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燃气脉冲在线吹灰装置及其控制系统的研制与应用

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摘　要: 针对火力发电厂回转式空预器积灰腐蚀严重, 流动阻力大和排烟温度高等问题, 研制开发了燃气脉冲在线吹灰系统, 采用爆炸气体作为吹灰气源, 并配套开发了计算机监控系统。实际应用表明, 本装置能实现安全可靠连续的在线吹灰, 可使烟阻下降 100～400 Pa, 排烟温度下降 5 ℃～10 ℃, 具有显著的经济效益和推广应用价值。

关　键　词: 燃气脉冲; 空气预热器; 吹灰; 计算机监控

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1　前言

回转式空预器具有换热效率高、结构紧凑、运行可靠等优点。广泛应用于火力发电厂, 但目前普遍存在积灰、腐蚀严重, 流动阻力大和排烟温度高等问题, 严重影响电厂锅炉安全与经济运行。近年来出现了不少新型吹灰器, 如蒸汽吹灰器、声波吹灰器、压缩空气吹灰器等, 但对回转式空预器效果均不理想, 并且结构复杂, 可靠性低, 使用维护不便, 难以满足现代大型锅炉较高的在线吹灰要求。据统计, 全国火电厂近 20%锅炉因空预器积灰严重而不能正常运行。因此, 开发安全、可靠、高效的在线吹灰系统是目前火电厂面临的迫切问题。针对上述情况, 采用可燃性气体爆炸所产生的强大冲击波对回转式空预器进行在线吹灰, 并采用工业控制计算机进行吹灰过程的自动监测监控, 较好地解决了空预器积灰和腐蚀等技术难题。

2　吹灰原理、装置流程

回转式空预器通过旋转波纹板的吸放热来加热冷空气, 为了加大换热面积, 波纹板一般布置较密, 由于尾部烟气中含有大量灰尘, 并且空预器低温段烟速较低, 在低温段波纹板上极易发生积灰和腐蚀, 若不及时消除, 积灰与烟气中的 SO_2、水蒸气共同作用会生成较硬的灰垢结在波纹板上, 使烟阻剧增, 排烟温度升高, 并极易产生低温腐蚀, 严重影响空预器换热效果和运行安全。由于积灰与波纹板结合较密, 并且大型锅炉空预器换热面积很大, 采用蒸汽、声波、压缩空气等吹灰均收效不大。燃气脉冲采用可燃性气体爆炸时产生的巨大冲击波作为吹灰气源, 冲击波直接作用于积灰上。通过爆轰、振动、气流冲击和声能热能的共同作用, 对松散积灰和致密灰垢均有较好的清除效果。

燃气脉冲吹灰装置流程如图 1 所示。

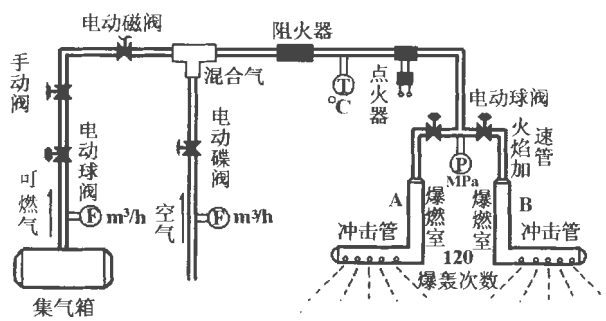

图 1　燃气脉冲吹灰装置流程图

如图 1 所示, 可燃性气体(乙炔, 甲烷, 天然气, 石油气等)由集气箱或贮气罐中导出, 通过减压阀、调节阀、电磁阀在混合段管道内与空气充分混合, 通过调节燃气浓度(5%～15%)使之达到爆炸范围, 点火器点火后, 产生的电火花引爆混合气, 爆炸产生的高温烟气经火焰加速管进入爆炸室进一步爆炸, 产

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生强大的爆炸冲击波(实际上点火、爆炸、加速和爆炸室内爆炸几乎在同一瞬间完成),冲击波经过安装在空预器下部向上开口的冲击管,轰击与之对应的波纹板。由于爆轰力极强(压力可达 0.98 ~ 2.94 MPa),波纹板上的积灰很容易被击落下来,然后被烟气带走。由于空预器不停地旋转,每处波纹板都有机会被冲击管轰击,因此可实现连续、均匀的吹灰。为防止回火和连续爆炸,在点火器之前安装了阻火器(通过调节点火时间、点火间隔和燃气温度来防止回火)。本吹灰器的技术难点在于确定脉冲强度,爆炸室爆炸强度及防止回火。

3 控制系统的研究

3.1 系统结构

由于吹灰系统安装在锅炉现场,灰尘多,振动大,温度高,干扰强,工作环境非常恶劣,采用人工控制劳动强度很大,必须设计高可靠性的自动控制系统,并且具备手动/自动,就地/远动等功能,鉴于上述要求,配套开发了多媒体网络监控系统。主机选用研华 586 工业控制计算机,前端机采用可长期在恶劣环境下工作的 ADAM4000 系列智能型远端数据采集及控制模块。主机与前端机通过转换器和中继器组成 RS—485CAN 网络监控系统。软件开发平台为 Geneie 3.0 工控组态软件开发系统。监控系统软、硬件均采用模块化组态结构,具有结构简单,可靠性高,抗干扰能力强等优点,尤其适于火力电厂现场恶劣的工作环境。系统结构如图 2 所示。

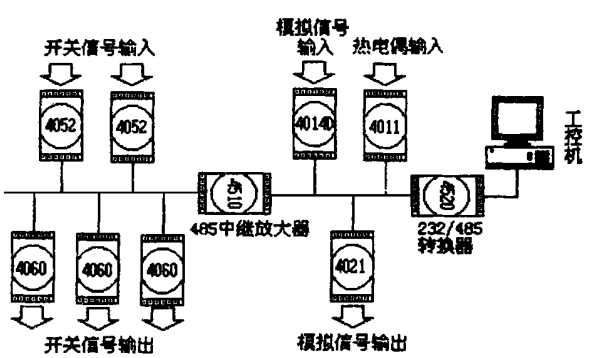

图 2 监控系统构图

图中模块功能如下:

232/485 转换器——联接标准 PC 机与 CAN 网络;

485 中继放大器——网络扩展及远距离通讯;

4052 开关量输入模块;

4060 开关量输出模块;

4011 热电偶输入模块;

4014D 模拟量输入模块;

4021 模拟量输出模块。

网络采用双绞线联接。

3.2 系统功能

本系统可完成的功能为:数据实时采集,存储,打印,CRT 显示台(包括动画显示、监控系统、曲线绘制和动态数据监视),CRT 操作台,语音报警及操作指导,故障处理与恢复回火保护,越限保护,在线设定,事故追忆,趋势预报,吹灰程控及手/自动无扰切换等多种功能。可由计算机完成从调试、启动、点火、吹灰、故障处理及停止吹灰等所有工作,正常吹灰时可做到无人值守和全部程控。

4 经济效益分析

本吹灰装置及监控系统开发成功后,已先后应用于宁波北仑电厂(2× 600 MW),四川江油电厂(4×300 MW),华能南京电厂(2× 300 MW)和陕西渭河电厂(4× 300 MW)。应用结果表明,本装置可实现安全可靠、有效的在线吹灰功能,可使烟阻下降 100 ~400 Pa,排烟温度下降 5 ℃~10 ℃,受热面清洁率大于 95%。一般排烟温度降低 10 ℃,锅炉效率可提高 1%。仅以宁波北仑电厂一台炉为例,年烧标准煤近 150 万吨,吹灰系统投运后,年节煤达 1.5 万吨,折合人民币 300 万元,整套装置与监控系统投资需 35 万元,燃气费用每天 200 元,全年共需 7 万元,这样不但当年收回全部投资,而且节省开支 300—(35+7)= 258 万元。另外,采用燃气脉冲吹灰系统后,不但降低了烟阻与排烟温度,而且从根本上消除了空预器的积灰和腐蚀,确保机组安全与经济运行,因此具有巨大的经济效益和应用推广价值。

参考文献

〔1〕 范从振. 锅炉原理. 北京:水利电力出版社,1986.7.

(复 编)

tion. This makes it possible to analyze the effect on gear mesh of such factors as gear box deformation, axial end loading and axial deflection, etc. A proper no-load gear mesh error may be generated to compensate gear mesh error under operating conditions. It is also feasible to verify gear strength on the basis of gear contact conditions. Under the precondition of an absence of increase in gear mesh error a rational support parallelism can be set. **Key words**: cylindrical gear, gear mesh error, strength

废气复合透平系统的热技术经济学分析和设计优化=**Thermotechnical Economics Analysis and Design of a Waste Gas Turbo Compound System**〔刊, 中〕/Tang Lichun (Southern China University of Science &Technology), Pan Jiayan (Guangzhou Municipal Energy Source Planning Design Institute)//Journal of Engineering for Thermal Energy &Power, 2000, 15(1). —28~30

By combining thermotechnical economics theory with BOX nonlinear constraint (compound type) optimization method a thermotechnico-economics analytical study and an optimized design calculation were conducted of a heavy-duty diesel waste gas turbo-compound system (TCS). The method discussed can provide some useful reference data during the scheme design of a power station at the feasibility study stage. **Key words**: waste gas turbo-compound system, thermotechnical economics, optimized design

某舰用冷凝器凝结水含氧量的测试=**Test of Oxygen Content in the Condensate of a Naval Condenser**〔刊, 中〕/Xu Yan, Meng Fanzheng, Yin Yuxiang, (Harbin No. 703 Research Institute), et al //Journal of Engineering for Thermal Energy &Power, 2000, 15(1). —31~32, 35

With the help of a novel device for measuring the oxygen content in water a dynamic detection was performed of the oxygen content of condensate at the outlet of a naval condenser working under various operating conditions. The resulting determination of the thermodynamic characteristics of the condenser can provide a requisite basis for its modification design later on. **Key words**: condensate, oxygen content, evaluation test

锅炉有缝电阻焊管制造工艺=**Manufacturing Technology for Boiler Tube Seamed Resistance Welding**〔刊, 中〕/Liu Shuzhen, Zhu Hong, Cheng Wanbe (Harbin Boiler Co. Ltd.), et al //Journal of Engineering for Thermal Energy &Power, 2000, 15(1). —33~35

LM5000STIG120 机组余热发电工程电气设计=**Electrical Design of the Waste Heat Power Generation Project of a LM5000 STIG Unit**〔刊, 中〕/Sun Shifeng, Hu Guoju, Zhang Qingjiang (Harbin No. 703 Research Institute), et al //Journal of Engineering for Thermal Energy &Power, 2000, 15(1). —36~38

A description is given of the main electrical connection design of a LM5000 STIG 120 unit for Shenzhen Yueliangwan Gas Turbine Power Plant. In addition, the plant auxiliary power supply of the Plant is also briefly discussed. **Key words**: short-circuit current, circuit breaker, reactor, dynamic stabilization, thermal stabilization

燃气脉冲在线吹灰装置及其控制系统的研制与应用=**Development and Application of a Pulsed Gas-based On-line Soot-blowing Device and Its Control System**〔刊, 中〕/Li Zhonghua (Shanghai Jiaotong University), Han Tongtai, Liu Jianjun (China National Mine Engineering University)//Journal of Engineering for Thermal Energy &Power, 2000, 15(1). —39~40

The use of rotary air heaters in thermal power plants generally gives rise to soot deposits-related serious corrosion, flue gas high flow-resistance and excessively high exhaust gas temperatures. To cope with the above-cited problems, the authors have developed a pulsed gas-based on-line soot-blower system, using explosive gas to serve as a soot-blowing gas source. In addition, a computer-based monitoring system has also been developed in connection with the soot-blowing unit. Practical use experience shows that the soot blower unit under discussion has the capability to conduct a safe, reliable and

continuous on-line soot blowing. It can reduce the flue gas resistance by 100 - 400 Pa and lower the exhaust gas temperature by 5 ~ 10 ℃. In addition to achieving significant economic benefits, the above unit enjoys a high potential for wide engineering applications. **Key words**: soot blowing, pulsed gas, air heater, computer-based monitoring

船用主锅炉的改进设计＝**Marine Main Boiler Improved Design**〔刊, 中〕/Chen Qinglong (Harbin No. 703 Research Institute) // Journal of Engineering for Thermal Energy &Power, 2000, 15(1). —41 ~ 42

A brief description is given of the marine main boilers currently manufactured in the People's Republic of China. Based on the analysis of some difficult issues involved in an improved design the author has proposed a new design scheme for academic discussion. **Key words**: marine main boiler, improved design, scheme

在不同工况下 300 MW 锅炉过热器, 再热器的特性试验研究＝**Experimental Study of the Boiler Superheater and Reheater Characteristics of a 300 MW Unit under Various Operating Conditions**〔刊, 中〕/Xin Zhiming, Wu Luchen, Liu Hengyu (Harbin Boiler Co. Ltd.), et al // Journal of Engineering for Thermal Energy &Power, 2000, 15(1). —43 ~ 46

Through the tests of a boiler under steady and dynamic operating conditions a comprehensive analysis is conducted of the wall temperature profiles of a superheater and reheater at various operating conditions. The suggestions given in the present paper can be helpful for solving overheating problems of the superheater and reheater. **Key words**: superheater, reheater, wall temperature characteristics

近流线数值计算方法在四角切圆燃烧炉膛中的应用＝**Application of Quasi-streamline Numerical Simulation Method for a Boiler Furnace with Tangential Firing**〔刊, 中〕/Zhang Ze, Wu Shaohua, Qin Yukun (Harbin Institute of Technology) // Journal of Engineering for Thermal Energy &Power, 2000, 15(1). —47 ~ 49

A numerical simulation method incorporating a composite coordinates grid system, strong non-uniform staggered grid arrangement and a staggered calculation mode was described in this paper. This method has been employed for the first time to perform a detailed computation of the three-dimensional flow field characteristics of a large-sized boiler furnace. The latter features a tangential firing mode with the use of burner nozzles of a sophisticated construction. Because of this, the false diffusion problem in the calculation domain caused by a relatively large included angle between a resultant speed direction and grid line one has been solved relatively well. Furthermore, a comparison with industrial test results shows that the numerical simulation method can quite accurately reflect the flow field characteristics in a boiler furnace combustion zone. A quasi-streamline numerical simulation is thus effectively realized. **Key words**: numerical simulation, false diffusion, quasi-streamline method, tangential firing

链条炉排的分区模型＝**Zoned Model for a Chain Grate**〔刊, 中〕/Zhu Jinrong (Nanjing Electrical Power Institute) // Journal of Engineering for Thermal Energy &Power, 2000, 15(1). —50 ~ 51

After the establishment of a mathematical zoned model for a chain grate some turbulence simulation tests were conducted. The test results were in full agreement with theoretical ones. The model can reflect the effect of air distribution on combustion results. **Key words**: boiler, chain grate, air distribution on a zone-by-zone basis, mathematical model

空冷塔内外流场的数值分析＝**Numerical Analysis of the Inner and Outer Flow Field of an Air-cooling Tower**〔刊, 中〕/Zhang Xiaodong, Zheng Yonggang, Wang Qingzhao (North China Electrical Power University) // Journal of Engineering for Thermal Energy &Power, 2000, 15(1). —52 ~ 54

With the use of a numerical simulation method the performance of a natural draft air-cooling tower working in a cross-wind has been investigated. By consulting the Heller type air-cooling system employed at Fengzhen Power Plant in Inner Mongolia an analysis was conducted of a specific calculation example. The analytical calculation results bring forth a perfor-