

# A STUDY FOR SPOT CHECKING MANAGEMENT OF BOILER “FOUR TUBES”

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## Abstract

This paper analyzes the method to find state inspecting-spot opposed corresponding to boiler heated face invalidation formation. Combined with the boiler actual circumstances of the power plant, this paper also raises the deterioration tendency supervision project of construction period.

**Keywords:** boiler; tubes; deterioration; spot checking

## 1 Introduction

Spot checking and regularly repairing is a sort of equipment management model that management core is Spot checking and total staff is attached to entire process management , the ultimate goal is to effectively prevent the equipment " over maintenance " and " less maintenance ", to improve equipment reliability, reduce Failure rate, reduce the maintenance costs of equipment maintenance.

Spot checking is according to that principle that is "fixed point, the principle fixing law, picketage, fixing cycle, fixing person at the regular intervals" to give a test to equipment right away , whose essence is according to the location and project setting up in advance , examine that , determine to equipment go along, thereby, know to bring forward countermeasures with the degree and developing trend grasping equipment degradation, and handling in time. Point is inspected up managing the basis being that equipment prevents from being maintained, core being modern equipment control, it is charged for being to manage a target with equipment, change equipment "in order to repair the main", control device "in order to manage the main," process is hit by maximal synthetical beneficial result to look forward to gaining equipment entire life-span.

Spot checking management is the core of the " management of deterioration trend ", that is, through the detection of statistical data and analysising to identify trends and patterns of equipment deterioration, the decision-making. will be offered for repairing.

## 2 Spot checking and regularly repairing in a boiler “four tubes” on the application

The accident of Boiler four tubes explodes leaks is one of primary cause that the power unit stop in a non-planned way, how to implement boiler four tubes specifically the spot checking, makes its to enhance boiler four tubes reliable aspect to play the role is the topic which the specialists must face.

Under the plan overhaul system boiler heating surface's management concentrates much in aspects and so on explosion precaution, key spot, key question. The administrative personnel or overhaul the personnel the experience which explodes through many years four tubes leaks to try to find out that has drawn up the concrete explosion precaution to the concrete boiler heating surface, had determined the key spot, the inspection cycle, the processing method and so on, have made the massive transformations, the research work in view of the frequency detonator's question, has made the quite good progress. But these work are the summary which, the analysis, the refinement after having explodes leaks carries on, i.e. only then after the cartridge igniter or the leakage has happened, only then prevents and controls, therefore may also talk into is manages afterward. But when the boiler to certain average life, has often needed to pass through occurs many times explodes leaks, can make the big area to trade tube's decision-making, this is generating set's reliable request cannot permit under the current situation. The boiler four tubes spot checking management namely must contain original explodes leaks afterward management which the experience summarizes, but must complete the tubes to deteriorate the tendency monitor in anticipation management. It also must be in guarantee that the boiler safe steady operation in the foundation, completes the four tubes' tendency management, can provide a basis for a large number of pipe sections for the replacement of the overhaul for decision-making, this is spot checking and management the central content. [1]

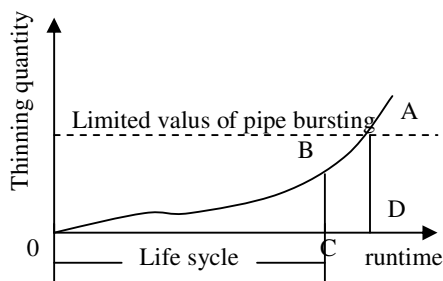
The boiler four tubes completely in the stove, can run in response to the pressure, temperature, flow, sound, inflation and so on, is insufficient degree which deteriorates on behalf of the equipment. Reasons such as the tube wearing and tearing, corroding, overheated, stress etc. cause the serious deterioration, before it has not occurred explodes leaks,

it does not affect boiler's normal operation and the output, but these deteriorations cannot use by some information way under the running status respond that gives the people. Therefore the boiler four tubes spot checking must place the inspection key point in the engine off disintegration inspection to carry on.

The boiler four tubes' deterioration is along with the boiler operation time growth, the pipe from the primitive condition to the mode of failure development process. Its expiration degree and the time have certain functional relations in this developing process, in the different time, its deteriorated degree is different. Carries on the quantification record to this process, then carries on the statistics and the analysis, summarizes the deteriorated rule, calculates its deteriorated speed, estimates its surplus life, the overhaul method must be carried on before its thorough expiration, this is deterioration tendency management. [2]

The boiler four tubes deterioration tendency's key is to find a "quantification" and "point", how namely to track tube's deteriorated tendency. In view of the pipe different failure mode, adopts the appropriate examination method, indicates its deteriorated process with the data.

Figure 1 shows a tube as a result of wear and tear, corrosion caused wall thinning and the running time relational curve, in the chart point A express that pipe was burst at the limit, points B for the replacement of the tubes, corresponding to the Points C, D were replaced and the running time limit. Put into operation from the tube to replace the point C which must arrange before point D, and the closer we get to be the more desirable, if surpasses point D to carry on the overhaul replacement again, is "less maintenance"; On the contrary, like between C, D oversized, is " has repaired " The four tubes spot checking management is to determine the best location of the C-point, reduces C points with D spot distance, obtains the biggest service life cycle. It must inspect the data the analysis and the summary, judges the heating surface accurately the expiration tendency, determined that is most economical and the safest overhaul strategy, this is spot checking and customizing repair system to promotion and the application of the ultimate goal.



**Fig.1** Deterioration curve of pipe thinning

### 3 Boiler four tubes deterioration tendency to set up monitoring points

Boiler four tubes deterioration tendency to monitoring should have the characteristics: a. representation, b. quantification, c. accumulation of the data.

a. representation: the point is to be set up on behalf of the state of deterioration. Wear and tear, corrosion, crude expansion, oxidation, and deformation, changes in the performance of organizations are a direct bearing on behalf of the deterioration components.

b. quantification: the purpose of monitoring can be used to express the values, so as to carry out statistical analysis of data. [3]

c. accumulation of the data: that is quantifiable data monitoring and measurement of long-term record is the accumulation of statistics and analysis of the foundation, only the accumulation of data, only to realize deterioration tendency analysis and management of possible.

The boiler four tubes' scope is quite big, their own material and working conditions are different, present the question the reason, the mechanism and the way are many and varied. With is one kind of heating surface pipe, the type of furnace structure and the arrangement way is different, its failure mode also has the very big difference. Hence the need for specific kinds of heating surface of the furnace tube failure in the form of specific analysis.

#### 3.1 Evaporation heating surface

The water cooling wall's failure mode mainly corrodes, water cycle failure caused by overheating, the tube outer wall corrosion. The economizer failure mode is mainly the tube outer wall attrition and the tube endophragm's corrosion. The water cooling wall and the economizer failure mode is finally causes the pipe wall to attenuate, therefore it can be wall thinning as the amount of this heating surface evaporation of the monitoring stations. The following analysis of the wall is thinning whether it has representative and quantifiable characteristics.

Electrical energy [1992] 1069 "prevent the power plant boiler four tube crack technical guidelines" (hereinafter referred to as "guidelines") pointed out: low-alloy steel and carbon steel pipe's wall thinning is more than 30% to press (1) type the computation, the remaining life expectancy is less than an overhaul period of time are required to be replaced:

$$C = (b_1 - b_2) / \tau \quad (1)$$

b1, b2--- Two surveys obtain pipe wall thickness.

$\tau$  ---The sampling interval time, is bigger than suitably for 10,000 hours.

Then it may appraise pipe's remaining life  $\tau_y$ :

$$\tau_y = [b(2\sigma_y - P) - P(D - 2b)] / (2C\sigma_y - PC) \quad (2)$$

b---- the original thickness of the pipe mm,

D---- the original diameter of the tube, mm

$\sigma_y$  -----the most low intensity below steel products slow change temperature

P-----In tube working pressure, Mpa

Pipe's wall thickness from the original manufacturer to the ultimate failure of the entire process, whether wear and tear, oxidation, corrosion, overheating or mechanical damage caused by thinning and other reasons, the concrete data can be obtained through the concrete survey, therefore wall thickness attenuates also has the quantification characteristic.

### 3.2 High temperature (again) superheater

This kind of pipe's main failure mode is the inflation creep, the high-temperature oxidation, the structural change and the mechanical properties drop and so on. The tubing will have many changes under the high temperature function, for example the total creep, the performance will be usually thick for the pipe diameter's bulge; The high-temperature oxidation, displays for the pipe wall attenuates; The long-term hot operation will also create the steel products organization's change, simultaneously will cause its mechanical properties directly the change. The high temperature heating surface pipe's material quality is diverse, the different tubing its organization failure mode is not same. Regarding the Cr-Mo steel and carbon steel, main performance for material quality graphitization and spheroidization; Cr-Mo-V steel mainly for spheroidization and decarbonization; But the austenite stainless steel is mainly the carbide separation and the accumulation, specially Sigma the separation, will cause the stainless steel the intensity, the plasticity and toughness drops suddenly. The pipe endophragm's oxide film immediate influence heat transfer causes the pipe wall excess temperature, creates the pipe overheated. Therefore, for high-temperature heating surface can be rough inflation diameter, endophragm oxidation film thickness, the material quality Microstructure structure, the outside surface oxidation thickness of skin, the tubing skin hardness, the pipe (row) deformation, the wall temperature and so on to take the test point.

#### 3.2.1 Expansion diameter bulge

"Guide" pointed out that "when the carbon steel tube bulge surpasses 3.5%D thickly, the alloy-steel tube surpasses 2.5%D" must carry on the replacement. High-temperature heating surface temperature over the tube running as a direct result of overheating of the tube, long-term overheated displays thickly prominently in pipe's caliber bulge on. Expansion of rough outside diameter can be used in general or special fixtures caliber to measure.

#### 3.2.2 Endophragm oxidation film thickness

In the vapor temperature 500~600°C scope, the steel pipe endophragm can have the oxidizing reaction, destroys original has the protective function compact oxide film, and forms the oxide skin. The carbon steel tube's oxidized thickness of skin and the application temperature assume the linear relationship, the low-alloy structural steel oxidized thickness of skin and the period of revolution assume the complex index relations. After the boiler tube endophragm has the oxidation, forms the oxide skin in the internal surface, the oxide skin thermally conductive energy level is bad, the thermal conductivity is lower than several hundred times the steel products, is only 0.1~0.25W/(mK). The oxide skin will cause pipe wall metal temperature increment directly, will cause the alloying element desolution, the carbide accumulation, the organization to spheroidize the acceleration, will cause the steel products organization and the performance worsening, will reduce the service life, will cause the cartridge igniter accident. According to the related literature that each 0.01mm oxide skin may cause pipe wall temperature increment approximately 0.43 °C, therefore present to the service boiler should immediate measure tube endophragm oxidation film thickness, understands the high temperature furnace tube's excess temperature level.

At present the endophragm oxidation film thickness measuring technique has tube cutting and ultrasonic measurement method, 2 methods may obtain the quite accurate data, as the thickness of the oxide film that is to say monitoring is also quantifiable characteristics. After obtaining the oxidized film thickness, it can use formula (3) to estimate its equivalent operating temperature:

$$T = a/(lg\tau + b - lg0.4687X) - 273.15. \quad (3)$$

T- pipe wall metal equivalent operating temperature

$\tau$  – the tube of furnace running time

X- endophragm oxidation film thickness

a, b- constant

#### 3.2.3 Material quality Microstructure structure

In the high temperature of the material microstructure and composition changes in the microstructure can test the performance of the material to be assessed, such as the spheroidization analysis, carbide particles of rough analysis,  $\sigma$ -phase assessment component analysis and so on is the most direct service life of steel Basis, therefore the material quality Microstructure structure most has the deteriorated tendency representation. Through the use of the dedicated professionals of equipment and facilities to carry out the on-line or sampling testing should have access to such data, this may

induce in the inspection management into the areas of Precision Inspection.

### **3.2.4 thickness of oxidation skin in Outer wall**

"Leads" stipulated: The high temperature super-heater surface oxide skin surpasses 0.6mm to carry on the replacement. The outer wall oxidation took place in the general high-temperature location of a number of low-alloy steel pipe, its reason often creates as a result of the long-term low scope excess temperature, specially in some reheater's high temperature part, often in startup procedure's cooling insufficient easy to have this kind of oxidation. Such oxidation can be found through the naked eye, and through the grinding thickness can be measured.

### **3.2.5 Tubing mechanical properties**

Hardness is the material intensity level of macroeconomic performance, hardness and the application temperature and the time has a certain functional relations. Can make use of change of the hardness to predict the metal temperature of using, therefore takes the tube's surface hardness to refer the test point to carry on the surveillance. If the original 12Cr1MoVG pipe's hardness is HB153, after undergoing a period of time movement, hardness declining trend is obvious, then it shows that this spot the actual application temperature is high, must bring to the attention; hardness can be sampled for testing.

Tensile strength reduction is the important performance which the pipe Fine texture deteriorates, through takes a sample to carry on mechanics analysis, may obtain the mechanical properties' quantification value

### **3.2.6 Tube (row) deformation**

Tube (row) deformation is a common problem of the heating surface, the pipe leaves ranks, curve, a tube row of distortion, the entire row of displacement and so on, mostly is because non-smooth inflates,, hanging branch failure, the fixed damage caused. Leaves ranks the pipe can have the attrition, overheated; Superheater vertical pipe curving mostly with inflation related, often follows the pipe overheated occurrence; tube row overall deformation or occurrence displacement display changes with the neighboring part's gap or the distance, often caused by mechanical Wear and tear, or obstructed expansion and so on questions. Therefore pipe row or tube of abnormal deformation and displacement should be provided to the monitoring as an anomaly information, abnormal deformation and displacement can be gained by a simple method measuring

### **3.2.7 Pipe wall temperature**

Wall temperature can be used as a very useful reference point for monitoring, because the pipe wall excess temperature creates the pipe material organization and the performance change directly, through the records in the operation of the over-temperature range, over-temperature time, in the union overhaul carries on the key data survey and the analysis to the long-term pipe

wall excess temperature's pipe, the judgment movement accommodation mode correct and the rationality. Can make use of Larson-Miller formula calculating to the pipe life

### **3.2.8 Mechanical damage**

Pipe and tube, pipe and tube folder between the wear and tear, blowing the medium-purge, coke, and other pieces of the injured are mechanical damage. They are very destructive, often very quickly lead to burst pipes. Such monitoring requires frequent inspection and measurement, according to the actual situation of setting the specific location detection.

## **4 Boiler four tubes inspection tendency management foundation**

Realizes the boiler four tubes inspection management to have the data accumulation most importantly, this realizes the deteriorated tendency analysis foundation. That is the above-mentioned quantifiable data on a regular basis-point measurement, moreover must starts from the most initial manufacture and the installment stage to implement. Because the boiler four tubes life estimate is based on the experience formula and the test data, either wall thickness attenuates or the expansion of rough diameter, pipe's Microstructure structural change and so on, in the four tubes of the life cycle process's deterioration is very small, but the original manufacturer or the installation of error is not negligible.

For example, according to GB5310-1995 "with high-pressure boiler seamless steel tubes" to create the standard tube, the diameter of its biggest allow the error was 0.20mm, the maximum allowable thickness of error was  $\pm 10\%$ . But the relevant rules of order tube wear no more than 0.2mm every year, the corrosion rate is 1.1~1.5mm/a generally, therefore the primitive manufacture error will bring the very big error to the life estimate precision.

Moreover the tubing primitive Microstructure structure, some alloy tubing leaving the plant spheroidization already achieved certain degree, if like this does not make gathering and the record to its primitive shape, then has the possibility to make judges by mistake, thus causes the decision error.

Along with new material application's increase, to the new material's life surveillance is a new topic, a new kind of steel performance examination should not be in merely the laboratory, makes the surveillance and the examination in the actual movement is also very important. Therefore from entire industry in long-term angle embarking, establishes the new material the primitive database, and carries on the unceasing monitor in the movement, obtains the tendency data, has the very vital significance.

## **5 SG-2026/17.47-M903 boiler four tubes deterioration tendency management system's establishment**

According to Hebei Guohua Cangdong Power Co., Ltd. of the boiler structure, combine the same type and the same coal actual operation conditions of boiler, in the infrastructure stage set a detailed monitor of a four tubes deterioration tendency and collect data related to the original, to establish a spot checking database for the boiler four tubes life-cycle management to lay the foundation.

### 5.1 Formulation spot checking standard

The technical standard is the core standard of spot checking, its function is clear in detail sentences the waste standard which equipment's design feature and corresponds. Decides on the concrete equipment inspection standard according to the technical standard system, demarcates the test point in detail the concrete position, the project, the examination method, the examination cycle, the examination condition, the determination standard.

a.The economizer set up attrition and the tube endophragm corrosion the test point. In view of the fact that this type of furnace combustion with the Shenhua coal, the attrition is light, accumulates the ash heavy characteristic, wears the test point to establish certain spots along the chamber width direction, the position establishes after the first or second stove bend. Stands in line the first position under the soot blower traveling schedule scope's tube to establish certain points. Manages the endophragm corrosion the historic record after the acid pickling through the survey pipe wall sample measured that obtains thick.

b.The water cooling wall's tube endophragm corrosion after the acid pickling chemistry sample measured that obtains thick. Wall thickness monitoring stations set up in the burner on the site of 2 meters and soot blower tube purge within the scope of 1 meter.

c.The low temperature superheater establish the attrition test point and the bulge thick test point, the attrition test point is established in the first vertical tube, the elevation before the package of wall fluorescent tube corresponding to the root of the site; The bulge thick spot establishes lower part the stove ceiling 1 meter place and the first vertical tube place. Establishes several the tubing metallography test points of low-alloy structural steel to the export part.The screen, the last stage superheater and the reheater according to the tube screen characteristic, compare the pipe design specification, combined with practical experience in setting expansion diameter crude, endophragm oxidation film thickness, the pipe wall temperature, location of the tube screen, metallography and mechanical properties, outer wall hot corrosion, high-temperature oxidation and so on monitoring, the position elects in the internal and external operating mode relatively quite bad spot.

### 5.2 Primary data gathering

The union capital construction installment, has established various projects to carry on the primary data gathering work, the caliber carries on the survey using Caliper, wall thickness carries on the survey using the thickness gauge, a tube row of position carries on the

survey using the line tape, to the metallography and the mechanical properties of cutting through the sampling tube,obtain the data with the aid of EPRI.

From the raw data collected shows that the original pipe wall thickness and diameter in the manufacturing process of error is larger, for example is lower than the pipe wall thickness biggest error to have achieves 0.40mm, but some  $\phi 63$ mm pipe's outer diameter error achieves 0.70mm, And such a great value if there is not the original survey record, not only give the tendency management to bring the enormous deviation, but also will give the judgment equipment running status to create a barrier.

### Conclusion

The boiler four tubes' spot checking management needs to obtain from its abate characteristic, reasonably set a state monitoring "point". Carry on the primary data from the manufacture and the installation stage gathering, set up the primitive database; put into operation in the maintenance of the status of ongoing monitoring point, through the long-term data's accumulation, carries on the statistical analysis, obtains the deteriorated tendency and the trend of development, evaluates remaining life, "customizing repair" to provide the accurate basis for the decision-making. Only then through the effective management system in order to achieve the goal which the boiler four tubes is controlled.

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