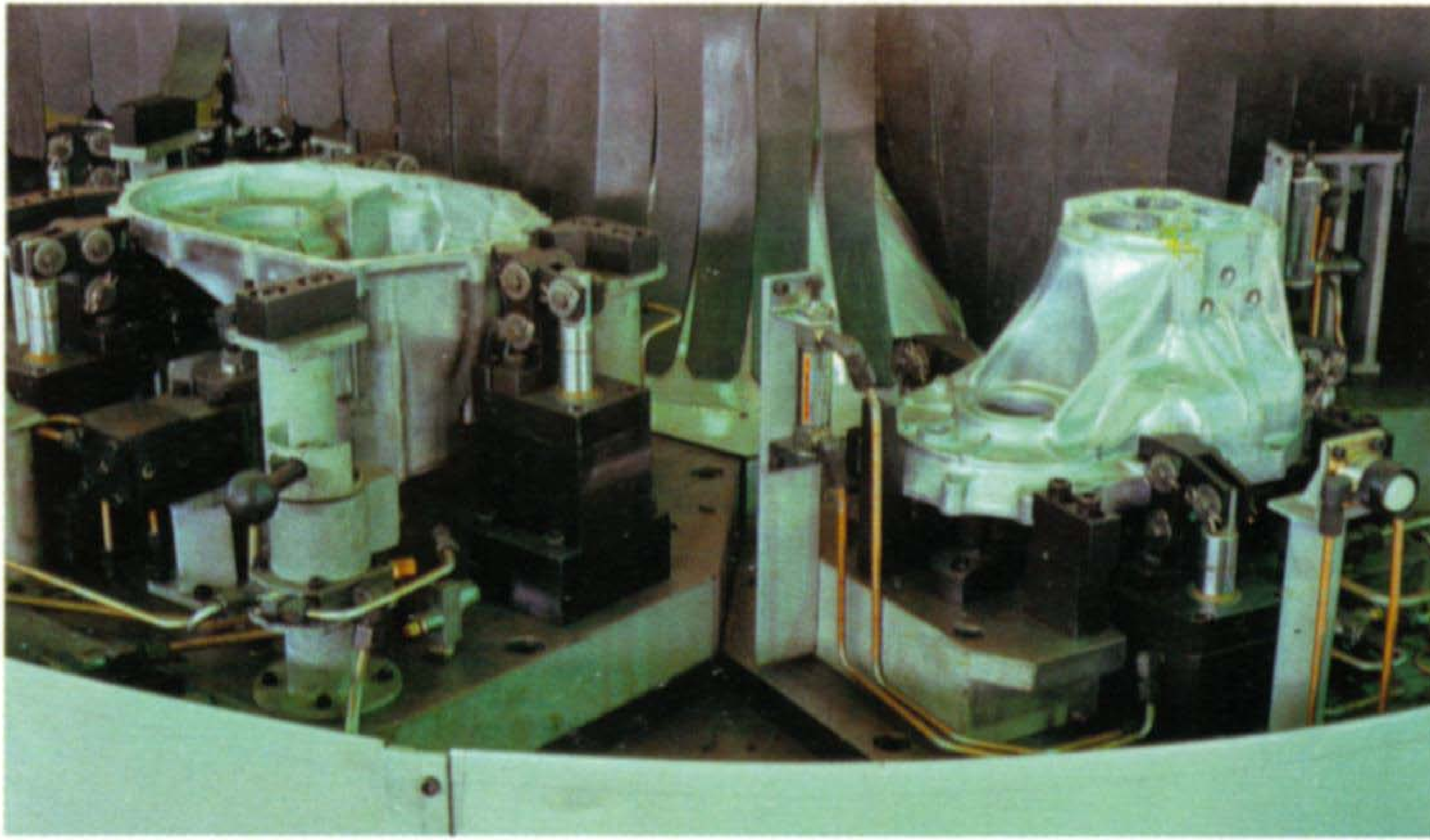
FIXTURE



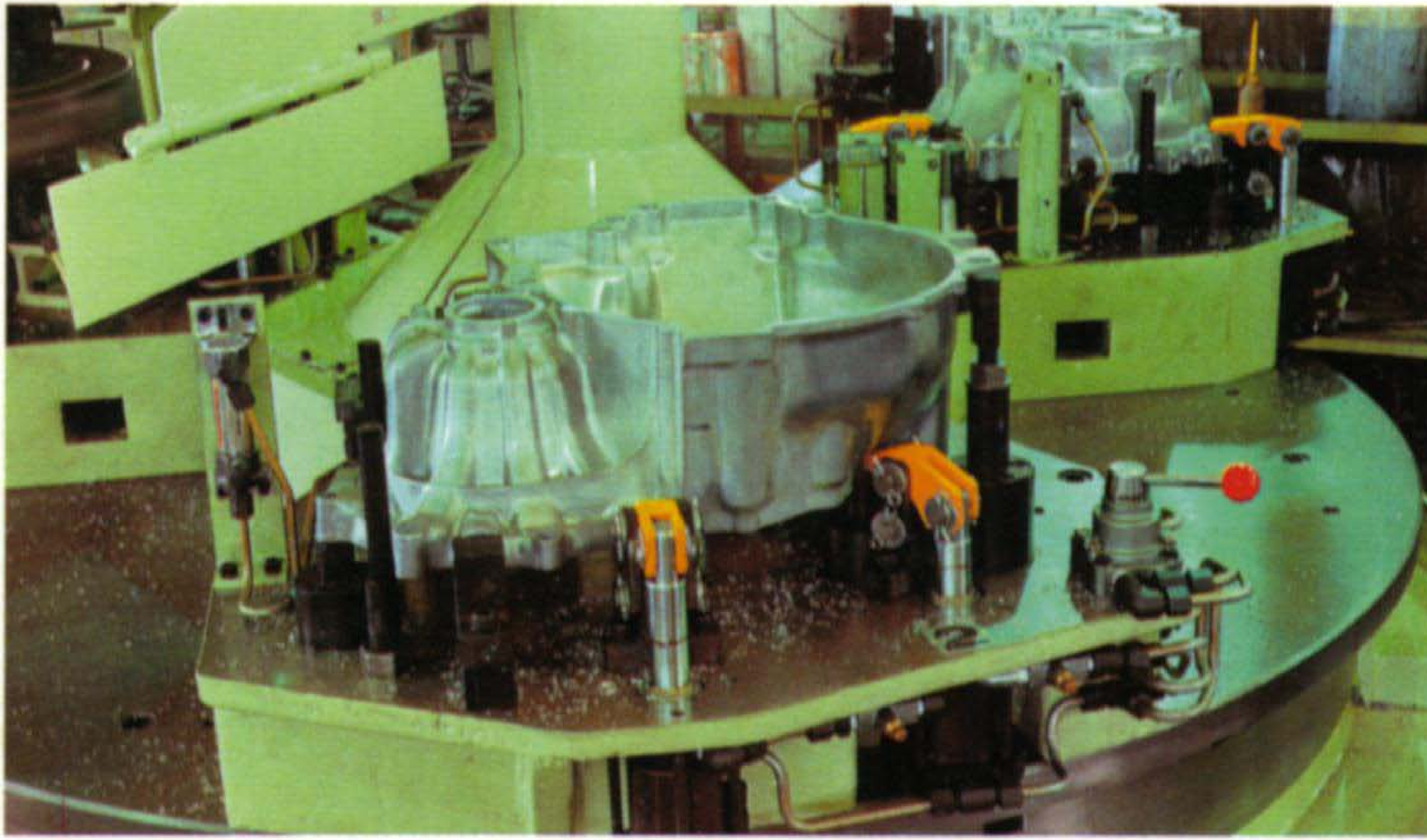
Case Study of Fixtures

- MANUAL FIXTUERS
- HYDRAULIC FIXTURES
- PNUEMATIC FIXTURES

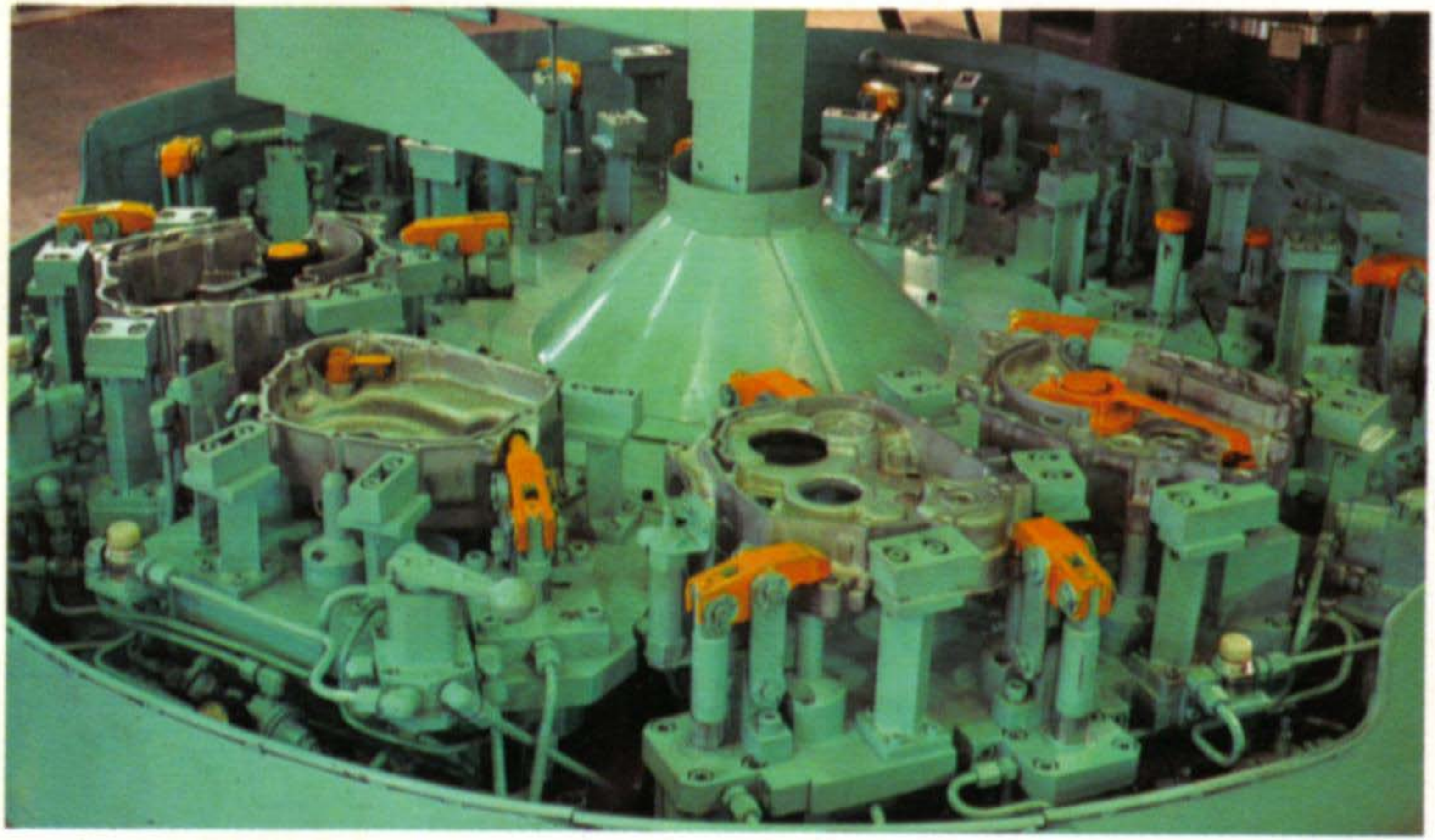
PNUEMATIC FIXTURE
COMPONENT- TRANMISSION HOUSING



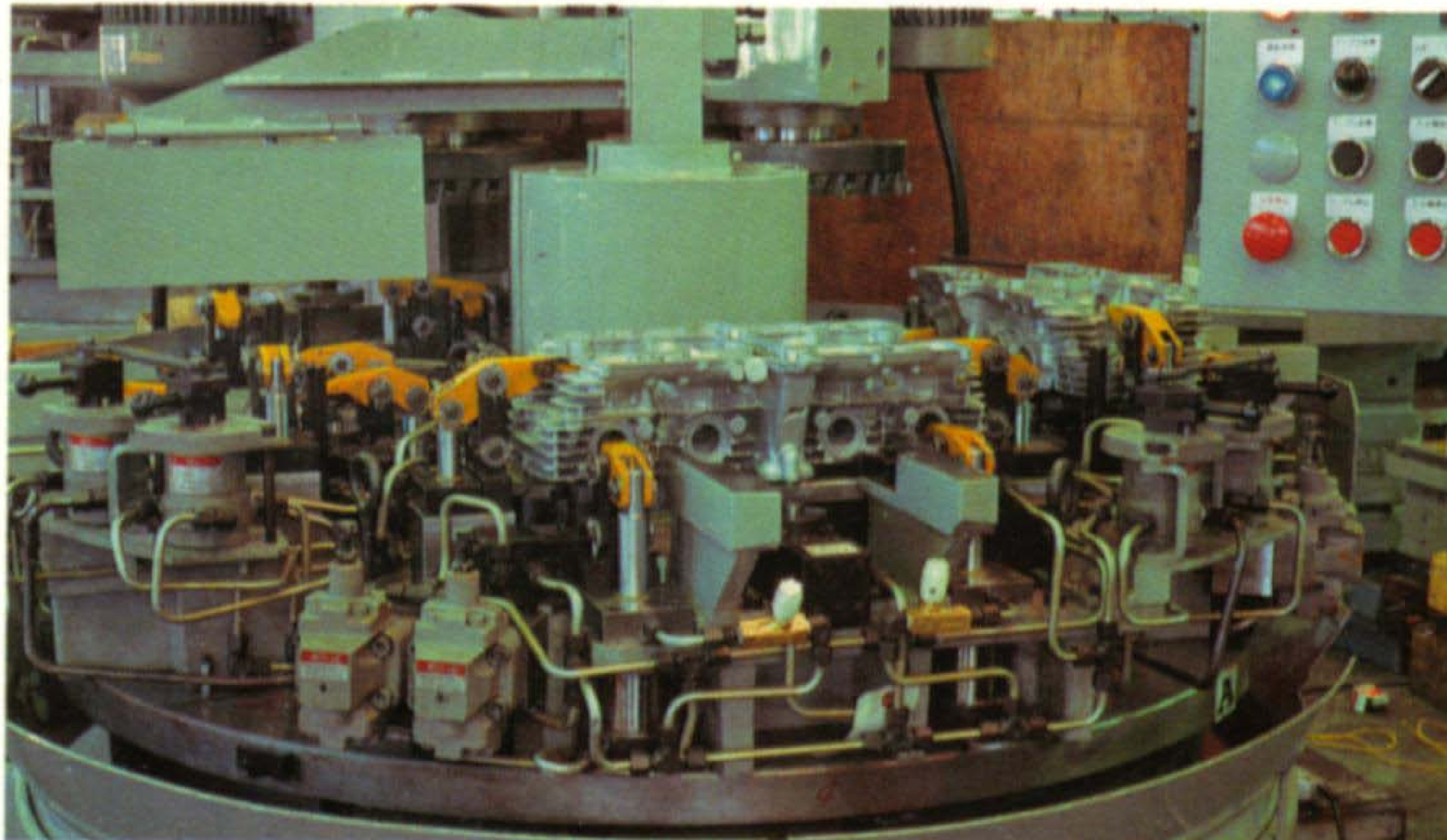
PNUEMATIC FIXTURE
COMPONENT- CLUTCH HOUSING



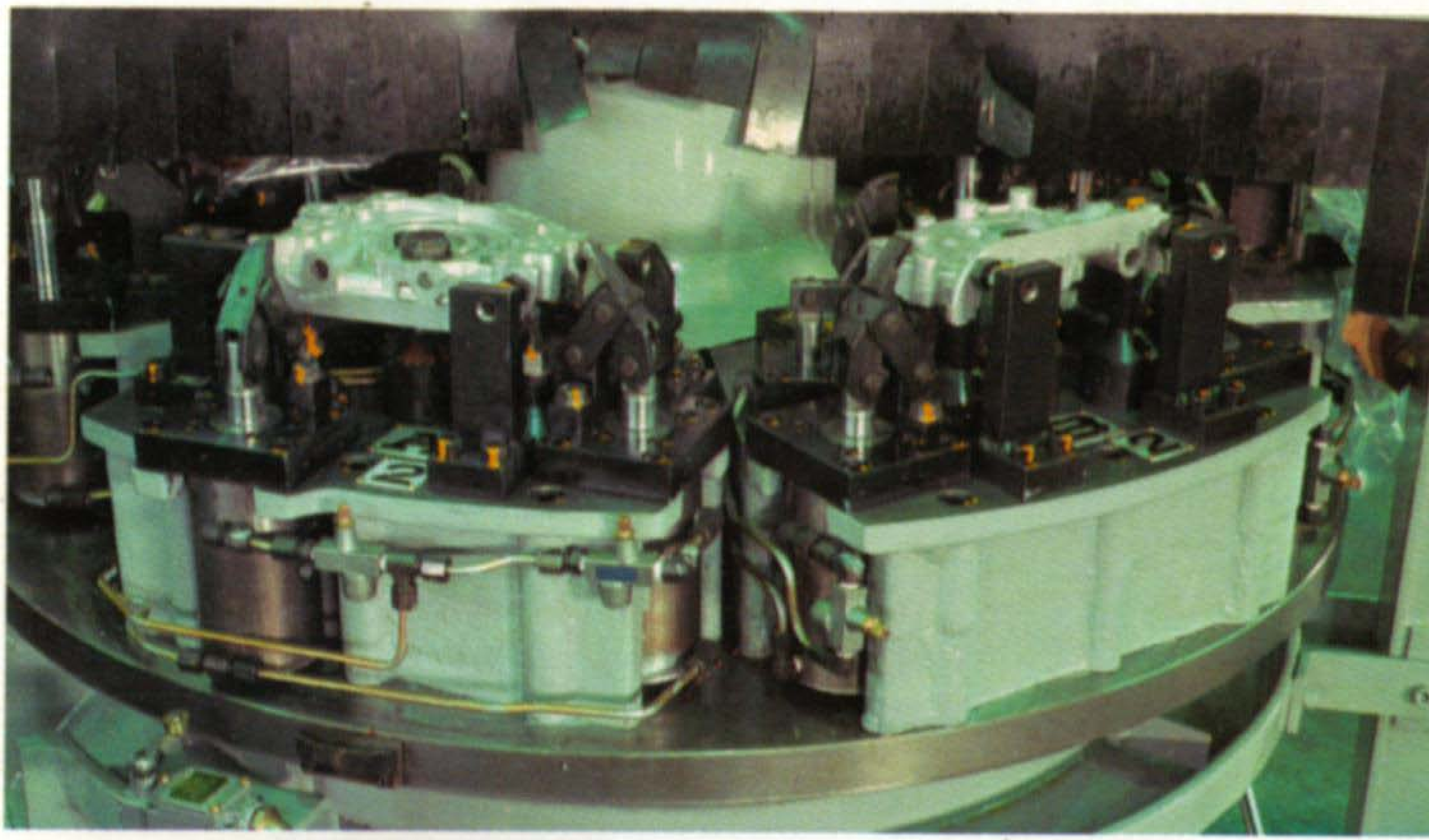
PNUEMATIC FIXTURE
COMPONENT- R/L CRANK CASE



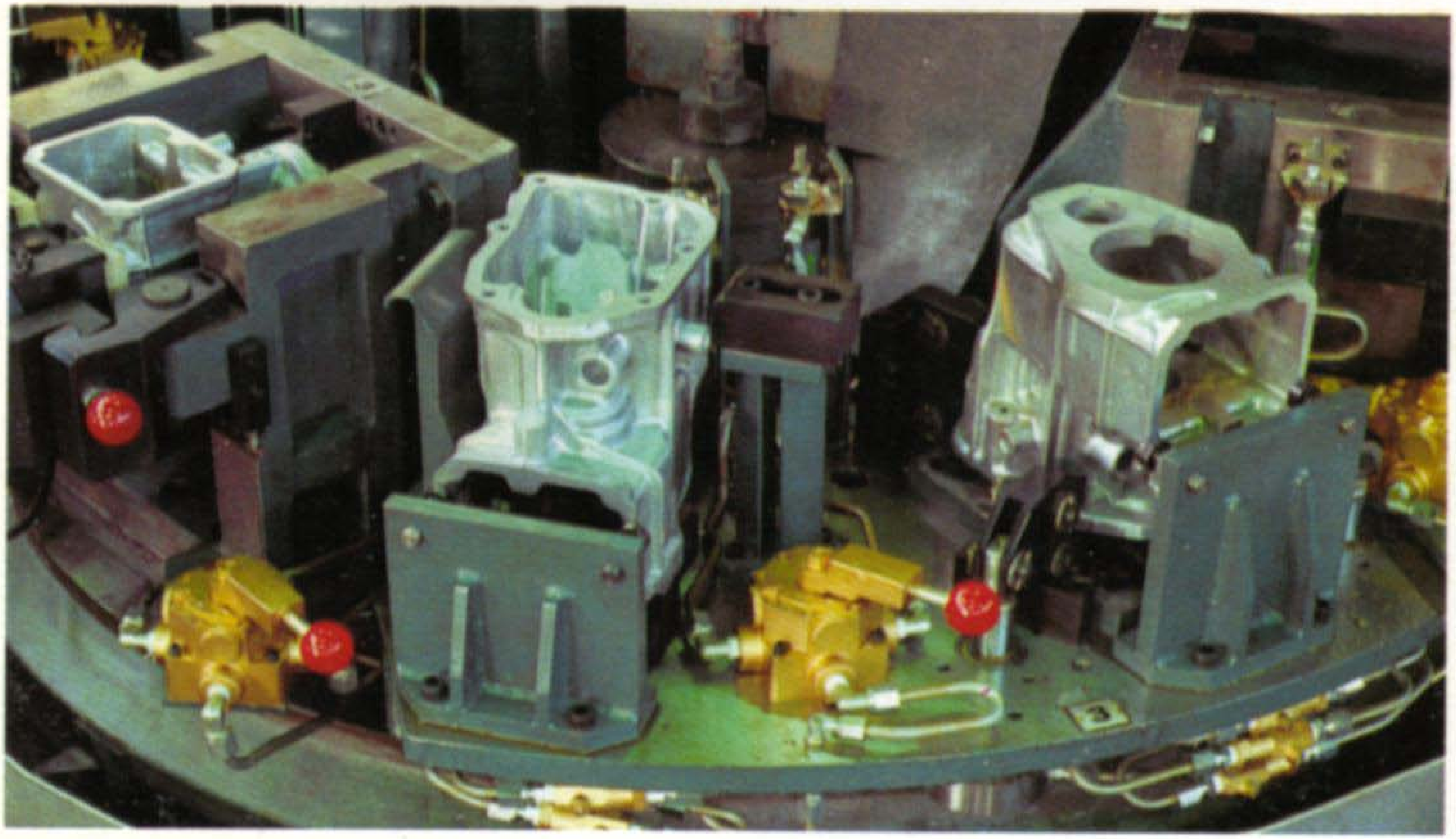
PNUEMATIC FIXTURE
COMPONENT- CYLINDER HEAD



PNUEMATIC FIXTURE
COMPONENT- OIL PUMP BODY

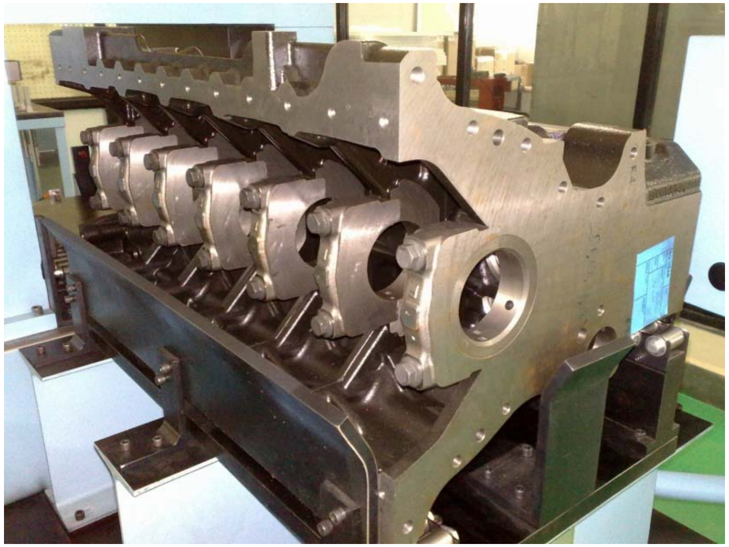


PNUEMATIC FIXTURE
COMPONENT- TRANSMISSION CASE

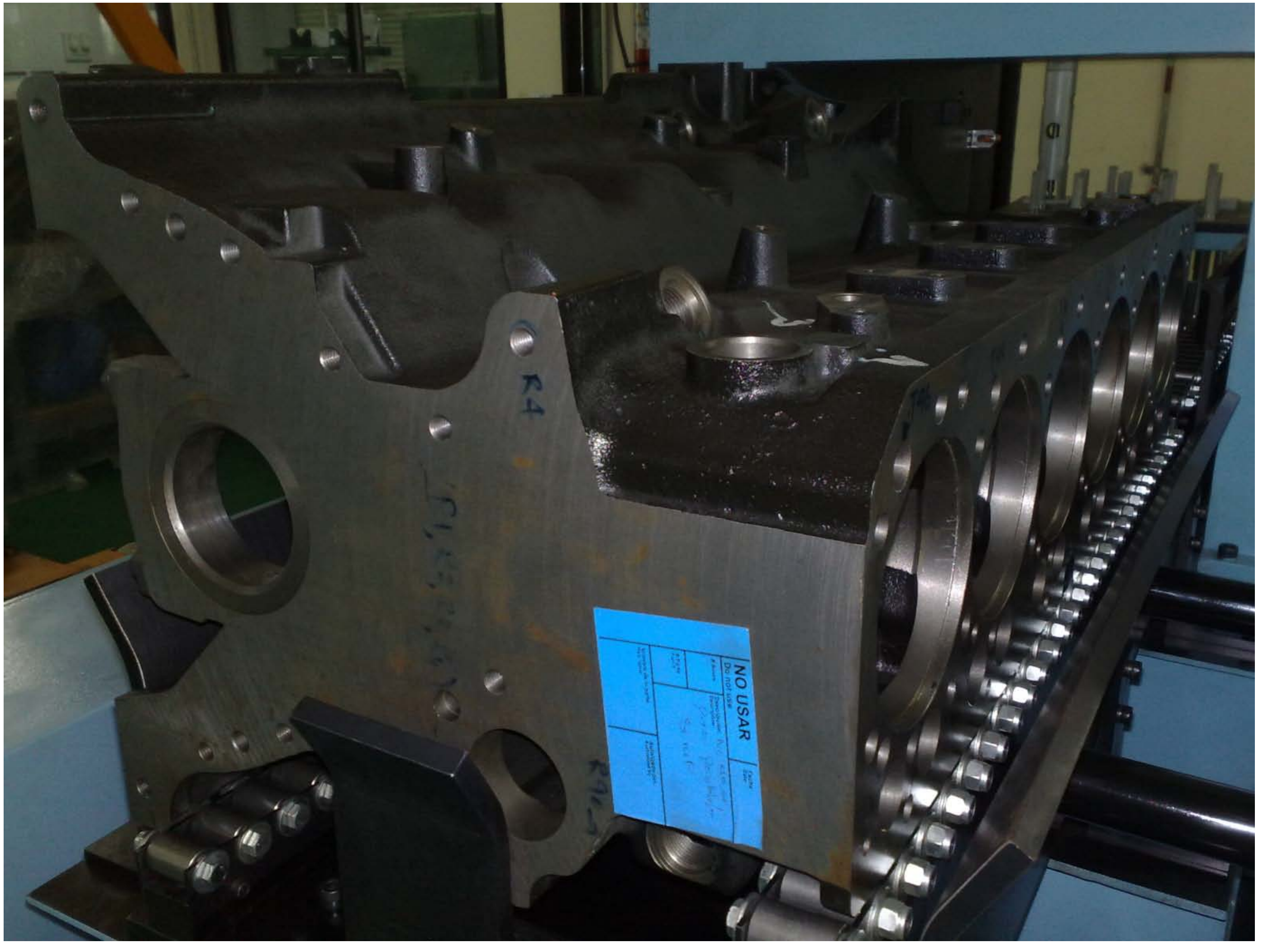


- INSPECTION FIXTURES

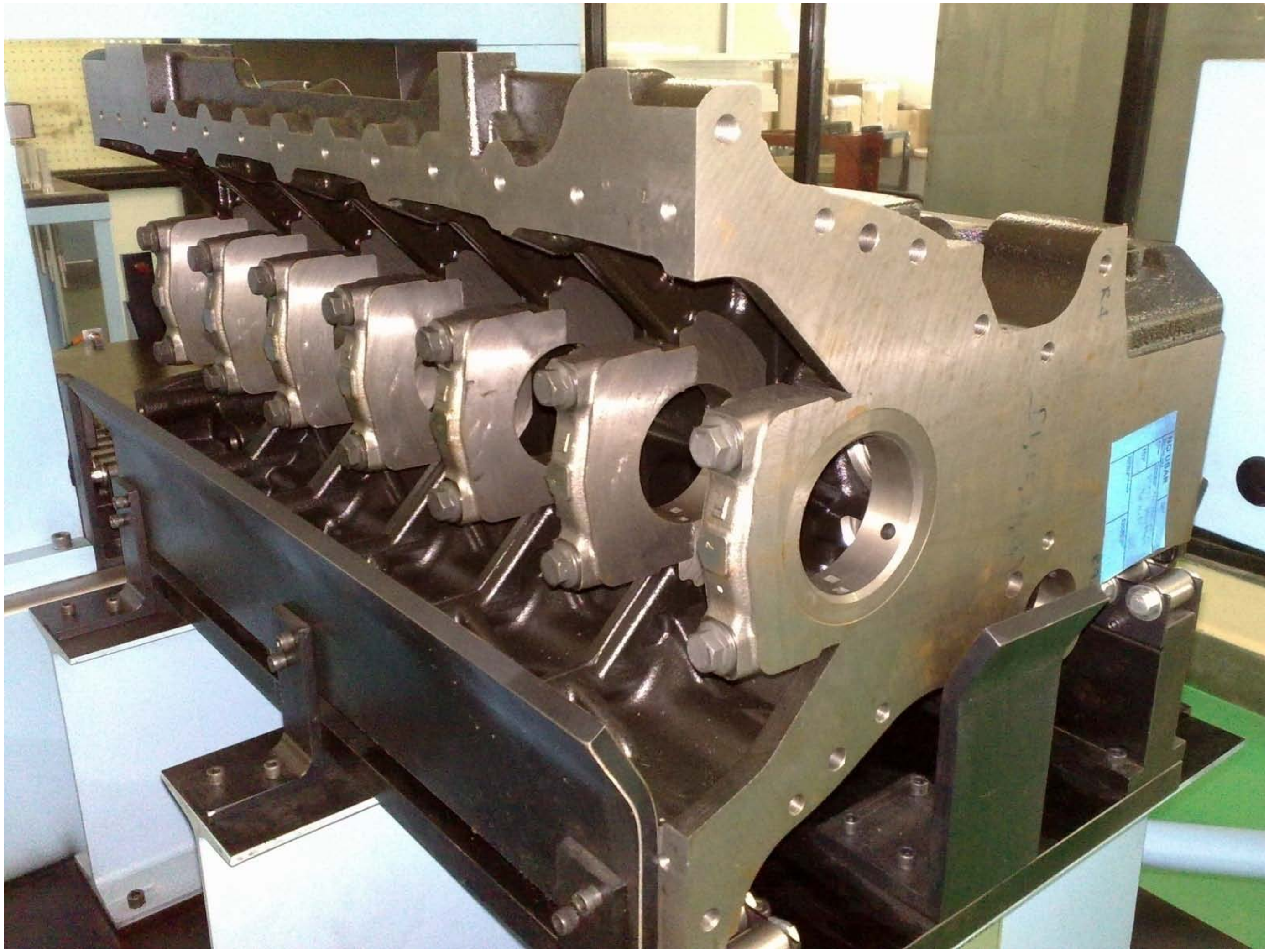
- Example –
  - Component 4 Cylinder
  - Component 6 Cylinder



Inspection Fixtures

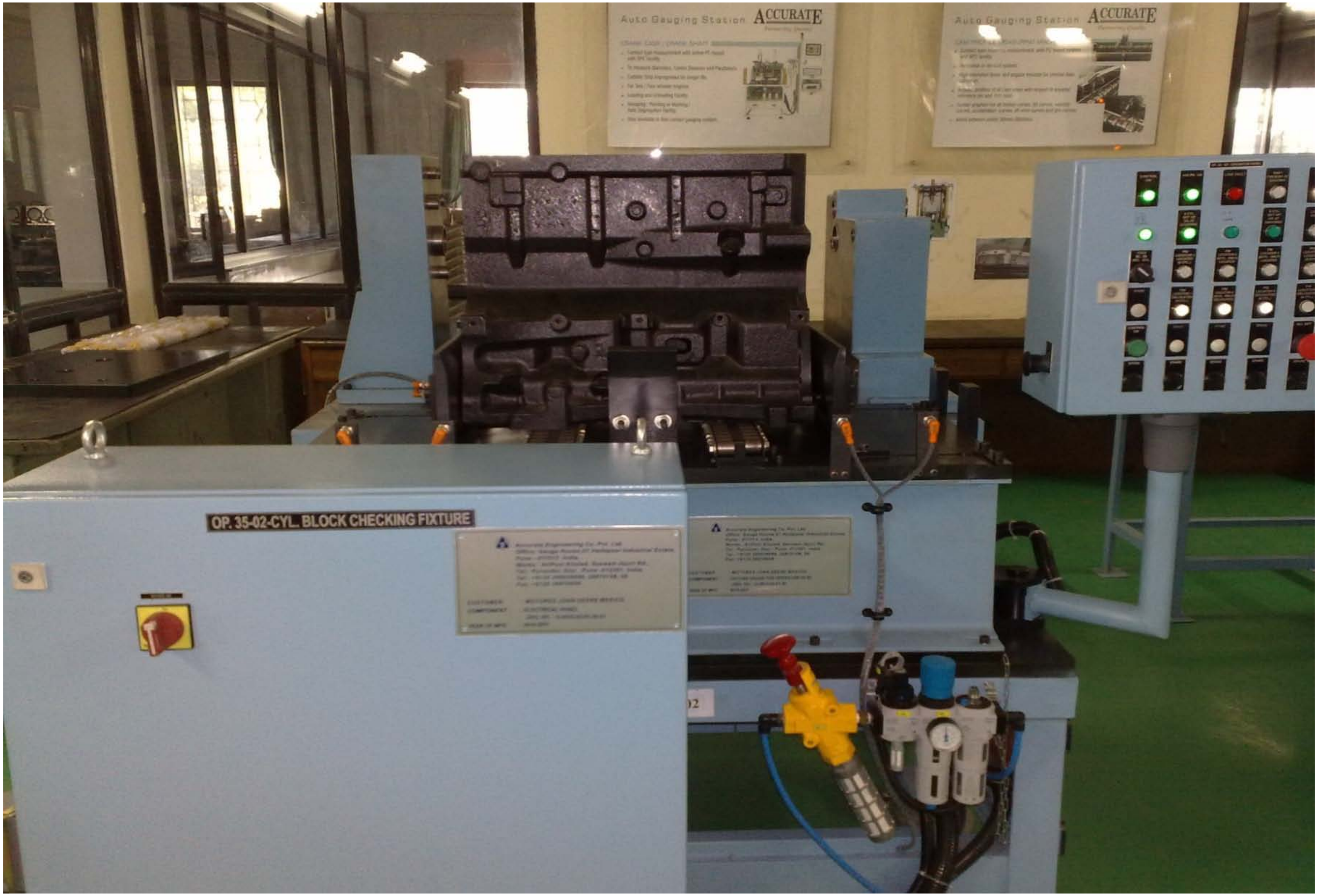


Inspection Fixture (component Cyl Block)



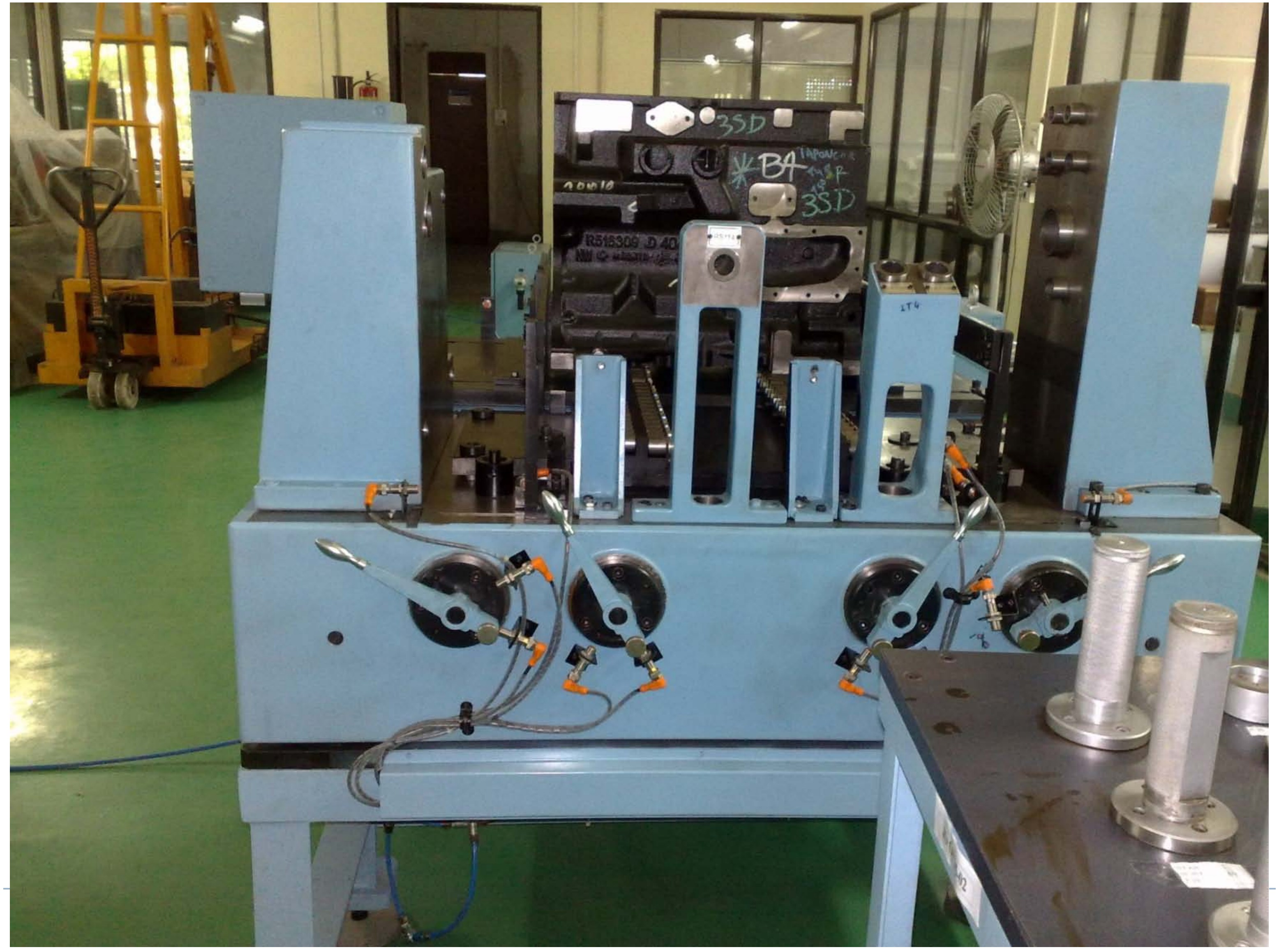
Inspection Fixture

Inspection Fixture



Inspection Fixture

Inspection Fixture



Inspection Fixture

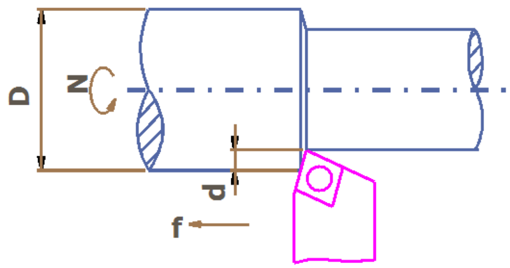
WORK HOLDING DEVICES FOR TURNING

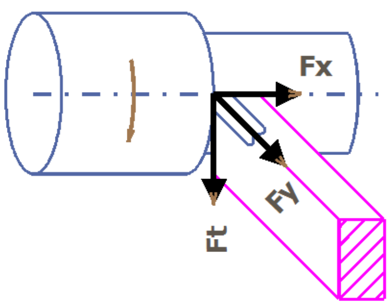
- Chucks
- Collets
- Face clamping fixtures
- Face and work drivers
- Special fixtures

GRIPPING FORCES-POWER CHUCK

- Gripping force is the sum of radial forces exerted on the job by the jaws
  MAIN CUTTING FORCE Fs= d x f x sp
- d – Depth of cut, f – Feed rate, sp – Specific cutting force,
- REQUIRED GRIPPING FORCE = $\frac{Fs\ Sz}{\mu} * \frac{dz}{dp} + Fc$
- Sz -SAFETY FACTOR
- μ - FRICTION CO-EFFICIENT
- dz - MACHINING DIAMETER
- dp - CHUCKING DIAMETER
- Fc - CENTRIFUGAL FORCE

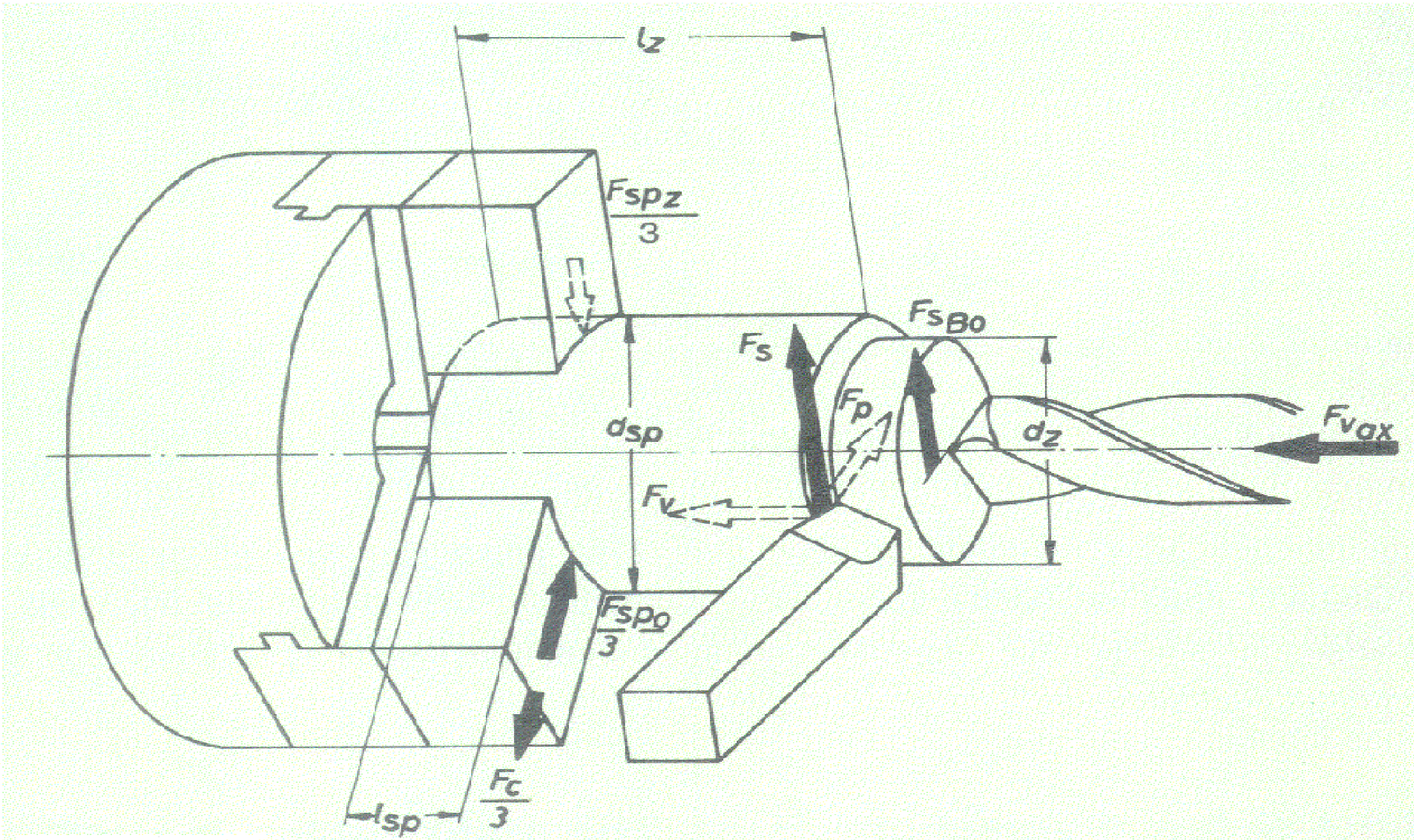
CUTTING FORCES





- Chip Cross-section a= d*f
- Tangential Force Ft =chip c/s *Sp. Cutting force =a *Fs
- Torque=Force *radius = Ft*D/2
- Power in KW =T*N/975

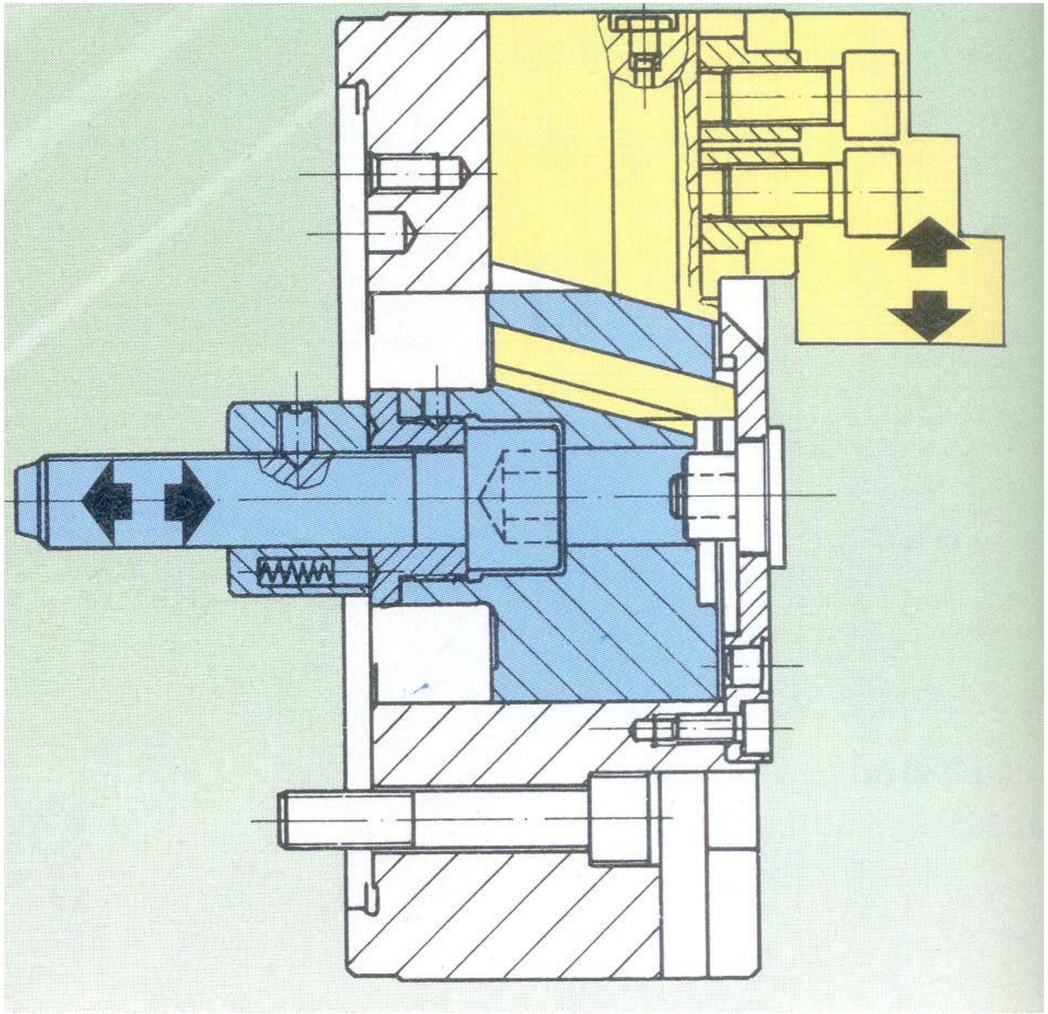
CUTTING FORCES



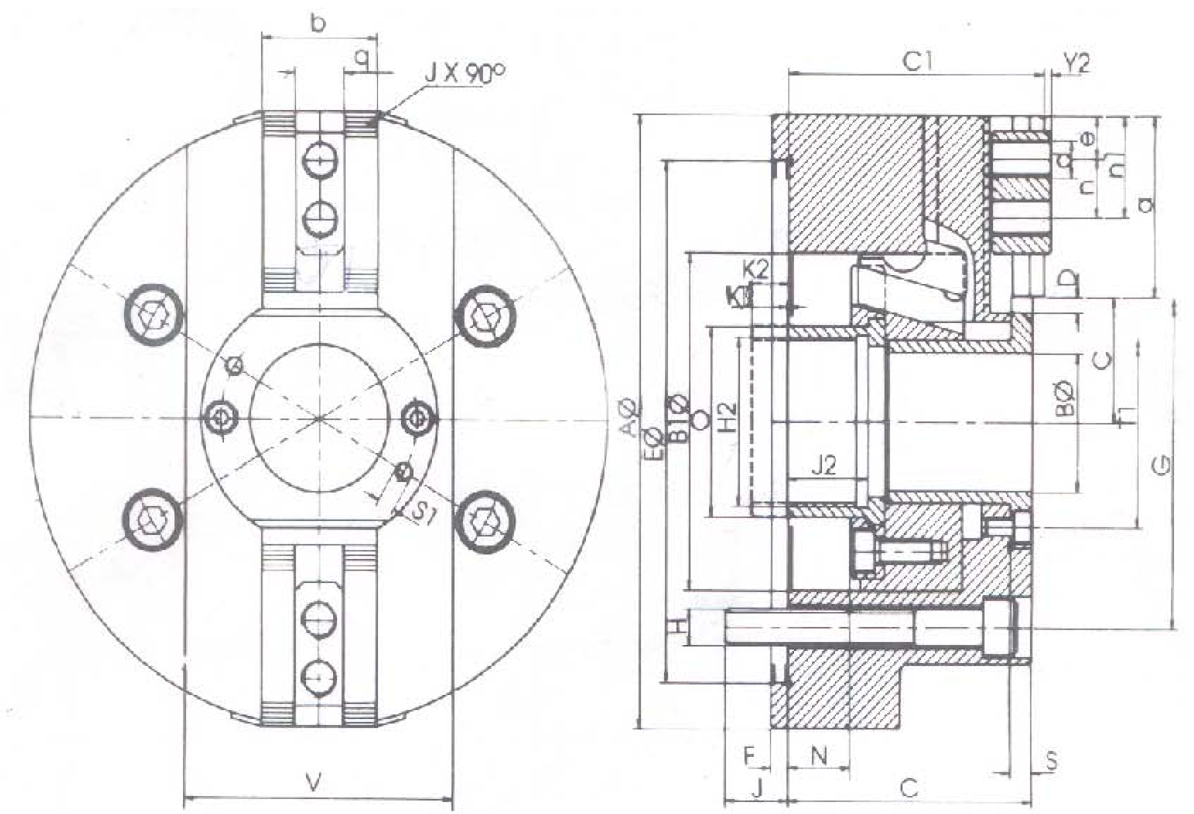
CHUCKS

- Solid chucks
- Hollow High speed chucks
- Centrifugally compensating chucks
- Eccentric compensating chucks
- Diaphragm Chucks

SOLID CHUCK



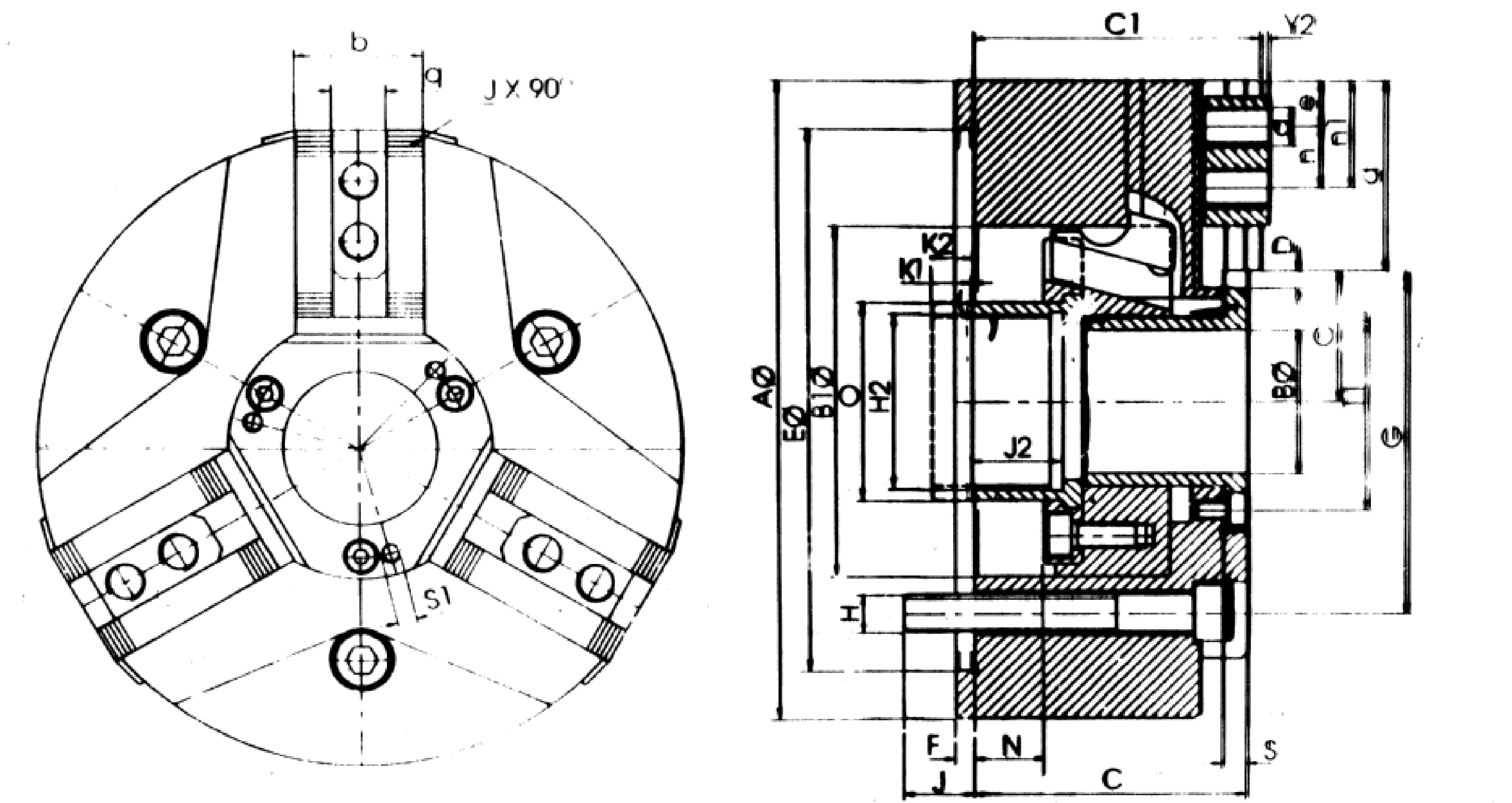
HOLLOW 2 JAW CHUCKS



2 JAW CHUCKS

- Used for non round and irregular shaped components
- Centralising by other means is required

HOLLOW 3 JAW CHUCKS



HOLLOW 3 JAW CHUCKS

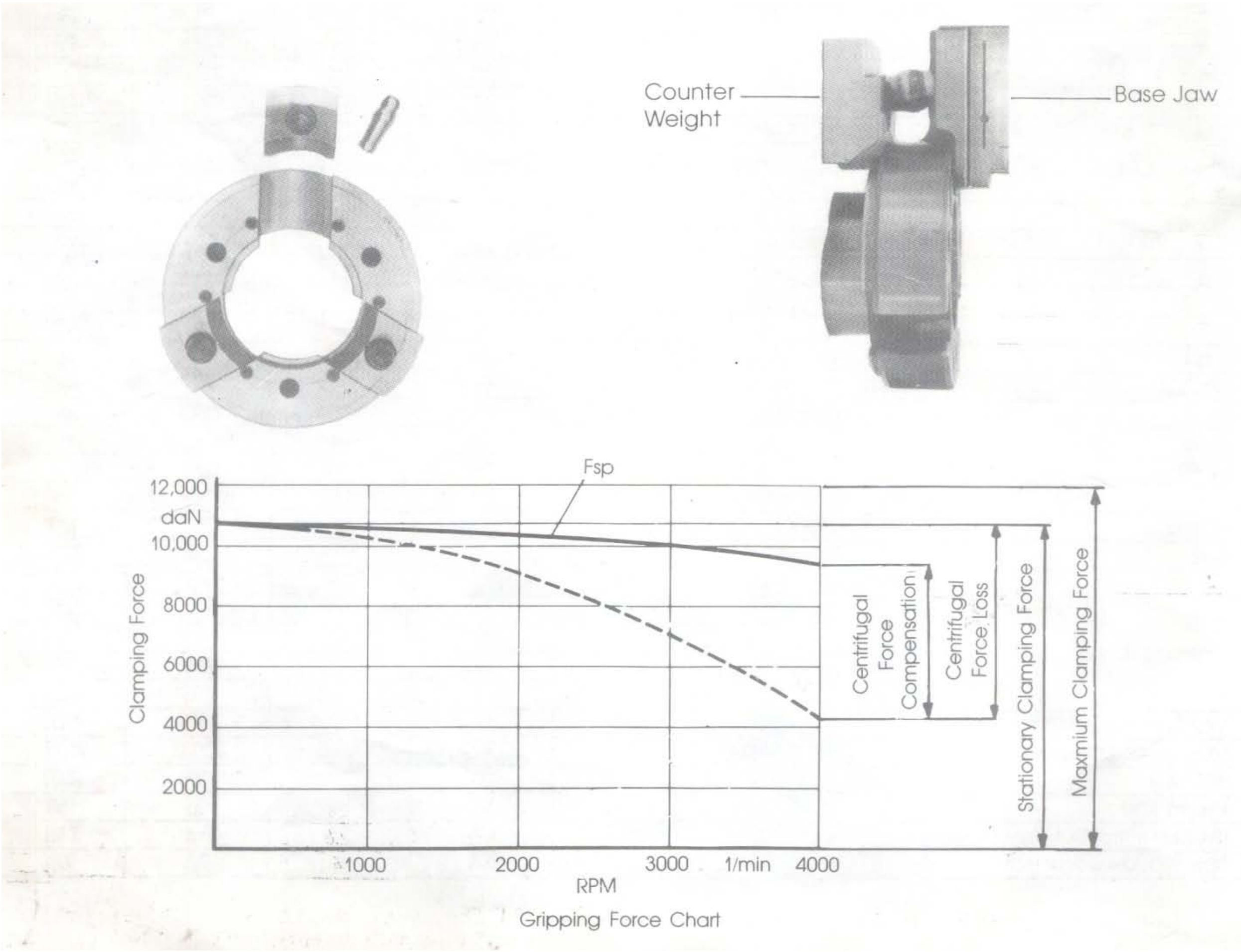
- Self centering type
- Suitable for round and regular shaped components
- Suitable for Bar work and high speed running

SPECIAL JAWS FOR STANDARD CHUCKS

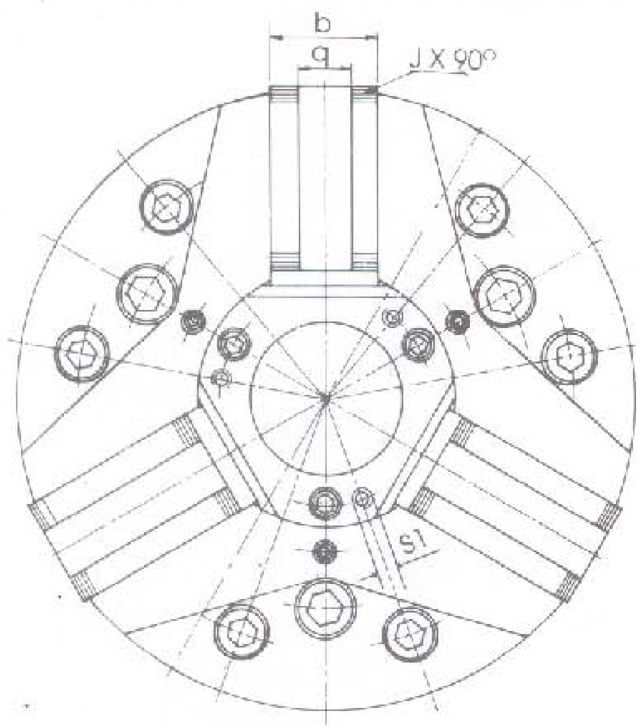
- Jaws should be designed in such a way that their weight and height is as low as possible
- For design considerations, if the jaws are heavier and wider, centrifugal force effect should be considered
- Clamping point to be as close to the front face of the chuck as possible
- As a thumb rule, maximum diameter of job should be d+d/3 where "d" is the diameter of the chuck

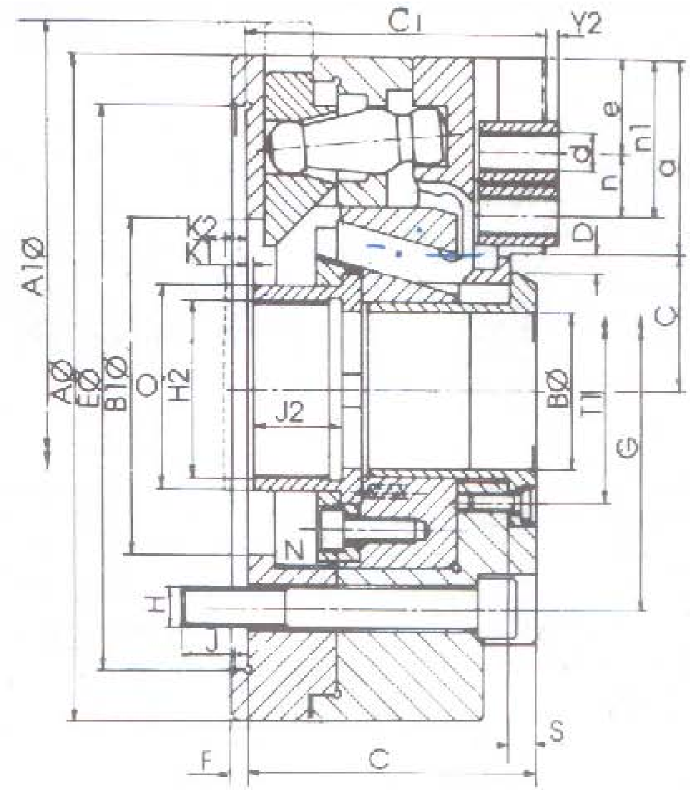
Special Jaws

CENTRIFUGAL LOSS



CENTRIFUGALLY COMPENSATED HOLLOW HIGH SPEED CHUCK

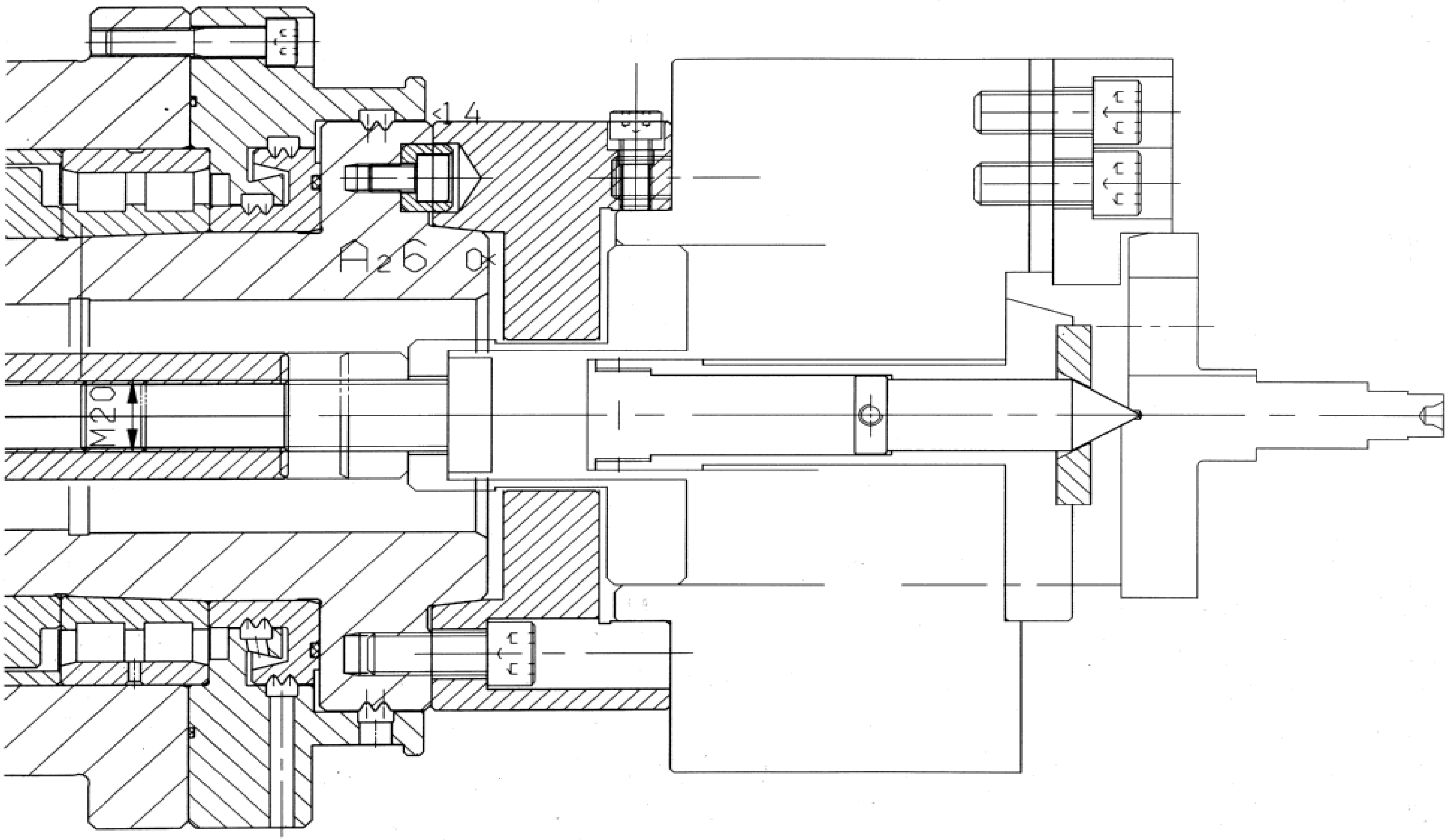




CENTRIFUGALLY COMPENSATED HOLLOW HIGH SPEED CHUCK

- Compensates for loss of gripping force due to centrifugal forces
- Can run at speeds higher than normal hollow high speed chucks

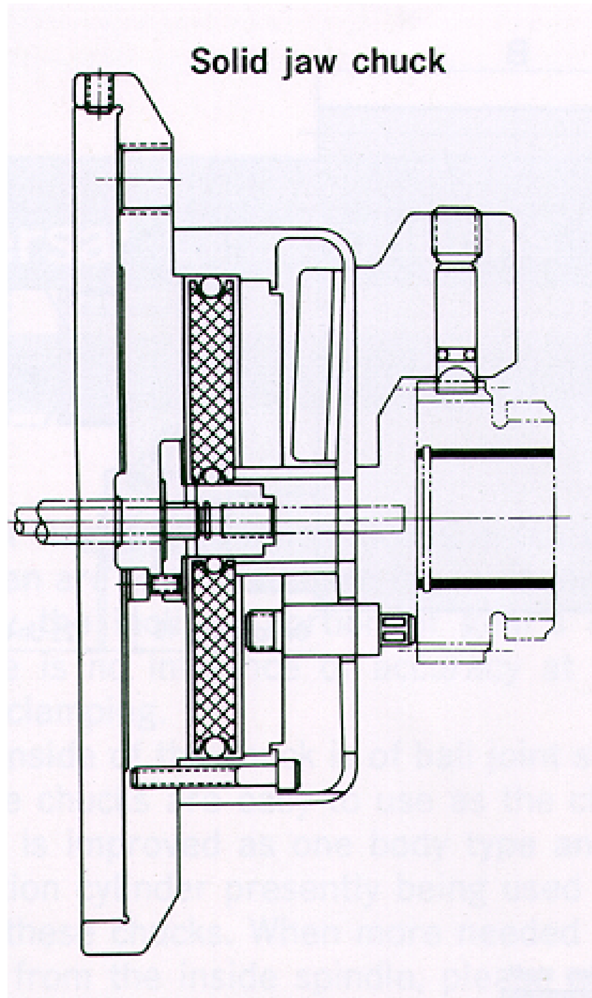
ECCENTRIC COMPENSATING CHUCK



ECCENTRIC COMPENSATING CHUCK

- Floating wedge design
- Compensates OD eccentricity wrt centre line(value limited to 3 to 4 m on dia)
- Between centre support is a necessity

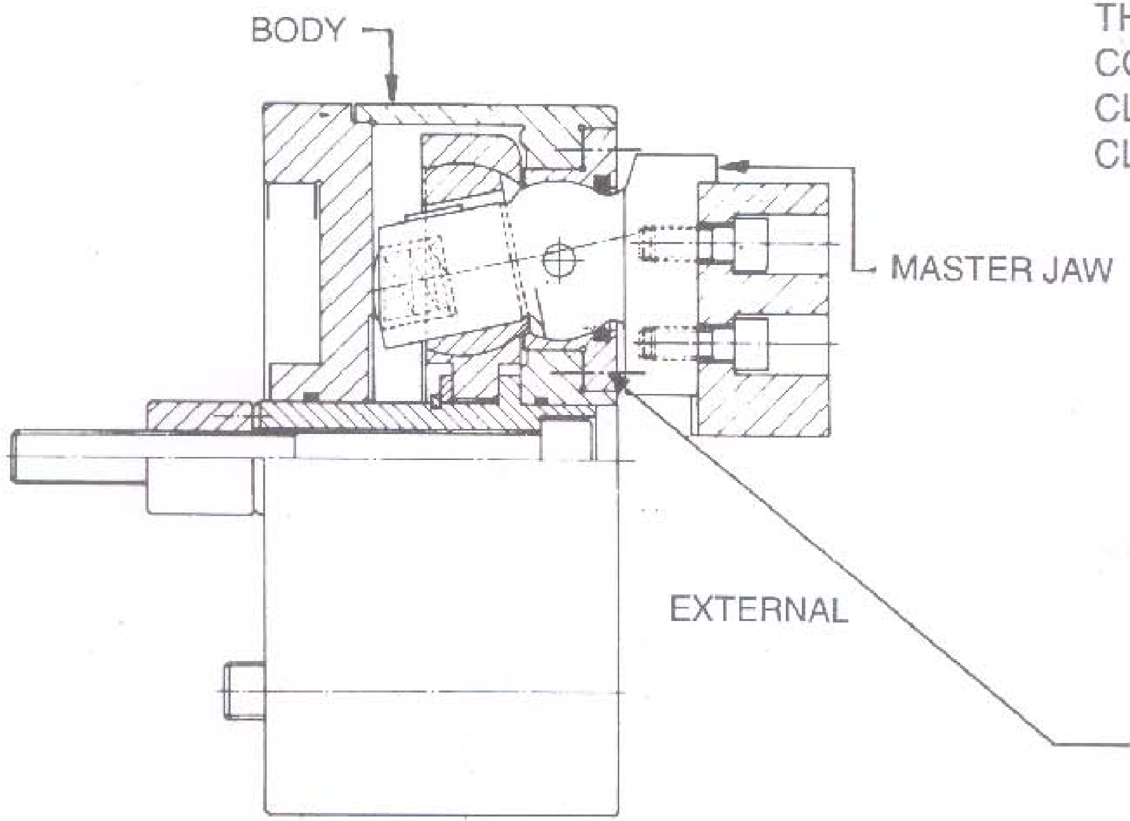
DIAPHRAGM CHUCKS



DIAPHRAGM CHUCKS

- Suitable for components with low machining allowance
- PCD reference(Pitch line clamping for gears)
- Almost no moving parts

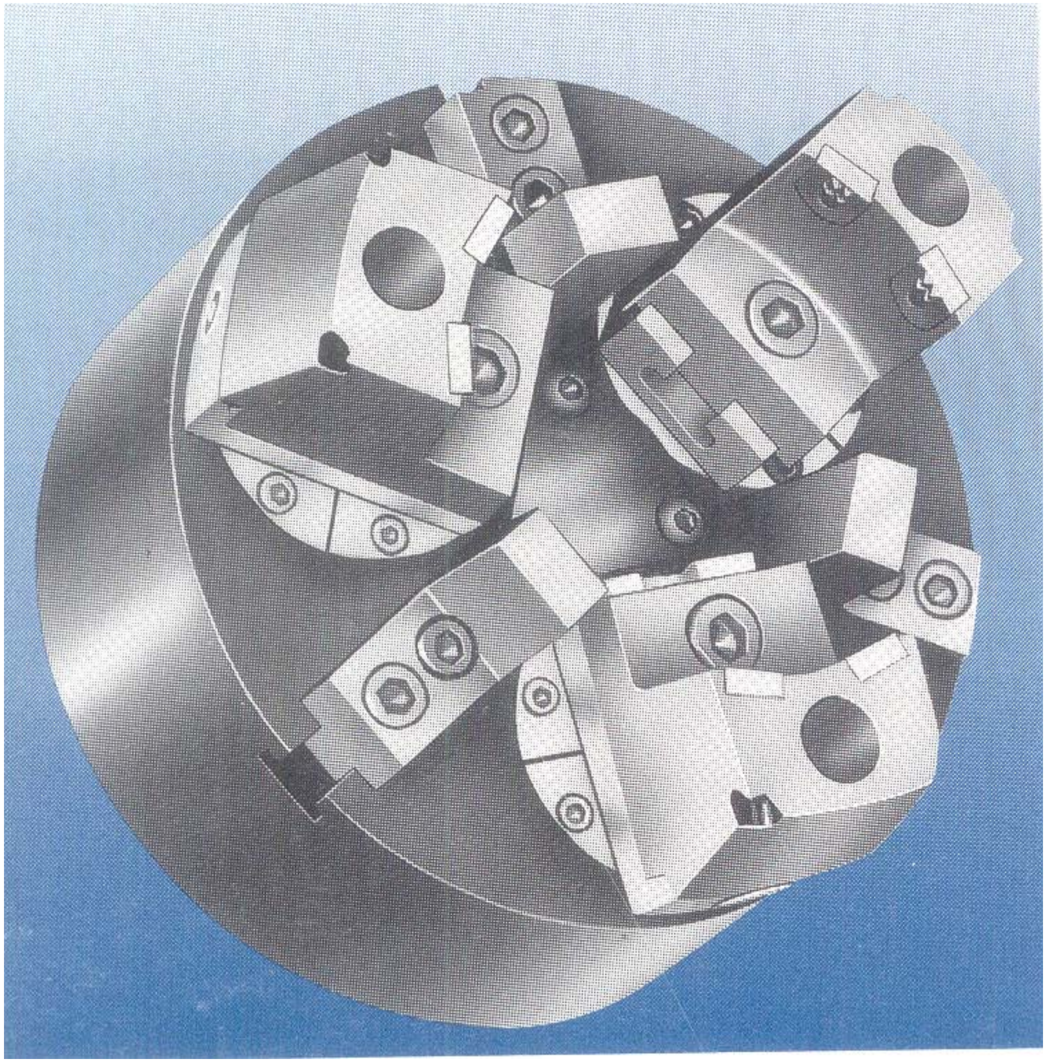
BALL LOK CHUCK



THE BASE JAWS CAN BE CONVERTED FROM EXTERNAL CLAMPING TO INTERNAL CLAMPING IN MINUTES.

TO CHANGE FROM EXTERNAL TO INTERNAL, REMOVE 4 SOCKET HEAD SCREWS AND ROTATE MASTER JAW(S) 180 DEGREES RETIGHTEN 4 SOCKET HEAD SCREWS

BALL LOK CHUCK



BALL LOK CHUCKS

- For better length control and parallelity
- Used for holding on to rough castings and forgings
- Holding can also be done on tapered parts up to 10 degrees
- Even thin walled components can be gripped
- Jaw equalising angle upto 5 degrees

BALL LOK CHUCK

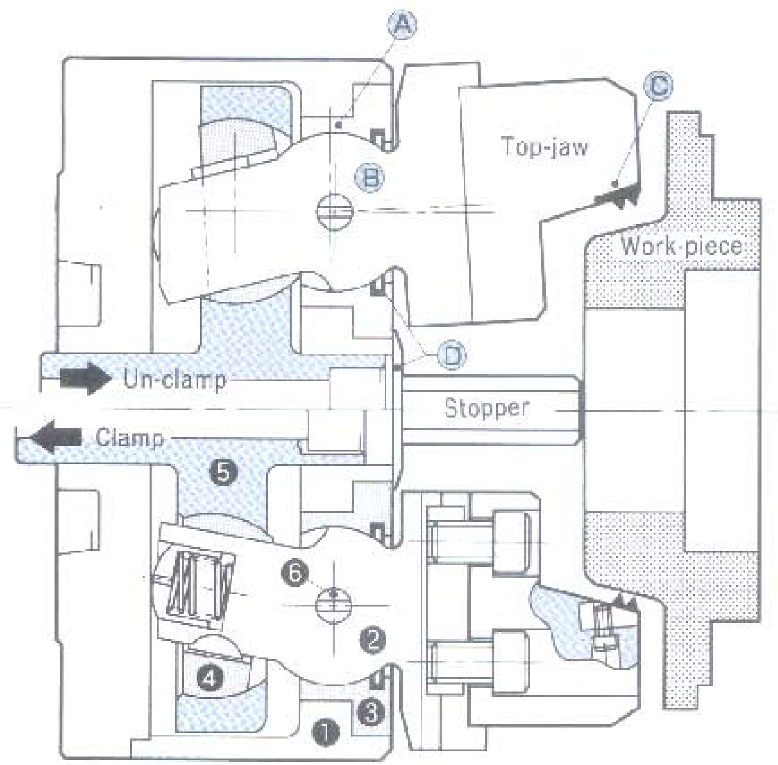
Advantages

Ⓐ **Land** ……This is a portion to retract the work-piece toward the stopper.

Ⓑ **Equalizing unit**
……This is a key device to the top-jaw's swing motion.

Ⓒ **Carbide insert**
……The carbide insert offer greatly improved service life and clamping torque, while providing excellent interchangeablity.

Ⓓ **Cover & Sealing**
……It is outstanding in the preservo-ability in the protection against dust and being waterproof. Especially, it is the optimal for the FA manufacture line.



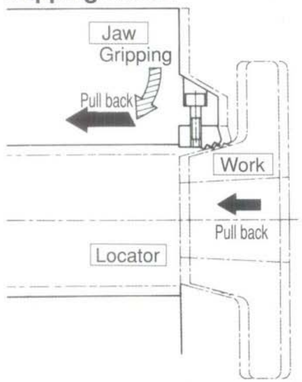
❶Body
❷Jaw actuator
❸Front bearing race
❹Eccentric ball
❺Actuator
❻Equalizing unit.

BALL LOK CHUCK

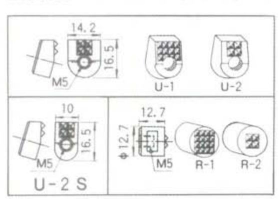
Powerful Gripping

After gripping the component in a radial direction, a Powerful PULL-BACK action is applied which significantly increases the Gripping Force, allowing heavier machine cut to be taken.

Gripping Action



Inserts *Carbide inserts vary depending on the workpiece.

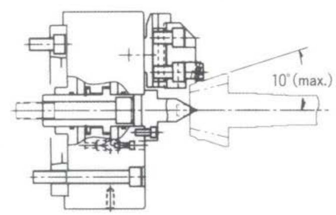


High Durability

Master jaws are of spherical design and sealed against swarf and coolant. This permits High Gripping Forces to be retained between lubrication periods.

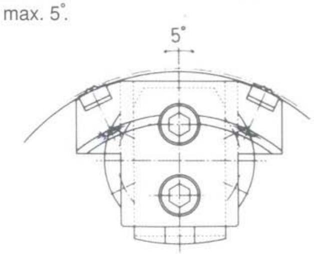
Gripping on Tapered Parts

The radial and PULL-BACK jaw action allows rough tapered castings and forgings to be securely gripped to maximum 20°.



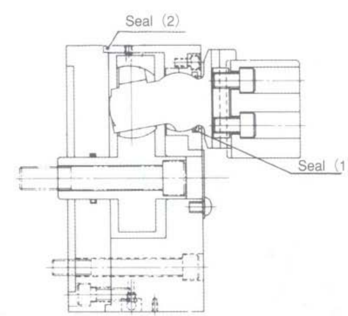
JAW Equalising 5° max equalising angle

Various workpieces can be firmly gripped by the self-equalising jaws to max. 5°.

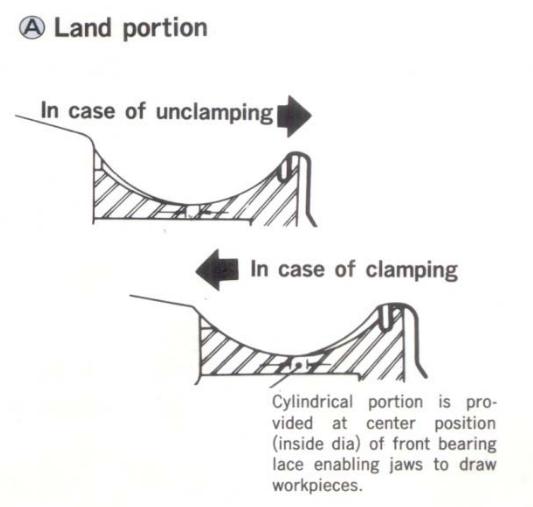


Complete Sealing

The seal (1) is fitted to the bearing bush and the seal (2) is inserted, which has improved the sealing for lubrication grease.



BALL LOK CHUCK



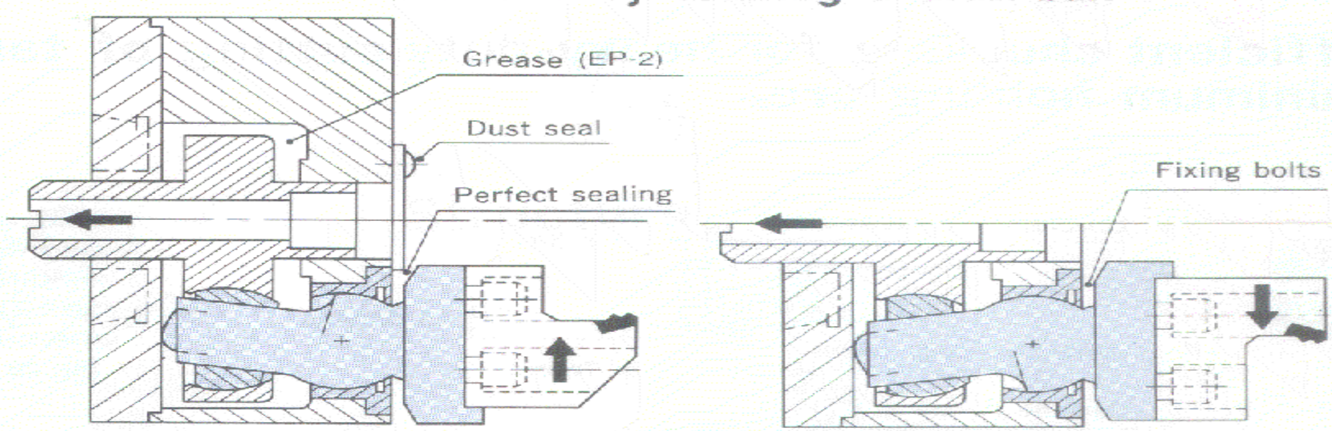
BALL LOK CHUCK

Change of outside dia. clamping from inside dia. clamping.

It unfasten 4 pcs. of fixing bolts from bearing lace and 180 degrees as the bearing lase incorporated with the jaw actuator without removing from the chuck body and tightens up the 4 pcs. of fixing bolts.

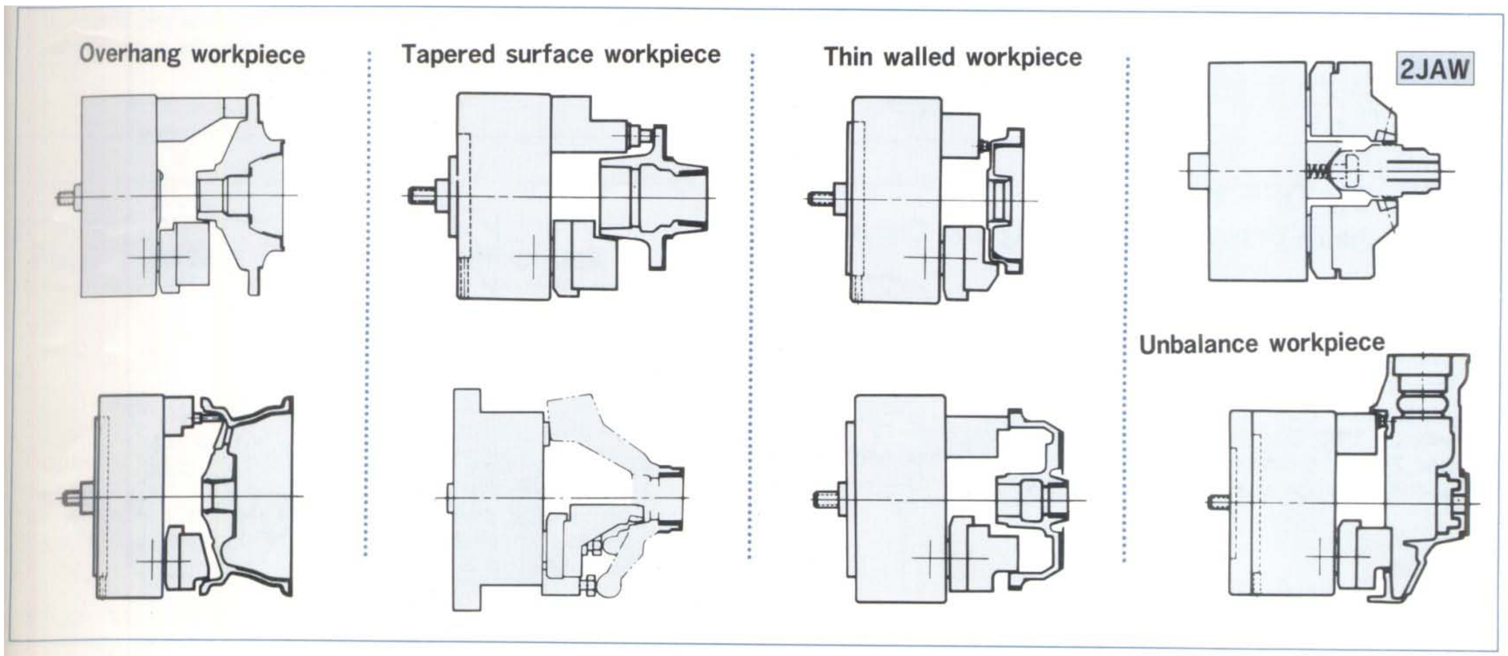
※ In this case, special water proof seal is not needed.

Outside dia. and inside dia. clamping are both available by drawing a draw-bar.

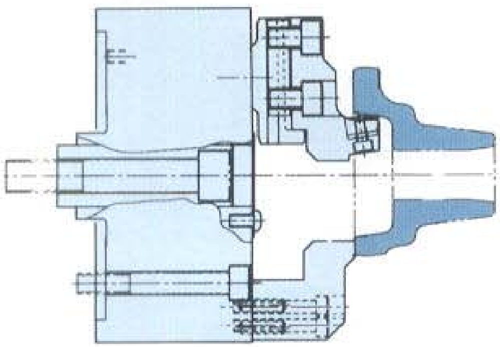


Outside clamping Inside clamping

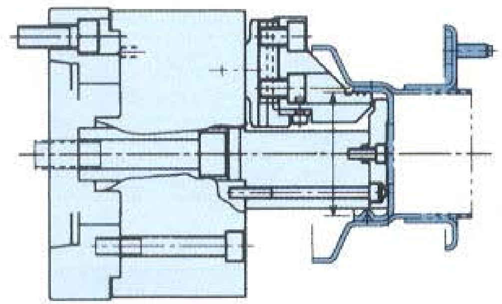
BALL LOK CHUCK APPLICATIONS



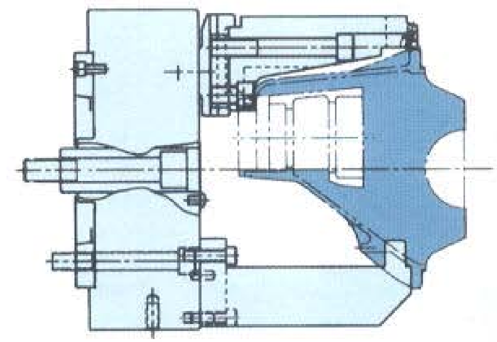
BALL LOK CHUCKS APPLICATIONS



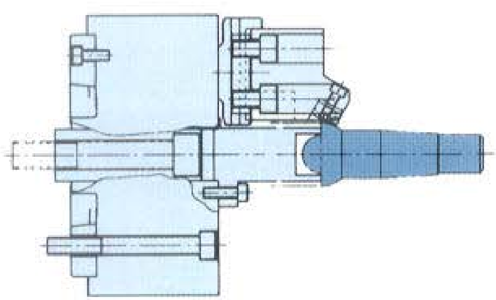
Coupling



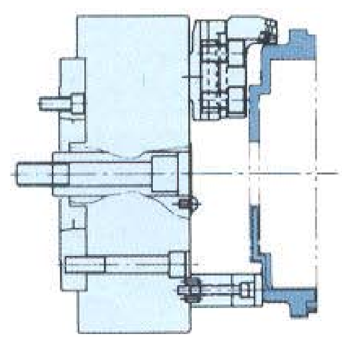
Housing



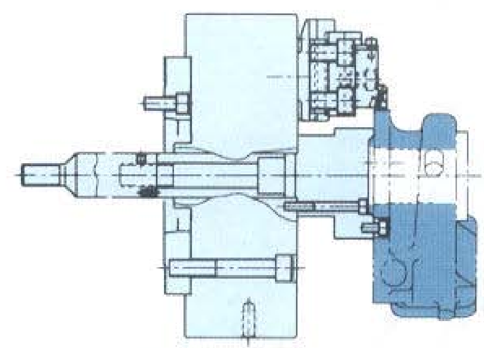
Housing



Shaft



Brake

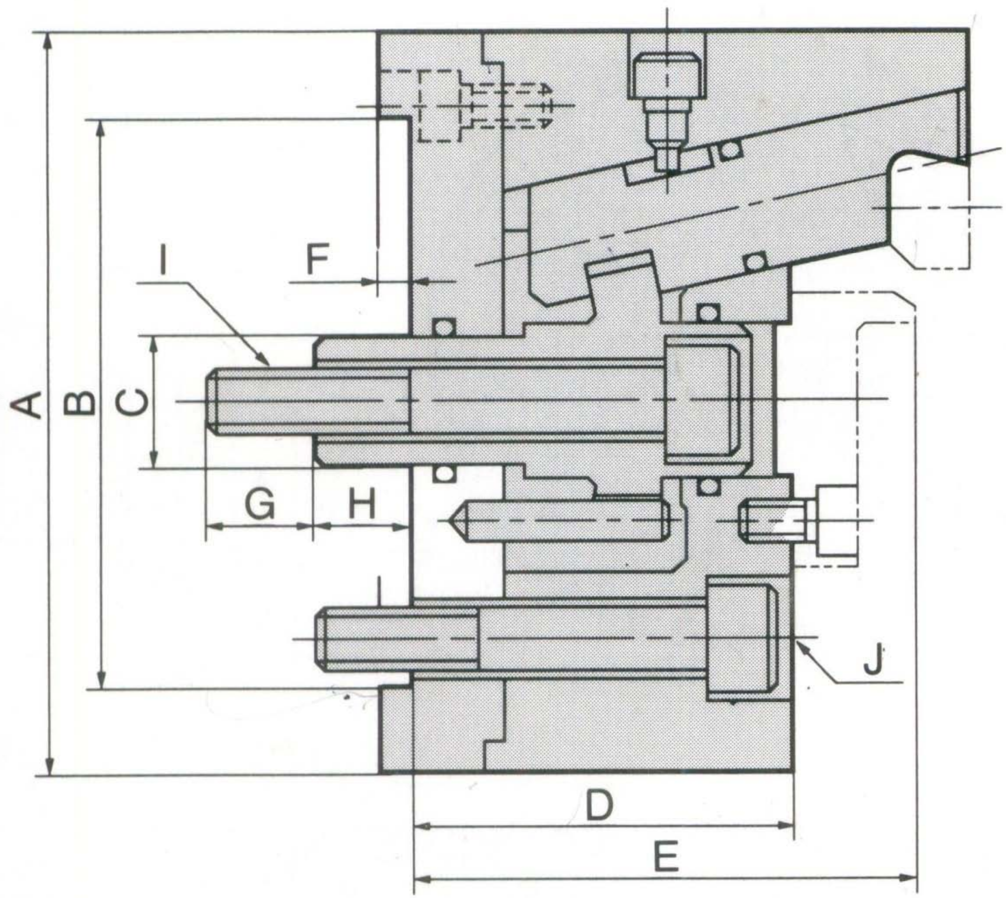


Turbine Housing

Pin Arbor Chuck

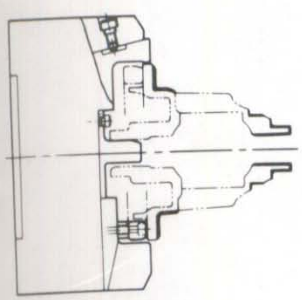
- Can be considered equivalent to pull back collet
- Can ensure parallelity within 10 microns
- Add on jaws facilitate changeover to different components.
- Chip entry into holding area is avoided as compared to collets

PIN ARBOR CHUCKS

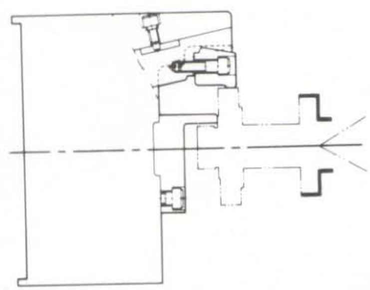


PIN ARBOR CHUCK APPLICATIONS

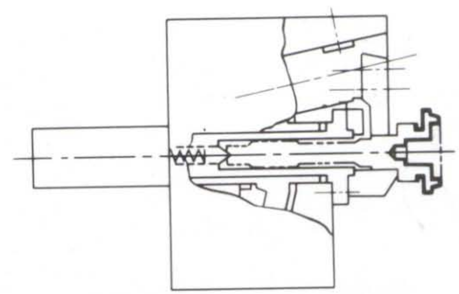
Workpiece : Differential gear
Clamping dia : ϕ162



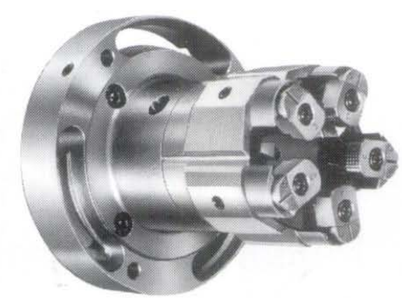
Workpiece : Shaft in plate
Clamping dia : ϕ87



Workpiece : Main drive gear
Clamping dia : ϕ35



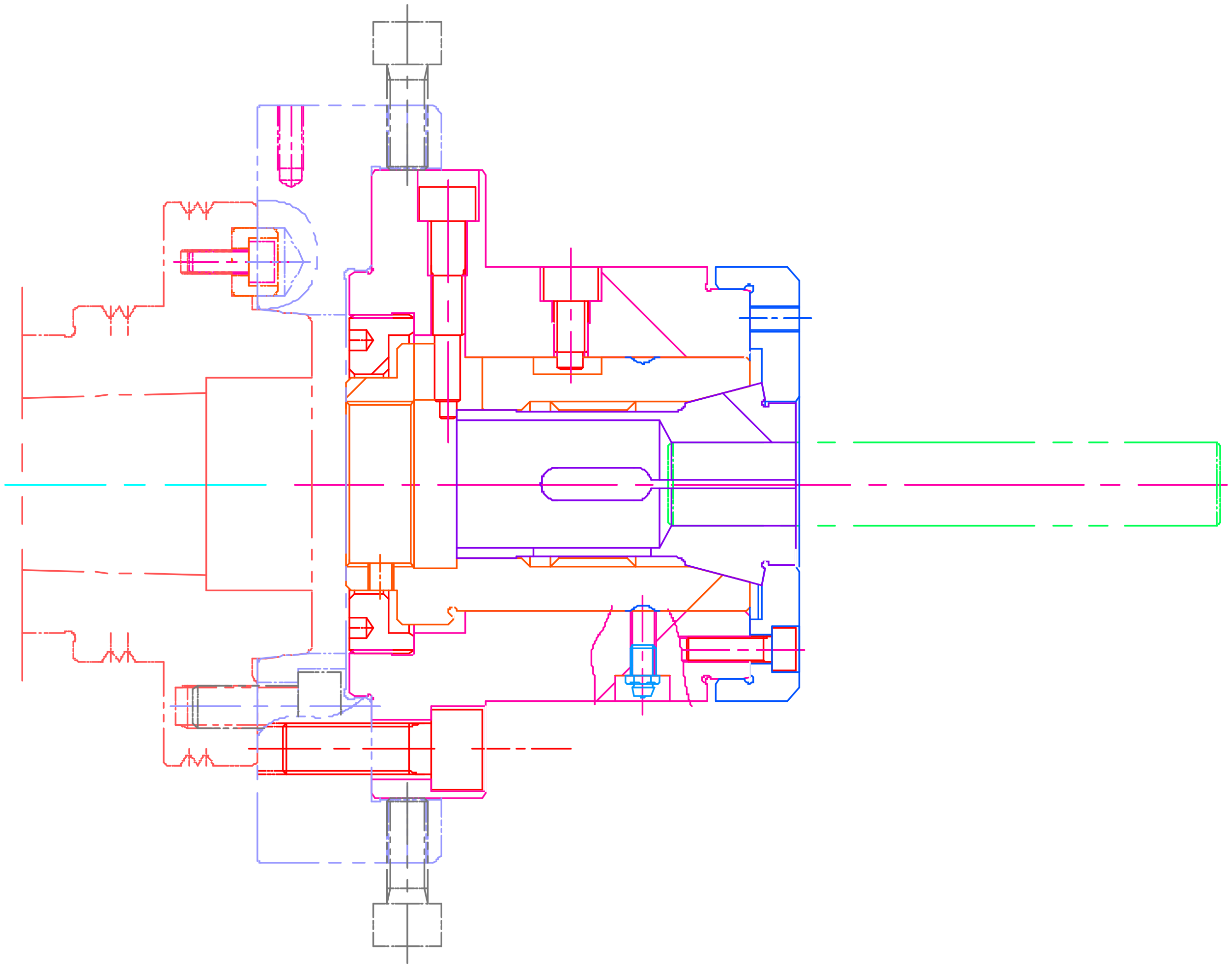
[Special type]
Multiple pin type



Work : Air control parts

Also, eccentric type, double clamping type, large dia thruhole type, seating detection type, and other special designs are available.

DEAD LENGTH COLLETS



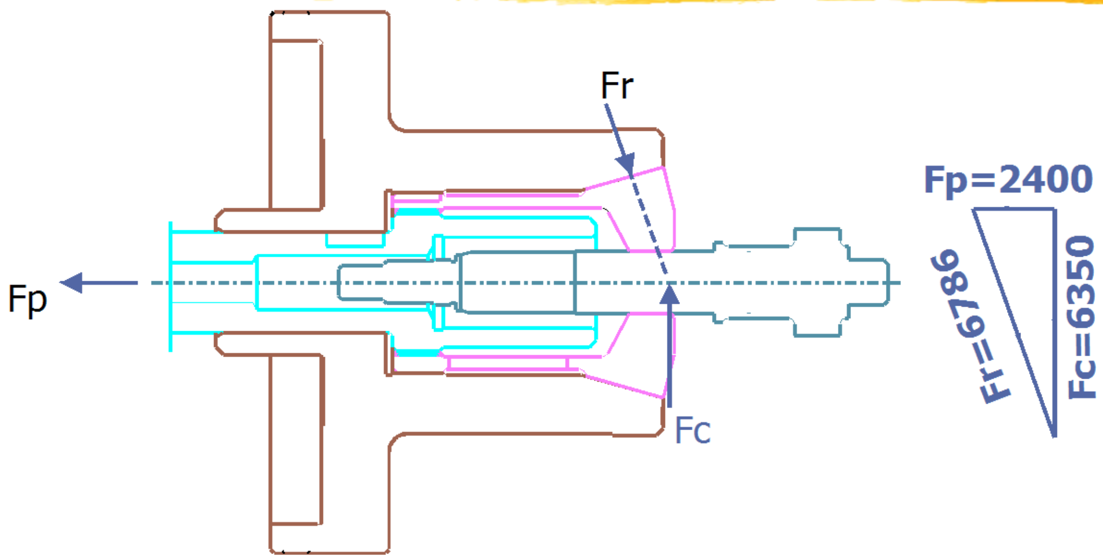
DEAD LENGTH COLLETS

- No axial movement of collet and hence called dead length collet
- By design, length consistency cannot be achieved
- Contact around periphery more compared to jaw holding
- Suitable for bar work circular or polygonal
- Change over time is less

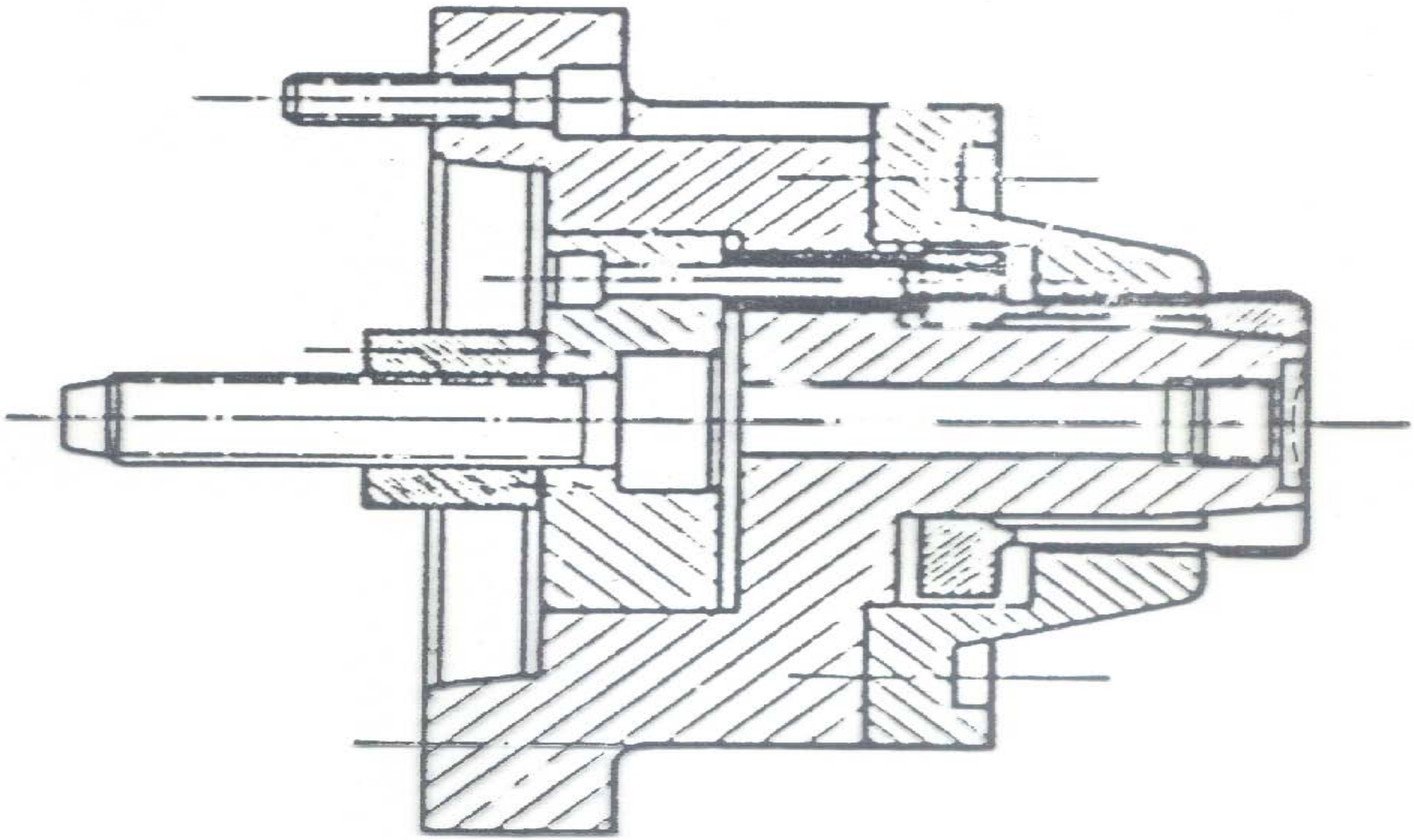
  Standard designs follow the DIN 6343 series for different sizes

COLLET CLAMPING FORCE

CLAMPING FORCE IN COLLET



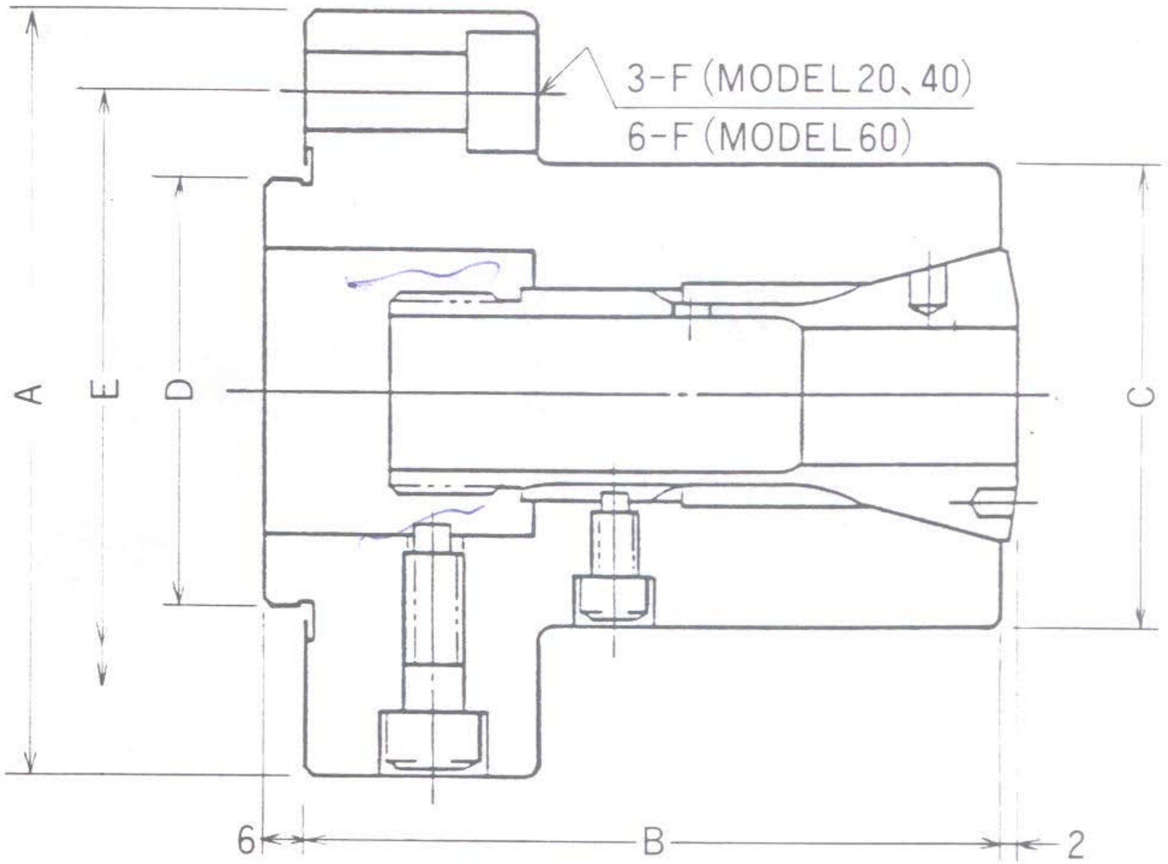
DRAW IN TYPE COLLETS



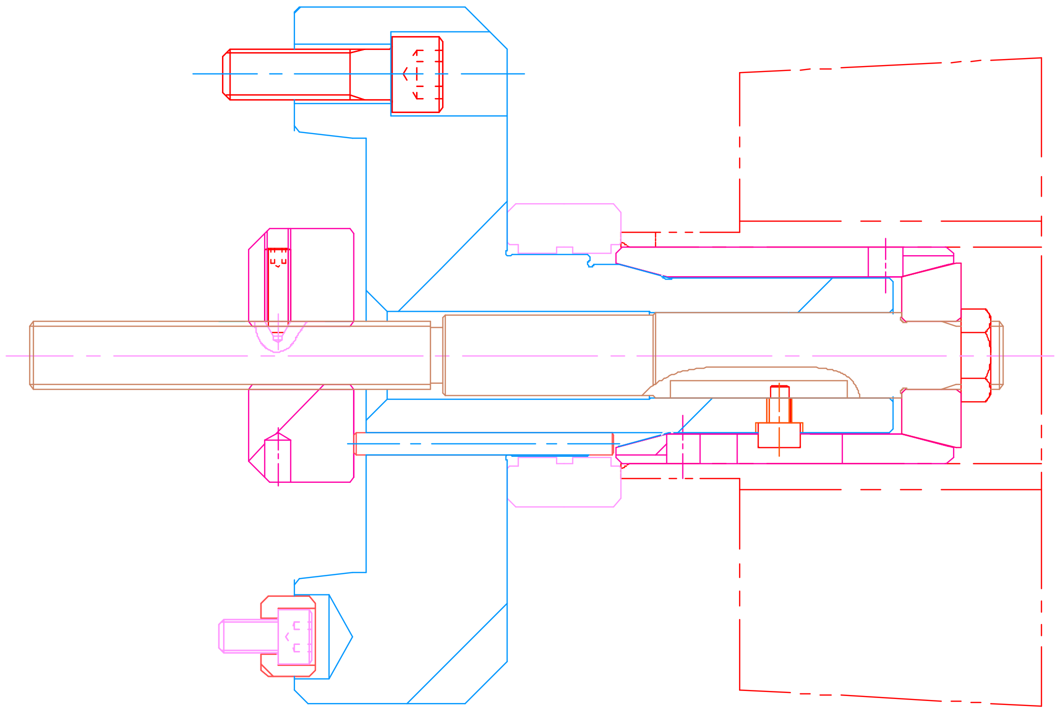
DRAW IN TYPE COLLET

ADAPTORS

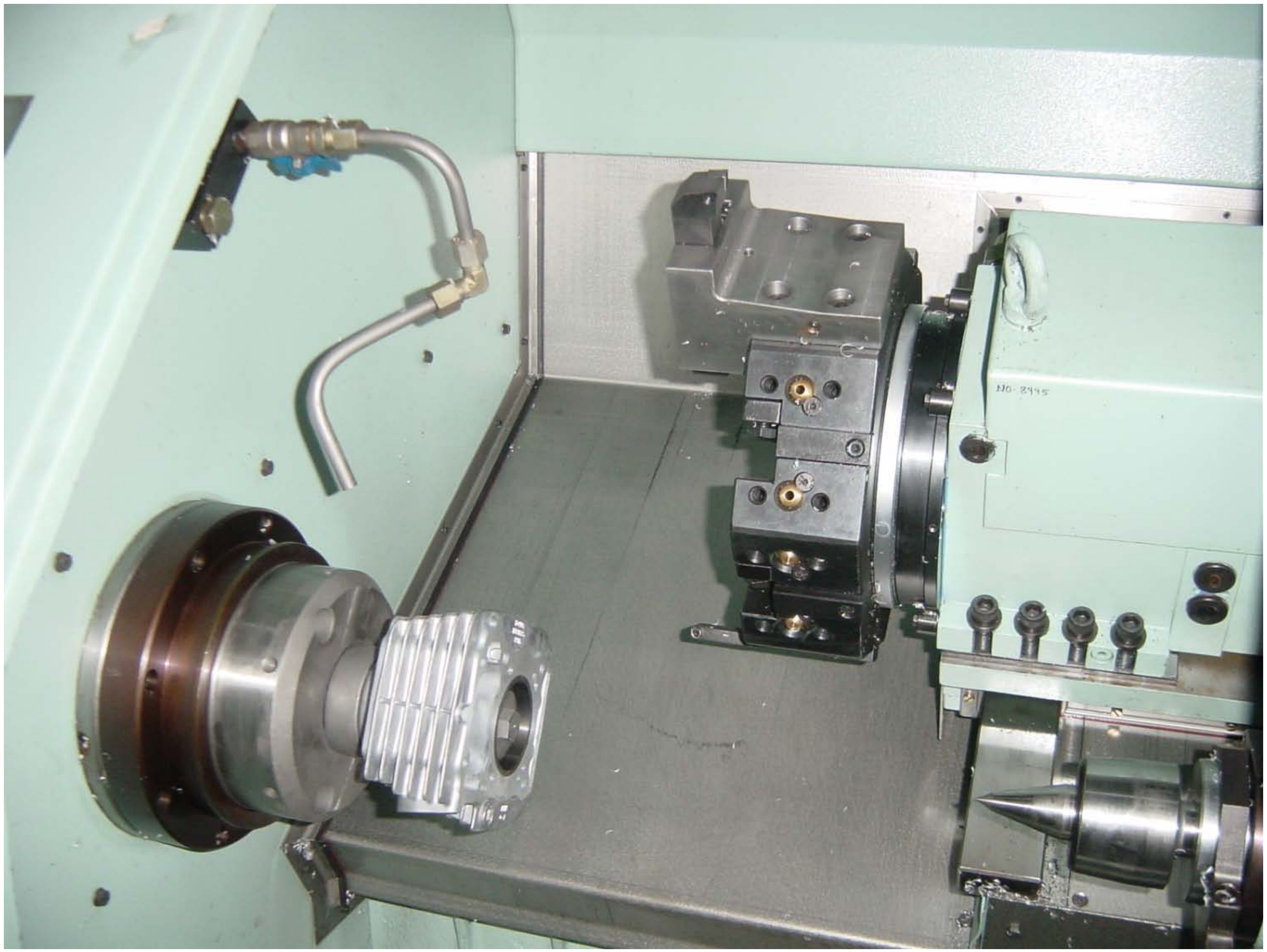
FIG. 9



DOUBLE ANGLE COLLETS



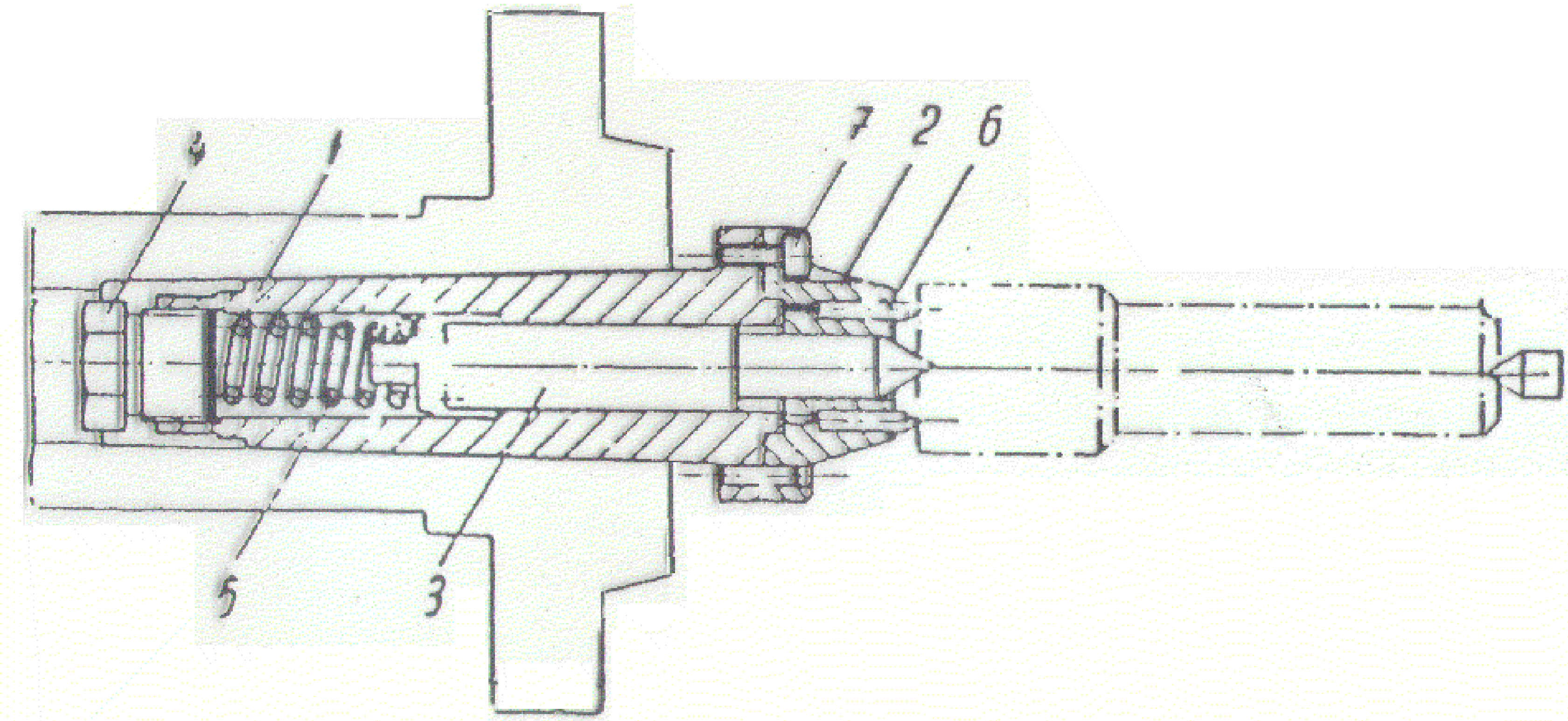
DOUBLE ANGLE MANDREL



DOUBLE ANGLE COLLETS

- Suitable for holding on long bore length
- Tailstock support may be required to improve ID and OD concentricity

FACE DRIVERS



FACE DRIVERS

- Suitable for long components
- Requires facing and centering on both end faces
- Can be used when component cannot be held between chuck and centre or between centre with dog drive

SPECIAL FIXTURES

- Face clamping fixtures
- Indexing chucks
- Single Jaw chucks
- Special 2 Jaw chucks

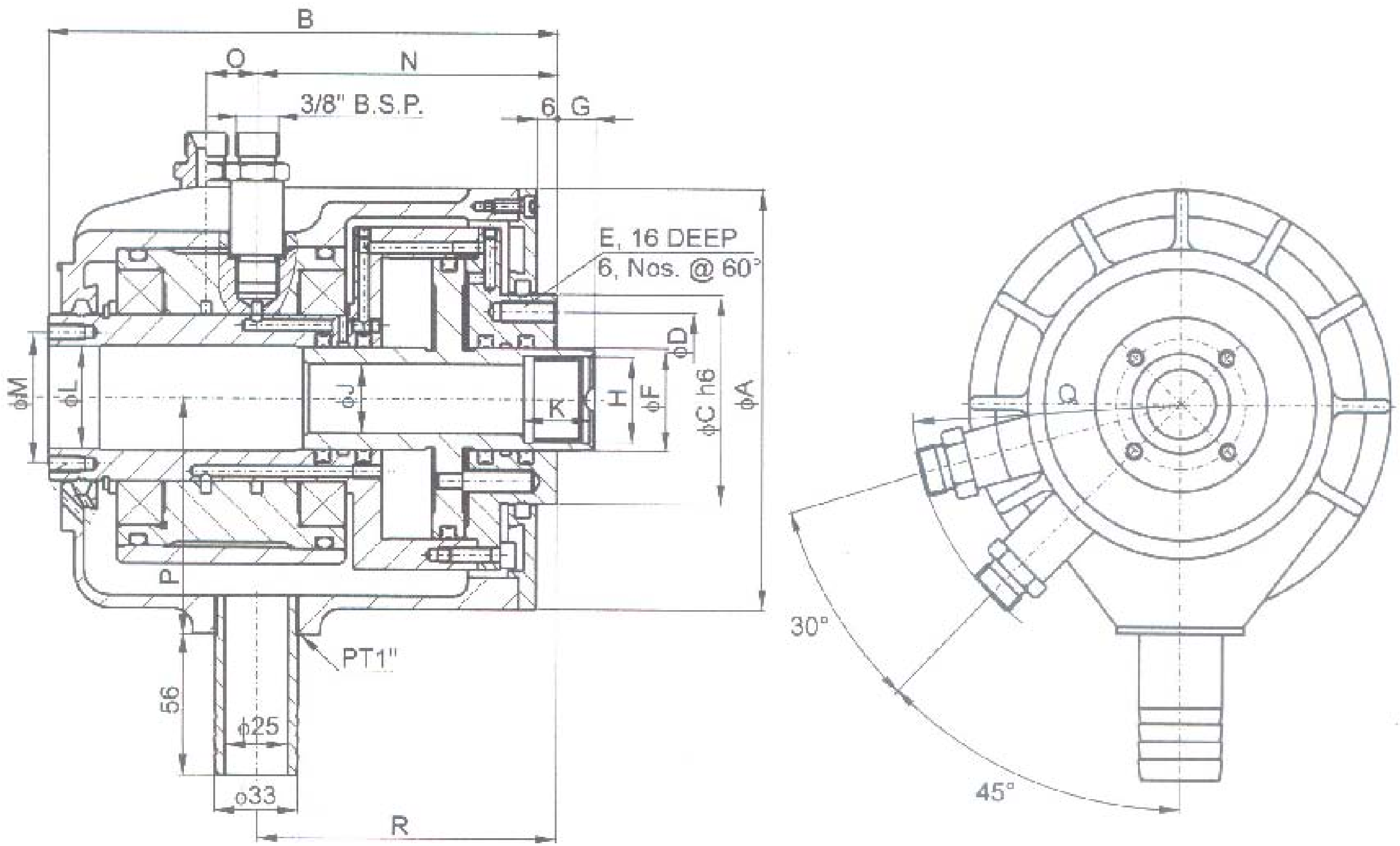
ROTARY HYDRAULIC CYLINDERS

- Act as the actuators for the work holding devices
- Designed as rotary linear cylinders
- Mounted at rear end of spindle and connected to work holding by draw bar or draw tube
- Available in different area capacities which in turn determines the pull force achievable by the cylinder.
- Incorporates a safety built in check valve to retain the pull force in case of power failure

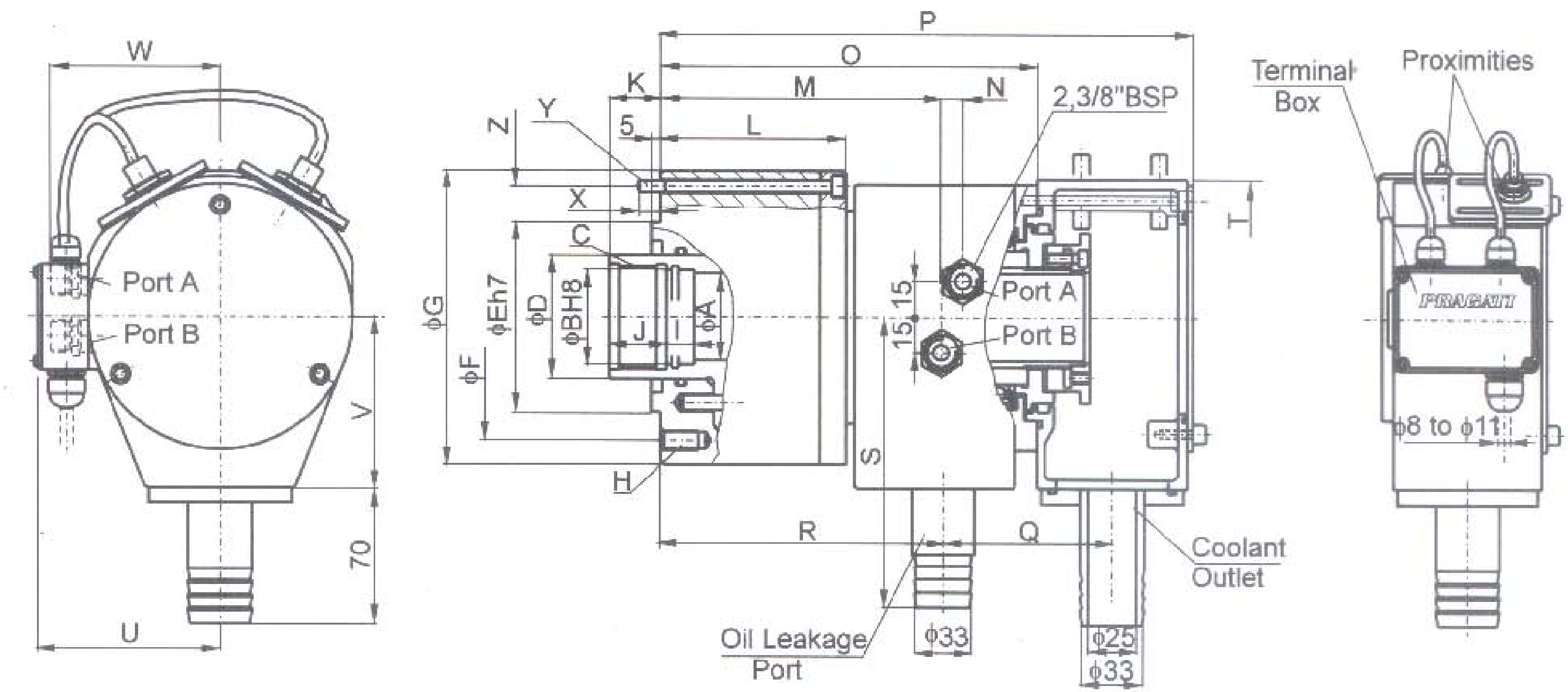
ROTARY HYDRAULIC CYLINDERS

- Another safety device in the form of stroke position indicator is also available on these cylinders
- Hollow cylinders used for thro bore applications
- Hollow cylinders suitable for bar feeder interfaces, rear stopper mounting, air thro spindle and coolant thro spindle applications

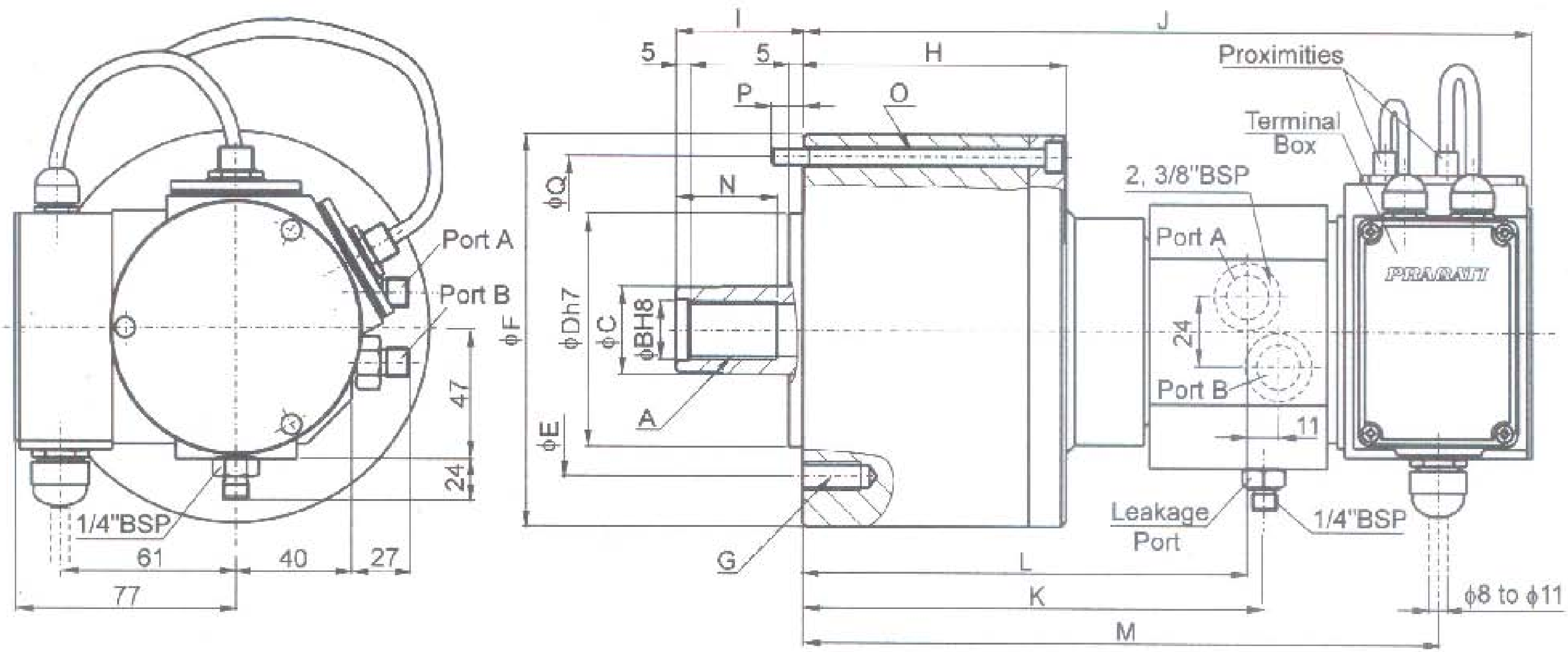
HOLLOW CYLINDER WITHOUT PROXIMITY AND COOLANT COLLECTOR



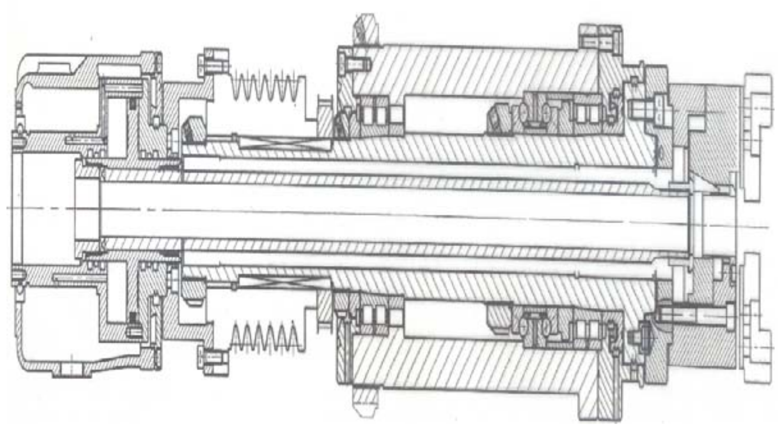
HOLLOW CYLINDER WITH SAFETY VALVE, PROXIMITY AND COOLANT COLLECTOR



SOLID CYLINDER WITH SAFETY VALVE AND PROXIMITY



ROTARY CYLINDER-WORK HOLDING INTERFACE



MAINTENANCE OF WORK HOLDINGS

- Lubricate the chuck once every shift
- Clean the jaws and butting surfaces regularly
- Establish the life of Jaws, Collets, Stoppers, etc., and replace them at regular intervals
- Avoid air gun for cleaning the work holding
- Balancing of the fixture is a must
- Take care of proper tightening since elements are running at high speeds

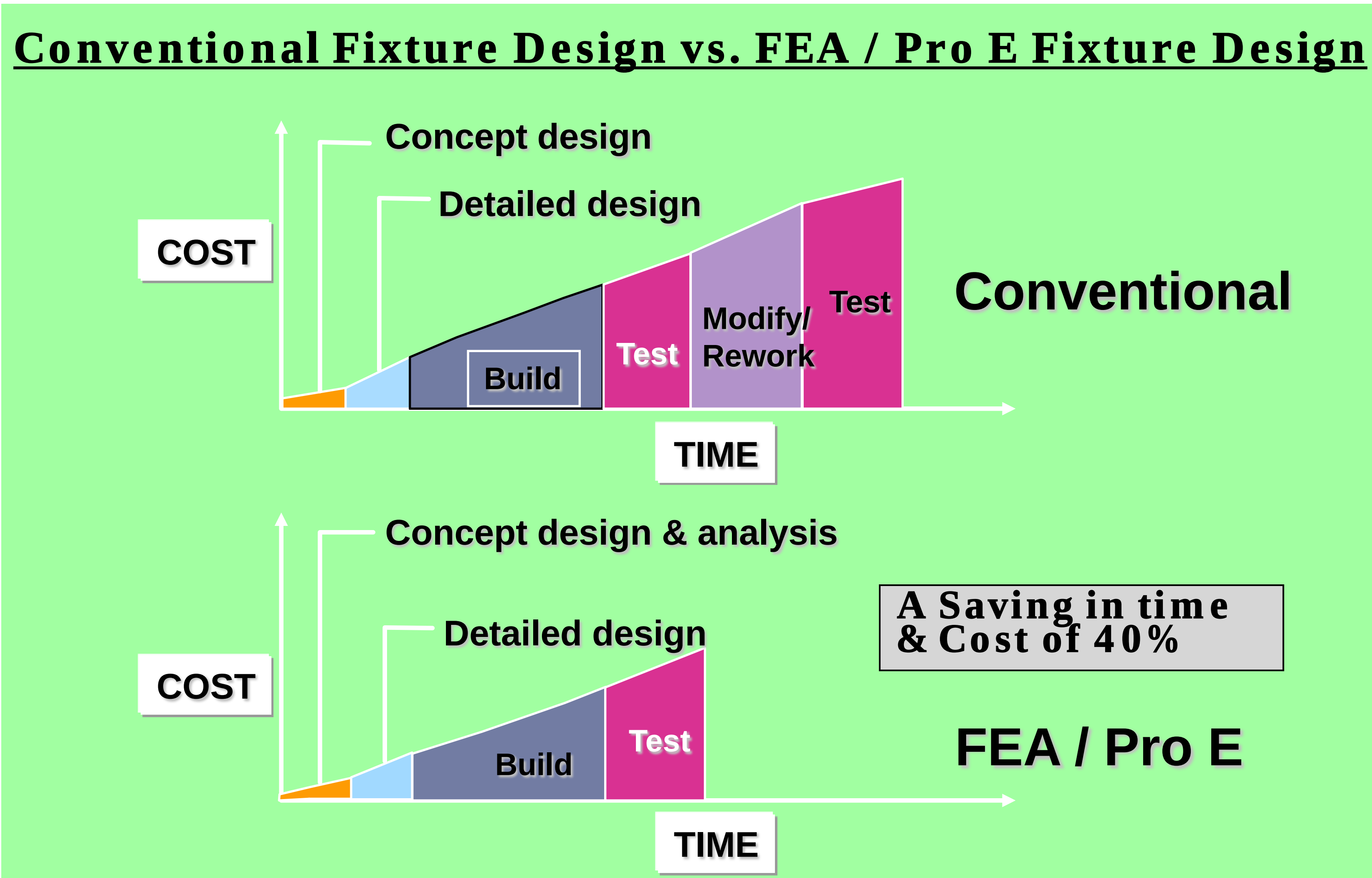
HINTS TO REDUCE CYCLE TIME

- Increase feed rates instead of cutting speeds
- Try to retain the direction of rotation same during the entire operation by suitable tooling
- Choose proper cutting tools and inserts
- Limit to the requirements of drawing
- Form plunging helps in higher productivity
- Optimise the program to eliminate idle times

SAFETY MEASURES for TURNING

- Spindle should start rotating only after clamping pressure is reached and unclamping is possible only after the spindle comes to complete stop
- Parts should remain firmly clamped even in case of power failure
- Consideration of speed limits of the work holding
- Consideration of pull force limits of the work holding

Cost Control – Competitive Advantage



Competitive Advantage

Superior Process Capability And Reliability

- FEA determines optimal clamping conditions
- Automatic hydraulic clamping can simplify loading process and increase repeatability
- Integral pallet/fixture can eliminate stacking of tolerances

Competitive Advantage

Higher Process Efficiency

- Low profile & Simple fixtures can provide more spindle access and allow consolidation of operations
- Innovative fixture design can reduce fixture costs and optimise Component machining processes

Reference Guide for Fixture Design

- JIGS AND FIXTURES – HIRAM E. GRANT

Q&A

- Thanks !!

Indian Machine Tool Manufacturers' Association