BOILER PERFORMANCE IMPROVEMENT BY RETROFITTING OF BOILER AT NTPC-KANIHA

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ABSTRACT:

The second largest station of NTPC is having six units of 500 MW. The four Units of Stage-II Units are having BHEL manufactured Boilers, commissioned between 2005-2007. Right from commissioning, problems like low MS temperature, high reheater metal temperature, imbalance in left and right side main steam & reheat temperature were the issues. To address these issues retrofitting of these Boilers were planned and this year it has been executed in one of the boilers.

Retrofitting in an existing brownfield project is a gigantic and non-conventional task. This paper focuses on the background history for retrofitting of boilers, approach for implementation, meticulous planning done for the first time implementation in one unit and execution aspects of the retrofitting works carried out in the boiler. The paper has discussed in detail on the initial preparations, selection and mobilisation of a mobile crane. The paper also has enlisted some of the hindrances during execution, safety and quality issues involved and learning during execution. Finally, a pre- retrofit and post-retrofit performance has been presented. The paper is for sharing of experience and will help the readers regarding associated activities in a major retrofitting job in an existing boiler in a brownfield project.

Key words: Boiler performance, Criss-cross connection, MS Temperature, Retrofitting, Siamese Header, Temperature unbalance

1.0 BRIEF DESCRIPTION OF BOILERS AT TALCHER-KANIHA:

Talcher super Thermal Power station of NTPC Ltd. is the second largest thermal Power plant of NTPC Ltd. having 6 units of 500 MW. In the Stage-I, there are 2 units constructed in collaboration with France and in stage-II, there are 4 units constructed by BHEL. The stage-I units are having single pass tower type, sub critical, drum less, corner fired, dry bottom boilers manufactured, supplied and constructed by M/s STEIN Industries of France. The stage-II units are having conventional two pass, sub critical, radiant reheat, corner fired, dry bottom boilers manufactured, supplied and constructed by M/s BHEL, Tiruchirappalli. A general arrangement drawing is as shown in fig.1

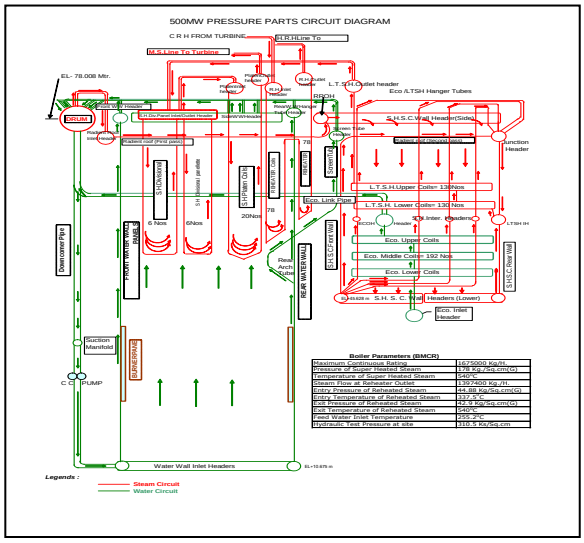

Fig.1: Stage-II Boiler General Arrangement

2.0 PRE-RETROFIT PERFORMANCE:

All the four stage-II Boilers were commissioned between Aug.2003-Aug.2005. Ever since commissioning, some of the problems as detailed below were encountered.

a. Low MS temperature. The attainable temperature was 500-510 deg C against 540 deg C at Superheater outlet. The Turbine inlet temperature was nearly 500. This was more predominant for operation of the boilers with bottom mill combination.
b. Imbalance in MS temperature between left & right hand side. There was a difference of as high as 20-30 deg C.
c. Although a design of zero Reheater spray was planned, but as the Reheater metal temperature was increasing beyond 600 deg C, so even after bottom mill operation, adjustment of burner tilt, temperature control was difficult. Reheater Spray of 30 TPH-60 TPH was required. Also, Operation with top mill combination was nearly difficult to achieve design load.
d. Imbalance in Hot Reheater steam temperature between left & right was also noticeable.

3.0 GLOBAL SETTLEMENT BETWEEN NTPC & BHEL:

To address the problem in 15 boilers across NTPC, it was decided between NTPC and BHEL to carry out certain upgradations / retrofitting of these boilers. The four Talcher-Kaniha units were included in such agreements. It was decided that BHEL shall provide the materials and NTPC shall implement the same. The list of the works to be carried out against each of the issue is summarized below:

a. <u>Low MS temperature for bottom mill combination &Unbalance in MS temperature between Left & right hand side:</u>

To address this issue, the following were planned:

i. Addition of 2942Sq. M of Heat transfer surface in LTSH: A complete bank of 130 coils to be added over the existing two banks. In all there will be three banks. The arrangement is as illustrated in figure-2. The coils are of full length with 12 tubes in each coil.
ii. Shifting criss-cross from LTSH outlet to between divisional superheater and platen superheater. A scheme is as illustrated in figure-3 for better understanding.

The expected result by this modification was reduction in imbalance in MS temperature between left & right and achieving rated MS temperature.

b. <u>Reheater Spray in Unit 4 ,5 & 6:</u>

To address this issue, the following were planned:

i. Two loops have already been removed in all the 78 assemblies of Reheater in Unit 3.Similar modification to be done in Unit 4,5 & 6.

The expected result by this modification was reduction in Reheater spray.

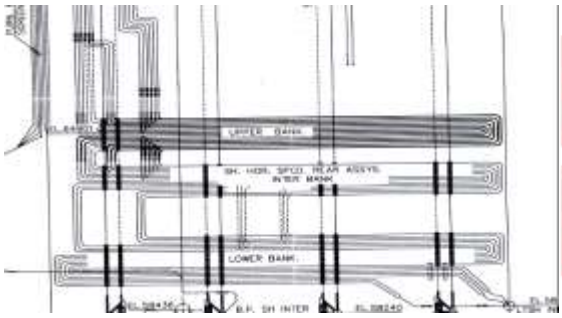

Figure-2: LTSH Bank addition

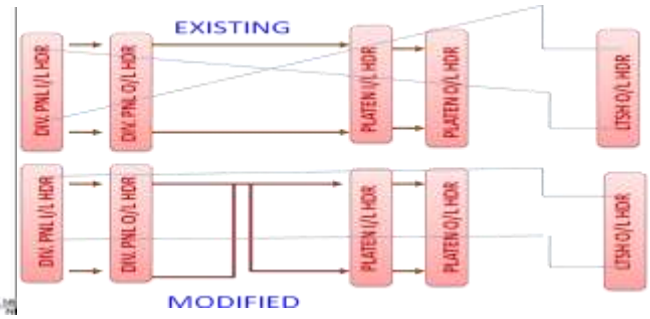

Figure-3: Removal of 2 loops & material upgradation of 4 loops

c. <u>High Reheater tube metal temperature inside penthouse:</u>

To address this issue, the following were planned:

i. Upgradation of Reheater material in the Gas touched length of 10 elements in final Reheater(rear) from T91/T22 material to Stainless steel TP347H material in assembly (coil) No 56 to 78 (23 assemblies) as illustrated in figure -4.

ii. Up gradation of Reheater material in the Gas touched length of 4 leading tubes of T91/ T22 material will be upgraded to TP347H in assembly (coil) No 1 to 55 (55 assemblies) as illustrated in figure-5.

The expected result by this modification was to resolve tube metal temperature limitation problem and instead of restricting metal temperature to 577 deg. C the same can be raised to 600 deg. C. Also, it was expected that the Reheater spray will reduce.

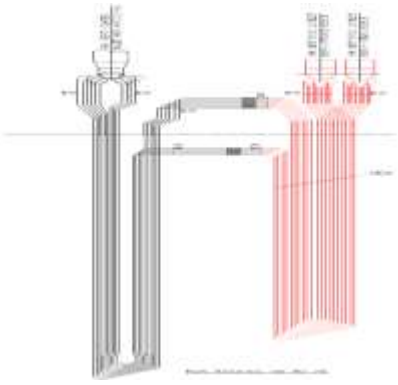

Figure-4: Material up gradation of final Reheater in 23 assemblies (Coil-56 to Coil-78)

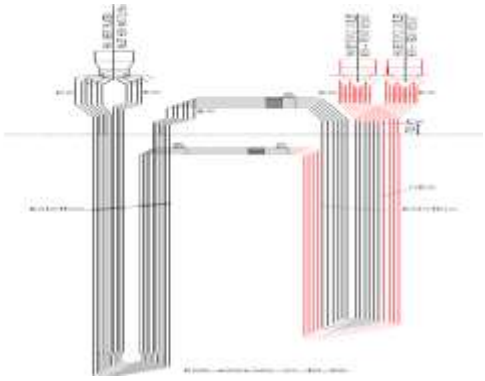

Figure-5: Material up gradation of 4 elements in 55 Assemblies (Coil-1 to Coil-55)

d. <u>Imbalance in Hot Reheater steam temperature between left & right:</u>

To address this issue, the following were planned:

i. Introduction of Siamese headers with T 91 header nipples in place of existing single Hot Reheater header with T22 nipples as illustrated in figure-4.

The expected result by this modification was eliminating unbalance in HRH steam temperature between left & right and reduction in Reheater spray.

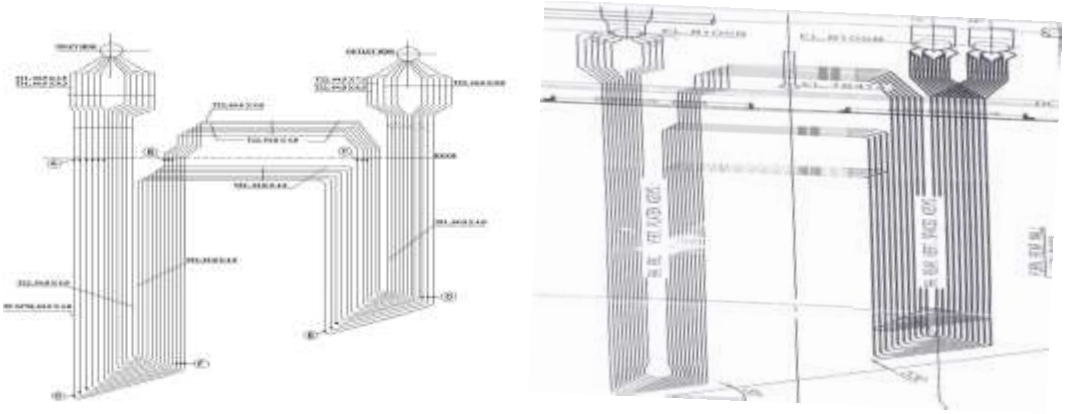

Figure-6: Modification of single Reheater Outlet header to Siamese header

4.0 APPROACH FOR EXECUTION:

When BHEL decided to supply the materials in the year 2013-14 implementation was planned. The following approaches were done for the implementation of job.

4.1 Study and discussion of the proposal and finalization of road map:

A thorough study of the proposal was done. Repeated discussions with various people like amongst the colleagues, some of the agencies, discussion with site management, corporate Operation services-Boiler group and discussion with the manufacturers (BHEL) was held. Even some of the erection experienced personnel were contacted for betterunderstanding and further clarity and a road map was drawn after visiting and discussion with the BHEL officials. A power point presentation was made and discussion referring to the same was held with various sections. A bar chart was prepared and the various aspects were discussed in detail. Physical witnessing of the materials was done at Trichy and idea for implementation was formulated. A road map was finalized.

4.2 Budgeting: How much will be the expenditure, Projection in ABB:

For implementation, provision in Budget was required. After preparation of the work plan and finalization of the items and their scope of work, the terms and conditions of the contract was finalized. Accordingly, estimate was prepared. When altogether a new work which is totally unconventional was to be done, consultation for similar works and discussion with experienced personnel in this field was done and accordingly the contract was finalized. For such new jobs, service codes were taken and projected in Budget. Fund allocation for implementation was ensured.

4.3 Materials :

Some of the issues on materials front were as follows:

The detailed list of materials was not known, hence, BHEL was requested for submitting a shipping list along with the PGMA and DU nos. It was found that a total of around1400 MT of Pressure parts materials and 3000 MT of Air preheater baskets was to be supplied by M/s BHEL. Some of the items like cassette baffle, front side tube shields and other minor items were missing, which was incorporated in the list of BHEL subsequently. For such items storage is a big issue in a brownfield project. Defining the ownership of such materials, proper storage and their preservation are very important as otherwise retrieval of materials as per site requirement may lead to a huge problem and delay the completion of implementation schedule. Equally important was immediate unloading of such huge quantity and their proper storage. Arrangements were accordingly done for storage space, immediately unloading of materials on receipt, storage and care of the materials. Issues like entry tax and waybill issue were also duly addressed. A weight and dimension chart was also prepared for easy and fast handling and incorporation in the work schedule for better understanding of the working agency. Reconciliation of materials was done at frequent intervals and the priority requirement items were regularly taken up with the manufacturer.

4.4 Finalisation of service provider for retrofitting:

Selecting a suitable service provider for such jobs is a very critical aspect for such huge jobs to be completed on allocated schedule. Also, important was timely award of a contract. In the contract, a provision to mobilise a crane of suitable capacity was incorporated. This necessitated timely award of the contract as a required mobilization time of 45 days was essential. For awarding a contract, after the job planning, finalization of qualifying requirements to select a capable and resourceful vendor having any such experience was done. The contract was awarded to M/s BHEL through Open tendering, who were the manufacturers also. However, a synchronized effort between NTPC and BHEL was required.

4.5 Approval from DOB (Statutory authority):

Carrying out modifications in an operating boiler requires approval of the state authorities. All necessary Drawings, calculation details and undertaking from the manufacturer regarding post boiler modification and statutory requirements were complied. Technical discussion was held with the authorities and

approval was obtained. Approval of the agency mobilised and the welding schedule was required. The same was also complied.

4.6 Planning & Mobilisation of Crane:

For safe and faster working, mechanization of the lifting process was planned. Accessibility for approaching the reheater coils, reheater headers and the criss-cross piping arrangement was to be decided. Several options were explored. Maximum weight and span of the items was to be lifted is listed in Table-1.

Sl No	Material	Dimension (Span, m)	Quantity in Nos	Weight (MT)	Maximum Lifting Height (m)
1	Hot Reheater Header	7	6	6.5 - 7	85
2	Reheater Outlet Coil	16	23	1.7	115
3	LTSH Coil Pair	12	65	2	65
4	Criss Cross Pipe	10.6	2	7	90
		3 – 6.5	10	1.5 – 4	90

Table-1: Major material list along with weight and dimensions

Such huge pipes, headers with 1.2 mtr. Long antellars, coil assemblies and their safe lifting was to be ensured without disturbing any other major assembly. Although possibility of winch machines was there, but it necessitated multiple pulley-rope arrangements. Since, there are 5 bowl mill assemblies, the bunker house was longer as compared to other stations. After several site investigations and discussions, it was thought to mobilise a tower crane or a Tyre mounted telescopic / crawler crane. But, such long heights, it required to mobilize crane with luffing boom arrangement. Load centres, height and position of the crane was finalized after studying the layout drawings and the weight of the components. It was decided to go for a tower crane of minimum 20 MT capacity and having provision for lifting to 115 mtr. or, a mobile crane of minimum 350 MT capacity with luffing boom arrangement for lifting to 115 mtr. Height. The agency finally mobilized a tyre mounted lattice boom crane of 400 MT capacity with luffing boom arrangement. The crane was most suitable for all the works of criss-cross piping, reheater header pieces and reheater outlet coils and approach was made from the boiler left side.Even the 780 nos. bent tubes to connect between the coils and the headers and loose tubes for replacement of the loops of coil-1 to coil-55 were handled with the cranes. The scrap headers, old coils, loose tubes of loops were smoothly removed. However, for simultaneous working, it was planned to make arrangements for lifting of LTSH coils from boiler right side using two nos 5 MT winch machine.

4.7 Supervision of BHEL:

As this was a job being carried out for the first time, M/s BHEL was requested for sending a competent and experienced person. Competent and experienced person from BHEL, Trichy and Chennai piping center were deputed for the jobs which helped in resolving many of the technical issues which had arisen during the course of implementation and smoothly the works were completed.

4.8 Services of diploma qualified engineers & Ex-BHEL personnel:

To ensure the quality of work and proper coordination during execution, some experienced diploma engineering qualified personnel and an ex-BHEL person was additionally hired. It will not be appropriate

here if their contributions are not acknowledged. They were asked to follow all the quality norms as per the quality plans and ensure protocols for such jobs.

4.9 Planning and mobilisation of other resources:

Manpower: Mobilisation of proper number of skilled, semiskilled and unskilled manpower was required. For this a job wise chart was prepared for the key personnel like supervisors, fitters, Riggers, HP welders for tubes, pipes, headers having approval from the state authorities and attachment welders. Mobilisation of the same on a 24x7 basis was ensured for timely completion of works.To facilitate their accommodation, food arrangement and other amenities were looked into.

Tools tackles: Suitable tools tackles, winch machines, pulleys, ropes, Gas cutting sets with flash back arrestors, argon welding sets, welding generators and rectifiers, grinding machines for tube and pipe works and other major equipments were listed in detail job wise. Load test and certification by competent person of directorate of factories for all the lifting tools tackles was ensured. Similarly, electrical testing of all the welding machines, grinding machines was ensured.

Material shifting contract: A separate agency having Hydra Cranes and Trailer arrangement facilities was engaged for shifting and proper storage of the materials at site. A separate agency was also ensured for removal of the huge scraps on a daily basis.

Additional Platform Fabrication:- An additional platform was required at 60 mtr to ensure proper storage and handling of LTSH coils. A separate contract was awarded to fabricate the additional platforms in boiler.

Electrodes, filler wires and other consumable requirements: The job involved 5500 tube joints and 30 pipe joints. Proper planning being first of such kind job was necessary. The job involved Filler wires and electrodes confirming to AWS:7018, AWS:8018, AWS:9018 and AWS:347 and of different sizes. The same were procured and mobilised. Planning for contingent arrangement was also done. Other major consumables involved like cutting gas, argon gas and Grinding wheels etc. were listed and their availability 24x7 was also ensured. For faster mobilisation at site, a site store was also constructed. A site store for all tools, tackles and consumables was set up, Master Electrode ovens were maintained at site at site for keeping welding electrodes in maintained preheated conditions.

Radiography, Stress relieving and Ultrasonic test facilities: Arrangements were made for sufficient no. of radiography sources, their proper and safe use. For development of films, reports etc. for faster working, new Radiography dark rooms were constructed at site. Stress relieving sources for carrying out preheating and post weld heat treatment (PWHT) with suitable number of digitally controlled machines, coils, recorders and skilled technicians were ensured at site on round the clock basis

HP Welder test: The job required a mobilisation of 12 HP welders for LTSH, 15 welders for welding of T91 and SS welding of Reheater and 10 pipe welders for welding of 30 nos. header, criss-cross pipe joints. Detailed action plan was drawn for schedule of tests. Test set up was done at site and all the welders were tested in presence of site quality department. To ensure quality at site, pipe welders were also tested with pipe test pieces. Continuous monitoring of all the welders was done and any welder with repeated defective joints was removed.

5.0 EXECUTION OF WORK:

The work was started before the shutdown of the unit. The pre shut down works involved material shifting from stores, internal steam cleaning of all the coils and tubes, carrying out sponge ball test of all coils, keeping in safe locations ready for lifting after fixing identification stickers duly signed by the supervising officials.

The crane was assembled after finalization of the position, which took 46 hours. The crane movement was checked and approachability for different jobs was assessed and found acceptable. Load test of the crane was done. During the execution, even two times the boom length was varied to take up the

works of criss-cross pipes and the reheater coils, which took 12 hours each. However, the earmarked area of 150 mtr x 10 mtr. was ensured to be clear for the boom assembly works.

After two days of shut down, for the reheater and criss-cross works, access was made by breaking of roof refractory and removal of structures in the identified areas. The pipes were locked and cutting operation was started. It took 25 days for removal and replacement of the pipes of criss-cross connection, removal and replacement of coils and removal and replacement of Reheater headers. After the header alignment, the connection between the reheater header antellars and the coils was done, which took a considerable time as there were some hindrances during the execution period, which is mentioned section-6. However, the LTSH coils installation work started after internal washing, supporting the LTSH coils from bottom by use of ISMB-400 in four rows, clamping of the hangers in all four rows by using pipe clamps and opening of four nos. access doors at four locations in the rear steam cooled wall. Nearly, 8-12 pairs of coils were installed daily and within 21 days of shut down, the coil installation work including welding was completed. New manhole doors accordingly were installed.

Boiler super heater circuit hydraulic test was done followed by Reheater Hydraulic test. Reheater hydraulic test arrangement was done before the unit shut down by putting the blanks in the CRH and HRH line NRVs. Air pressurization test at 5 ksc was done and then hydraulic test was carried out. After completion of hydraulic test, normalization of the CRH and HRH NRVs was done.

All temporary support structures were removed. Permanent hangers were installed as per drawings. Permanent supports, guides, drain and vent lines etc. were provided as per drawing. All refractory works and insulation works were done as per drawing. Cold setting of all hangers were done. Some of the relocated hangers and tie rods were fitted in position.

After successful completion of hydraulic tests & thorough checking of boiler internals was done, all scaffoldings were removed and boiler was lighted up.

6.0 OBSTACLES DURING EXECUTION:

Even if thorough planning was done and works of removal and erection went on smoothly, some of the problems led to delay in completion of the works. While some are technical nature of problems, some were agency related problems and some were local issues that led to problems. However, all these were dealt with suitably to accomplish the retrofitting work.

Technical Problems Observed:

i. The Reheater bent tubes connecting the new 23 Reheater Outlet Panels were found to be having lesser / mismatch internal diameter as compared to the corresponding header bent nipples. Resizing of the same was done in all.
ii. The end coils of reheater outlet were having excessive offset of bent tubes with the bent nipples connected to the headers. The same was modified and fitted in position.
iii. The two extreme tubes of the 23 panels were fouling with each other in the 23 new panel zone. The same were rectified.
iv. All the bent tubes were not exact and also the lengths varied from coil to coil and tube to tube. So, uniform cutting is not possible and it took a considerable time in fitment.
v. The new right coils (23 nos.) were having extra gap of 40 mm. at the bottom.
vi. Cutting of 7 nos. Riser tubes and alternate routing during restoration. New riser tube bends were fitted.
vii. Fouling of Roof sheet Hangers 8 nos. for Criss-Cross Platen-Divisional header connection
viii. Fouling of Boiler Roof Hanger 1 No. for Criss-Cross Platen-Divisional connection

ix. Fouling of Riser tube Hangers 3 nos. for Criss-Cross Platen-Divisional connection
x. Fouling of Screen Tube Hanger with HRH Pipe (Left).
xi. Fouling of HRH Bend (Right) with Reheater outlet coil End Bar hanger.
xii. Fitment issues for restoration of various pipes cut.
xiii. Other minor fouling and fitment issues also faced were resolved.

Agency Related Problems:

Some of the issues arise with working agencies while such major job is carried out. The problems are related to timely availability of consumables, material handling equipments, availability of cranes and its operation, timely presence of the site-in-charge, requisite number of skilled manpower, timely reporting of skilled manpower etc. On a day to day basis such problems were dealt with and resolved. Some delay is also attributable to the agency, which can be addressed during the next course of boiler modification in other units.

Other Problems:

Some of the other problems encountered were strikes and blockades in local area, Bandh of local area followed by state bandh and followed by all India strike. Local area festivals and community festivals also affected partially the completion schedule even if we had taken care of to some extent.

7.0 SAFETY & QUALITY ISSUES:

Special attention was paid for safety and quality as such huge nature of work and lifting very heavy objects upto 7.5 MT to a height of 100 mtrs. is not a regular task in any operating Boilers. So, proper use of Lifting tools, their tests, the use of skilled and trained manpower, proper electrical power supplies with ELCB, use of Personal protective equipments (PPEs) etc. were ensured during the course of work. A separate safety supervisor was deputed to ensure safety at work site.

To ensure quality, all best practices like testing of welders, testing of argon gas purity, 100% radiography of joints, Ultrasonic test of pipe joints and post weld heat treatment suitably under strict supervision was ensured.

8.0 POST-RETROFIT PERFORMANCE:

a. Design MS Temperature of 537 degree is achieved with top and middle mill combination. However, some shortfall is noticed with the bottom mill combination. Earlier, the temperature was 510-515 degree C.
b. Average MS temperature rise is 20-25 degree C. So, the turbine inlet temperature of 525 degree is achieved.
c. HRH temperature of nearly 520-525 Degree C is achieved.
d. While, Operation at full load with zero Reheater spray could not be achieved but, operation with zero superheater spray in middle and bottom mill combination is achieved.
e. Earlier, operation with Top mills was difficult due to Reheater metal temperature excursion.
f. Metal temperature of 577 Degree C has been changed to 600 Degree C.
g. Operation with Burner tilt upwards is also done as per requirement.
h. Operational flexibility due to operation with top mills.
i. Generation loss due to metal temperature excursion is eliminated.
j. MS temperature in Left side and Right side are balanced to a limit of 3-5 degrees.
k. Reheater metal temperature in Left and Right side is uniform.
l. Payback period due to additional shutdown of 817 hrs. (34 days), considering partial losses due to metal temperature restrictions and unit shutdown due to failure of tube comes out to 508 days.

Moreover, the morale and confidence of all the team members increased. The motivational level of all the people involved has enhanced.

9.0 KEY LEARNINGS:

Since, this was a retrofitting job, some of the deficiencies noted during the course of implementation has been listed. Actions shall be taken so that in future retrofitting jobs, such problems shall not arise.

Some such learning are: Reheater header and Coil removal to be given top priority, As references are available now, the hangers can be placed in position and the RBs can be fitted in position, Roof Refractory breaking can be taken up based on the references from unit-6, pre-assembly of loose loops for left 55 coils can be prepared, test pieces for welders' test to be kept ready before unit shut down, Crane with 2 operators to be taken and proper illumination in crane to be ensured for night work. Deployment of separate fitters for criss-cross connection and reheater area works and LTSH area works to be ensured and deployment of sufficient quantity of stress relieving equipments to be ensured before shut down of the unit.

10.0 CONCLUSIONS:

Every job when is carried out for the first time, there are many apprehensions, but, once it is achieved, the team spirit and motivational energy level increases. Such kind of retrofitting job is very unusual and there were many apprehensions. This needed lot of preparations, needed to ensure safety and quality at every level of work. After resolving the hindrances and after gaining experience, the team is enthusiastic to complete the job within a schedule time of 40-45 days bar to bar. If this is done, it will bring down the payback period further.

However, the same team spirit of all departments and corporate OS Boiler group for timely actions and interventions must be ensured. Also, the team must work without compromising for safety and quality at any stage during the boiler retrofitting of the other three units, which can be a good contribution for the project performance.