QUALITY ISSUES IN RCC CHIMNEY OF POWER PLANTS AND ITS MITIGATIONS

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Abstract

In Modern Power plants are constructed with Chimneys of 275m tall for discharge of hot waste gas at high altitude level. Hot waste gas is carried through flues made up with either brick or steel material supported on RCC wind shield. Construction of RCC shell and flues are challenging due to its height. Quality issues due to dragging in slip forming, improper flue can installations are the major problems faced in chimney construction works. Rectification of these problems are time consuming and very expensive. This paper high light on the quality issues faced in few chimneys, mitigations and rectification of these problems.

Keywords: *Key Chimney, Flues, Slip Form, Bearing,*

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1. INTRODUCTION

Modern power plants constructed in recent times are adopting super critical technology. They needed environmental clearances from Government body. One of the criteria is to discharge waste gases generated by burning of coal at high altitude of 275m from ground level. Hot waste gas generated in the boiler is carried through flue cans/shafts which will be made up of steel or heat/acid resistance brick flue. Number of flues provided is based on the numbers of boilers exhaust connections. In power plants multiple units are connected to single RCC chimney for economic reasons. These are supported by RCC Shaft structure. This RCC shell chimney structure, housing steel/ brick flues, will resist lateral forces acting on the chimney. Design and construction of RCC-Chimney of 275 m is a challenging and most critical in a power plant.

2. DESIGN ASPECTS

2.1 RCC Chimney consists of wind shield and flues. RC Wind shield is a cantilever structure housing the platforms, staircase, lift, aviation warning lights, gas probes and flues. It is analysed and designed for gravity loads, thermal load and lateral loads. Platforms are provided at every 40m intervals for supporting steel flues and at every 10m intervals for brick flues. Normally single brick flue is supported on RCC brackets taken from wind shield and in case of multiple flues they are supported on steel platforms beams. Size of steel/brick flue will be arrived based on the properties of gas flow considering exit velocity of 25 to 28m/sec at top.

2.2 Brick flues are constructed with fire clay bricks/acid resistant bricks. Fire clay bricks are conforming to IS 1526 Group-A Type 1 and the acid resistant bricks are conforming to Class I of IS:4860 and the mortar for this brickwork is conforming to IS:4832 Part 1 - Silica type with potassium silicate liquid binder. Galvanized Mild steel straps in vertical & horizontal direction around the brick flue are provided at 1 to 1.2 m intervals for stability of brick flue and to resist thermal expansion of flue. In case of single brick flue air gap of minimum 100mm will be provided between wind shield and brick flue for air circulation. Adequate area of ventilation openings are provided in wind shield at bottom and top of chimney for air circulation and heat dissipation. In case of multiple brick flues insulation on outside face of flue is necessary for keeping the air temperature around 40° C for human movement on the platforms during maintenance. Insulation material can be mineral or rock wool of required thickness to achieve the desired outside temperature.

2.3 Steel flues are vertically supported at top (top hung) of chimney or at every 40m intervals. Steel beams platforms will be used for supporting the flues. Since steel flues suspended from top, lateral restraints are needed at regular intervals, generally at 40m intervals. Steel flues are allowed to expand freely in vertical direction due to flue gas temperature, which is generally at 120 to 140° C. Expansion compensators are provided at platform levels. At top of chimney due to gas condensation effects steel flues are prone to acid corrosion attack. Therefore top 10m length will be provided with stainless steel. Steel flues are fabricated with mild steel plates of grade E250 (410W) quality B (Killed) and stiffeners will be fabricated out of structural steel grade E 250 (410W) quality A-killed. Stainless steel used for top portion of the flue will conform to AISI 304L.

3. CHIMNEY CONCRETE WORKS

RCC chimney supporting flue cans is very sensitive to wind loading and mainly wind load will be governing the design. Large openings in the RCC shell are required at ground level for shifting of construction materials/ erection of internal flues and entry into the RCC shaft for maintenance during life of power plant. At 50 m level, generally called breaching level, large openings are needed for duct entry. In addition, smaller size openings are required for support of intermediate platform, beams, sampling ports, ventilation openings at various levels. In order to economize the design, chimney shell is flared up from large diameters at lower level to smaller diameter at 1/2 and 2/3rd height of chimney. Above this level, diameter is kept uniform till top of chimney. Construction of lower portions of chimney with many large openings is challenging and in order to have good quality of concreting generally it is preferred to have jump-form work up to top of duct opening level and thereafter slip form work for construction. Chimney construction is a long duration activity and many times falls on critical path of the project. Completion of chimney construction in time is very crucial for light up of boiler and commissioning. The time constraints and difficulties in installation of slip forming arrangement at breaching level, often lead to expediting constructionactivities by adopting slip form work from foundation level instead of atbreaching level, thereby causing, quality compromises/ issues. Slip forming arrangement is shown in Figure-1.

Fig -1: Slip Form assembly

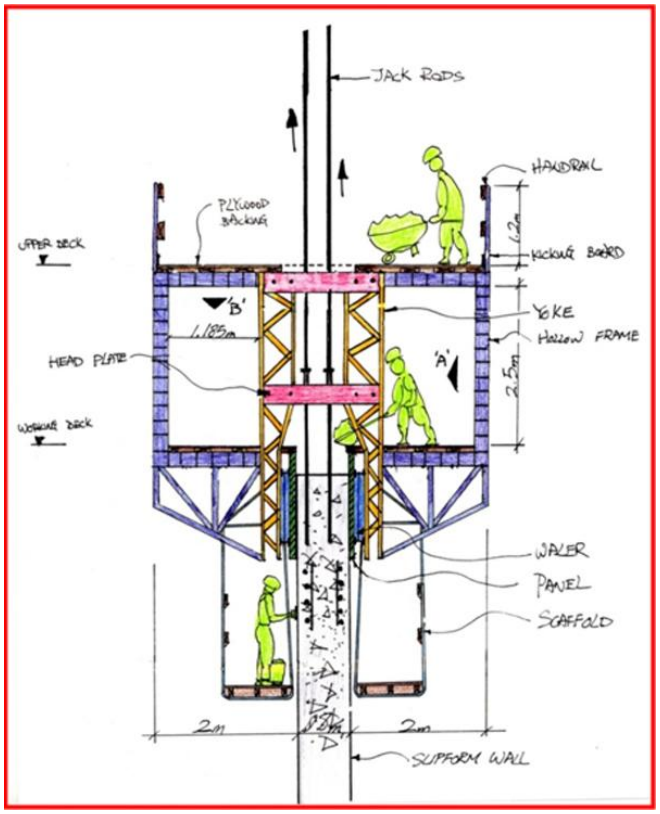

Fig -1: Slip Form assembly

3.1 Quality Issue In The Slipform Concreteing

Due to the presence of many openings at lower level slip form is leading to quality issues in concreting. Dragging of wet concrete is the major issue in chimney concrete leading to 25 to 75mm depression in concrete surface, porous concrete, visible honeycomb on sufcae. In some portion even reinforcement bars are exposed. These problems experienced in few of the chimney constructions are given in below exhibits 1 to 4.

Exhibit-1


Exhibit 2


Exhibit 3


Exhibit 4

3.2 Reasons for dragging of wet concrete can be attributed to

a) Increased setting time of concrete.

b) Slow Rate of slippage

c) Slow rate of concrete pouring

d) In between stoppage of concreting

e) Lower slump in concrete at the time of pouring.

f) Rough/ un-cleaned shuttering plates of slip form work

g) Twisting cleats of slip form work

3.3 Precautions To Avoid Quality Issue

Initial setting time, final setting time, rate of slippage and rate of pouring concrete are inter related in slip-forming concrete works. For a chosen parameter others are suitably modified to get best results in concrete quality by keeping following aspects.

a) Concrete shall be placed in about 200 mm thick layers uniformly in one continuous pour for the full circumference of the shell, so that, there will be no vertical or inclined construction joint.

b) Pour sequence shall be such, that the next layer of concrete is placed, over the layer already placed, well within initial setting time of the earlier pour.

c) The rate of movement of the sliding formwork shall be such that the concrete at the bottom of the formwork should have attained sufficient strength, so that it can support itself and all the loads that may be imposed upon it at that time.

3.4 Generally Following Aspects Are Considered To Get Better Quality Of Concrete.

a) Generally final setting time shall be 5 to 6 hours. Setting time lesser to this will lead to adhesion of shuttering plate to concrete and when slipping occurs, portion of concrete will come along with plate leading to dragging.

b) Good rate of slipping shall be 100mm to 150mm per hour. Lower to this speed will allow more time for given lift /slip of shutter leading to more time for setting of concrete and more adhesion to shutter plate leading to reason for dragging.

c) Good speed of concrete pouring is 2 to 2.5m height per day considering two shifts 10hr of each. Lower speed of concreting will lead to concrete setting before slipping and adhere to shuttering plate. Movement of shuttering plate after this time will drag the concrete surface leaving undulations. Faster to this speed also harmful since the shuttering slip will be earlier to final setting time of concrete.

d) In between stoppage of continuous concreting work due to mechanical failure in the slip form system / labour problem/ delay in concrete arrival to the spot. Contractor shall make arrangement for stand by equipment / additional spares so that mechanical system problems can be addressed immediately. Skilled Labour is very important in slip form work and contractor shall keep stand by skilled team to address the shortage/ illness etc.

e) Slump of concrete at the time of pouring concrete shall be 150mm to 200mm in order to get good quality of concrete. Slump at the location of concrete preparation shall be kept little more keeping transportation time of concrete such that at placement location slump shall be as mentioned above.

f) Shuttering plate made up with EN8 grade steel is preferred as it is more malleable. Surface of the plate on the concreting side shall be coated with epoxy or polymers to minimize adhesion.

g) Any small steel component of shuttering arrangement projecting beyond shuttering sheet shall cause dragging. Therefore this is to be checked at initial stage of slip form work progress and at intervals. Any such things noticed shall be rectified immediately. Components poses such problems are twisting cleats, stiffeners provided for shuttering plate.
h) During construction of chimney if dragging occurs it is essential to stop the concreting and check the quality of concrete using non-destructive testing like Ultrasonic pulse velocity test. If the velocity of wave found to be less than 4000m/sec but greater than 3000m/sec, it is necessary to rectify the quality of concrete. If the measured Velocity of wave less than 3000m/sec it indicates that the quality of concrete is poor.

3.5 Rectification Of Concrete

Concrete having UPV of 3000 to 4000m/sec indicates presences of porosity in the form of voids, cracks and in some places loss of integrity. These areas shall be pressure grouted using epoxy or polymer grouts to ensure structural integrity. For areas where reinforcement is exposed, weld mesh to be tied to reinforcement and micro concreting to be performed. For areas where reinforcement is not exposed, area is to be plastered with repair mortar. UPV tests shall be re-conducted for acceptance.
For the concrete where the UPV is less than 3000m/sec, further core test samples shall be taken at adequate number of locations across full depth to study the quality and compressive strength for acceptance. If the strength is within the acceptable limits, grouting, as mentioned above is carried out. UPV tests shall be re-conducted for acceptance. If the core test results are not satisfactory, Concrete shall be removed and re-done.

4.0 CONSTRUCTION /INSTALLATION OF FLUES

4.1 Brick Flues

Brick flues are constructed on RC brackets or RC ring beams or on steel beams. In case of RC brackets adequate openings is to be provided for air circulation if the bracket is continuous. If the bracket is not continuous, ring beam with gap between wind shield and ring beam face is provided for air circulation.

4.2 Quaility Issues In Brick Flue Construction And Remedial Measures

Laying of brick masonry joints is very important since they are weak points for gas leakages and joint failure. Joint on inner periphery of flue is to be kept not more than 2mm and on outer periphery not more than 12mm. More the thickness more the probability of weak joint and crack may develop over a long period leading to gas leakage and fall of bricks. Therefore skilled labour and adequate time shall be given for construction of fire/acid resistant brick work. Also shaped bricks with required curvature (matching to inner & outer radius of flue) are to be used to get better joints. Continuous inspection of quality of work is very important to achieve better quality of work. In order to achieve this it is necessary to have suitable access arrangement for inspection team to reach the working level at any time of construction. Therefore a access opening/ manhole at every platform level is to be provided along with a temporary rack & pinion lift to approach these openings quickly & safely for inspection team.

4.3 Steel Flues

Flues are fabricated in circular segments (cylinder) and erected from top to bottom. A bigger opening is provided in chimney at bottom for transportation of segments inside chimney and erection. For convenience in fabrication, handling, transportation and erection the length of the flue 'CAN' is to be limited to 6000mm.The cans are to be classified as typical flue cans, support cum restraint flue cans, restraint flue cans and S.S. flue cans.

Typical flue CAN will have stiffener angle 130x130x10 at top and bottom with outstanding legs in horizontal plane serving as flanges for bolted connection.

Support cum restraint flue can is provided at the top of each unit of flue between expansion joints. This flue can supports the total weight of this particular unit and transfer the load to the support beams through four brackets. This 'can' also accommodate restraint buffers for the top restraint bracket of the unit. At the end of this can, where the bracket / restraint buffers are provided, stiffness of CAN is increased by providing stiffeners and local higher thickness for CAN. Flange connection at the end of the CANs as well as stiffeners will be provided similar to typical flue CANs.

Restraint flue can is provided at the bottom of each unit of flue immediately above the expansion joint in the case of hung portion of the flue and at the top of the bottom supported portion of the flue.

The total length of the Stainless Steel portion of the flue shall normally be fabricated into two cans of equal length. The top can shall have a box shaped stiffener

The supporting / restraining arrangements of the flue/duct shall be such that the movement of the flue longitudinally or circumferentially is not restrained.

4.4 QUALITY ISSUES IN STEEL FLUE INSTALLATION

It is very important to fabricate the cans with stiffeners, brackets at exact designed locations and same shall be checked before shifting to chimney for erection. If bracket location is not in proper position and not checked the

position before lifting, it will invite many shim plates to keep the flue can vertical/ plumb after it is placed on the floor beams. If not kept flue CANs in plumb, CAN bracket will induce lateral thrust on support bearing and over a period of time, support bearing will dislodge in its position. These problems have been experienced in one of the chimney which is under operation. The photos are given in below exhibits 5 to 6.

Exhibit-5- Dislodged bearing pad

Exhibit-6 Eccentric load transfer

Exhibit-7- Too many shim platesover the bearing pad

Exhibit-8- Dislodged bearing pad

4.5 Rectification

Rectification of such dislodged bearings can be taken up during boiler maintenance period. Additional brackets are welded to existing brackets and all brackets are lifted simultaneously using hydraulic jacks. Lift of brackets are to be within the designed expansion compensation allowance. After lifting the brackets, support bearings are relocated to its postion and jacks are released. Sliding arrester in the form of plate welded to fixed support is suggested to prevent lateral movement beyond the fixed support.

5. CONCLUSIONS

5.1 Quality of concrete affected by dragging in slip form concreting can be eliminated by adopting proper rate of slippage, rate of concreting, slump based on the initial setting and final setting time of concrete. Shuttering plate made of EN8 grade steel is preferred. Stand by equipment and skilled labour force is necessary for continuous concreting operation.

5.2 Brick flue construction shall be executed by skilled labour with adequate time given to them.

5.3 In case of steel flues fabrication of brackets, end flanges as per design drawings are important. Quality checks of flue cans before shifting to its position shall be done strictly and any mistakes noticed shall be corrected at fabrication yard only. Adequate and safe approach arrangement shall be provided to reach all levels for inspection /supervision during construction time.

5.4 Rectification works at higher elevations are difficult due to approach problem, it is more time consuming and expensive. Therefore it is very important to do proper early planning of construction, arrange adequate construction facility/equipment/skilled labour and quality checks. Rectification of work at later stage or during service of chimney will be leading to shut down of plant in addition to being very complicated and costly activity.

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BIOGRAPHIES

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