

Invitation of

**Expression of Interest for**  
**Power Transformer**  
**Drawing Automation**

**Transformer Engineering Department**  
**BHEL Jhansi**

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## About Bharat Heavy Electrical Limited

BHEL is a premier engineering and manufacturing organization, majority owned by Government of India, catering to core infrastructure sectors of India economy viz Power Generation and Transmission, Industry, Transportation, and Renewable Energy. The company has 14 manufacturing units, 4 Power sector regions, 8 service centers and 15 regional offices, besides host of project sites spread all over India and abroad. BHEL supplied equipments account for 65% of total thermal generation capacity in India and contribute 73% of the total Power generation in the country.

BHEL Jhansi is one of the manufacturing units of BHEL. BHEL Jhansi is having two Main Products i.e. Transformers and Locomotives. The Transformer division is in the market of all type of Transformers i.e. Power Transformer, Rectifier Transformer Dry type transformer, Instrument Transformer, EMU Transformer, Furnace Transformer, ESP Transformer, Earthing Transformer, and Single phase railway Transformer. BHEL Jhansi manufactures Power Transformer of upto 220kV and 250MVA. The Locomotive division is in manufacturing of Electrical and Diesel Locomotives. BHEL Jhansi is presently developing AC EMU coaches for Indian Railways and has developed WAG7 electric loco, DE Shunters in the range of 350 hp to 1400 hp, various other utility vehicles including Rail cum Road Vehicle, Battery Powered Road Vehicle, dynamic track stabilizer, ballast cleaning machine, Hoist assembly for ship lift system etc. BHEL has also done many enhancements in existing products like eye bolt CT, Aluminum foil cast resin Dry type Transformer, 132 KV Live Tank CT, 400KV CT Design, StepLap Core and many more. BHEL Jhansi is also expanding its manufacturing capacity in Power Transformer and Locomotive, and also entering in 400kV Power Transformer market. Presently BHEL Jhansi is having huge order of Transformers and WAG7 Locos.

## Scope of Work

The turnover of Transformer division for financial year 2010-11 is more than Rs.700crores. Power Transformer is a tailor made product and its engineering totally depends upon customer requirement. For each type of transformer detail design (Engineering calculation, Drawings etc) is done. Transformer Engineering Department (TRE) wants to automate the manufacturing/ customer drawings of Power Transformer.

Each Power transformer design involve preparation of approximately 30 to 60 nos. of manufacturing drawings of about eight different sub assemblies. The preparation of manufacturing drawings takes an average of three months time. Due to market pressure to reduce the delivery cycle time to 3-4 months and to save on engineering manpower cost, it is intended to carry out the automation/ customization of engineering drawings. Our goal is to bring down the engineering cycle time from present 12 weeks to 2-3 weeks for issue of manufacturing drawings and information to our production section.

Presently BHEL generates 2D Drawings & Bill of Material (BOM) in AutoCAD. BHEL has also started manual punching of BOM in Oracle database, which is directly

linked to BHEL in-house developed ERP system (like planning, material handling etc). The creation of 2D drawing in AutoCAD takes lot of time in drafting & BOM calculation like weight, Material, Size etc. To reduce this time and to increase accuracy, BHEL wants the Automation of the Power Transformer 2D manufacturing/ customer drawing through 3D Parametric Models and export of BOM in BHEL Oracle system.

## Familiarization of the Product

As has been mentioned above, transformer is a tailor made product. There are many features in a transformer, which vary from one customer to the other. Transformer is having following 8 assemblies.

### 1. Core & Endframe Assembly

Any transformer consists of core and winding. Core is the magnetic circuit through which flux flows. Core is made by stacking the 0.27mm/ 0.23mm thick CRGO steel. Core is clamped by Yoke bolt/ Belt and Top/ Bottom Endframe. Clamp Plate of rectangular cross section/ Tie Rod are used to clamp the top and bottom end frames through pin pad assembly. Pressure pad are placed on projected edge in Top Endframe and are used to exert pressure on the coil in axial direction to avoid shrinkage of coils.

There are following types of core available:-

- a. Three limb core
- b. Two limb core
- c. Five limb core
- d. Core with elliptical yoke section
- e. Core with flat yoke

There can some more variation keeping the basics same. Core & Endframe assembly is a standard assembly with variations in type of Core, Endframe, Yoke bolt/ belt, clamping arrangement, Lifting arrangement, Ring etc.

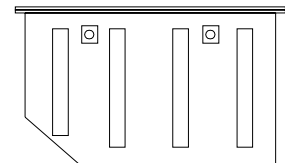
### 2. Tank & Base Assembly

#### A. Tank

Transformer tank is an enclosure which contains inside it the live parts such as core and winding assembly, electrical connections and insulating oil. Generally few transformer tanks falls exactly in any one of the categories described below. Most of the tanks have a combination of the features described in these categories.

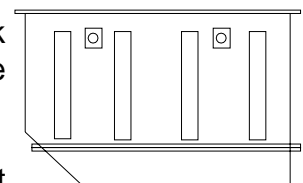
#### a. Conventional tank

A tank in which the tank to cover junction is at the top of the tank.



#### b. Bell type tank

A tank in which the cover is not flat in shape and the tank to cover junction is near the bottom of the tank. Thus the tank has got two parts – 'top tank' and 'bottom tank'.



Theoretically a transformer tank can have any shape but

keeping in mind the fabrication convenience, following shapes are generally adopted.

1. Rectangular
2. Semi cylindrical on one end /either ends
3. Semi cylindrical on the longer walls
4. Main walls tapered on the bottom side

The tank may have pockets/ cuts in any of the side walls for the placement of fitting or to save the oil.

#### **B. Tank Base**

Base can be with or without rollers. Rollers are of 4 types and are of standard design. Skid base is an assembly of Stiffeners and is at the bottom of Tank Base.

#### **C. Tank Assembly**

Tank body is the skeleton of final tank that goes into the product. Various operations to create circular, elliptical or rectangular openings on the tank wall or tank cover are carried out in the assembly stage. Pads for mounting valves, inspection covers, terminal boards, turrets etc are placed in Tank. Pads for mounting name plates /rating plates are welded on the body. Arrangement to mount motor drive unit and marshalling box. Arrangement to mount radiators/ integral coolers.

To give adequate strength and rigidity to tank different types of stiffeners like ribs, gussets, T- section, I-section, channel sections in horizontal/ vertical orientation are welded on the tank body.

Welding of jacking pads meant for jacking the transformer and lashing lugs to tie the transformer with ropes while shipment.

Lifting bollards or lifting lugs are used for lifting the transformer. Bollards are cylindrical solid rods or hollow pipes housed inside a channel section. Lugs are normally meant for lifting weights in the range of 40 to 50 tonnes and are of the shape of a hook.

### **3. Cover Assembly**

Tank cover assembly is of following type

- A. Flat type
- B. Slopes at either ends and centre is flat
- C. Slope on one side only
- D. Dome at the centre and flat plates on either side.
- E. Flat on one side of the dome
- F. Stepped on the end wall side to house the M-III type OLTC.

On cover end leads of Transformer Winding is connected to the system by any of following methods. It is mounted on the tank cover (or topmost horizontal plane in the tank) or in some cases some bushings are mounted on vertical end walls.

#### **A. Over head bushings**

High voltage, low voltage and in some cases third winding "Tertiary" or "Stabilizing" leads are brought out through bushings. They are called HV bushing, LV bushing and tertiary bushing. These bushing are mounted directly or on Turrets. Turrets are Round or Rectangular in shape.

#### **B. Cable boxes**

In sites where customer has laid cables instead of overhead conductors the termination (connection) is through cable boxes. Cable boxes are enclosures attached externally to the transformer tanks.

C. Bus duct

Generator transformer primary is connected to the generator through Busduct. For Busduct connections bushings are brought out through cover or through independent/ common turrets. These bushings are enclosed circumferentially by hoods which in turn receive the Busduct flange.

D. A combination of above

Termination of different windings can be through different combinations e.g. ("HV-bushing, LV-cable box", "HV-bushing, LV- Busduct", etc).

On Load Tap changer (OLTC) is mounted on Tank cover/ walls. Its purpose is to add or subtract turns from the main coil. It is housed inside the transformer tank (except CTR OLTC). These are the standard products and based on the variant in use their dimensions are known in advance. Like MIII tap changer is housed in a pocket on one end of the tank. 3-MI tap changers are placed along the longer wall on LV or HV side. CTR tap changers have their own housing attached externally to main transformer tank. Their sizes are also standard.

#### 4. Cooling pipe work

When the transformer is in service the windings get heated up. In oil filled power transformers oil is the cooling medium for windings. Oil is in turn cooled by means of radiators/ integral coolers with water/ air as cooling medium. Cooling are of following types

- A. ONAN COOLING: Oil flow is through natural convection. Air flow is also natural (not forced). Cooling equipment is radiators.
- B. ONAF COOLING: Oil flow is through natural convection. Air flow is not natural but forced. Cooling equipment is radiators and fans, ONAF coolers.
- C. OFAF/ OFWF COOLING: Oil flow is forced by means of inline oil pumps. Air flow is forced by means of fans/ blowers. Cooling equipments is radiators, fans and pumps or integral OFWF coolers.

**Radiators:** Radiators (a bought out item) used in Transformer cooling are of standard profile. They are normally described in the following fashion: e.g. 10 - "5 or 9" - 34 - 3000 where 10: no. Of radiators, "5 or 9": no. of flutes in a radiator element, 34: no. Of elements in a radiator, 3000: distance between valve centers. Radiators can be directly mounted on the tank wall, if the no. of radiators is not large. Radiators can be mounted in a bank formation i.e. Group of radiators are mounted on headers and are placed separately from tank.

**Header:** Headers are pipes of square cross section. There shall be one top header and one bottom header for a group of radiators. The header and radiator assembly is supported over "A" frames (named so because of resemblance with alphabet "A").

**Header pipe work:** Headers are in turn joined with the tank where suitable valves for connecting pipe work are provided. These pipes require pipe supports with suitable foundation header pipe work or cooler pipe work drawing shows the arrangement of radiators, headers supporting structures and the interconnecting pipe work. Arrangements of fans/ inline pumps along with their supports are also shown in the header pipe work drawing.

#### 5. Main Conservator pipe work

A conservator is a cylindrical vessel which provides space for expansion of oil inside the transformer or supplies oil to the transformer when the transformer oil cools and contracts in volume. A conservator is always placed above the transformer. Standard drawings for the conservator are available. When the conservator is used for the main transformer it is called “main conservator” and when it is used for the OLTC it is called “auxiliary or OLTC conservator”.

#### **6. OLTC conservator pipe work**

#### **7. Winding Assembly**

Winding looks like concentric cylinder with inner and outer diameter, length. It is lowered in the core limb. It is of following type (but such classification doesn't affect the basic shape of winding)-

- a. Disk
- b. Helical
- c. Spiral
- d. Integral

Windings are of following class

- a. Power transformer
  - i. Low voltage
  - ii. Intermediate voltage
  - iii. High voltage
  - iv. Tapping
- b. Auto transformer
  - i. Series
  - ii. Common
  - iii. Intermediate
  - iv. Tapping

All windings are made separately in the mold. Each winding is wound on dovetail strips and blocks. All windings of same phase are lowered on single core limb. They can have any arrangement like. “LV-HV-Tap”, “SV-LV-Tap-HV”, “Common-Tap-Series” etc.

Initially bottom wooden ring and bottom block washer are lowered in the core limb. Then all coils of one phase are lowered in the limb and rests on the block washer. Cylinders and strips insulation are placed between each coil. Then again top block washer and top wooden ring are lowered.

#### **8. Terminal Gear (TG) Assembly**

TG is of following types:

- A. **High Voltage Side Connection (HV TG):** taking out and termination methods, insulation and lead holding arrangements are shown in HV TG drawing. If there is a tapping winding associated with this winding then tapping connections and connections with the on load tap changer or off circuit tap switch as the case may be are also shown.
- B. **Low Voltage Side Connection (LV TG):** leads termination and connections with respect to forming star or delta formation are shown in this drawing. In case tapping winding is also associated then termination arrangement of tapping leads are also shown.

After preparation of Electrical design first Transformer Layout is prepared. Layout is prepared by keeping the core and winding assembly in focus and deciding



various clearances and placement of fittings on the tank. Once layout is prepared the profile of the tank, placement of various fittings including cooler/ radiator banks and conservator, air clearances in bushings are known. From layout information for fabrication drawings like tank, end frame, header pipe work and conservator drawings and for electrical drawings like TG and winding assembly drawings are obtained. Outline General Arrangement (OGA) drawing can immediately be taken up with information available from layout.

## Power Transformer Drawings

Following drawings are generated for a Power Transformer:

1. **Layout:** Following details are available in Layout (Outline of core, Outline of outermost coil superimposed on core, Tank base, Two longer walls parallel to core length (taking into consideration type of terminal gear and OLTC being employed), position of bushing lower end, position of Cover, position of bushing top end, Bushing air clearance, fittings on Tank cover, position of internal fittings, Side walls, Tank profile, placement of cooling equipments, connection of cooling equipment and tank through pipes, placement of main conservator and OLTC conservator along with associated pipe work, placement of welded parts on tank and any other fittings external to transformer).
2. **Customer Drawings:**
  - a. OGA Drawing: OGA as the name suggests is the outline of a transformer and depicts how a transformer along with its accessories would look like when erected at site. OGA drawing preparation gets top most priority as this drawing is to be supplied to the client for their approval and ideally any manufacturing activity starts after getting approval from the client on this drawing. Normally internal details are not shown in this drawing. In addition some dimensions like overall length, breadth, height, transport (shipping) dimensions, phase to phase bushing air clearance, rail gauge etc.
  - b. Foundation Drawing: This drawing shows the foundation detail (foot print) like roller position, Foundation bolt position in a ground. It is required to customer to plan the civil work in advance.
  - c. Bushing Drawing
  - d. R&D plate
3. **Manufacturing Drawings**
  - a. End frame drawings
    - 1) End frame fabrication
    - 2) End frame insulation
    - 3) End frame assembly (includes Top & Bottom Ring Drawing, Core to coil packing drawing, Ring Packing drawing)
  - b. Tank drawings
    - 1) Tank body
    - 2) Tank assembly (includes Turret Assembly Drawing, Neutral Grounding Drawing, Cable Box/ Busduct hood Drawing)
    - 3) Tank details
    - 4) Tank Base
    - 5) Tank Cover

- c. Cooling Pipe Work
- d. Main Conservator Pipe Work
- e. OLTC Conservator Pipe Work
- f. Winding drawings
  - 1) Individual windings (rarely exceed five)
  - 2) Winding assembly
- g. Terminal Gear (TG) drawings
  - 1) HV TG Copper details
  - 2) HV TG Cleat details
  - 3) LV TG Copper details
  - 4) LV TG Cleat details

Other than above drawings related to a product, BHEL is also having standard drawing. Standard drawings are the drawings of standard parts/ assemblies. For standard type of part these drawing are referred in the parent drawing BOM. Standard drawings are also being used for parts/ assemblies that are similar in profile but vary in dimensions. These drawing are called parametric drawings. When these drawings are referred in parent drawings then its parameters are also passed in BOM.

### **Software Capabilities**

As stated earlier that Power Transformer is a highly tailor made product and it is not possible to standardize the profile of the Transformer. The fittings placed on the Transformer is also depends upon the customer requirement. Therefore the proposed 3D CAD software should handle such variation by providing very user friendly and fast tools like help user to troubleshoot to constrain the sketch by showing unconstrained curve in different color, User defined configuration in a part (Different similar components in one part that can be called by selecting the user defined configuration and can be controlled through excel), automatic dimensioning, provision of all types of holes (like tapped, counter sink etc), dimension the tolerance directly in the model, changing the sketch parameter directly from 3D without entering into sketch, 2 way attribute parameter transfer from excel to model and from model to excel, parametric welding option in 3D model, placement of linked component (like washer, bolt etc) and operational features (like cut etc) during placement of standard fittings in an assembly, modification of 3D model parameters directly from 2D drawing, developed length calculation, 3D sketch, negative dimension, routing of pipes & cables (also calculate length of cable), inbuilt standard component like gusset etc should be available in software. In assembly, the type of fitting to be placed should be driven by relationship (i.e. if user select single roller then single roller should place and if user select twin roller then twin roller should place in an assembly).

The software should be very user friendly and shall be able to use by all age group of BHEL ITI qualified draftsman. User should not confuse in clumsy menus/ toolbars and these menus can be configured by user as per there requirement. The 2D drawing generated from the software should be transferable in AutoCAD without losing the sketch entity (i.e. sketch property like layer, color, thickness etc; unexploded dimension, leader, part numbering etc). The BOM should be as per BHEL format and the part attribute like weight, length, width, height, ID, OD, Material code



etc should come directly from the model without using any manual calculation. BOM should also be able to handle using relationship (like if Pin pad dia = 40 then Material code attribute is 1234 else 3456).

All the above solution should be available out of the box from the software without using any programming. The total Power Transformer automation should not involve more than 10% of programming. The programming should be very easy and should not restrict user to change the model manually.

Firm engaged in manufacturing of Power Transformer of 132&220 kV class need not apply.

### **Procedure for Registration**

Details received will be scrutinized by BHEL and bidders found capable of doing the Power Transformer drawing automation will be registered for this work. Subsequently tender for finalization of this service contract will be issued to all registered contractor.

### **Proposal**

Interested party may submit their Expression of Interest by 1:30 PM on 03<sup>rd</sup> August, 2010.

Expression of Interest should be accompanied by:

- Details on company background
- Experience list (with details) of execution of similar type of work (copy of orders to be enclosed)
- List of technical competent person with specialization in related field
- Annual financial report of at least last two years, etc
- BHEL may also ask to do free of cost one small pilot project to access the capability of the software & company.

The proposal incorporating above details may be sent at following address:

**AGM (TRE&FES)**  
**Transformer Engineering Department**  
**Bharat Heavy Electricals Limited**  
**Jhansi (Uttar Pradesh) – 284129**

Phone No: 0510-2412709  
Fax No: 0510-2412118  
e-mail: [arkuls@bheljhs.co.in](mailto:arkuls@bheljhs.co.in)

Any clarification on technical details may please be addressed to following:

**Amit Khatloiya, Dy Manager (TRE), Phone No: 0510-2412791**  
e-mail: [akhatloiya@bheljhs.co.in](mailto:akhatloiya@bheljhs.co.in)