Installation of Indigenously Developed Rotor Pole in Hydro Generator of Tehri HPP


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Abstract

The major objective behind the "Make in India" initiative is to focus upon the heavy industries and public enterprises while generating employment, empowering secondary and tertiary sector and utilizing the human resource present in India. In the developing country like India the policy of import should be protected as a major national objective. Self sufficiency and self reliance should be achieved in the certain areas where proven capability is available over a period of time. Tehri HPP has indigenously developed Rotor poles from BHEL, Bhopal for the hydro generator of 250 MW machine. 04 nos Poles were erected in the Unit#3 and after taking all necessary vibration data and satisfactory performance of the unit, the view of the indigenization has also endeavoured.

Keywords: Indigenization, Glass Textolite, Rotor Rim, Pole Impedance, pole keys, Dynamic Balancing, Radial clearances

1.0 Introduction:

Every organisation proceeds systematically and establishes an effective spare parts management system. The inventory analysis carried out on the basis of different characteristics of the spare parts, such as annual consumption value, criticality, lead time, unit cost and the frequency of use, help the company in establishing suitable policies for selective control. This also helps in focusing our efforts on real problem areas.

For smooth operation of power plant and to reduce the down time, inventory of necessary spares is required to be maintained. The availability of source & spares need to further strengthen up in case of foreign equipment. In order to replenish the need of imported spares, it was thought that same may be developed indigenously so that local vendors may be encouraged as well saving of foreign exchange. The commercial aspects and availability of imported spares in Indian market also endeavoured the thought of indigenization.

It is very difficult to mark out the OEM (Original Equipment Manufacturer), where machinery of the power plant supplied by consortium of foreign firms in package along with major equipment. However, if it is traced then they do not responds for small value
order therefore the response from OEM for supply of imported spares is a time taking process as compared with indigenously developed spares.

2.0 Hydro Generator of Tehri HPP

Rotor of hydro generators consists of 14 Arms fastened to rotor hub, Thrust Bearing Hub, Shaft Extension with Upper Guide Bearing bush attached to it, Rotor Frame, laminated rotor rim, 28 nos. poles and current supply circuits. The rotor is of shaft less since the rotor cast hub whose upper flange is fastened to the shaft-extension replaces the shaft and the lower flanged us coupled to the turbine shaft. Arms are secured to the rotor hub and air separating shields are secured to the upper and the lower parts of the rotor arms. The rotor rim is made up of segments punched from 4mm rim has been assembled at site. The pole cores are stacked at site. The pole cores are stacked of steel sheets 2mm thick with T-shaped tails, which secure the poles to the rim with the aid of wedges.

The coils of pole are made of specially shaped copper straps, which ensure intensive cooling of their surface. The winding insulation is of class F. The turn insulation is made of epoxy glass tape based on epoxy binders. The frame insulation of pole cores is made of glass textolite (Fiberglass). The poles are equipped with damper winding.

Rotor is provided with damper system, which consists of copper bars in pole core shoes and short-circuiting copper segments.

3.0 Need for Indigenization for Rotor Poles of Tehri’s Generator:

Degradation in the generator field can be caused by a number of factors, including a breakdown in insulation due to time and temperature and mechanical wear. This degradation can lead to shorted turns, a field ground, or an in-service operational incident that can require premature maintenance work. The type of work needed to repair and upgrade depends upon the generator rotor design, length of time in service and the manner in which the rotor was operated.

With the problem in the rotor poles of generator in Tehri Units during reverse power incident in Nov’10 and poles failure during major maintenance check, refurbishing the poles, procurement /indigenous development of these imported poles were the only option. After detailed discussion, it was emerged that rotor poles should be developed indigenously through BHEL.

BHEL developed the 12 nos poles based on the reverse engineering and the data of teh existing rotor poles. However, the weight and the corner design of the BHEL make pole was different from the original Russian poles. The original poles of the Tehri was edge wound type, whereas the BHEL offered the fabricated type poles having the edges as shown in figure 1. The provision of inter changeability were also maintained in the newly developed poles.
After the development of rotor poles, it was a challenge to install those poles with the existing Russian poles due to different weight. The pole developed by the BHEL is shown as below in Fig.2.

Original weight of the pole (Russian) = 6200 Kg.
Weight of the newly erected BHEL make rotor pole = 6335 Kg.

It was speculated that the problem pertains to the balancing maybe arise, which may contribute towards the higher vibration in the generating unit.

4.0 Installation of 4 nos BHEL make rotor poles in Unit#3

It was decided to check the performance of the BHEL make rotor poles during the annual maintenance of unit#3 in May 2017. Accordingly the preparation was made. 4 nos diametrically opposite poles (pole nos 7,14, 21 and 28) were replaced with the existing poles.

The following tests were conducted on the individual poles before installation.

1. IR measurement
2. HV Test
3. Pole Impedance Measurement
Accordingly, after finding the test results satisfactory, poles were erected. During installation the pole keys of pole no. 14 were found loose and same were replaced with the new pole keys. After tightening of the pole keys of all 04 nos Rotor poles, the following tests were conducted in the complete rotor pole assembly.
1. IR measurement
2. HV Test
3. Pole Drop test
<table>
<thead>
<tr>
<th>Test</th>
<th>On Complete rotor Pole assembly</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR Measurement (500 V) before HV test</td>
<td>R_{15}=10.4 , \Omega \quad R_{00}=13.9 , \Omega</td>
<td>Earlier the IR test was carried out in the rotor pole assembly and measured IR values were R_{15}=2.10 , \Omega and R_{00}=3.38 , \Omega. Subsequently, dry out by heating was carried out and IR values improved.</td>
</tr>
<tr>
<td>HV Test (1.6 KV)</td>
<td>Test was carried out for 1 Min. and found satisfactory</td>
<td></td>
</tr>
</tbody>
</table>
| IR after HV Test                          | R_{15}=12.3 \, \Omega \ 
|                                           | R_{00}=15.1 \, \Omega                                           |                                                                       |

Table 2. Test values after pole installation

Pole drop test

<table>
<thead>
<tr>
<th>Pole No.</th>
<th>Voltage Drop (V)</th>
<th>Pole No.</th>
<th>Voltage Drop (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.12</td>
<td>15</td>
<td>5.09</td>
</tr>
<tr>
<td>2</td>
<td>5.36</td>
<td>16</td>
<td>5.09</td>
</tr>
<tr>
<td>3</td>
<td>5.30</td>
<td>17</td>
<td>4.54</td>
</tr>
<tr>
<td>4</td>
<td>5.25</td>
<td>18</td>
<td>5.15</td>
</tr>
<tr>
<td>5</td>
<td>5.32</td>
<td>19</td>
<td>4.61</td>
</tr>
<tr>
<td>6</td>
<td>4.85</td>
<td>20</td>
<td>4.75</td>
</tr>
<tr>
<td>7</td>
<td>4.07</td>
<td>21</td>
<td>4.17</td>
</tr>
<tr>
<td>8</td>
<td>4.79</td>
<td>22</td>
<td>4.76</td>
</tr>
<tr>
<td>9</td>
<td>5.18</td>
<td>23</td>
<td>5.09</td>
</tr>
<tr>
<td>10</td>
<td>5.15</td>
<td>24</td>
<td>5.14</td>
</tr>
<tr>
<td>11</td>
<td>5.14</td>
<td>25</td>
<td>5.15</td>
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<tr>
<td>12</td>
<td>5.10</td>
<td>26</td>
<td>5.11</td>
</tr>
<tr>
<td>13</td>
<td>5.11</td>
<td>27</td>
<td>5.02</td>
</tr>
<tr>
<td>14</td>
<td>4.87</td>
<td>28</td>
<td>4.54</td>
</tr>
</tbody>
</table>

Table 3. Voltage drop test in all 28 nos poles

The value of voltage drop in the newly erected rotor poles shall be taken as reference value for the upcoming years.

Fig.6 Soldering of Rotor lead connection joints
Soldering of Rotor lead connection at all 08 nos joints of 4 poles were carried out. Subsequently insertion and tightening of inter pole spacers was done. After the complete box up of unit, it was ready for the mechanical run along with dynamic balancing.

5.0 Dynamic Balancing of the assembly

M/s ProTech Monitoring were called for Dynamic balancing of Generator (Unit-03) after installation of 04 nos of Rotor Poles (BHEL make) in Unit#3. In order to ascertain the need of dynamic balancing, vibrations were measured at UGB, LGB & TGB during the mechanical run followed by Excitation to rotor and different loading conditions.

5.1 Need of balancing

Balancing is a procedure by which the mass distribution of a rotor is checked and, if necessary, adjusted to ensure that the residual unbalance or the vibration of the journals and/or forces on the bearings at a frequency corresponding to service speed is within specified limits[2].

Unequal distribution of a weight of a rotor about its rotating centreline causes unbalancing. Excessive unbalancing results in vibration of the rotor and supporting bearing. Rotor unbalance can be caused by design, material, manufacturing and assembly. Every rotor has an individual unbalance distribution along its length, even in a series production.

Rotors out of balance tolerance need correction. These unbalance corrections often cannot be performed in the planes where the balance tolerances were set, but need to be performed where material can be added, removed or relocated.

5.2 Dynamic Unbalancing

It is the unbalance when the central principal axis and rotating centreline don not coincide.

5.3 Vibration Measurement in unit#3

The rotor voltage & current (120 Volt & 900 Amp) was found normal during above exercise.

Radial clearances of the bearings: UGB = 250 micron  
LGB = 250 Micron  
TGB = 230 Micron  
Rotation of the machine = Anti clockwise direction

Instrument: B&K VT60 Vibration Analyzer & Dynamic balancing equipment.
Table 4. Vibration measurement in different loading conditions

The vibration reading was found normal & there was no need for dynamic balancing as confirmed by M/s ProTech. The physical inspection of the newly installed BHEL poles was also assessed after stopping the machine, which was found in order.

6.0 Benefits of Indigenization:

These are the following benefits for indigenisation of spares and development of new vendors, even if the spare is available from the existing source:

a. To reduce dependency on imported source.
b. To reduce uncertainty in supply from existing source.
c. Cost reduction / control in rising cost.
d. Quality improvement.
e. Conserve the precious foreign reserve of the country.
f. Shorter lead time can result in reduced inventory.
6.1 Cost benefit Analysis

In addition to the cost benefit due to procurement of indigenous spares, foreign exchange with the country also saves. Also, price of imported spares is dependent on fluctuation of currency exchange rates. With the indigenous procurement of poles company save approx. 3.5 crore rupees. Further, BHEL has also provided their services during installation of poles.

7.0 Conclusion

Indigenization of equipment is an important activity to ensure sustenance of equipment for its life time. Maintenance, repair and overhaul are necessary to ensure the mission reliability and availability of equipment to the user in a serviceable state. If imported spares are still to be provided by the manufacturer, the cost is exorbitant. Therefore, there is a need to achieve maximum self reliance in manufacturing of indigenous spares of imported equipment.