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锅炉多管除尘器改进

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摘　要: 介绍了高效多管除尘器在环保方面的意义和冬季采暖 1～75 t 锅炉运行中所起的作用, 论叙除尘器的改造情况, 以及除尘效果比较。

关　键　词: 多管除尘器; 旋风子; 沿程阻力; 负压作用

中图分类号: TK229. 6　　文献标识码: B

1　前　言

烟囱冒黑烟现象的发生对大气环境污染已成为日益突出问题。例如一个 4 t 锅炉烟气排放量按每小时 1. 6 万 m^3 计算, 那么全市按 200 个锅炉房计算, 每天燃烧 4 h 则废气排放为 128 万 m^3, 若除尘不好, 严重危害人们的生存环境。究其原因是锅炉除尘不够彻底, 除尘效率不高所致, 因此有必要研究燃煤锅炉除尘问题。

2　多管除尘器原理剖析

燃煤锅炉中常用除尘效果较好的除尘器是多管除尘器, 多管除尘器又分为陶瓷型和铸铁型两种。这里只就铸铁多管除尘器加以研究。多管除尘器取代原来牛角式旋风除尘器, 但从原理上而言, 仍是一种旋风除尘器, 它是利用离心力分离烟尘, 将含有烟尘的气体在负压作用下吸入旋风子中, 然后呈高速螺旋运动烟尘在离心力作用下, 被甩向筒壁, 并在其自重作用下沿筒壁滑落灰斗中, 由落灰阀排出完成烟尘与气体分离。从下列公式可看出: $F = mv^2/r$ (式中 F － 离心力, m － 烟尘质量, v － 烟尘在旋风子中运动的线速度, r － 旋风子回转半径), 当流速 v 一定时, 离心力 F 与筒壁内半径 r 成反比关系, 即 r 越小, F 越大, 除尘效率越高。实验证明当 $2r = 210$ mm 左右效果最佳。

3　旋风子本身结构改进

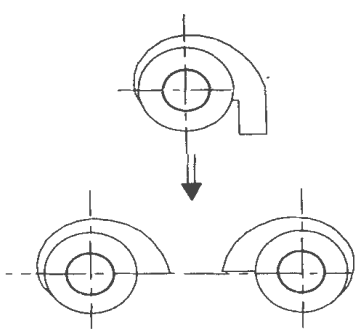

图 1

根据多年锅炉运行情况, 逐步摸索将除尘器中旋风子结构作如下改进。

(1) 从单一旋风子结构改成左右两种对称结构形式。这样结构与原来相比, 结构更加紧凑, 降低进风阻力, 提高负压作用(见图 1)。

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对低温级过热器未起保护作用是引起爆管的重要原因, 管材选用、蒸汽流程结构布置和燃料由油改变为高炉煤气使炉膛出口烟温升高对爆管产生的影响也是不可忽视的。根据这些原因提出了解决爆管的措施, 如减少低温级过热器受热面积, 提高临界喷水减温负荷, 以此减少其中蒸汽的温升; 爆管局部管段可选用耐温等级较高的材料; 炉膛出口宽度减小, 用延长的水冷壁隔墙遮挡来自炉膛的高温烟气对爆管部位直接冲刷。这些措施基本可根除爆管事故的再次发生, 具体采用哪些措施可根据实际要求确定。

参考文献:

[1]　郑昌浩. 电站锅炉对流过热器和再热器壁温数值计算方法的研究[J]. 动力工程, 2000, **20**(4): 730－734.

[2]　袁益超. 大容量电站锅炉汽温问题及过热器与再热器超温爆管原因的分析[J]. 动力工程, 1994, **14**(6): 21－28.

(何静芳　编辑)

(2) 将旋风子吸入端直线段部分去掉, 这样可以大大节约布置空间。原来旋风子进口只能有一个方向, 通过去掉直线段后, 旋风子可以根据距除尘器进风口远近而摆放任何角度, 使各旋风子产生均衡负压, 提高除尘效率, 但特别注意旋风子进口千万不能背朝除尘器进风口, 否则不但无法除灰尘, 还会增大沿程阻力损失, 影响锅炉引风机效率, 锅炉产生正压运行, 烟囱冒黑烟污染人们生活环境等一系列严重后果。

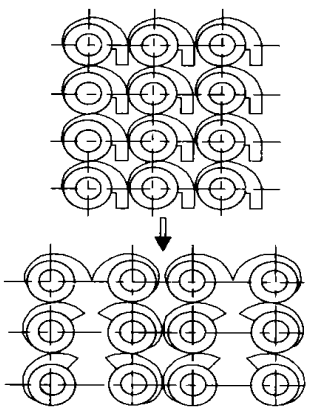

图 2

(3) 将旋风子与风管法兰式连接变成嵌入式结构, 以减少漏风量, 防止旋风子短路。在改造前我厂采用石棉绳缠绕形式密封旋风子与风管螺栓联连处。实践证明, 这样运行一段时间后, 由于烟尘的冲刷, 温度作用, 使石棉绳老化、失效, 并且被抽走, 风管与旋风子之间由于无石棉绳而产生一定缝隙, 原先缠绕越多, 缝隙越大, 一般皆在 5 ~ 12 mm 之间。烟尘在进入除尘器进风口后一部分从旋风子进口进入, 另一部分从缝隙中进入, 降低烟尘甩向筒壁的离心力作用, 烟尘中颗粒在负压状态下吸入风管进入锅炉引风机, 由引风机作用排入烟囱, 再由烟囱进入大气污染环境产生锅炉冒黑烟现象, 后果严重。经改进后, 效果显著, 消除了上述现象(见图 2)。

(4) 将旋风子下部法兰去掉, 不再让旋风子与下部钢板螺栓连接, 改成轴孔卡死结构, 以防止漏气短路, 保证旋风子垂直度。这样做的目的有两个: (a)可以避免由于旋风子下部法兰外表不加工, 直接铸出而产生毛面凹凸不平, 石棉绳缠绕不均造成旋风子歪斜现象, 使风管与出风口内钢板孔"错位"无法安装, 必须采用外加方法兰, 扩孔方法才能装配上的补救方法; (b)采用耐火水泥、添加剂(骨料)混合+水制成浆料, 灌注在下部钢板表面上, 封死所有漏气部位, 层厚度宜在内 40 ~ 70 mm 左右, 这样可大大提高除尘效率。

4 旋风子合理布置及结构方式改进

(1) 将旋风子一种角度改成 45°、60°、90°三种角度布置, 可以使烟尘进入除尘器进口, 均匀分布到各个旋风子中, 防止因压力不均产生扰流现象(见图 3)。

(2) 将旋风子平面布置改成立体分层布置, 充分利用旋风子进口吸入作用, 增加吸入量, 减少不必要阻力损失, 提高风量。

(3) 将左右旋风子背对背对称布置(见图 3)。

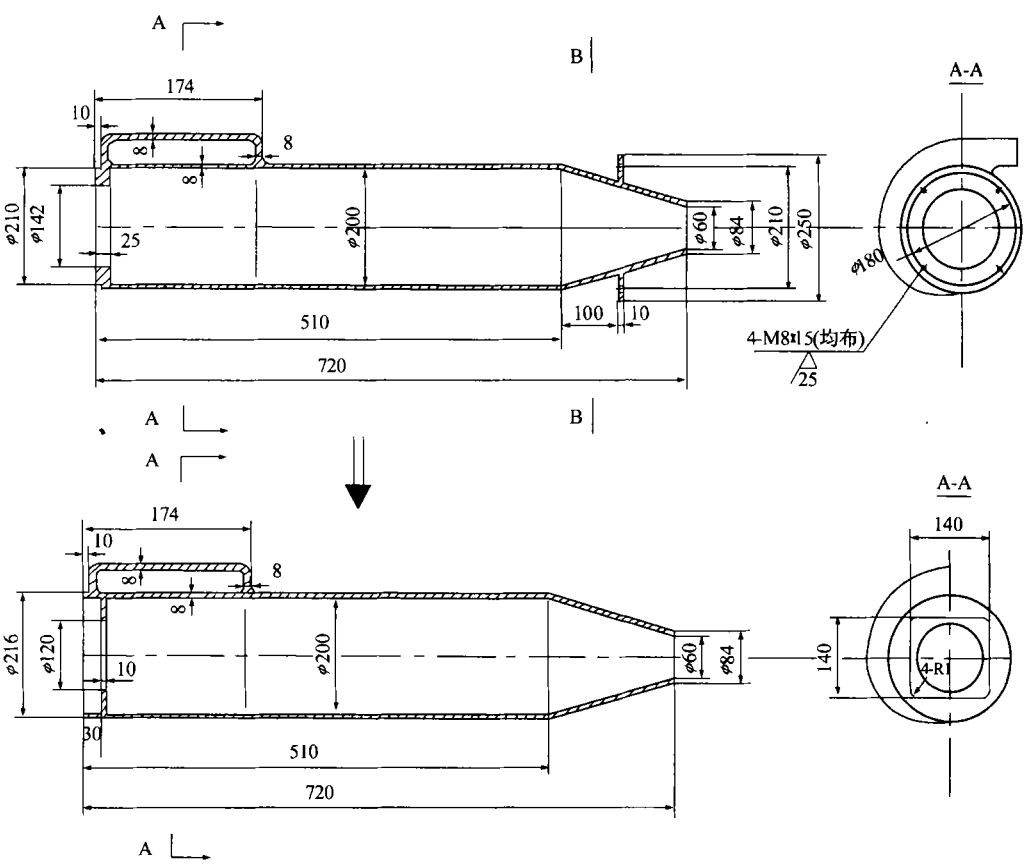

图 3

（4）采用灰斗部位加装隔板方法来减少各旋风子之间因压力差不均而产生串流干扰。

（5）风管直径与旋风子内径保持最佳比值 1∶2。两者比值大与小非常重要，若比例过大，风管直径过小，旋风子内径过大，会使 r 增大，离心力 F 下降，降低除尘器效率；若比例过小，风管直径与旋风子内径接近，则阻力太大，烟尘无法通过，或者通过阻力太大，也会降低除尘量，影响到锅炉引风机出力，干扰锅炉正常运行。

（6）将落灰阀由原来的搬手压盖式改成插板式结构，便于放灰运输控制。原来用搬手压盖式结构，停炉放灰时，打开阀后，灰须放完才能关闭；插板式结构可自由打开关闭阀门，操作方便简单。

5　改进后旋风子性能参数

表 1　DLX 系列高效多管除尘器性能

除尘器型号	锅炉容量 /t·h^{-1}	处理烟气量 /m^3·h^{-1}	阻力损失 /kPa	除尘效率 /%	重量 /t
DLX－2	2	6 000～6 300	0.7～0.9	93～95	2.2
DLX－4	4	12 000～12 700	0.7～0.9	93～95	3.6
DLX－6	6	18 000～19 080	0.7～0.9	93～95	6.2
DLX－10	10	30 000～31 000	0.7～0.9	93～95	8.2
DLX－20	20	54 000～58 000	0.7～0.9	93～95	16.5
DLX－35	35	96 000～105 000	0.7～0.9	93～95	26
DLX－40	40	110 000～120 000	0.7～0.9	93～95	32
DLX－75	75	225 000～236 000	0.7～0.9	93～95	55

6　结论

该除尘器旋风子设计方案，经过改造后的实践，各项性能指标，除尘效率达 94%以上，该除尘器的锅炉烟尘排放浓度、烟气黑度、二氧化硫排放浓度符合（GWPB3－1999）国家《锅炉大气污染排放标准》排放标准。例如一汽重型车厂用户所购 4 吨锅炉除尘器经当地环保监测中心站测试完全达到国家标准要求。依据 GB5468－91《锅炉烟尘测试方法》和 GB/T16157－1996《固定污染源排汽中颗粒物测定与气态污染物采样方法》要求，测试结果为：当该锅炉（除尘器）运行出力达额定值的 98%的测试结果如下：

锅炉出力：4.12 MW；

烟气黑度：＜1 级，符合环保要求；

锅炉出口烟气浓度：2 030.73 mg/m^3；

除尘器出口烟尘浓度：78.33 mg/m^3，＜80～250 mg/m^3（其中 80 mg/m^3 的为一类地区；250 mg/m^3 的为三类地区[3]）；

除尘器阻力：2 081.7 Pa，符合设计要求；

除尘器处理烟气量：1 581.31 m^3/h；

除尘效率：96.11%，符合设计要求；

脱硫效率：31.73%，符合环保要求，低于最高允许排放浓度 900～1 200 mg/m^3。

参考文献：

[1]　GWPB 3－1999，锅炉大气污染物排放标准[S].

[2]　李庆宜. 通风机[M]. 北京：机械工业出版社，1981.

[3]　张宝康. 工业锅炉实用手册[M]. 南京：江苏科学技术出版社，1991.

（何静芳　编辑）

新技术

1500 MW IGCC 合资企业

据《Gas Turbine World》2001 年 5～6 月号报道，美国田纳西河电力管理局正计划与 Texaco（德士古）石油公司联合建立一个有关 1 500 MW 煤气化电站项目的合资企业，该项目将建在已撤消核电站场址。

该 IGCC（整体煤气化联合循环）装置围绕 Texaco 气化技术设计，环境影响研究现正在进行，并将在 2001 年末完成。

按照工业项目工程师的说法，这一规模的 IGCC 电站将需要 100 人来营运。

（思娟　供稿）

煤燃烧过程中汞释放的研究现状＝**Recent Advances in the Study of Mercury Release in a Coal Combustion Process** [刊,汉] / WANG Quan-hai, QIU Jian-rong, WU Hao (National Key Laboratory of Coal Combustion under the Huazhong University of Science &Technology, Wuhan, China, Post Code: 430074) //Journal of Engineering for Thermal Energy &Power. — 2002, 17(6). —547～550

The average content of mercury in Chinese coals is higher than that found in coals of the United States and other countries, resulting in a relatively serious mercury-related pollution. The authors have summed up some study results concerning such pollution, focusing on the following aspects: distribution features of mercury found in coal, migration/transformation and emission characteristics as well as their control. **Key words**: mercury, coal, distribution law, migration/transformation, emission of pollutants

IGCC 电站中气化炉控制系统研究＝**A Study of the Control System of a Gasifier in a IGCC Power Plant** [刊,汉] / NI Wei-dou WEI Si-liang, LIU Shang-ming (Department of Thermal Energy Engineering, Tsinghua University, Beijing, China Post Code: 100084) //Journal of Engineering for Thermal Energy &Power. — 2002, 17(6). —551～554

By way of analyzing the operating characteristics of a gasifier in an integrated gasification combined cycle (IGCC) power plant the basic configuration of a control system of the gasifier has been determined. On the basis of the gasifier dynamic characteristics a control system was designed. The results of its simulation indicate that the coupling factor between the two major links of the gasifier, namely, its temperature and syngas heating value, is relatively low. By using the control system designed by the authors its is possible to fulfill the main control aim of the gasifier. **Key words**: integrated gasification combined cycle (IGCC), gasifier, control system

部分煤气化结合流化床燃烧技术的联合循环(PGFBC－CC)发电系统参数分析＝**Parametric Analysis of a Partial Gasification and Fluidized Bed Combustion-based Combined Cycle (PGFBC－CC) Power Generating System** [刊,汉] / YU Yan-fang, LIN Zhong-da, CAI Ning-sheng (Power Engineering Department, Southeastern University, Nanjing, China. Post Code: 210096) //Journal of Engineering for Thermal Energy &Power. — 2002, 17(6). —555～558

A relatively comprehensive parametric analysis was performed with respect to a typical partial gasification and fluidized bed combustion-based combined cycle (PGFBC-CC) power generating system and the main parameters influencing the system performance were identified. Furthermore, some beneficial measures and proposals have been put forward with a view to enhancing the performance of this type of power generating systems. **Key words**: partial gasification and fluidized bed combustion-based combined cycle system, power generating system, parametric analysis

超声波检测汽轮机中水蒸气湿度方法的探讨＝**Exploratory Study of an Ultrasonic Method for Detecting Steam Wetness in a Steam Turbine** [刊,汉] / LI Kai, SHANG De-min (Department of Thermal Energy and Power Engineering, Harbin Institute of Technology, Harbin, China, Post Code: 150001) //Journal of Engineering for Thermal Energy &Power. — 2002, 17(6). —559～560, 564

The use of an ultrasonic method for detecting the two-phase flow wetness of wet steam is theoretically explored with an accurate analytical expression being obtained. The determination of sonic speed in a two-phase flow by the use of a pulse time-difference method features simplicity, rapidity and precision. The composition and operating principles of a wetness-detection ultrasonic device are predicted from an theoretical perspective. **Key words**: ultrasonic method, water steam, wetness, sonic speed, detection

热力学分析与经济理论结合的新探讨——从热力学定律中揭示其内含的经济理论＝**A New Exploratory Study on the Combination of Thermodynamic Analysis with Economic Theory - an Economic Theory Aimed at**

Revealing from the Law of Thermodynamics Its Connotation [刊, 汉] / WANG Jia-xun, WANG Qing-zhao, ZHANG Xiao-dong (Power Engineering Department, North China University of Electric Power, Beijing, China, Post Code: 102206) // Journal of Engineering for Thermal Energy & Power. — 2002, 17(6). —561 ~564

The exposition and seeking of an implicit economic theory from many a law of physics can serve as a new approach for combining a thermodynamics analysis with an economic one. A specific analysis has been conducted of the economic theory of revealing its connotation from the first and second laws of thermodynamics. To this end, it is essential to clarify the existing misguidance of these two laws, especially the deep-seated misguidance of the second law. A further deepening of the understanding has been attained of the reasoning used by Georgescu Roegen in the statement "entropy law per se constitutes in substance the most cost-effective economic process among numerous laws". **Key words**: entropy, entropy law, new classic economics, ecological economics

地源热泵运行经济性分析= **An Analysis of the Operating Cost-effectiveness of a Ground-source Heat Pump** [刊, 汉] / WANG Yong-biao, LI Bing-xi, JIANG Bao-cheng (Energy Science and Engineering School under the Harbin Institute of Technology, Harbin, China, Post Code: 150001) // Journal of Engineering for Thermal Energy & Power. — 2002, 17(6). —565 ~567

In the light of the excessively low outdoor temperatures prevailing in Chinese northern frigid regions the authors have proposed a space heating system based on the use of ground-source heat pumps. There exist three driving modes for such pumps, namely, by electric motors, diesels and gas engines. In addition, there are three auxiliary heat supply sources, i.e., electric boilers, oil-fired ones and gas-fired ones. The authors have analyzed and compared the operating cost of various systems during a change of primary energy utilization rate and fuel price. The results of this comparison show that the operating cost of the driving modes by using gas engines, electric motors and diesel engines are respectively 6%, 40% and 57% higher than that of a central district heating system using boilers. **Key words**: ground-source heat pump, space heating, primary energy utilization rate, operation cost-effectiveness

纳米流体强化导热系数机理初步分析= **A Preliminary Analysis of the Intensified Thermal-conductivity Mechanism of Nano-fluids** [刊, 汉] / LI Qiang, XUAN Yi-min (Power Engineering Institute under the Nanjing University of Science & Technology, Nanjing, China, Post Code: 210094) // Journal of Engineering for Thermal Energy & Power. — 2002, 17(6). —568 ~571, 584

The mechanism of an intensified thermal conductivity achieved through the use of nano-fluids is analyzed from the following two aspects, namely, a changed liquid structure due to the addition of nano-particles and the micro-motion of nano-fluids. The results of the analysis indicate that relative to the enhanced thermal conductivity effected by the addition in fluids of millimeter or micrometer-grade particles the enhanced thermal conductivity made possible by nano-fluids has come about mainly due to the micro-motion of the nano-particles. Through the measurement of the thermal conductivity of nano-fluids under various temperatures it has been verified that the micro-motion of the nano-particles represents a major factor contributing to the enhancement of thermal conductivity by the nano-fluids. **Key words**: nano-fluid, intensified heat transfer, thermal conductivity, micro-motion

电厂送粉系统煤粉浓度测量的热探头方法研究= **Research on a Thermal Probe Method for the Measurement of Pulverized-coal Concentration in a Pulverized-coal Transport System of a Power Plant** [刊, 汉] / LIU Lei, ZHOU Fang-de (National Key Laboratory for Power Engineering Multi-phase Flows under the Xi' an Jiaotong University, Xi' an, China, Post Code: 710049) // Journal of Engineering for Thermal Energy & Power. — 2002, 17(6). —572 ~575

The measurement of pulverized coal concentration represents one of the problems requiring an urgent solution in the area of gas-solid two-phase flows. The authors have developed a measuring system incorporating thermal probes. The feasibility

of measuring pulverized coal concentration by the system was investigated. In consideration of the thermal relaxation effect in two-phase flows a calculation formula is proposed based on a revised Reynolds number and Nusselt number. The test data obtained by using the above two revised numbers to correlate the gas-solid two-phase flow round the thermal probes have shown that the gas-solid two-phase flow and single-phase one have an identical heat exchange relation. On the basis of this mechanism the thermal probe measurement method has made it possible to keep the relative deviation of pulverized-coal concentration measurement results within ±15%. **Key words**: gas-solid two-phase flow, pneumatic transport, heat transfer, measurement, thermal probe

射流对高温空气燃烧过程中 NO_x 生成的影响= **The Influence of Jet Flows on NOx Generation during a High-temperature Air Combustion Process** [刊, 汉] / WANG Jie-teng QI Hai-ying, LI Yu-hong, YOU Chang-fu (Institute of Thermal Energy Engineering under the Tsinghua University, Beijing, China, Post Code: 100084) // Journal of Engineering for Thermal Energy & Power. — 2002, 17(6). —575 ~ 579

Presented are the NOx generation mechanism during a fuel combustion process and various influencing factors. In addition, in connection with the specific features of high-temperature air combustion (HiTAC) and the basic theory of jet flows the authors have investigated the influence of an entrainment of fuel and air jet flows on NOx generation rate occurring at the HiTAC mode. The results of the investigation may provide a theoretical basis for the selection of a rational design and operating parameters as well as for the attainment of super-low NOx emissions and sizable energy-savings when operating at the HiTAC mode. Furthermore, they can also promote the industrial application and popularization of this advanced HiTAC technology in China. **Key words**: jet flow, high-temperature air combustion, NOx emissions

声空化场下浸没在多孔介质中水平圆管传热的实验研究= **Experimental Research on the Heat Transfer in a Horizontal Circular Tube Immersed in a Porous Medium under the Action of an Acoustic Cavitation Field** [刊, 汉] / ZHOU Ding-wei, LIU Deng-ying, HU Xue-gong, ZHANG Zheng-fang (Institute of Engineering Thermophysics under the Chinese Academy of Sciences, Beijing, China, Post Code: 100080) // Journal of Engineering for Thermal Energy & Power. — 2002, 17(6). —580 ~ 584

With the outside portion of a horizontal circular tube being packed by solid granules acetone is used to serve as a working medium. Under this condition an experimental research has been performed to identify the influence of various parameters on the single-phase convection and boiling heat transfer, including boiling hysteresis, in the above-cited tube immersed in a porous medium. Such parameters include the intensity and distance of acoustic cavitation, granule diameter, height of a porous layer, fluid subcooling, etc. **Key words**: acoustic cavitation, porous medium, boiling heat transfer, hysteresis

低浓度 CTAC 减阻流体流动性能试验研究= **Experimental Investigation of the Flow Properties of a Low-concentration CTAC (Cetyl Trimethyl Ammonium Chloride) Drag Reducing Fluid** [刊, 汉] / XU Peng, WANG De-zhong, HU Li-guang, ZHOU Hao-jun (Institute of Mechanical and Power Engineering under the Shanghai Jiaotong University, Shanghai, China, Post Code: 200030) // Journal of Engineering for Thermal Energy & Power. — 2002, 17(6). —585 ~ 588

Through the measurement of the drag reducing properties of a CTAC (cetyl trimethyl ammonium chloride) solution obtained were the characteristics of variation of these properties with the change in salt concentration. The results of an investigation indicate that even for one and the same drag reduction mode there exists a limiting value and an optimized selection for drag reduction. Meanwhile, a laser phase Doppler anemometer was employed to investigate the turbulent flow characteristics of a drag reducing fluid and, as a result, speed pulse curves were obtained for 50 kinds of operating conditions. It has also been discovered through the investigation that the transverse and axial speed pulses as well as Reynolds stress of the drag reducing fluid are markedly smaller than those of a Newtonian fluid. The correlation between the axial

and transverse speed pulsation of the drag reducing fluid has been conspicuously suppressed. **Key words**: drag-reducing fluid, turbulence structure, surfactant solution, phase Doppler anemometer

220 t/h 电站燃油炉改烧水煤浆炉内传热及排放特性的试验＝**Heat Transfer and Emission Characteristics Tests of a 220 t/h Oil-fired Utility Boiler Retrofitted for Firing Coal-water Slurry** [刊, 汉] / WANG Ling, ZHAO Xiang, CAO Xin-yu, HUANG Zhen-yu, et al (Institute of Thermal Energy Engineering under the Zhejiang University, Hangzhou, China, Post Code: 310027) // Journal of Engineering for Thermal Energy & Power. — 2002, 17(6). —589 ~591

Heat transfer performance and pollutant emissions were measured and tested for an oil-fired 220 t/h utility boiler being retrofitted to fire coal-water slurry, a new type of clean fuel as a replacement for oil. Measurements were taken of the temperature field, flame emissivity, superheater tube wall temperature, exhaust gas temperature and composition. These data represent some special features of coal-water slurry combustion and may serve as reference data during the design and retrofitting of a boiler for firing coal-water slurry. **Key words**: coal-water slurry, flame emissivity, pollutant emission, boiler

高硫石油焦燃烧污染物排放特性的试验研究＝**Experimental Investigation on Pollutant Emission Characteristics Resulting from the Burning of Petroleum Coke with a High Sulfur Content** [刊, 汉] / YUAN Gui-cheng, LIU Wu-biao, ZHANG Chun-lin, LIU De-chang (National Key Laboratory of Coal Combustion under the Huazhong University of Science & Technology, Wuhan, China, Post Code: 430074) // Journal of Engineering for Thermal Energy & Power. — 2002, 17(6). —592 ~594, 606

On a hot-state test rig a desufurization test was conducted for the burning of high-sulfur petroleum coke. On this basis discussed was the influence of such factors as combustion temperature, calcium/sulfur ratio and excess oxygen content on SO_2 and NOx emissions. As a result, a theoretical and practical basis is provided for the industrial application of petroleum coke with a high sulfur content. **Key words**: petroleum coke with a high sulfur content, combustion test, SO_2 emissions, NOx emissions

无烟煤与贫煤混煤燃烧和 NO_x 排放特性的实验研究＝**Experimental Research on the Burning of Anthracite Mixed with Lean Coal and Its NOx Emission Characteristics** [刊, 汉] / FANG Li-jun, HUI Shi-en (Institute of Energy and Power Engineering under the Xi' an Jiaotong University, Xi' an, China, Post Code: 710049), GAO Zheng-yang, YAN Wei-ping (Department of Power Engineering, North China University of Electric Power, Baoding, China, Post Code: 071003) // Journal of Engineering for Thermal Energy & Power. — 2002, 17(6). —595 ~598

By using a thermobalance and a small-sized pulverized-coal combustion test rig an experimental study was conducted for a multitude of test items. The latter include the combustion characteristics of anthracite, lean coal and the blends of the above two coals in three different proportions, NOx generation mechanism at different combustion-air supply rates, and burn-out characteristics. Through the processing and analysis of the test data it is concluded that there exists some differente in combustion performance between the anthracite and lean coal with the performance of the blends of these two coals exhibiting intermediate characteristics. A proper selection of excess air factor can lead to a high-efficiency combustion of anthracite and lean coal blended in different ratios and to low NOx emissions. With respect to coals being blended in three different ratios a suitable range of excess-air factor values is proposed to attain a high-efficiency combustion and low pollutant emissions. This may serve as a guide for the cost-effective and clean operation of power plants firing the above coal blends. **Key words**: burning of anthracite mixed with lean coal, combustion characteristics, NO emissions, burn-out characteristics

1025 t/h“W”火焰锅炉燃烧特性试验研究＝**Experimental Study of the Combustion Characteristics of a 1025 t/h**

"W" Flame Boiler [刊, 汉] / MIAO Chang-xin, LIU Zhi-chao (Shandong Electric Power Research Institute, Jinan, China, Post Code: 250002) // Journal of Engineering for Thermal Energy & Power. — 2002, 17(6). —599 ~ 602, 631

Presented are the design features and combustion characteristics of a W-flame boiler designed and manufactured by British MBEL Co. and installed at Heze Power Plant. In connection with the commissioning test results expounded and analyzed are the air distribution of burners, the characteristics of fuel burn-out and NOx and SO_2 emissions. In addition, there existed a whole range of problems, such as the poor mixing of combustion-air distribution in a parallel-flow field at a later stage, the slag formation on a lower furnace refractory-belt, and the excessive amount of NOx emissions. To deal with these problems, the authors have made some preliminary recommendations to alleviate them. **Key words**: W-flame boiler, design features, combustion characteristics, proposals for improvement

内置过滤元件流化床的最小流化速度= **Minimum Fluidizing Speed of a Fluidized Bed with Built-in Filtration Elements** [刊, 汉] / ZHANG Shi-hong, LIU De-chang, ZHENG Chu-guang (National Key Laboratory of Coal Combustion under the Huazhong University of Science & Technology, Wuhan, China, Post Code: 430074) // Journal of Engineering for Thermal Energy & Power. — 2002, 17(6). —603 ~ 606

With a novel fluidized-bed granular filter (FBGF) serving as an object of application an experimental investigation was conducted of the minimum fluidizing speed of a fluidized bed with built-in filtration elements. It has been discovered by the investigation that the greater the effective area of immersed material layer of the filtration element, the greater the minimum fluidizing speed. In this regard a dimensionless magnitude has been defined as the ratio between the following two items: the effective surface area of a filtration element immersed in the bed material, and the fluidized bed cross-section area. And, by means of regression obtained was an empirical expression of the minimum fluidizing speed of a fluidized bed with built-in filtration elements. This has laid a solid basis for the further study of a fluidized-bed granular filter. **Key words**: minimum fluidizing speed, fluidized bed with built-in filtration elements, granular filter

连续转子轴承系统的非线性动力学行为研究= **Research on the Nonlinear Dynamic Behavior of a Continuous Rotor-bearing System** [刊, 汉] / JING Jian-ping, SUN Yi, XIA Song-bo (School of Energy Science & Engineering under the Harbin Institute of Technology, Harbin, China, Post Code: 150001), LI Jian-zhao (Harbin No. 703 Research Institute, Harbin, China, Post Code: 150036) // Journal of Engineering for Thermal Energy & Power. - 2002, 17(6). —607 ~ 610

By using a finite element method a nonlinear continuous rotor-bearing system model has been set up for a rotor-bearing system. With the use of respectively a direct integration method and modality synthesis method the rotor nonlinear dynamic behavior under unbalanced conditions was analyzed. The results of comparison of the above two methods indicate that the direct integration method is more effective for solving nonlinear vibration problems. The rotor-bearing system was analyzed by using a simple discrete method. The results of the analysis are quite different from those obtained under the finite-element analysis method. The results of the latter method show that the dynamic response of a rotor-bearing system is of a typical oil-whip process with its nonlinear dynamic-motion behavior being of a Hopf bifurcation form. **Key words**: continuous rotor system, nonlinearity, finite element, oil whip

多股流板翅式换热器温度交叉的数值分析= **Numerical Analysis of the Temperature Crossover of a Multi-stream Plate-fin Heat Exchanger** [刊, 汉] / LU Hong-bo, CUI Guo-min, LI Mei-ling (Research Institute of Thermal Energy Engineering under the Shanghai University of Science & Technology, Shanghai, China, Post Code: 200093) // Journal of Engineering for Thermal Energy & Power. — 2002, 17(6). —611 ~ 613

With a parallel multi-stream plate-fin heat exchanger serving as a target of study the authors have presented an energy equation for both the fluid and fins of the said heat exchanger, taking into account the bypass effect of the fins. A numerical solution is conducted of the energy equation under the conditions of changing the fluid parameters and flow modes of

various channels as well as the structural parameters of the heat exchanger. As a result, obtained were the fluid temperature distribution of various channels and the fluid temperature difference of neighboring channels. Furthermore, analyzed was the effect of the variation of fluid parameters, flow modes and structural parameters on the fluid temperature crossover of the neighboring channels. **Key words**: multi-stream plate-fin heat exchanger, temperature crossover, fin bypass, flow mode

烟气含氧量软测量新方法研究＝**The Study of a New Method Incorporating the Soft Sensing of Oxygen-content in Flue Gases** [刊, 汉] / LU Yong, XU Xiang-dong (Department of Thermal Engineering, Tsinghua University, Beijing, China, Post Code: 100084) //Journal of Engineering for Thermal Energy &Power. — 2002, 17(6). —614～617

In view of the high first cost of conventional oxygen-content analyzers for industrial applications, their high maintenance expenses and low durability the authors have on the basis of comparing several commonly used methods come up with a new method for measuring oxygen content in flue gases. The proposed method involves an oxygen-content soft sensing model set up through the use of a NNPLS (neutral network partial least square) approach based on statistical analyses and neural network technology. It enjoys both the merits of PLSR (partial least square regression) and neural network technology, making it possible to identify a target model by utilizing historical process data. A simulation verification of the method has been conducted by using on-site industrial data. In addition, the simulation results are compared with traditional linear PLSR method and the direct neural network-based modeling method. The results of comparison indicate that the soft sensing model based on the NNPLS approach features a more effective generalizing ability. Furthermore, an extension of a static model to a dynamic one was also performed. **Key words**: soft sensing, partial two least squares, neural network, cross validation, generalizing ability

用预报误差校正的锅炉燃烧系统预测控制研究＝**A Study of the Predictive Control of a Boiler Combustion System through the Correction of a Forecast Error** [刊, 汉] / ZHU Xue-li, QI Wei-gui, LI Li-yan (School of Electric Engineering and Automation under the Harbin Institute of Technology, Harbin, China, Post Code: 150001) //Journal of Engineering for Thermal Energy &Power. — 2002, 17(6). —618～621

To improve the performance of a boiler-combustion control system, a dynamic matrix control (DMC)-based algorithm with the correction of a forecast error has been put forward to fulfill relevant control functions. After a brief description of the DMC composition and an internal-model control structure a model error is predicted based on a time sequence analysis, parameter estimation and an optimum forecast theory. Furthermore, by forecasting the model error and using the model forecast error to replace the model error the rolling optimization of a predictive control can be duly corrected. Finally, through the simulation tests of the predictive control for the boiler control system it is shown that the correction of the forecast error can result in a marked improvement in such characteristics as tracking ability, anti-interference and robustness when compared with an error correction algorithm in general. **Key words**: combustion system, predictive control, time sequence, forecast error

劳伦斯法在热工对象动态特性辨识中的应用＝**The Application of Lawrence Algorithm in the Identification of Dynamic Behavior of Thermodynamic Objects** [刊, 汉] / XU Hou-qian, JIANG Gui-zhen (Power Engineering College under the Nanjing University of Science &Technology, Nanjing, China, Post Code: 210094) //Journal of Engineering for Thermal Energy &Power. — 2002, 17(6). —622～624

Described is the process of a transfer-function fitting performed through the use of Lawrence algorithm by way of frequency domain data. Furthermore, the above method was employed to conduct the fitting of transfer functions for a split-shaft gas turbine under three operating conditions. Under various operating conditions the results of fitting agree relatively well with those of experiments, testifying to the credibility of the Lawrence algorithm. In addition, by using a method, which com-

bines system identification with a numerical simulation, the results of fitting were simplified, thereby obtaining a simplified model, which complies with experimental results. **Key words**: Lawrence algorithm, system identification, transfer function fitting

基于OPC规范的火电厂监控信息系统研究=**A Study of the Supervisory information System for a Thermal Power Plant Based on an OPC (Object-linking-and-embedding for Process Control) Specification** [刊, 汉] / QUAN Xin-jian, LIN Zhong-da (Power Engineering Department, Southeastern University, Nanjing, China, Post Code: 210096) // Journal of Engineering for Thermal Energy & Power. — 2002, 17(6). —625~628

The study mainly focuses on a plant-level supervisory information system for a thermal power plant by adopting the design conception of a modularized program based on COM/DCOM technology. A standard OPC (object-linking-and-embedding for process control) interface (OPC client program and OPC server program) in compliance with OPC specification has been adopted to serve as the communication interface of the supervisory information system. This gives full play to the identity and opening characteristics of the OPC interface, thereby providing a new realistic approach for organizing an open and flexible plant-level supervisory information system for thermal power plants. **Key words**: thermal power plant, supervisory information system, design

饱和蒸汽减温在燃机余热锅炉的应用=**The Application of Saturated Steam Attemperation in Gas-turbine Heat Recovery Boilers** [刊, 汉] / ZHANG Yong, YAO Dong, WEI Shao-jie (Harbin No. 703 Research Institute, Harbin, China, Post Code: 150036), ZHAI Zuo-wu (Harbin No. 3 Power Generation Co. Ltd., Harbin, China, Post Code: 150036) // Journal of Engineering for Thermal Energy & Power. — 2002, 17(6). —629~631

Described is a method of superheated steam regulation for the heat recovery boiler of a gas-steam combined cycle power plant, the so-called boiler-drum saturated steam attemperation. The design of such a saturated-steam attemperating system is analyzed with some problems worthy of close attention in practical use being pinpointed. **Key words**: gas-steam combined cycle power plant, heat recovery boiler, saturated steam attemperation

百叶窗式水平浓淡煤粉燃烧器在燃贫煤300MW机组的应用=**The Use of a Horizontal and Louver-type Concentrated-diluted Pulverized Coal Burner in a 300 MW Lean Coal-fired Power Plant** [刊, 汉] / WANG Ji-hong (Boiler Repair Shop at Anyang Power Plant, Anyang, Henan Province, China, Post Code: 455004) // Journal of Engineering for Thermal Energy & Power. — 2002, 17(6). —632~634

The steady combustion and low NOx emission mechanism of a horizontal and Louver-type concentrated-diluted pulverized coal burner was analyzed from the perspective of its construction features. After a modification of the burners installed on boilers No. 9 and 10 of Anyang Power Plant test results indicate that an optimum performance has been attained in respect of both NOx emissions and combustion stability. This has a certain reference value for similar type of boiler units. **Key words**: 300MW power plant, horizontal and Louver-type concentrated-diluted pulverized coal burner, modification, test, combustion stability

高水分燃料的沸腾层烟气热平衡方程=**A Thermal Energy Balance Equation Obtained for the Flue Gases of a Fluidized Bed When High-moisture Fuels Were Fired** [刊, 汉] / HUANG Yi-min, YU Hong-bin (Power Engineering Department, Harbin Institute of Technology, Harbin, China, Post Code: 150001) // Journal of Engineering for Thermal Energy & Power. — 2002, 17(6). —635~637

A thermal energy balance equation has been obtained for the flue gases of a fluidized bed operating on high-moisture fuels. With bark, lignite and bituminous coal of grade 1 serving as fuels analyzed was the effect of heat absorption during the water evaporation of unburned fuel in the fluidized bed on two factors. The latter are the quantity of heat absorbed by a submerged tube and the temperature of the fluidized bed. The results of calculation and analysis indicate that when

high-moisture fuels are burned, the heat quantity needed for water evaporation-related heat absorption is relatively great. In view of this, the latter should be taken into account in the thermal energy balance for the flue gases of a fluidized bed. **Key words**: high moisture fuel, thermal energy balance equation, fluidized bed boiler

通道形面对PSR性能影响的分析＝**An Analysis of the Effect of Plate Corrugation on the Performance of a Primary Surface Recuperator (PSR)** [刊, 汉] / ZHANG Zhi-jun, CHENG Hui-er (Power Engineering Institute under the Shanghai Jiaotong University, Shanghai, China, Post Code: 200030), WEN Xue-you, XIAO Dong-ming (Harbin No. 703 Research Institute, Harbin, China, Post Code: 150036) // Journal of Engineering for Thermal Energy &Power. — 2002, 17(6). —638 ~640

With respect to an innovative type of compact heat exchanger, the so-called primary surface recuperator (PSR), newly emerging in the international arena, analyzed is the effect of plate corrugation formed respectively by elliptic, sinusoid and parabola curves on exchanger core performance. In connection with the design of a PSR sample unit used as the recuperator of a gas turbine the authors have given the main performance of three types of PSR core, based on three plate corrugation configurations. The superior performance of the PSR core can be demonstrated through its comparison with the core performance of plate-fin heat exchangers. **Key words**: primary surface recuperator, plate corrugation, core performance

国产UP直流炉水冷壁改造方案分析＝**An Analysis of the Water Wall Modification Scheme for a Chinese-made Once-through Boiler** [刊, 汉] / TANG Ren-hu, HU Zhi-hong, CHEN Ting-kuan, et al (National Key Laboratory of Multi-phase Flows under the Xi' an Jiaotong University, Xi' an, China, Post Code: 710049) // Journal of Engineering for Thermal Energy &Power. — 2002, 17(6). —641 ~643

A hydrodynamic analysis was conducted in connection with the modification scheme of a 300MW once-through boiler at Yaomeng Power Plant. On the basis of a comparison of the boiler water-wall negative and positive flow-rate response characteristics existing prior to and after the modification the authors noted the poor hydrodynamic characteristics of the furnace water-wall composed of vertical tube coils. An excessively high water-wall temperature and the big difference in metal and inter-tube fluid temperatures leading to tube explosion can mainly be attributed to the high mass flow speed and the resulting negative flow rate response characteristics. The above discovery may provide a helpful guide during the modification of analogous boilers. **Key words**: boiler water wall, negative-flow response characteristics, hydrodynamic calculation, mass flow rate, once-through boiler

40 t/h燃气锅炉过热器爆管原因分析＝**An Analysis of the Cause of a Superheater Tube Explosion Occurring in a 40 t/h Gas-fired Boiler** [刊, 汉] / FAN Wei-dong, ZHANG Ming-chuan (School of Mechanical &Power Engineeirng under the Shanghai Jiaotong University, Shanghia, China, Post Code: 200240), HONG Mei (Shanghai Boiler Co. Ltd., Shanghai, China, Post Code: 200240) // Journal of Engineering for Thermal Energy &Power. — 2002, 17(6). —644 ~647

The tube explosion occurring in a low-temperature stage superheater of a gas-fired industrial boiler was analyzed from various aspects, such as boiler design, superheater structure and layout, etc. With the cause of explosion being identified some effective measures were proposed to solve the problem. **Key words**: industrial boiler, superheater, tube explosion

锅炉多管除尘器改进＝**The Improvement of a Multi-tube Dust Separator for a Boiler** [刊, 汉] / LIU Bao-jun, WANG Tie-yan (Harbin Hongqi Boiler Works, Harbin, China, Post Code: 150080) // Journal of Engineering for Thermal Energy &Power. — 2002, 17(6). —647 ~649

A high-efficiency multi-tube dust separator is described. After a modification its use on 1 - 75 t/h boilers for space heating during the winter has played a significant role in the protection of environment. **Key words**: multi-tube dust separator, cyclone, flow resistance, role of negative pressure