NG-130/39-M2型锅炉的节能技术改造与运行

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[摘要] 通过对某热电厂 NG-130/39-M2型锅炉及制粉系统的测试,分析了锅炉飞灰和大渣可燃物含量偏高和热效率偏低的原因,并提出了相应的改造措施。改造结果达到了预期改进目标。

关键词　锅炉　磨煤机　制粉系统　热效率
中图分类法　TK223,227

0 前言

某热电厂 6#、7#炉是杭州锅炉厂设计的 NG-130/39-M2型锅炉,每台炉配 4台 FM220.420风扇磨,设计燃料为霍林河褐煤。由于种种原因,锅炉一直全烧或掺烧小窑煤,致使飞灰和大渣可燃物含量偏高,其中飞灰可燃物含量为 7.48%~20.46%,大渣可燃物含量为 17.66%~24.40%,锅炉运行的经济性很差。为查明原因,热电厂和哈电站成套所对 7#炉的燃烧系统做了调整试验。试验结果表明:造成锅炉飞灰和大渣可燃物含量偏高的原因是:粗分器设计容积小,煤粉细度粗,且合格煤粉中大于 1mm的粗粒子多,制粉系统漏风大,磨煤机干燥出力不足,燃烧器的配风方式不当等。

1996年 9月,双方对上述缺陷问题进行了消缺处理。实践证明:这次改造调试,对锅炉存在问题分析准确,采取措施得当,改造后的锅炉飞灰可燃物含量为 2.28%,大渣可燃物含量为 3.11%,取得了令人满意的效果。

1 设备概述

1.1 NG-130/39-M2型锅炉参数

过热蒸汽流量	130 t/h
过热蒸汽压力	3.82 MPa
过热蒸汽温度	450℃
给水温度	170℃
热风温度	380℃
锅炉热效率	89.16%

1.2 FM220.420型风扇磨煤机参数

风扇磨叶轮直径	2200 mm
风扇磨叶轮宽度	420 mm
风扇磨磨煤出力	13.5 t/h
风扇磨通风量	32000 m^3/h
风扇磨提升压头	1960 Pa

2 NG-130/39-M2型锅炉燃烧系统存在的问题分析

为了摸清 NG-130/39-M2型锅炉燃烧系统所存在的问题,有效地对该炉进行改造,双方 7#炉制粉系统做了全面的测试。测试结果见表 1.2 由测试结果和现场情况可知,锅炉飞灰和大渣可燃物含量偏高的原因有以下几方面。

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表 1　7# 炉 2# 风扇磨制粉系统测试结果

项 目 名 称	符号	单位	1	2	3	4
粗分器调节档板开度	y	格	0	2	4	6
磨煤出力	B_m	t/h	11.385	11.095	11.095	11.095
煤粉细度	R_{90}	%	48.2	40.1	31.1	36.2
	R_{200}	%	18.4	15.9	9.4	11.2
	R_{1000}	%	0.78	1.36	0.51	0.82
50克煤样粒径大于 1mm粒数			186粒	304粒	115粒	243粒
煤粉颗粒均匀性指数	n	—	1.054	0.8761	0.8787	0.9534
磨煤机提升压头	Δp	Pa	1687	1687	1638	1638
磨出口温度	t_2	℃	92	90	109	105
磨煤机通风量	Q	m^3/h	30765	31680	29980	31210
容积强度	q_v	$m^3/(m^3\cdot h)$	4339	4467	4228	4402

表 2　2# 炉回粉档板对煤粉细度的影响

煤粉细度	单位	回粉管未堵	回粉管堵塞
R_{90}	%	40.1	71.0
R_{200}	%	15.9	28.2
R_{1000}	%	1.36	5.1

2.1 粗粉分离器调节档板与锥形板间隙值过大

由表 1可看出, 50克煤粉样中大于 1mm的颗粒较多,最多达 304粒,平均 212粒。这主要由于粗分器调节档板与锥形板间隙过大而引起的。试验后,我们测量粗分器调节档板与锥形板的间隙值为 36mm,而西德 EVT公司制造的 $S_{36.50}$风扇磨的此间隙值是 20mm,前者是后者的 1.8倍。据 $S_{36.50}$风扇磨的性能测试中, 50克煤粉样大于 1mm的颗粒平均仅为 8粒,最多为 25粒。为此,我们对 FM220.420风扇磨粗分器调节挡板和锥形板的间隙进行堵焊,堵焊后的间隙值为 15mm,堵焊后测得 50克煤粉样中大于 1mm的颗粒为 32粒。说明堵焊的效果较好。

2.2 某热电厂燃煤发热值低,且煤中多杂质,如炮线、铁丝、编织袋等,这些不易清除的杂质进入磨煤机后,因质地柔软不易破碎使回粉管堵塞。由表 2可看出,在回粉管堵塞情况下,煤粉细度 R_{90}高达 70%, R_{1000}高达 5.1%,这无疑是造成机械未完全燃烧热损失增加的原因。

2.3 FM220.420风扇磨所配粗分器的有效容积偏小,为 7.09m^3,容积强度为 4467$m^3/(m^3\cdot h)$。我国的 S型风扇磨所配的粗分器,磨制硬质老年褐煤,煤粉细度 R_{90}为 40%时,推荐的经验容积强度为 q_v = 3200 $m^3/(m^3\cdot h)$(表 3)。

表 3　我国 S型风扇磨运行的容积强度

项 目 名 称	符号	单位	富拉尔基电厂	通辽发电总厂	元宝山发电厂	沈阳气化热电厂	龙口发电厂	通辽热电厂
磨煤机型号			$S_{36.50}$	$S_{35.50}$	$S_{35.50}$	$S_{9.100}$	$FM_{275.580}$	$FM_{220.420}$
磨通风量	Q	m^3/h	99510	97762	107400	16900	62000	31680
磨出口温度	t_2	℃	115	118	101	103	145	109
煤粉细度	R_{90}	%	37.0	47.8	46.7	42.7	40.0	39.6
提升压头	ΔP	Pa	1110	1775	1519	1690	1270	1687
粗分器容积	V	m^3	27.92	30.76	30.76	4.8	—	7.09
容积强度	q_v	$m^3/(m^3\cdot h)$	3564	3173	3362	3521	4634	4467

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显然,要想达到合适的燃烧细度 R_{90} = 30%~ 40%, FM 220. 420风扇磨的容积强度为 4467 m^3 /(m^3· h),比推荐值 3200 m^3 /(m^3· h)大,煤粉细度偏粗。应增加粗分器箱体部分的容积。

2. 4 制粉系统的漏风量较大,这主要由于冷风门不严,磨煤机伸缩节缝隙大等原因造成的。运行时磨出口温度仅为 90~ 110℃。据我们的测试结果,系统的最大干燥出力在磨出口温度为 109℃时,磨煤机的磨煤出力仅为 11. 095 t/h,低于设计值。这无疑将给锅炉的燃烧工况带来不良的影响。同时,由于干燥出力不足而限制了磨煤机的出力,降低了制粉系统的经济性。

3 改造措施

根据 FM 220. 420风扇磨制粉系统所存在的问题,双方经研究决定做如下技术改造。

3. 1 对粗分器调节档板和锥形板的间隙值进行堵焊,以防煤粉气流短路,其间隙值为 15 mm。

3. 2 粗分器箱体部分增加 400~ 600 mm 左右,增加分离效果(见图 1)。

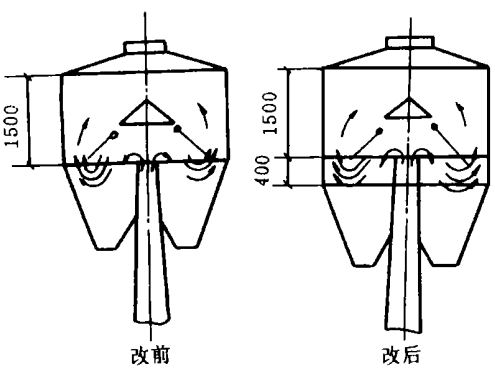

图 1 双流道惯性分离器改造方案

3. 3 对制粉系统的漏风点,如磨煤机伸缩节和冷风门等进行堵漏,以提高干燥出力。

3. 4 采用腰鼓形式的配风,即上二次风率大,中二次风率小,下二次风率大的配风方式。上二次风率大具有一定的动量把主火炬往下压,延长煤粉粒子的停留时间,减少飞灰可燃物的含量。下二次风率大的目的是使具有足够的动量能托住一次风煤粉气流,防止煤粉粒子的离析,减少大渣可燃物的含量,从实际的配风情况看,具有一定的效果。由于冬季采暖期的到来,第 4. 2项未做实验。

4 改造效果

4. 1 FM 220. 420风扇磨粗分器分离特性试验

表 4给出的是改造后的 FM 220. 420风扇磨粗分器调节特性试验结果。

表 4 改造后的 FM 220. 420风扇磨粗分器调节特性试验

项目名称	符号	单位	1	2	3
粗分器调节档板开度	Y	格	0	2	4
煤粉细度	R_{90}	%	41. 6	35. 8	28. 6
	R_{200}	%	14. 4	8. 71	4. 4
	R_{1000}	%	1. 82	0. 71	0. 22
50 g 煤粉样中大于1mm粒数			558粒	107粒	32粒
煤粉颗粒均匀性系数	n	—	1. 095	1. 121	1. 145
磨出口温度	t_2	℃	125~150	125~150	125~150
磨通风量	Q	m^3 /h	31200	31200	31200
提升压头	ΔP	Pa	1637	1637	1637

4. 1. 1 从表 4可以看出,煤粉细度有较好的改善,调节档板在 4格时,50克煤粉样中大于 1mm的颗粒仅为 32粒, R_{90}= 28. 6%, R_{200}= 4. 4, n= 1. 145,基本上达到了燃烧所要求的煤粉细度。

4. 1. 2 磨出口温度明显提高,达 125~

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150℃,比改造前提高了近 40℃,这对于提高磨煤机出力改善制粉系统的经济性起到了良好的作用。

4.2 NG- 130/39- M2型锅炉热效率试验

锅炉热效率测试结果如表 5所示。

表 5　NG- 130/39- M2型锅炉热效率试验结果

项目名称	符号	单位	1	2
锅炉折算蒸发量	D'	t/h	116	116
热风温度	t_{rf}	℃	378	385
一次风温度	t_2	℃	105 ~ 110	125 ~ 150
飞灰可燃物含量	C_{fh}	%	7.48	2.28
大渣可燃物含量	C_{LZ}	%	17.66	3.11
机械未完全燃烧热损失	q_4	%	5.61	1.56
锅炉热效率	Z	%	84.39	88.13
燃尽率	C_{yj}	%	93.1	98.0

1—— 改前工况　　2—— 改后工况

4.2.1　从表 5看出,锅炉蒸汽温度,压力和流量均略低于设计值,这并不是锅炉因素,是受汽机、发电机的负荷限制所致。

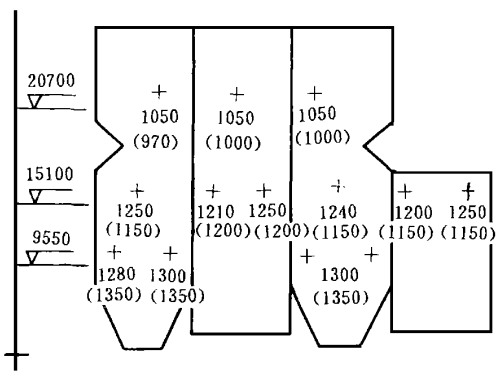

图 2　炉内烟气温度特性图

注: 括号内、外分别是改造前后的炉内烟气温度(℃)

4.2.2　经过改造后的锅炉热效率达 88.13%,比改前提高 3.74%。燃尽率比改前提高 5%。

4.2.3　炉膛温度水平及火焰中心位置标志着炉内燃烧的优劣,燃烧的优劣的关键是配风好,煤粉送入炉膛后,哪里有配风,就在哪里着火。采用腰鼓形式的配风,目的是减少飞灰,大渣可燃物的含量,从实际的配风情况看,具有一定的作用。飞灰可燃物含量由改前的 7.48% ~ 20.46%降低到 2.28%,大渣可燃物含量由改前的 17.66% ~ 24.06 降低到 3.11%。

在标高 15.10处,调整前工况,此孔烟气温度 1210℃,而调整后都在 1150℃,比调整前降低 60℃,而燃烧器区域烟气温度普遍提高 50℃ (图 2)。

5　结论

5.1　FM 220.420风扇磨所配粗分器经过堵焊和制粉系统的漏风点清除后,效果明显,煤粉细度有所降低,煤粉颗粒均匀性系数改善。特别是 50克煤粉样中大于 1mm的颗粒明显减少,仅为 32粒,且风扇磨系统的干燥出力明显提高,磨出口温度达 125~150℃,这对组织锅炉燃烧工况起着良好的作用。

5.2　改造后的锅炉热效率达 88.13%,燃烧器区域火焰温度提高,且火焰中心下移。其飞灰和大渣可燃物含量明显降低,分别为 2.28%和 3.11%,燃料的燃尽率在 98%以上。

5.3　改造后的锅炉每年可节约原煤 8914吨,节约资金 143万元。

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University)// Journal of Engineering for Thermal Energy & Power. -1998, 13(3). -178~ 182

Through an experimental study conducted on a circulating fluidized bed model (height 5.9 m, inner diameter 0.14 m) the formation mechanism of a wall-adhered return flow was explored and discussed with a physical model of the wall-adhered return flow proposed. The above work is meaningful for both engineering design and theoretical research of circulating fluidized beds. **Key words**: wall-adhered retun flow, circulating fluidized bed

《热能动力工程》引文分析和研究= **Analysis and Study of the Engineering Literature Citations of "Journal of Engineering for Thermal Energy & Power"** [刊,中]/Huang Mao Lin (Harbin Institute of Technology) Liu Changhe(Harbin No. 703 Research Institute)// Journal of Engineering for Thermal Energy & Power. -1998, 13(3). -183~ 184

逆算法对涡轮特性柯特略尔估算的改进= **An Improvement on Kotlial Prediction of Turbine Performance by the Use of an Inverse Computation Method** [刊,中]/Xie Zhiwu, Wang Yonghong, Hong Bo, Chen Delai (Shanghai Jiaotong University)// Journal of Engineering for Thermal Energy & Power. -1998, 13(3). -185~ 188

Taking Kotlial method as an example, this paper discusses the applicability of an inverse computation method for the calculation of stage superimposed type turbine performance. It has been proved that the last stage first stagnation hypothesis can be naturally fulfilled under the condition of identical design pressure ratio for each corrected stage. In case of the design pressure ratio for each corrected stage not identical given are ascertainment criteria for finding the first stagnant stage. In addition, the use of a combined sequential-inverse computation method is proposed for the treatment of critical issues, thus making a breakthrough regarding the last stage first stage hypothesis. Computation procedures have been optimized, resulting in an enhancement in evaluation precision. **Key words**: turbine, inverse computation method, Kotlial method

弯曲叶片涡轮叶栅二次流损失计算经验模型= An Empirical Model for Calculating Secondary Flow Losses of Curved Blade Turbine Cascades [刊,中]/Yu Qing (Beijing University of Aeronautics and Astronautics) // Journal of Engineering for Thermal Energy & Power. -1998, 13(3). -189~ 192

On the basis of the experimental data analysis of inclined and composite curved plane cascades the author has come up with a secondary flow loss calculation model applicable for turbine cascades of curve-twist aerodynamically formed design. This model reflects the effect of such factors as blade inclination angle, aspect ratio, cascade solidity on the magnitude and distribution mechanism of secondary losses. With the help of this model evaluated in advance are the losses of a small aspect ratio gas turbine guide vane device under two forms of blades, i. e. straight and curved. The model-calculated values are in good agreement with those of the test and measuring results. **Key words**: curved blades, turbine cascade, secondary loss model

恒热流竖壁降膜发展段流动换热分析= **Flow Heat Exchange Analysis of Constant Heat Flow Vertical Wall Downcoming Liquid Film Development Section** [刊,中]/Shi Jinsheng, Shi Mingheng(Southeastern University)// Journal of Engineering for Thermal Energy & Power. -1998, 13(3). -193~ 195

With the help of a boundary layer analogous solution an analysis is conducted of the laminar flow and heat exchange characteristics in the constant heat flow vertical wall downcoming liquid film development section. Obtained is the calculation expression of the development section length, liquid film thickness and non-dimensinal heat exchange factor. **Key words**: downcoming film, development section, speed boundary layer, temperature boundary layer

NG-130/39-M_2型锅炉的节能技术改造与运行= **Energy Saving-oriented Technical Modification and Operation of a Model NG-130/39-M_2 Boiler**[刊,中]/Cheng Qingang, Bao Yanjun, Zhang Guojun, et al (Harbin Power Equipment Design Institute)// Journal of Engineering for Thermal Energy & Power. -1998, 13(3). -196~ 199

Through the tests of a NG-130/39-M_2 boiler installed at a thermal power plant and its pulverized coal system analyzed are some causes leading to the excessively high fly ash and slag combustible content and ex-

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cessively low thermal efficiency of the boiler. Relevant modification measures are proposed, with the help of which anticipated improvements have been attained. **Key words**: energy saving, fly ash, combustible

小型燃煤锅炉改烧天然气的措施及效果= **Measures and Effectiveness of Switch-over to Natural Gas Firing by a Small-sized Coal-fired Boiler** [刊,中]/Guo Jianqiang, Han Hongjia, et al (Harbin No. 703 Research Institute)// Journal of Engineering for Thermal Energy & Power. -1998, 13(3). -200~203

Specific measures are described regarding the change-over to burning natural gas by a small-sized coal-fired boiler. In this connection some valuable experiences are provided for coal-fired boilers to switch over to firing natural gas. **Key words**: boiler, natural gas, modification

论折合㶲的概念及其应用= **On the Concept of Reduced Exergy and Its Application** [刊,中]Han Xueting, Zhang Jie (Hebei Institute of Architectural Science & Technology)// Journal of Engineering for Thermal Energy & Power. -1998, 13(3). -204~207

On the basis of the assumption that factor K of the ratio of use value of non-usable energy and exergy is equal to energy level Ω, deducted is a universally applicable formula for calculating reduced exergy. From this one can perceive the variation relationship of reduced exergy with energy level, thereby proving that the reduced exergy is a status function. The analysis of the reduced exergy can lead to a more comprehensive and accurate evaluation of the use conditions of various energy quantities. Moreover, the determination of the price of heat, electricity and cold products by the reduced exergy method is more scientific and rational. **Key words**: reduced exergy, usable non-usable energy, unusable energy level, practical exergy, avergae thermodynamic temperature

一种新型的电站热力系统矩阵模型及其应用= **A New Type of Power Station Thermodynamic System Matrix Model and Its Application**[刊,中]/Si Fengqi, Hu Huajin, Xu Zhigao(Southeastern University)// Journal of Engineering for Thermal Energy & Power. -1998, 13(3). -208~212

The authors have come up with a new type of power station thermodynamic system matrix model. It takes into consideration in a comprehensive way the object characteristics of a regenerative system and various auxiliary systems and features a simple and easy-to-understand physical concept. By the use of a heat balance method the algorithm of the model is reliable and universally applicable. Through the implementation of a computer software it is possible to make use of the idea of configuration. This outstanding merit can enhance the robustness and transplantability of the power plant performance monitoring software, creating wide application prospects in the area of power station performance analysis. **Key words**: thermodynamic system, matrix, mathematical model, power station, configuration, software

Windows平台上锅炉微机监控系统的开发应用= **Development and Application of a Microcomputer-based Boiler Monitoring System on a Windows Platform**[刊,中]/Wan Jingyi, Liu Qingge (Harbin No. 703 Research Institute), Zhao Xia, Jin Hongda (Suibin County Television Station)// Journal of Engineering for Thermal Energy & Power. -1998, 13(3). -213~217

The authors give a brief description of the hardware structure and regulating principle of a Yanhua industrial control model PC486 boiler microcomputer-based monitoring system, detailing the development of microcomputer-based boiler monitoring system and software design method on a Windows platform as well as the important role played by dynamic data exchange (DDE) and dynamic chain connection function base on a Windows platform. **Key words**: windows, boiler, microcomputer monitoring

可编程控制器在声能吹灰控制中的应用= **The Use of Programmable Controllers in Sonic-Energy Soot Blowing Control**[刊,中]/Zhang Rui, Jin Haifeng (Harbin No. 703 Research Institute)// Journal of Engineering for Thermal Energy & Power. -1998, 13(3). -218~220

Described is the technological process and control method involved in the use of programmable controllers for controlling sonic-energy soot blowing and the resulting energy-saving. The application of such programmable controllers in the above-mentioned area is not only proper but also cost-effective. **Key words**: programmable controllers, sonicenergy, soot removal, control

JKTH-1000DEH系统在 50 MW 汽轮机组上的应用= **The Use of JKTH-1000DEH System in a 50 MW**

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