Manufacture of Core Subassemblies & Fertile Fuel Assemblies for Indian Fast Breeder Programme

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DAE, India
### Three Stage Nuclear Power Program

#### Stage – I
- **PHWRs**
  - 16 - Operating
  - 2 - Under construction
  - Several others planned
  - Scaling to 700 MWe
  - Gestation period being reduced
  - POWER POTENTIAL $\approx 10,000$ MWe

<table>
<thead>
<tr>
<th>Year</th>
<th>Availability/Capacity Factor (%)</th>
</tr>
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<tbody>
<tr>
<td>1995-96</td>
<td>69</td>
</tr>
<tr>
<td>1996-97</td>
<td>72</td>
</tr>
<tr>
<td>1997-98</td>
<td>75</td>
</tr>
<tr>
<td>1998-99</td>
<td>84</td>
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<td>1999-00</td>
<td>84</td>
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<td>2000-01</td>
<td>86</td>
</tr>
<tr>
<td>2001-02</td>
<td>85</td>
</tr>
<tr>
<td>2002-03</td>
<td>90</td>
</tr>
</tbody>
</table>

#### LWRs
- 2 BWRs Operating
- 2 VVERs under construction

#### Stage - II
- **Fast Breeder Reactors**
  - 40 MWth FBTR - Operating since 1985
  - Technology Objectives realised
  - 500 MWe PFBR - Under Construction
  - POWER POTENTIAL $\approx 350,000$ Mwe

#### Stage - III
- **Thorium Based Reactors**
  - 30 kWth KAMINI - Operating
  - 300 MWe AHWR - Under Development

POWER POTENTIAL IS VERY LARGE

Availability of ADS can enable early introduction of Thorium on a large scale
Schematic Diagram of Fast Breeder Test Reactor
## Main Characteristics of FBTR

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Initial Design</th>
<th>Present Small Core</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reactor Type</td>
<td>Sodium cooled, loop type</td>
<td></td>
</tr>
<tr>
<td>Reactor Power</td>
<td>40MWt/13.2MWe</td>
<td>15MWt/2MWe</td>
</tr>
<tr>
<td>Fuel</td>
<td>MOX (30% PuO2 + 70% UO2 with 85% enrichment)</td>
<td>Mark I (70% PuC + 30% UC)  *Mark II (55% PuC + 45% UC)</td>
</tr>
<tr>
<td>No. of Fuel subassemblies</td>
<td>65</td>
<td>25 Mark-I + 13 Mark-II</td>
</tr>
<tr>
<td>Fuel Pin Diameter (mm)</td>
<td></td>
<td>5.1</td>
</tr>
<tr>
<td>No. of Pins/Subassembly</td>
<td></td>
<td>61</td>
</tr>
<tr>
<td>Max. linear Heat rating (W/cm)</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>Max. Burnup (GWd/t)</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Peak Neutron Flux (n/cm²/s)</td>
<td>3.5E15</td>
<td>2.2E15</td>
</tr>
</tbody>
</table>
FBTR Core Configuration

163 STEEL REFLECTOR SUBASSEMBLIES
3. TEST SUBASSEMBLIES

C.R. STOCKAGE POSITION
6 CONTROL ROD AND SHEATH ASSEMBLIES

65 FUEL SUBASSEMBLIES
142 NICKEL SUBASSEMBLIES

342 BLANKET SUBASSEMBLIES

SOURCE

22 FUEL STOCKAGE POSITIONS

SODIUM INLET (SOUTH)
Materials for FBTR Subassemblies

- Foot Assembly SS 316L
- Gripper Spring Nimonic 80A
- Axial Blanket Clad SS 316L
- Fuel Clad SS 316M
- OHT SS 316L
- IHT SS 316L
- Handling Head SS 316L
- Hard Chrome Plating on OHT Buttons
## Test Subassemblies for FBTR

<table>
<thead>
<tr>
<th>Type of Subassembly</th>
<th>Qty.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carrier SAs with Capsules for Irradiation Experiments</td>
<td>29 Nos.</td>
</tr>
<tr>
<td>ISZ-100</td>
<td>14 Nos.</td>
</tr>
<tr>
<td>IBZ-100</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>INZ-100</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>CIPTEX</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>Source Carrier SA</td>
<td>1 No.</td>
</tr>
<tr>
<td>SA for Sodium Void-Coefficient Measurement</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>SA for Delayed Neutron Detection (DND)</td>
<td>1 No.</td>
</tr>
<tr>
<td>Special SAs for Sodium Filter</td>
<td>8 Nos.</td>
</tr>
<tr>
<td>SAs for Flow Blockage Experiments</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>IFZ-100</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>IF 1300</td>
<td>1 No.</td>
</tr>
</tbody>
</table>
I. AXIAL BLANKET PIN FABRICATION

1. 1ST END PLUG WELDING (GTAW) WITH CLAD TUBE

2. LOAD THE ThO2 PELLET STACK IN THE 1ST END PLUG WELDED CLAD TUBE

3. 2ND END PLUG WELDING IN CLOSED CHAMBER IN He GAS ATMOSPHERE

4. SPACER WIRE WRAPPING & SPOT WELDING (RESISTANCE) AND WIRE END WELDING BY GTAW

5. INSPECTION

6. ACCEPTED AXIAL BLANKET PINS

II. LOWER INNER PORTION OF FUEL SA

7. ASSEMBLE FUEL RAILS AND RIVETS WITH LOWER INNER HEXAGONAL TUBE

8. ASSEMBLE AXIAL BLANKET PINS (7 NOS.), SPACERS, LOWER INNER HEXAGONAL TUBE AND RIVETS, FORM & FLARE THE RIVETS

9. ASSEMBLE LOWER INNER HEXAGONAL TUBE WITH FOOT ASSEMBLY AND WELD BY GTAW
III. UPPER SA OF FUEL SUBASSEMBLY

1. Assemble axial blanket pins (7 nos.), spacers, upper inner hexagonal tube and rivets, form & flare the rivets.

2. Assemble upper inner hexagonal tube with lifting head and weld by GTAW.

3. Assemble upper inner hexagonal tube along with lifting head with outer hexagonal tube and weld by GTAW.

4. Assemble fuel pins (6 nos.) over rails of lower part of fuel subassembly. Enveloping the fuel pins and lower inner hexagonal tube with OHT of upper subassembly.

5. Weld OHT to foot by GTAW.

6. Final inspection of finished fuel subassembly.

7. Alcohol cleaning of fuel subassembly.

8. Packing and dispatch/store.
Components for FBTR Subassemblies
Components for FBTR Subassemblies
Tubular Components for FBTR Subassemblies
Welding Techniques Used for FBTR Subassembly Fabrication

- OHT to Foot & Head Portion Welding (GTAW)
- Bottom Plug Welding (GTAW)
- Top Plug Welding (GTAW)
Developments in $\text{ThO}_2$ pellet production

**Production**

1. Addition of MgO (0.5 mol%) to get higher sintered densities while sintered at 1600°C under hydrogen.

2. Ball milling of long stored powders to increase sinterability.

3. Low temperature sintering at 1150°C in air atmosphere, with addition of $\text{Nb}_2\text{O}_5$ (0.25 mol%) as sintering aid.
   - Saving in energy consumption.
   - Avoiding usage of hydrogen.
Quality Checks:
1. Thermal etching techniques
   - Re-sintering of well polished pellet surface, revealed clear grain boundaries.
2. Faster dissolution of thoria pellet during chemical analysis by modified technique.

```
Thoria Pellet Pulverising
  ↓
Heating
  ↓
Addition of HNO₃ and Boiling
  ↓
Addition of few drops of HF
  ↓
Complete dissolution with in 4-5 hrs
```
Ceramographs of ThO$_2$+0.5 mol% MgO for 3h in Hydrogen. Sintered at 1600ºC & thermally etched at 1600ºC
Particle Size Distribution of Thoria Powder

MEDIAN = 1.24 μm
SP. AREA = 87223 cm²/cm³

% on DIA: 10.0 μm = 100.0 %
DIA on %: 90.0% = 2.98 μm
### Chemical Characteristics of Thoria Powder

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Name</th>
<th>Impurities max. level in ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al</td>
<td>Aluminium</td>
<td>50</td>
</tr>
<tr>
<td>B</td>
<td>Boron</td>
<td>0.3</td>
</tr>
<tr>
<td>Be</td>
<td>Beryllium</td>
<td>1.0</td>
</tr>
<tr>
<td>C</td>
<td>Carbon</td>
<td>100</td>
</tr>
<tr>
<td>Ca</td>
<td>Calcium</td>
<td>200</td>
</tr>
<tr>
<td>Cd</td>
<td>Cadmium</td>
<td>0.1</td>
</tr>
<tr>
<td>Ce</td>
<td>Cerium</td>
<td>4.0</td>
</tr>
<tr>
<td>Cr</td>
<td>Chromium</td>
<td>5.0</td>
</tr>
<tr>
<td>Cu</td>
<td>Copper</td>
<td>50</td>
</tr>
<tr>
<td>Dy</td>
<td>Dysprosium</td>
<td>0.2</td>
</tr>
<tr>
<td>Eu</td>
<td>Europium</td>
<td>0.08</td>
</tr>
<tr>
<td>Er</td>
<td>Erbium</td>
<td>0.2</td>
</tr>
<tr>
<td>F</td>
<td>Fluorine</td>
<td>10</td>
</tr>
<tr>
<td>Fe</td>
<td>Iron</td>
<td>100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Name</th>
<th>Impurities max. level in ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gd</td>
<td>Gadolinium</td>
<td>0.2</td>
</tr>
<tr>
<td>Mg</td>
<td>Magnesium</td>
<td>50</td>
</tr>
<tr>
<td>Mn</td>
<td>Manganese</td>
<td>2.0</td>
</tr>
<tr>
<td>Mo</td>
<td>Molybdenum</td>
<td>20</td>
</tr>
<tr>
<td>Ni</td>
<td>Nickel</td>
<td>30</td>
</tr>
<tr>
<td>P</td>
<td>Phosphorus</td>
<td>50</td>
</tr>
<tr>
<td>Si</td>
<td>Silicon</td>
<td>60</td>
</tr>
<tr>
<td>Sb</td>
<td>Antimony</td>
<td>2.0</td>
</tr>
<tr>
<td>S</td>
<td>Sulphur</td>
<td>50</td>
</tr>
<tr>
<td>Sm</td>
<td>Samarium</td>
<td>0.4</td>
</tr>
<tr>
<td>V</td>
<td>Vanadium</td>
<td>5.0</td>
</tr>
<tr>
<td>U</td>
<td>Uranium</td>
<td>100</td>
</tr>
<tr>
<td>Zr</td>
<td>Zirconium</td>
<td>20</td>
</tr>
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</table>

- Not more than 100ppm of any other element except thorium and oxygen.
- EBC<1.5ppm
Need for Certified Reference Materials (CRMs)

- The qualification of ThO$_2$ needs the validation of analytical procedure, which, in turn, requires CRMs for the purpose.
- CRMs are used for assessing the performance of an individual laboratory.
- Also, ThO$_2$ CRMs are very expensive in international market to buy.
- NFC has made CRMs of Thoria Powder and also ThO$_2$+2.5%UO$_2$ Powder.
Flow Sheet for producing CRMs

Thorium Nitrate Crystals

Dissolution in Hot DM Water

Addition of 20 impurity elements mixture Solution to Th(NO$_3$)$_4$ solution

Precipitation of Thorium oxalate

Filtration

Filtrate for storage & Safe disposal

Drying & calcination

Blending & Storage of Final ThO$_2$ Oxide powder
Classification for the Analytes in Four Samples

<table>
<thead>
<tr>
<th>Sample</th>
<th>Elements</th>
<th>Class</th>
<th>Elements</th>
<th>Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>ThO₂ –B</td>
<td>Al, Ca, Cr, Cu, Mg, Mn, Mo, Ni, Sm, V</td>
<td>A</td>
<td>B, Be, Cd, Ce, Dy, Er, Eu, Gd, Fe, Sb</td>
<td>C</td>
</tr>
<tr>
<td>ThO₂ -S</td>
<td>Al, Cd, Ce, Cr, Cu, Dy, Er, Eu, Fe, Gd, Mg, Mn, Ni, Sb, Sm, V</td>
<td>A</td>
<td>B, Be, Ca, Mo</td>
<td>C</td>
</tr>
<tr>
<td>ThO₂ - D</td>
<td>Al, Ca, Cd, Ce, Cr, Cu, Dy, Er, Eu, Fe, Gd, Mg, Mn, Ni, Sb, Sm, V</td>
<td>A</td>
<td>B, Be, Mo</td>
<td>C</td>
</tr>
<tr>
<td>ThO₂+ 2.5% UO₂ - MOS</td>
<td>Al, Ca, Cd, Ce, Cr, Cu, Er, Eu, Mg, Mn, Ni, Sm, Sb, V</td>
<td>A</td>
<td>B, Be, Dy, Fe, Gd, Mo</td>
<td>C</td>
</tr>
</tbody>
</table>

From the table it is clear that out of 20 elements added as impurities, upto 17 elements have got the status of class A which is the testimony to the homogeneity of the powder made at NFC. Further, more number of elements getting Class-C status in case of ThO₂-B sample is attributed to variations associated with analytical measurements of low concentrations.
ThO$_2$ Powder
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Main Vessel</td>
</tr>
<tr>
<td>02</td>
<td>Core Support Structure</td>
</tr>
<tr>
<td>03</td>
<td>Core Catcher</td>
</tr>
<tr>
<td>04</td>
<td>Grid Plate</td>
</tr>
<tr>
<td>05</td>
<td>Core</td>
</tr>
<tr>
<td>06</td>
<td>Inner Vessel</td>
</tr>
<tr>
<td>07</td>
<td>Roof Slab</td>
</tr>
<tr>
<td>08</td>
<td>Large Rotating Plug</td>
</tr>
<tr>
<td>09</td>
<td>Small Rotating Plug</td>
</tr>
<tr>
<td>10</td>
<td>Control Plug</td>
</tr>
<tr>
<td>11</td>
<td>CSRDM / DSRDM</td>
</tr>
<tr>
<td>12</td>
<td>Transfer Arm</td>
</tr>
<tr>
<td>13</td>
<td>Intermediate Heat Exchanger</td>
</tr>
<tr>
<td>14</td>
<td>Primary Sodium Pump</td>
</tr>
<tr>
<td>15</td>
<td>Safety Vessel</td>
</tr>
<tr>
<td>16</td>
<td>Reactor Vault</td>
</tr>
</tbody>
</table>
### PFBR Core Configuration

#### Table: Subassembly Count

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Type of Subassembly</th>
<th>Nos.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FUEL (INNER)</td>
<td>85</td>
</tr>
<tr>
<td></td>
<td>FUEL (OUTER)</td>
<td>96</td>
</tr>
<tr>
<td></td>
<td>CONTROL &amp; SAFETY ROD</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>DIVERSE SAFETY ROD</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>BLANKET</td>
<td>120</td>
</tr>
<tr>
<td></td>
<td>STEEL REFLECTOR</td>
<td>138</td>
</tr>
<tr>
<td></td>
<td>B4C SHIELDING (INNER)</td>
<td>125</td>
</tr>
<tr>
<td></td>
<td>STORAGE LOCATION</td>
<td>156</td>
</tr>
<tr>
<td></td>
<td>STEEL SHIELDING</td>
<td>609</td>
</tr>
<tr>
<td></td>
<td>B4C SHIELDING (OUTER)</td>
<td>417</td>
</tr>
<tr>
<td></td>
<td><strong>TOTAL SUBASSEMBLIES</strong></td>
<td><strong>1758</strong></td>
</tr>
</tbody>
</table>
Materials for PFBR Subassemblies

- Fuel Clad Tube - D9
- Hexcan - D9
- Components - SS 316LN
- Natural B₄C Pellets
- Top Axial Shielding Clad Tube – SS 316LN
Tubes for Core Structural

- **FUEL CLAD TUBES**
  - (6.6 x 0.45 x 2555 mm)

- **BLANKET CLAD TUBES**
  - (14.33 x 0.56 x 2350 mm)

- **CSR CLAD TUBES**
  - (22.4 x 1 x 1260 mm)

- **DSR CLAD TUBES**
  - (21.4 x 0.7 x 1110 mm)

- **REFLECTOR CLAD TUBES**
  - (44 x 1 x 3325 mm)

- **IBC CLAD TUBES**
  - (44 x 1 x 3325 mm)
Material Compositions

- **D9 for Clad Tubes:** Cr: 13.5-14.5, Ni: 14.5-15.5, Mo: 2, Ti: 5C-7.5C, N: 50 ppm, Inclusion Rating: 1

- **D9 for Hexcan Tubes:** Cr: 13.5-14.5, Ni: 14.5-15.5, Mo: 2, Ti: 5C-7.5C, N: 100 ppm, Inclusion Rating: 4

- **D9 for Spacer Wire:** Cr: 13.5-14.5, Ni: 14.5-15.5, Mo: 2, Ti: 5C-7.5C, N: 50 ppm, Inclusion Rating: 1

- **316LN for Bulk Components:** C: 0.02-0.03, N: 0.06-0.08

- **Spring Wire:** ASTM A-286
Flow Sheet for Natural Boron Carbide Pellets

Boric Acid Powder + Graphite

B4C Powder

Boron Carbide Pellet

- Blending
- Heating in Crystal Formation Furnace
- Crushing of B4C Lumps
- Pulverising
- Vibro-sieving & Drying

- Hot Compaction
- Sand Blasting
- Centreless Grinding
- Surface Grinding
Flow Sheet for Enriched Boron Carbide Pellets

- Boric Acid
  - Distillation
- Enriched Boric Acid
  - Dissolution in HF
  - Precipitation with KOH
  - Filtration & Drying
- KBF4
- Elemental Boron
  - Electrolysis
  - Crushing of cathode deposit
  - Leaching, filtration & drying
- Boron Carbide Pellet
  - Mixing with carbon
  - Green compaction
  - Heating in vacuum induction furnace
# PFBR Test Subassemblies

<table>
<thead>
<tr>
<th>Type of Subassembly</th>
<th>Qty.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel SA for Hydraulic Testing</td>
<td>1 no.</td>
</tr>
<tr>
<td>Fuel SA for FIV Testing</td>
<td>1 no.</td>
</tr>
<tr>
<td>Blanket SA for Hydraulic Testing</td>
<td>1 no.</td>
</tr>
<tr>
<td>CSR SA for Drive Mechanism Testing</td>
<td>2 nos.</td>
</tr>
<tr>
<td>CSR SA for Hydraulic Testing</td>
<td>2 nos.</td>
</tr>
<tr>
<td>DSR SA for Drive Mechanism Testing</td>
<td>1 no.</td>
</tr>
<tr>
<td>DSR SA for Hydraulic Testing</td>
<td>1 no.</td>
</tr>
<tr>
<td>Reflector SA for Hydraulic Testing</td>
<td>1 no.</td>
</tr>
<tr>
<td>Inner Boron Carbide Shielding SA for Hydraulic Testing</td>
<td>1 no.</td>
</tr>
<tr>
<td>Handling Experiment Subassemblies</td>
<td>28 nos.</td>
</tr>
<tr>
<td>37 Element Fuel SA</td>
<td>2 nos.</td>
</tr>
</tbody>
</table>
PFBR Subassemblies Fabricated

- Fuel Subassembly
- Blanket Subassembly
- Reflector Subassembly
- CSR Sheath & Rod Subassembly
- DSR Sheath & Rod Subassembly
- Inner Boron Carbide Subassembly
Manufacture of Hexcans & Square Channels through Pilgering Route

DIFFICULTIES ENCOUNTERED DURING FABRICATION

- Formation of twist
- Formation of bow
Components for PFBR Subassemblies

- Handling Head
- Piston
- Foot Upper Part
- Dash Pot Cylinder
- Bottom Plug
- Coolant Entry Tube
Bottom Plug Welding Machine

Top Plug Welding Machine

Wire Wrapping & Spot Welding Machine

Crimping Machine
Special Features of the Equipment

- Precision current control to ±0.5Amps with feedback system with smooth arc stability in Helium atmosphere.
- Automatic initial arc gap setting and arc gap control.
- Automatic data acquisition and feedback control system with recording facilities for critical parameters like current, voltage, (arc distance), weld speed, vacuum level, Helium pressure, oxygen level (inert gas quality), etc.
- Precision special purpose fixturing for GTAW, Resistance welding techniques.
Button Forming Machine
Automatic Hexcan Welding Machine

- Both conventional and orbital techniques with GTAW cum Plasma were applied successfully for hexcan peripheral welding with filler addition.
- Automatic torch inclination with Torch oscillation axis provided for keeping it perpendicular to welding face in synchronization with tube rotation.
- Software based automatic control with feedback system for all critical parameters with recording facilities.
- Arc Distance Control
Automatic Pin Assembling Machine

1. Pin Magazine (127 Pins)
2. Foot Assembly
3. Hexcan assembled with Top Assembly
4. Shielding
5. Input Trolley
6. Material Transfer Robot

7. Pin Assembling Robot
8. Pin Pushers
9. Special Grippers for Pin
10. Assembly Stn./Fixture
11. Lower Part Holding Stn.
12. Welding/Bead Grinding Robot
13. Finished Subassembly
Inspection Techniques Involved

- Fluorescent Die Penetrant Test
- Metallography
- X-Radiography
- Ultrasonic Testing (Pulsed Echo & Surface Wave Technique)
- Helium Leak Testing
- Visual & Dimensional
Surface wave based methodology for NDE of Hexcan weld of PFBR subassembly

Hexcan weld

Edge reflection

2.2 mm (W)

2.7 mm (W)

2.2 mm (HAZ)

(a)

(b)

![Graph showing amplitude vs. angle for different notch sizes and scan sides.](image-url)
Oxide Dispersion Strengthened (ODS) Steels

Precipitation hardening effect will be lost in ferritic steels above 923 K. Oxide dispersion strengthening will be effective even above 973 K.
Double clad tubes for Fast Breeder Reactors

Schematic of Double Clad Tube Fabricated at NFC

Desired dimensions as per specification

Tube Section showing Outer & Inner Walls of T91 & Zr Alloy

Enlarged View showing no gap at T91-Zr Interface along with wall thickness measurement

Tube-in-Tube design for metallic fuels
Conclusions

1. Indigenous development of technology for core sub-assembly fabrication for FBTR.
2. Development of process equipment and QA procedures for the above.
3. Currently, manufacture of core sub-assemblies for PFBR underway.
4. Actions on hand to establish facilities for sub-assembly manufacture for future FBRs, as part of Fuel Cycle Complex.
Thank You
Major Components of the Equipment

• Rail mounted predefined position mobile trolley with shielding for input components upper & lower parts, pins (217) in pin magazines (2).
• Specialized track mounted robots for components handling (R1), pins picking, orientation identifying and placing (inserting) over rails (R2) and hexcan to lower part welding(R3).
• Lower parts, pins & upper parts assembly fixture (customized lathe with specialized supports and shielding).
• Upper parts (hexcan & handling head) pin magazine support system with automatic hexcan inserting.
• Robotics & process controls with feedback system.
• Special end of the arm facility effectors for handling, pick and place, welding torch, excess bead grinding and inspection gadgets, tooling, if required.
• CCTV cameras (3nos.) for vision system.
Special Features of the Equipment

• Remotisation of radioactive pins assembling and fabrication processes (weld bead finishing and testing) with robotics.

• Specialized robots for heavy duty machine handling, precision pick and place and advanced GTAW welding functions with complete integration for their coordinated activities.

• Complete operation with remote controlled with CCTV camera and vision system.

• Localized (source) shielding provided for neutron and Gamma radiation.