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一台余热锅炉受热面积灰和烟气除尘的改进分析

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摘　要: 介绍了一台余热锅炉运行中存在的受热面积灰、管子变形和烟尘排放超标问题, 对其进行了分析, 并指出了解决问题的方法。

关　键　词: 余热锅炉; 受热面积灰; 除尘

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1　前言

目前, 我国有大量的余热锅炉正在运行, 其中一些热源来自水泥炉窑排出的烟气。烟气中含尘量非常大, 其危害是使余热锅炉的各受热面积灰, 传热条件恶化, 造成部分管子变形甚至爆管, 影响余热锅炉安全运行, 尤其是排放烟气的含尘量超标, 造成周围环境污染, 由此可见, 对该问题的解决有实际意义。

2　存在的问题

2.1　结构简介

某水泥厂的余热锅炉型号为 YR28.4/850－10－1.37/350, 是一台典型烟道式余热锅炉。烟道宽度是常量, 来自水泥炉窑的热烟气依次冲刷凝渣管束、蛇形管过热器、三组锅炉管束和两组经济器(如图示)。

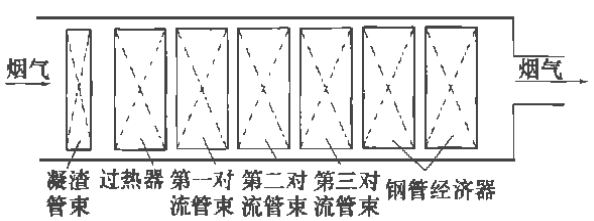

图 1　余热锅炉本体及烟气流向示意图

2.2　锅炉运行工况

通过该炉运行记录及现场观察可发现: 该炉出力一般维持在 5.2～6.5 t/h, 过热蒸汽出口压力: 0.6～0.98 MPa, 过热蒸汽温度 280 ℃～350 ℃。烟气进口温度在 840 ℃～1 012 ℃。排烟温度在 150 ℃以下。烟尘排放量超标。

2.3　运行中出现的问题

经停炉检查发现: 过热器前的凝渣管束有轻微变形, 过热器后的前两组高温段对流管束的管子均变形严重。所有的管子均有不同程度的积灰。积灰程度总趋势是沿烟气流向越往后越不严重, 其中第一管束位置与前面的受热面相比横向节距小, 烟道堵灰相当严重。积灰的主要特点是灰层厚度沿着管子正面迎着气流生长, 管子背面少些, 多数属于高温积灰。

3　问题分析

3.1　积灰严重的原因

积灰严重的原因是多方面的。首先, 水泥炉窑提供的热烟气本身含灰量很大; 其次, 锅炉实际运行长期处于低负荷状态, 烟气流速比设计值低很多, 据运行数据显示, 第二组锅炉管束位置烟速不足 3 m/s, 势必造成排列管束严重积灰, 甚至堵塞部分烟道, 引起流动阻力增加。在这种情况下, 为保证锅炉能够正常运行, 用户自行决定更换压头更高的引风机。第三方面原因是运行管理不严格, 没有进行定期吹灰, 使两侧墙上的压缩空气吹灰装置没有发挥作用。

3.2　管子变形的原因

除管材和焊接质量外, 管子变形主要是由锅炉积灰引起的。

从管内侧分析, 上升管与下降管的截面比在正常范围内, 锅内装置设计合理, 锅炉水质分析结果合格。但由于锅炉长期在低负荷下运行, 凝渣管中及

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管束中的汽水混合物流速下降, 管内壁面有部分气泡不能被及时冲走, 再加之管外壁积灰较厚, 形成厚度 1 mm 以上的硬壳, 其导热系数很低, 导热热阻很大, 使得管壁温升高, 管子长期处于过热状态造成管子变形。

4　改造措施

4.1　保证烟气一定的速度以防止积灰

余热锅炉的蒸发量及各受热面中烟气的速度是随着水泥炉窑的负荷而变化的。只有提高水泥炉窑的负荷, 余热锅炉才能保证出力, 从而烟速合理, 积灰热阻小。为此, 当余热锅炉低负荷时, 建议采用部分低温烟气再循环的办法来增加烟气容积, 保证烟速至少大于 4 m/s, 最好 7 m/s。

4.2　应加强运行管理, 使定期吹灰装置发挥作用

完全依靠锅炉设计及运行调整来解决余热锅炉受热面积灰问题是不可能的, 采用足够数量的吹灰器在锅炉运行中经常吹扫受热面, 能有效地减少余热锅炉受热面的积灰, 保证余热锅炉安全运行。

4.3　烟气高温段安装除灰器

在余热锅炉凝渣管束前加装高温槽形除灰装置, 用 1Cr18Ni9Ti 钢板制成。为提高分离效果, 在安装除灰器处, 将烟道宽度缩小 20%, 以提高局部烟速。

4.4　采用复合多管除尘器

在经济器和水膜除尘器之间加装复合多管除尘器, 进一步降低烟尘排放浓度, 达到环保要求。

5　结束语

采用上述措施改造这台锅炉以后, 经半年的运行检验, 积灰明显减少, 烟尘排放达标。

对于负荷较低的水泥炉窑, 采用上述改进方案是合理的。

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（复　编辑）

机组及应用

FPSO 和半潜式系统使用的燃机

据《Gas Turbine World》2000 年 7－8 月号报道, Solar Turbines 公司拥有其燃气轮机在北海和巴西的 FPSO (浮动生产、储存和卸载船)和半潜式系统上广泛的运行经验。这使该公司对于今后墨西哥湾工程项目申请处于有利的竞争地位。

各个政府机构, 包括美国海岸警卫队均探讨管理措施, 以便开放海湾地区, 用这些设备开采深水的原油和天然气。

到目前为止, 索拉公司大多型号燃气轮机已用于 17 个半潜式和 61 个 FPSO 项目。半潜式装置累计共使用 5×Mars 100, 3×Mars 90, 2×Taurus 60 和 4×Centaur 40 燃气轮机。

FPSO 累计共使用 2×Mars 100, 7×Mars 90, 21×Taurus 60, 3×Centaur 50, 8×Centaur 40 和 1×Saturn 20 发动机。

1 台 13.5 MW Titan 也已销售供计划于明年使用的墨西哥湾 FPSO 项目。所有设备均供混合使用, 包括基本和备用电力生产, 水/油泵送和天然气压缩服务。

（思　娟　供稿）

for enlarging CFL number is to select an implicit scheme. Under the condition of meeting both a required CFL number and precision a combination of Taylor expansion method and TVD scheme can produce a kind of implicit method featuring an accelerating convergence. **Key words**: TVD scheme, implicit method, accelerating convergence, viscous flow field

船用主汽轮齿轮机组调节控制保安系统故障分析＝**Fault Analysis of a Regulation, Control and Security System for a Naval Main Steam Turbine-geared Unit** [刊, 汉] / CHEN Lin-gen (Power Engineering Institute under the Naval Engineering University, Wuhan, China, Post Code: 430033), LIU Wei-guo (Naval Representative Office at Dalian Shipyard, Dalian, China, Post Code: 116024) // Journal of Engineering for Thermal Energy & Power. — 2001, 16(5). — 543 ~ 545

Discussed are the failure forms and features of a regulation, control and security system for a new type of naval main steam turbine-geared unit. In addition, with an analysis of the underlying causes of faults and failures some countermeasures for their prevention are also proposed. **Key words**: main steam turbine-geared unit, regulation system, security system, fault analysis

一种锅炉燃烧控制的混合智能控制器＝**A Hybrid Intelligent Controller for a Boiler Combustion Control System** [刊, 汉] / LIANG Jian-wu, CHEN Yu-lin, ZHOU Cheng (Changsha Railway Engineering University, Changsha, Hunan Province, China, Post Code: 410075) // Journal of Engineering for Thermal Energy & Power. — 2001, 16(5). — 546 ~ 548

The combustion control system of a boiler is known to have a multitude of specific features, such as a strongly coupled state, being subject to a variety of outside disturbances, typical non-linearity, etc. In light of the above a hybrid intelligent control system based on "theory plus experience" is proposed, which combines PID (proportional-integral-differential) control, feed-forward control and expert control. As a result, the simplicity, reliability, anti-disturbance, rapid reaction and flexibility of the above three control methods are organically grouped into an integrated whole, giving full play to their respective merits. Initiating a new approach for industrial control technology the system under discussion has been successfully employed for the combustion control system of a 20 t/h boiler installed at Changsha Shuguang Electronic Tube Factory. **Key words**: PID control, feed-forward control, expert control, intelligent control

300 MW 火电机组仿真机给水调节方案的改进＝**An Improvement on the Feedwater Regulation Scheme for a 300 MW Thermal Power Plant Simulation Unit** [刊, 汉] / WANG Xiang-wei (Anhui Electric Power Simulation Center, Hefei, Anhui Province, China, Post Code: 230051) // Journal of Engineering for Thermal Energy & Power. — 2001, 16(5). — 549 ~ 551

In the course of the adjustment test of a simulation unit the design defects of the original control scheme of a feedwater automatic control system were analyzed and on this basis an improved scheme was proposed. After a modification of the related design modules and procedures of the simulation unit the regulation quality of the feedwater regulation system has been greatly enhanced. This brought about the realization of a formerly unachievable protection function, which has been verified and confirmed in production practice. It is noted that the simulation unit can be employed not only to conduct on-the-post training but also possesses a highly effective adjustment-test function. **Key words**: simulation, feedwater automatic control, adjustment test, multi-circuit balanced output module

一台余热锅炉受热面积灰和烟气除尘的改进分析＝**An Analysis of the Measures for Alleviation of Ash Buildup on the Heating Surfaces of a Heat Recovery Boiler and the Enhancement of Dust and Smoke Removal Efficiency** [刊, 汉] / HAN Jia-de, LU Yi-ping (Mechanical Engineering Institute under the Harbin University of Science and Technology, Harbin, China, Post Code: 150080) // Journal of Engineering for Thermal Energy & Power. — 2001, 16(5). — 552 ~ 553

During the operation of a heat recovery boiler some problems have arisen, which include excessive ash buildup on heating surfaces, tube deformation and excessive dust and smoke emissions. Following an detailed analysis of these problems a series of methods were proposed for their effective resolution. **Key words**: heat recovery boiler, ash buildup on heating surfaces, dust and smoke abatement

滑参数停炉、停机的试验研究= **Experimental Study of Boiler and Turbine Shutdowns under the Operating Condition of Sliding Parameters** [刊, 汉] / ZHAO Bing (Kailuan Thermal Power Co., Tangshan, Hebei Province, China, Post Code: 063103) // Journal of Engineering for Thermal Energy & Power. — 2001, 16(5). —554 ~557

The boiler and turbine shutdown of a power plant under the operating condition of sliding parameters was conducted for the first time at Kailuan Thermal Power Co. By carrying out this trial the Co. has accumulated the experience of boiler and turbine shutdown under the sliding-parameters condition, which can serve as an effective guide for a plant shutdown under such circumstances. A detailed account is given concerning the necessity for and requisite conditions of such shutdowns as well as the temporary monitoring measures and specific operation procedures required in this regard. An analysis was given of the influence of such shutdowns on a power plant. Some issues demanding special attention are also presented. **Key words**: boiler, steam turbine, plant shutdown under sliding parameters, test

热力设备水冲击的原因分析及防范措施= **An Analysis of the Causes of Thermal Equipment Hydraulic Shocks and Measures Taken for their Prevention** [刊, 汉] / HUANG Sheng-ji (Wuhan Boilogical Products Research Institute, Wuhan, China, Post Code: 430060), ZHOU Ju-hua (Wuhan Electric Power School, Wuhan, China, Post Code: 430079) // Journal of Engineering for Thermal Energy & Power. — 2001, 16(5). —557 ~559

链条炉排的侧密封= **Lateral Seal of a Chain Grate Stoker** [刊, 汉] / WANG Yu (Harbin Hongqi Boiler Works, Harbin, China, Post Code: 150080) // Journal of Engineering for Thermal Energy & Power. — 2001, 16(5). —560 ~561

With commonly used fish-scale type chain grate stoker serving as an example the author cites the importance of lateral seal for a grate stoker. After an enumeration of the existing problems specific to a labyrinth seal the necessity of employing contact and running-in type seals was expounded along with an exploratory study of the lateral seal for a light-type chain grate stoker. **Key words**: labyrinth seal, contact seal, running-in seal

常压热水锅炉供暖系统安装错误事例分析= **An Analysis of the Mistakes Identified During the Installation of the Heat Supply System of a Constant-pressure Hot-water Boiler** [刊, 汉] / HOU Yun-tao (Boiler and Pressure Vessel Inspection Institute under the Harbin Municipal Labor Bureau, Harbin, China, Post Code: 150076) // Journal of Engineering for Thermal Energy & Power. — 2001, 16(5). —562 ~563

锅炉的计算效率与燃料的高低位发热值的关系= **Relationship Between the Calculated Efficiency of a Boiler and the Low and High Calorific Value of Fuel** [刊, 汉] / GAO Fei, YANG Wei-liang (Harbin Boiler Works Co. Ltd., Harbin, China, Post Code: 150046) // Journal of Engineering for Thermal Energy & Power. —2001, 16(5). —564 ~565

The thermal efficiency of a boiler and its various heat losses calculated through the use of low calorific value of fuel were compared with those calculated respectively on the basis of high calorific value of fuel. The relation among various heat losses was established to facilitate mutual conversion. **Key words**: boiler efficiency, calorific value, various heat losses

有效控制汽轮机变工况运行= **Effective Control of Steam Turbine Off-design Operation** [刊, 汉] / WANG Jin-ming (Huaibei City Thermal Power Plant, Huaibei, Anhui Province, China, Post Code: 235029) // Journal of Engineering for Thermal Energy & Power. — 2001, 16(5). —546