# 1021t /h煤粉锅炉高温炉烟管改造方案设计

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[摘要] 通过对某电厂 1021 t /h 煤粉锅炉制粉系统高温炉烟管的技术方案设计,分析了高温炉烟管在运行中产生故障的原因,阐述了方案的设计思想,提出了一种新型的高温炉烟管结构。

关键词　高温炉烟管　故障分析　结构设计

中图法分类号　TK223. 28

## 0　前言

随着电力工业的发展,与 30万千瓦汽轮发电机组配套的 1021 t /h煤粉锅炉在我国许多电厂已大量地投入运行。作为输送干燥剂通道的高温炉烟管是该煤粉锅炉制粉系统中的重要组成部分。其设计结构的合理性和可靠性直接关系到机组运行的平稳和安全。所以,它一直是各电厂和电力设计部门非常关注的问题。

目前在已投入运行的这种类型的锅炉中,多数存在由于高温炉烟管道结构设计不尽合理而造成管道的高温段发生裂纹、断裂和塌落等事故,不计因事故停机不能发电造成的经济损失,每年仅用于烟管的维修费要耗资近 300万元。

## 1　某发电厂 1021 t /h煤粉锅炉高温炉烟管结构及运行故障

1995年 4月我们承担了某发电厂 1021 t /h煤粉锅炉高温炉烟管的技术方案设计。该电厂一期工程装有 4台蒸发量为 1021 t /h的煤粉锅炉,配带 4台单机容量为 30万千瓦的汽轮发电机组。每台锅炉装有 6根直径为 Φ 1640 mm、长约 60 m的高温炉烟管道,吊装在锅炉的构架上。其上部混合室与炉膛烟气口连接;下部分别与相应布置在零米层的 6台 FM 340 - 1060风扇磨煤机相接。

烟管设计结构为单管外保温式,如图 1所示。混合室和烟管采用 ZG3Cr25Ni9Si2和 ZG3Cr25NiSi2铸钢、壁厚 20 mm,分段铸造,每段长 1000 mm。烟管在电厂施工现场焊接

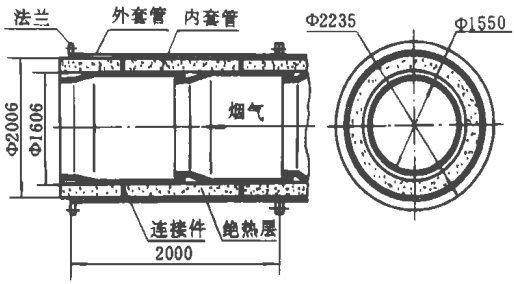


图 1　单管外保温烟管示意图

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组装。

高温炉烟管的工作参数为:

a.混合室烟气进口 (炉膛出口 )烟气温度 1093℃ ;

b.烟气流量 63 900 $m^3$ /h(设计值 );

c.烟气压力 - 1. 2 kPa;

d.预热空气进口 (进入混合室 )空气温度 309℃。

e.预热空气流量 56 100 $m^3$ /h; (设计值 )

f.预热空气压力 2k Pa;

g.烟管落煤口处烟气温度 704℃ ;

h.烟气粉尘含量 57. 2 g /N$m^3$;

i.烟气流速 15. 8 m /s;

j.干燥剂总量 12 000 $m^3$ /h。

电厂自 1号机组投入运行后 ,在半年多的时间内 ,发现该锅炉制粉系统的高温炉烟管在高温段 (标高 32 m至 55 m)的管段多处管壁裂纹和环焊缝开裂;吊架与管壁焊缝开焊 ,致使部分吊耳脱落。混合室裂纹尤为严重 ,裂纹长达 550 mm,局部铸钢板已脱落。混合室下沉 250 mm。烟管随时有塌落的危险。造成机组多次停机 ,不能正常连续运行。

经现场考查和分析认为 ,烟管长期处在近 800℃高温下工作 ,混合室和高温段烟管的工作环境是极为恶劣的。烟管采用分段铸造现场焊接的单管外保温形式 ,在热态下由于热膨胀变形和热应力的作用必然导致管壁裂纹和断裂事故的发生。其原因是: 所用材料为仿美牌号 ,其性能未达到相应标准;直径和壁厚为Φ 1640× 20的铸钢体的铸造工艺达不到质量要求 ,壁厚不均 ,最薄处仅有 12 mm,并存在大量裂纹、沙眼和夹渣等缺陷 ,且铸体高空分段焊接工艺不能保证焊缝质量;吊耳和支座直接焊在烟管外壁 ,因其既是高温烟气通道 ,又是承力管。重力和热应力作用将导致管壁产生裂纹。

## 3　套管式内保温高温炉烟管的设计思想及结构设计

综上分析 ,高温炉烟管采用分段铸造现场焊接的单管外保温结构 ,在热应力的作用下存在很多弊端。这在国内许多电厂的运行中已经得到证实。

工程实践证明 ,改善锅炉高温炉烟管的工作条件 ,使其在近 800℃高温下长期稳定地工作 ,比较有效的办法是在烟管的内壁涂装耐火水泥、“耐火可”等耐火材料 ,降低管壁的工作温度 ,以提高管壁的机械性能。但是这种办法不但造价高 ,施工难度大 ,且高温气流的冲刷和材料线胀系数的不同 ,易产生龟裂和脱落影响使用寿命。另外 ,这种办法将使烟管的重量成倍增加 ,危及锅炉构架的安全 ,这是本改造项目所不允许的。

针对上述故障和对故障产生原因的分析 ,这里提出了一种新的高温炉烟管的结构设计 ,即套管式内保温高温炉烟管。

本套管式内保温高温炉烟管结构设计的指导思想是 ,在保持与原设计烟管的重量和结构尺寸相当的条件下 ,即不影响锅炉构架的承载能力和利用现有安装空间的条件下 ,使内套管的热应力自身释放 ,降低外套管 (承力管 )的壁温;改善支、吊架管部支座和吊耳的工作环境 ,使烟管在高温下能长期稳定地工作。

该结构型式如图 2所示。

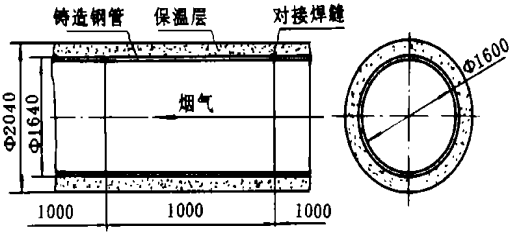


图 2　套管式内保温烟管示意图

烟管由外套管、内套管和绝热材料组合而成。外套管由低碳钢钢板焊接而成;内套管由国产耐 1200℃耐热合金薄钢板制成。两者之间填充 200 mm厚的耐 1260℃的轻质绝热材料。内外套管由特制的联接件连接,组成 2 m长的标准管段组合件。组合件外套管的两端设连接法兰。

为使内套管在工作状态下自由伸长,内套管设计成为分段结构。各段间采用顺烟气流动方向相互搭接的型式,使其在整个管段上沿轴向自由膨胀。

内外套管连接件沿烟管各截面周向布置,具有使内套管热态下沿径向自由膨胀的功能。

当烟管内介质温度为 800℃时,经计算表明,可使外套管壁温小于 100℃。这将明显改善支、吊架管部零件焊缝的应力状态。

由于本套管式内保温高温炉烟管为分段法兰连接,给现场安装带来很大方便,既缩短了安装时间又克服了原烟管现场焊接造成的质量问题。

## 4 结束语

(1)由热应力的基本概念可知:高温炉烟管作为典型的高温部件,在结构设计中我们对其在热态下产生热应力的状况进行分析、计算,消除外力对变形的约束是必要的,同时,解决管件本体内部各区域之间变形的约束对管件的高温强度和使用寿命的影响则更为重要。

(2)1995年 8月 4日及 1995年 8月 16日至 8月 18日分别在双辽电厂和哈尔滨召开了高温炉烟管改造方案和扩初设计审查会,与会有关专家和主管领导一致认为本技改方案设计在技术可能性和经济可行性方面都是可行的。技术设计指导思想正确,采用套管式内保温结构能有效地消除内套管热应力,降低主承力管(外套管)的壁温,改善了吊耳工作环境,其结构合理,可行性好。

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(辉 编)

## 核电工程 泰山核电站将开展第三阶段工程

据"Modern Power Systems"1997年 2月号报道,中国的国家开发银行与加拿大出口开发公司和美国进、出口银行签订了 18亿 4千万美元的贷款协议,以便为在浙江省建造核电站提供资金。

这些钱用于泰山核电站第三阶段的整套承包建设。该 27亿美元的工程项目包括由加拿大原子能公司制造的两个 700 MW Candu型反应堆(加拿大重水铀反应堆)。工程的子承包者是 Bechtel公司和 Itochu公司。

(思娟 供稿)

zhang (Central China University of Science & Techonlogy)// Journal of Engineering for Thermal Energy & Power. 01998, 13(1). – 19~ 22

Through a simple "input-output" relationship the ascertainment of pulverized coal flow flame stability is attempted. With the selected "input" parameter serving as the initial condition of a primary air operating regime the ascertainment criteria are made forthright and rational. A heat balance model based on the use of a return flow zone lumped parameter method has been established in order to solve for the primary air pulverized coal concentration, air speed and air temperature essential for the assurance of flame stability. The reliability of the model is verified by employing the hot-state experimental results of a single angle pulverized coal boiler. **Key words**: flame stability, ascertainment criteria, model of lumped parameter method

几种常见锅炉事故的机理分析= (**An Analysis of the Underlying Causes for Several Kinds of Common Boiler Failures**) [刊,中]/Kuang Pingjian, Wu Qingyu, Gao Yukuan(Boiler & Pressure Vessel Inspection under the Harbin Municipal Labor Bureau) // Journal of Engieering for Thermal Energy & Power. – 1998, 13(1). – 28~ 13

电站锅炉炉膛传热数值计算方法的研究= (**The Study of Furnace Heat Transfer Numerical Calculation Methods for Utility Boilers**) [刊,中]/Han Xiaohai, Zhang Mingchuan (Thermotechnical Institute under the Ministry of Electrical Power)// Journal of Engineering for Thermal Energy & Power, 1997, 12(6). – 23~ 27

The present paper deals with a reactor network comprehensive model for the engineering use-orented three-dimensional heat transfer numerical calculation of utility boiler furnaces. Prepared are three-dimensional comprehensive combustion-heat transfer process computational programs for pulverized-coal furnaces. Through the calculation of several different design and operating conditions the basic functions of the model are displayed and verified with some meaningful conclusions being obtained. **Key words**: furnace heat transfer, mathematical model, pulverized coal combustion, reactor network

大型中温热管性能的试验研究= (**Experimental Study of the Performance of Large-sized Medium-temperature Heat Pipes**) [刊,中]/Yao Shouguang, Peng Dongsheng, Zhu Deshu (East China Shipbuilding Institute), Zhang Jianxun, Zhang Shuzhao, Mei Guozhong (Heat Pipe Research Institute of Jiangsu Xin Yuan Group Co.)// Journal of Engineering for Thermal Energy & Power, 1997, 12(6). – 32~ 36

Performance tests have been carried out with respect to some large-sized medium-temperature heat pipes filled with two kinds of new working mediums. On the basis of an analysis of the test data compared are the start-up and heat transfer characteristics of these two types of heat pipes. It has been found that in the medium-temperature range of 250~ 400℃ there exists a marked difference in heat transfer performance between the heat pipes filled with these two different types of working mediums.

**Key Words**: medium- temperature, heat pipe, performance

某大型综合补给船的自动电站系统= (**The Automated Power Station System of a Large-sized Comprehensive Replenishment Ship**) [刊,中]/Zheng Ziqian, Li Qiao (Harbin No. 703 Research Institute)// Journal of Engineering for Thermal Energy & Power. – 1998, 13(1). – 37~ 39

This paper deals with the basic configuration and functions of an automated power station system for a large – sizd comprehensive replenishment ship. Key words: automated power station, replenishment ship

1021 t/h煤粉锅炉高温炉管改造方案设计= (**Modification Design of High- temperature Boiler Flue Gas Tubes for a 1021 t/h Pulverized Coal- fired Boiler**) [刊,中]/Xing Changwen(Harbin No. 703 Research Institute)// Journal of Engineering for Thermal Energy & Power. – 1998, 13(1). – 40~ 42

Based on the technical scheme design of high-temperature flue gas tubes of a 1021 t/h pulverized coal- fired utility boiler the author gives an analysis of the causes of the cited boiler tube failures during boiler operation,

discusses the design philosophy of the modification scheme and proposes a new type of high-temperature boiler flue gas tube construction. **Key words**: high-temperature boiler flue gas tube, failure analysis, structural design

模糊自组织神经网络在汽轮机转子故障诊断中的应用=(**Application of Fuzzy Self-organizing Neural Networks in a Steam Turbine Rotor Fault Diagnosis**) [刊,中]/Wang Jian, Jiang Dongxiang, Ni Weidou (Qinghua University)// Journal of Engineering for Thermal Energy & Power. - 1998, 13(1). - 43~45

In the light of the problems involved in a steam turbine rotor fault diagnosis proposed in this paper is a new diagnostic method based on a fuzzy self-organizing neural network. The proposed method features a simple structural algorithm, supervision-free self-study and lateral thought association, etc. This highly effective method for turbine rotor failure classification has been verified in the course of its practical use. **Key words**: steamt urbine totor, failure diagnosis, fuzzy mathematics, neural network

能源及化工过程中的事故仿真=(**Failure Simulation in Energy Sources and Chemical Engineering Processes**) [刊,中]/Xiao Lichuan, Xue Guoxin (Jiangsu Petrochemical Institute)// Journal of Engineering for Thermal Energy & Power. - 1998, 13(1). - 46~48

After a discussion of the universal method for failure setting in energy sources and chemical engineering processes the authors come up with a transitional general function for the interface of failure status and normal operating condition. A generally applicable form of failure occurrence and an exit from ascertainment criteria are also given. Furthermore, other details concerning the failure entering form and its succession have been taken into account. **Key words**: failure, simulation, transitional general function, failure ascertainment, failure succession

炉内冷态流场数值模拟算法讨论及验证=(**A Discussion and Verification of the Numerical Simulation of a Cold- state Flow Field in a Boiler**) [刊,中]/Sun Ping, Fan Jianren, Cen Kefa (Zhejiang University), Xie Hailong (Northeast Electrical Power Institute)// Journal of Engineering for Thermal Energy & Power. - 1998, 13(1) - 49~52

Studied in this paper are some convergence promotion methods for the simulation of flow fields in a boiler furnace by the use of a Simpler method and the specific features of Quicke scheme. Heating surfaces in the furnace are treated through the use of multi-hole rate in conjunction with resistance distribution. The calculated results agree well with experimental ones. **Key words**: simulation of flow field, Quicke scheme, multi-hole rate

旋转机械振动故障的模糊诊断=(**Fuzzy Diagnosis of Rotating Machinery Vibration Faults**) [刊,中]/Ruan Yue, Xu Shichang (Harbin Institute of Technology)// Journal of Engineering for Thermal Energy & Power. 01998, 13(1). - 53~56

After making an analysis of the existing difficulties in the failure analysis of rotating machinery vibration failures this papr presents a mathematical model for conducting failure mechanism study and failure diagnosis. On the basis of symptoms asserting a positive and negative trend of the vibration failures proposed is a fuzzy recognition matrix of fault diagnosis with the realization of a complex failure diagnosis. **Key words**: vibration failure, fuzzy diagnosis, mathematical model, rotating machinery

自然循环蒸发系统运行特性分析模型=(**A Model for Analysing the Operating Characteristics of a Natural Circulation Boiling System**) [刊中]/Wang Guangjun, Li Hongyuan (Northeast Electrical Power Engineering Institute)// Journal of Engineering for Thermal Energy & Power- 1998, 13(1). - 57~60

Proceeding from a basic physical equation a distribution parameter model of natural circulation boiling system was established and a numerical calculation method based on a fluid microelement tracing philosophy also proposed. By using this model it is possible to not only conduct the static-state calculation of the boiling system