RESTORATION OF HYDRO GENERATORS IN A FLOODED UNDERGROUND POWER HOUSE

SURAJ DHIMAN
Senior Manger (Mech.), NHPC Limited
Parbati-III Power Station
Behali, P.O. Larji, Distt. Kullu (HP)

ABSTRACT:

This paper details the experience of successful restoration of 4 nos. 70 MW vertical shaft hydro generators in an underground power house which was flooded during flash floods occurred in Uttarakhand in the year 2013. The generating units were under deposition of heavy silt and dirt and were restored with the original stator core and windings by adopting well defined dry out procedures.

1 INTRODUCTION:

In June 2013, a multi-day cloudburst centered on the North Indian state of Uttarakhand caused devastating floods and landslides becoming the country's worst natural disaster since the 2004 tsunami. The 4 x 70 MW Dhauliganga Power House of NHPC got submerged due to the heavy flood in Dhauliganga river and Elagad nala, on 16/17.06.2013. TRT outlet was completely blocked with debris and silt brought down by the river. The water level inside the power house crossed the false ceiling of service bay, thus submersing all the equipments of power house including Generating Units, Transformers, Control Panels, various LV distribution panels, GIS, EOT crane and service bay luminaries. All the equipments were submerged in heavy silt and sludge. However, the generating units and other auxiliaries were restored in a record minimum time of less than a year.

2 DESCRIPTION OF GENERATOR:

The generators are vertical shaft, three phase synchronous generators each having capacity 78 MVA, 0.9 pf, 50 Hz, 14 poles which generates power at a voltage of 11 KV. The rated characteristics of the generators are as per below:

Rated output	:	78000 KVA
Maximum output	:	86000 KVA
Rated Power factor	:	0 .9
Frequency	:	50 Hz
Rated Voltage	:	11000 V
Rated Current	:	4093 A
Rated Speed	:	428.6 rpm
Class of Insulation	:	Class F

3 PRELIMINARY INSPECTION:

After carrying out the dewatering for approximate two months, the generators were inspected in August 2013, which indicated the following:

- Silt as well as dirt was observed in between the stator core laminations.
- Rust was observed in various sections of stator core
- Silt & dirt was observed on & around the stator winding.
- Silt & dirt was observed on the rotor pole body as well as between the rotor inter-turn insulation.

Based on the above, it was decided to dismantle the entire generator for restoration activities.

4 RESTORATION PROCEDURE:

Following steps were taken in order to restore the units:

- Dismantling and cleaning of generator top cover and generator dome.
- Removal and cleaning of brush holder assembly, collector ring, upper bearing bracket cover.
- Dismantling and inspection of upper guide bearing, thrust block, thrust pads, thrust pad support plate.
- Removal of air guides and upper bearing bracket.
- Removal of rotor from unit pit on to erection bay.
- Disassembly of rotor poles, cleaning, dry out, insulation check, impedance check, polarity check and HV testing.
- Cleaning of rotor rim, dry out and painting.
- Cleaning and dry out of stator core and winding.
- ELCID test on stator core.
- Insulation and HV test for stator winding.
- Cleaning of stator air coolers and hydro testing of coolers.
- Removal and cleaning of lower bearing bracket cover.
- Dismantling and inspection of guide bearing pads.
- Cleaning of all cooling and oil piping
- Re installation of all components after ensuring their correct functionality.
- Repainting of complete unit.

5 CLEANING OF STATOR:

The stator core and windings were thoroughly cleaned for carrying out the dry out process. Each ventilation slot of stator core was manually cleaned to remove the deposited dirt and then through water jets using fire fighting hoses.

6 DRYING OUT OF STATOR:

After thorough cleaning of stator core and windings through water jets and further drying out, ELCID test was carried out on stator core and the test was successful. Subsequently, the stator was put under dry-out for achieving the desired Insulation Resistance (IR) and Polarization Index (PI).

The following dry-out procedures were adopted:

6.1 Hot Air Blower:

Initially, the dry out was planned through hot air blowers with stator completely covered through tarpaulins. However, no significant improvement was observed in the Insulation Resistance (IR) values.

Figure-1: Dry out of stator through hot air blower

6.2 DC Current Injection:

In the next stage, the stator heating was carried out with halogen lamps and DC current injection. Significant improvement in the IR values was achieved at this stage.

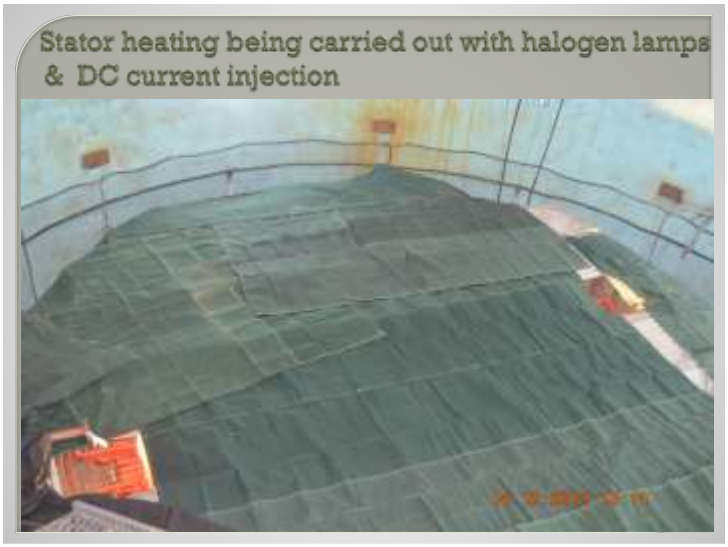

Figure-2: Dry out of stator with halogen lamps and DC current injection

However, it was decided to carry out the final dry out by running the machine at no load with cooling water supply to air coolers cut off.

6.3 DRY OUT THROUGH NO LOAD RUN:

The machine was put under dry run on 14.04.2014. During the dry out process logging of IR and PI values at regular intervals were carried out. The IR and PI values are shown in Table-1.

DATE	TIME	WDG TEMP ℃	CORE TEMP ℃	VOLT. APPLIED (V)	VOLT. MEAS. (V)	IR AT 15 SEC. MΩ	IR AT 60 SEC. MΩ	IR AT 600 SEC. MΩ	PI
4/14/2014	4PM	22	22	2500	2473	2.98	3.03	2.21	0.73
4/16/2014	7PM	74	73	2500	1526	0.492	0.51	0.51	1
4/18/2014	11AM	89	87	2500	2401	1.42	1.47	1.47	1
4/18/2014	7PM	91	89	2500	2394	1.75	1.84	1.37	0.74
4/19/2014	11 AM	90	89	2500	2407	1.26	1.38	1.51	1.1
4/19/2014	7PM	88	85	2500	2424	1.23	1.41	1.75	1.24
4/20/2014	11AM	88	85	2500	2440	1.44	1.68	2.02	1.2
4/20/2014	5pm	90	87	2500	2445	1.56	1.82	2.14	1.18
4/21/2014	11AM	88	85	2500	2458	1.82	2.12	2.46	1.16
4/21/2014	7PM	88	85	2500	2462	1.94	2.26	2.61	1.15
4/22/2014	11AM	86	83	2500	2471	2.2	2.51	2.9	1.15

Table-1: IR & PI values of generator during dry run

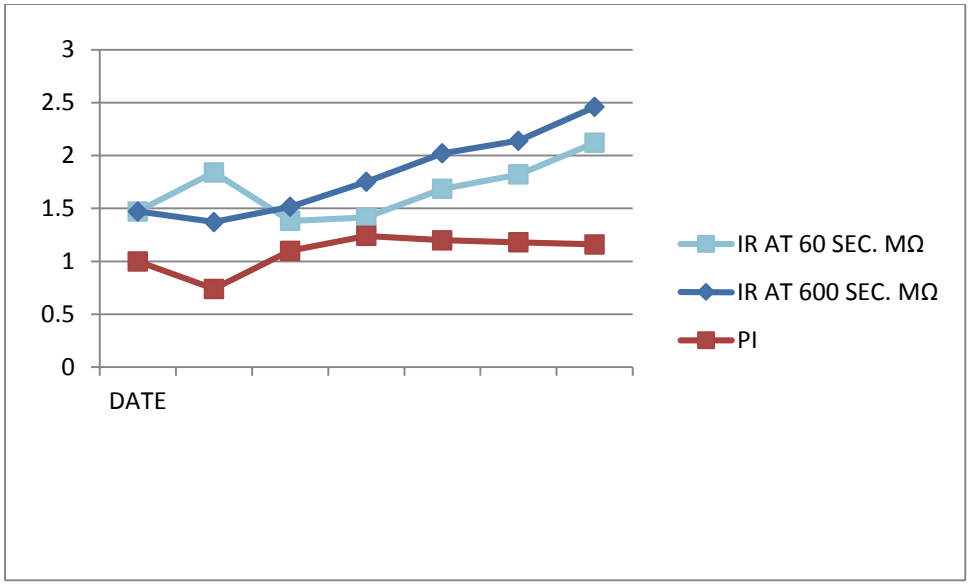

Figure-3: Graph showing IR & PI values of generator during dry run

7 HV TEST OF STATOR:

After achieving the IR & PI values as above, DC High Voltage (HV) test on the generator was carried out at a low, but safe value of voltage. The IR & PI values measured before carrying out HV test are shown in Table-2. The test results are shown in Table-3 and the post HV Test IR & PI values depicted in table-4.

Ambient Temperature:	22	° C
Winding Temperature :	30	° C
Relative Humidity :	80	%
Voltage :	2500	V
"U" Phase:-		
Insulation Measurement After 15 Seconds	32.8	MOhm
Insulation Measurement After 1 Minute :	39.5	MOhm
Insulation Measurement After 10 Minutes :	48.5	MOhm
Index = Value 10 Minutes / Value 1 Minute :	1.23	
Voltage	2551	V
Leakage Current	52.1	µ A
"V" Phase:-		
Insulation Measurement After 15 Seconds	3.36	MOhm
Insulation Measurement After 1 Minute :	3.96	MOhm
Insulation Measurement After 10 Minutes :	5.54	MOhm
Index = Value 10 Minutes / Value 1 Minute :	1.40	
Voltage	2482	V
Leakage Current	452	µ A
"W" Phase:-		
Insulation Measurement After 15 Seconds	3.94	MOhm
Insulation Measurement After 1 Minute :	4.24	MOhm
Insulation Measurement After 10 Minutes :	4.91	MOhm
Index = Value 10 Minutes / Value 1 Minute :	1.16	
Voltage	2494	V
Leakage Current	509	µ A

Table-2: IR & PI values of generator before HV Test

Tested Winding Bar	DC Voltage (KV)	Leakage Current (mA)	Duration / Test Time (Second)	Remarks
"U" - PHASE	1	0.00		Satisfactory
	2	0.07		
	3	0.07		
	4	0.05		
	5	0.10		
	6	0.12		
	7	0.15		
	8	0.20		
	9	0.25		
	10	0.30		
	11	0.35		
	12	0.40	60 Seconds	
"V" - PHASE	1	0.50		Satisfactory
	2	0.75		
	3	1.10		
	4	1.40		
	5	1.61		
	6	2.00		
	7	2.50		
	8	3.00		
	9	3.50		
	10	4.00		
	11	4.20		
	12	4.50	60 Seconds	
"W" - PHASE	1	0.06		Satisfactory
	2	0.10		
	3	0.10		
	4	0.15		
	5	0.20		
	6	1.40		
	7	2.00		
	8	2.20		
	9	2.50		
	10	3.00		
	11	3.00		
	12	3.30	60 Seconds	

Table-3: HV test results of generator

Ambient Temperature:	22	° C
Winding Temperature :	28	° C
Relative Humidity :	80	%
Voltage :	2500	V
"U" Phase:-		
Insulation Measurement After 15 Seconds	45.4	MOhm
Insulation Measurement After 1 Minute :	48.6	MOhm
Insulation Measurement After 10 Minutes :	59.2	MOhm
Index = Value 10 Minutes / Value 1 Minute :	1.22	
Voltage	2545	V
Leakage Current	43.3	µ A
"V" Phase:-		
Insulation Measurement After 15 Seconds	8.25	MOhm
Insulation Measurement After 1 Minute :	7.05	MOhm
Insulation Measurement After 10 Minutes :	4.8	MOhm
Index = Value 10 Minutes / Value 1 Minute :	0.68	
Voltage	2502	V
Leakage Current	500	µ A
"W" Phase:-		
Insulation Measurement After 15 Seconds	6.5	MOhm
Insulation Measurement After 1 Minute :	6.6	MOhm
Insulation Measurement After 10 Minutes :	7.45	MOhm
Index = Value 10 Minutes / Value 1 Minute :	1.13	
Voltage	2516	V
Leakage Current	340	µ A

Table-4: IR & PI values of generator after HV Test

8 DRYING OUT OF ROTOR:

Thorough Cleaning of Rotor Rim with ethanol & compressed air was carried out. Rotor Poles were shifted over separate assembly & halogen heating was carried out. After successful drying out of rotor, HV test of rotor was conducted successfully.

9 VOLTAGE BUILD-UP:

After successful HV Test, voltage build up was completed and the unit was synchronized successfully with the grid.

10 CONCLUSION:

The dry out procedure of generator windings and the methods to be adopted for achieving the desired insulation resistance values is a matter of concern in the successful commissioning of the generating units. The experience of successful restoration of Dhauliganga generating units under the worst conditions of debris and silts gives tremendous confidence for future applications of generator stator dry out. The procedures adopted for cleaning and drying out of class F insulation of generator stator windings in Dhauliganga Hydroelectric Power Station can be adopted for such applications in future.