Best Maintenance Practices in 21MW & 16 MW Steam Turbo-Generators in Seshasayee Paper Mill

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ABSTRACT

In any steam turbine, the generator part is the lifeline of power generation. The increased power generation results in iron and copper core losses through increased winding temperature. In this paper, the need for maintaining the winding temperatures well within limits at all loads & power factor of operation of both the 21 MW as well as 16 MW Steam turbo-generators through periodic cleaning of the heat exchanger (interior and exterior) is brought out through live illustrations. This apart ,the cathodic protection scheme through provision of zinc anode in place in the heat exchanger shell for galvanic corrosion mitigation , thereby ensuring longevity and continuous availability of the generators is discussed.

Introduction

In Seshasayee Paper Erode unit, 2 steam turbo-generators (a) 21 MW Double Extraction Condensing Steam turbo-generator (Fig.1) related to High pressure Fluidised bed combustion coal fired boiler and (b) 16 MW Extraction Back Pressure Steam turbo-generator (STG) related to High pressure Chemical Recovery Boiler-both supplied by BHEL (Hyderabad) are in operation, to meet the power demand of the mill. 21 MW Steam turbo-generator is in continuous operation since its commissioning during March 2005; whereas, the 16 MW Steam turbo-generator was in commercial operation since Aug. 2008.

It is a known fact that the Generator core winding temperature increases with increased power generation. The resultant heat is dissipated to air sent in closed circulation within the machine. The heat in hot air, in turn, is transferred to the cooling water circulating through the air water heat exchanger located below the generator. The heat exchanger is one of modular constructions, in which cooling water (CW) from cooling tower/ambient is sent through the tubes with hot air flowing across the tubes on the shell side of the heat exchanger.

Fig.1. View of 21 MW Steam Turbo- Generator

Issues

The 21 MW generator air-water cooled heat exchanger is of 7 modules located in parallel alongside. As already stated, cooling water flows inside the steel finned brass tubes and air flows across the finned tubes on the shell side. The tube sheets are of steel construction. The heat exchanger had probably being designed with air side being clean devoid of dirt or dust and water side being reasonably clean due to soft water (devoid of suspended impurities) being advocated by the designer. The supplier had agreed to the usage of clarified water being used as cooling medium.

Over the years of continuous operation, the winding temperature had started to rise in 21 MW STG in particular, as also to an extent in 16 MW STG. This had called for root cause analysis (RCA) of the problem and subsequent measures to be implemented for mitigation of the same .

The winding temperature shot beyond 90°C at times with alarm set at 83°C. The cooling water inlet temperature was around over 36°C. Clarified water is being used for cooling. The issue was identified as one of water side fouling due to deposits/foulant and air side fouling due to dust and fine particulates in air in closed circulation across the heat exchanger.

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Mitigating Solution

It was decided to clean the heat exchanger on tube side on -line. Foulant inside each of the seven heat exchanger modules (Fig.2) were removed through mechanical cleaning. The winding temperature dropped by 6 to 7 °C.

Fig.2. Air-water cooled Heat exchanger Modules

Table -1
21 MW Steam Turbo- GENERATOR
Temperature record of Generator Winding and other related temperatures

		Before Cleaning of HX	After Cleaning of HX	Temperature reduction, DegC
Date/Time		20/3/14:11.30 h	20/3/14:11.15 h	
Power Generation	MW	12.5	11.8	
Winding Temperature				
#1	°C	83.5	77.7	7
#2	°C	85.5	79	7
#3	°C	86.7	80.5	6
#4	°C	76.1	70	6
#5	°C	73.4	67.3	6
#6	°C	86.0	79	7
#7	°C	86.5	79.6	7
#8	°C	88.4	81.4	7
Cold air temperature	°C	56	51	5
Hot air temperature	°C	67	61.5	6
CW in temperature	°C	36.5	36.5	
CW out temperature	°C	40	40	

Fig. 3. 21 MW ST Generator- Temperature Schedule

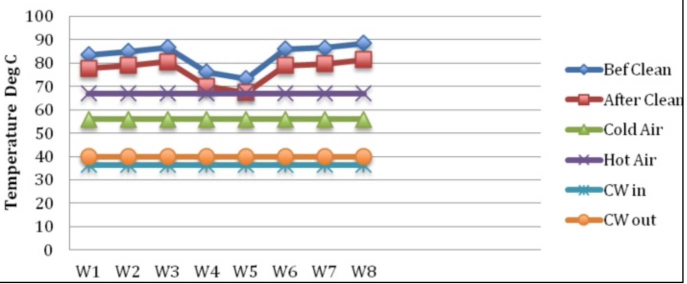


Table-1 illustrates the temperature record of generator winding temperatures before and after cleaning of heat exchanger, as also air and cooling water temperatures. The temperature pattern is displayed in Fig.3.

The above operational cycle was repeated after 3 months of operation of the unit under review. The operational gains with cleaning of the heat exchanger were repeated as can be seen from Table 2 and Fig.4 as under :

16 MW STG - Status

Closely following the above, it was decided to check the air side of the heat exchanger for foulant. The opportunity came by, when there was a short stoppage of Recovery Cogen unit. The air side of 16 MW STG was opened and it was totally dedusted of particulates and fines. There was a noticeable drop of 5°C in winding temperature.

Brief Analysis of Results

Thus it can be seen with both sides of the air and water side of the heat exchanger cleaned of foulant and deposits (during earliest available shut-down of the boiler), the winding temperature shall be maintained below 80°C. Besides, with improved cooling tower performance planned, the cooling water temperature is expected to be lowered by 3 to 4°C (from 36.5 to say 33 °C).

The designer had generously designed for a low figure of 3°C temperature differential of cooled air and cooling water temperature , whereas it would be expected to be much higher (over 10°C).

Lastly, it was noticed that the winding temperature was in variance right through. The possible reason could be one of the windings being covered with fine dust, thereby impairing heat dissipation from hot winding to the air in circulation. After correcting the above, in case the winding temperature variation still persists, - for ensuring uniform air flow on bot the issue shall be taken up with BHEL- the supplier of the turbo-generators the left and right sides of the air chamber encompassing the winding. The winding temperatures of all the 6 units would be within, say 3 to 5°C, instead of the wide variation of 10 to 12°C as at present.

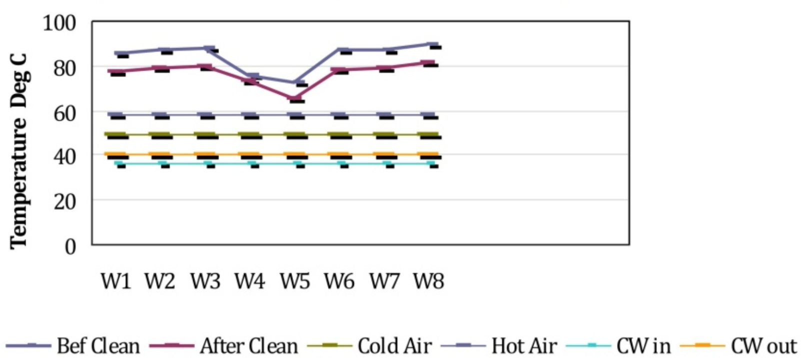
Impact of Low Power factor

A brief study made on the impact of operating the unit at lower power factor because of the need had revealed the fact that the winding temperatures do increase substantially because of the increased heat dissipation. As heat dissipation is a function of actual generating power load (in terms of MVA & not MW), the winding temperature increases with reduction in PF & vice-versa.

Table -2
21 MW Steam Turbo-GENERATOR
Temperature record of Generator Winding and other related temperatures
PF : High [0.97-0.98]

		Before Cleaning of HX	After Cleaning of HX	Temperature reduction, DegC
Date/Time		05/06/14:14 h	19/06/14 : 20 h	
P.F.		0.97	0.98	
Power Generation	MW	15.3	15.3	
Winding Temperature				
#1	°C	85.3	77.2	8
#2	°C	-	-	-
#3	°C	88.1	80.1	8
#4	°C	76.1	73.6	3
#5	°C	72.9	65.2	8
#6	°C	86.7	78.3	8
#7	°C	87.5	79.4	8
#8	°C	89.6	81.2	8
Cold air temperature	°C	54/56	49	6
Hot air temperature	°C	65/6	58/59	7
CW in temperature	°C	37	35	2
CW out temperature	°C	42	39	3

Fig. 4. 21 MW ST Generator-
Temperature Schedule
[Before & After Cleaning of Air & Water Sides]



The design of the heat exchanger is for rated design capacity of the generator as illustrated in Table -3 as under :

Table - 3
Power input rating of the Generators

Rated Power	21 MW		16 MW	
Power Factor	0.80	0.98	0.80	0.98
Power input [MVA]	26.25	20.6	20	16.3

As can be seen from Table - 4 relating to the operating data with low and high power factor of the 16 MW Steam turbo-generator, the winding temperature on an average gores up by as high as 9 to 10°C , with power factor dropping from 0.98 to 0.81. Naturally the air temperatures circulated for heat dissipation also goes up by 3°C.

With cleaning of the generator in place, the winding temperatures could be maintained within generator supplier recommended limits; of course with cooling water temperature being low because of direct clarified water intake.

Gains

With the four schemes as stated above in place, the winding temperature shall never exceed 80°C at any place. This shall ensure long term healthiness of the turbo-generator.

Any one of the heat exchanger modules can now be taken out for cleaning of internal foulant in place , even during running of the turbo-generator.

Cathodic Protection of Heat exchanger

It may be recalled that right from the commissioning of both the generators, galvanic protection of the heat exchanger tube sheet was given in the form of zinc blocks serving as anode. Zinc , being highly electro-positive serves as sacrificial anode in protecting against galvanic corrosion between two dissimilar materials (tubes and tube-sheet) in terms of corrosion potential.

Conclusions and Recommendations

Cleaning off dirt and silt from air-side and foulants and scales from the water side of the air-water cooled heat exchanger during the available shut of 21MW STG had resulted in maintaining winding temperature s well below the limits prescribed by BHEL (turbo-generator supplier).

Replication of the above maintenance scheme carried out in 16 MW STG had ensured that the winding temperature remains well within the suppliers recommendations even when the turbo-generator had to be operated at with low power factor(0.80).

The successful case studies (as stated in the note) bring out the importance and need for maintaining the cleanliness of the heat exchanger devoid of foulants on both sides of the unit. This shall ensure not only the healthiness of the generator auxiliaries , but also increased availability of the main unit.

The sacrificial anode in the form of Zinc block being provided on the shell side of the heat exchanger (probably first of its kind) had served as an effective protection device against galvanic corrosion. This scheme being introduced by SPB in both 21 MW & 16 MW Generator heat exchangers had protected

Table - 4
16 MW Steam Turbo-GENERATOR
Temperature record of Generator Winding and other related temperatures
IMPACT OF HIGH & LOW PF ON WINDING & AIR TEMPERATURES

Power Factor		0.98	0.81	Temperature increase, °C
Date/Time		13/06/14	11/06/14	
Cleaning of HX		After	After	
Power Generation	MW	11.13	10.7	
Winding Temperature				
#1	°C	72.2	81.8	9.6
#2	°C	74.0	82.7	8.7
#3	°C	73.0	83.5	10.5
#4	°C	75.0	83.7	8.7
#5	°C	71.7	82.5	9.2
#6	°C	73.6	83.5	9.9
Cold air temperature	°C	42/41	44.6/44.4	3
Hot air temperature	°C	59.6/55.6	62.2/58.8	3
CW in temperature	°C	27	28	
CW out temperature	°C	34	35	

the heat exchanger tube-sheet from corrosion , thereby ensuring longevity and availability of STGs since commissioning of the units.

As a matter of fact, the guidelines related to the maintenance of the heat exchanger and providing Cathodic Protection Device on shell side of the unit should henceforth be included by the Generator supplier in their O&M Manual.

It is highly desirable that both the air as well as the water circuits are kept in clean condition through de-dusting and cleaning of the heat exchanger tubes on a periodic basis.

It is recommended that the schemes successfully implemented by SPB, can be easily followed in the turbo-generators in all the paper mills in particular and other industries in general.

Bibliography

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