热力工程

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造气炉渣与无烟煤混合燃料燃烧特性分析

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摘 要: 采用高温微量热天平对造气炉渣与无烟煤混合燃料进行了燃烧试验。得到造气炉渣与无烟煤不同混合比的 TG-DTG曲线, 分析了不同混合比对造气炉渣与无烟煤混合燃烧的影响, 得到造气炉渣与无烟煤混合燃烧的着火温度、燃烧特性指数。结果表明: 造气炉渣和无烟煤混合燃烧特性指数随着渣煤比的增大, 燃烧特性指数先减小、再增大、再减小。当渣煤比为 4∶6时, 燃烧特性指数最大, 渣煤比为 5∶5时, 燃烧特性指数仅次于渣煤比为 4∶6的情况。渣煤不掺混时, 燃烧特性指数很小; 当掺混时, 燃烧特性指数大得多。

关 键 词: 造气炉渣; 热重分析; 燃烧; 烧失量
中图分类号: TK227.1 文献标识码: A

引 言

化肥生产过程中, 造气炉排出的炉渣由于其发热值和挥发分比一般煤炭低、难于燃烧和利用, 通常将其作为废弃物排掉。这不仅浪费了大量的能源, 而且加重了对环境的污染。因为炉渣中含未燃尽的碳引起烧失量的超标, 又使炉渣无法用来制造建筑材料, 影响了对其进行综合利用。因此很有必要对造气炉渣进行回烧利用[1]。我国小氮肥企业众多, 对这些炉渣尤其是残碳含量及热值较高的炉渣, 如能采用燃渣锅炉加以综合利用, 必然为企业带来可观的经济效益, 同时, 还可减少炉渣对环境的污染。因此, 综合利用造气炉渣是一项既有利于小氮肥行业节能, 又有利于环境保护的技术。

1 试验研究

1.1 试验仪器

本试验采用上海精密科学仪器有限公司天平仪器厂生产的高温微量热天平 WRT-3P。测量温度范围: 室温 ~1 450 ℃(工作温度: 1 350 ℃); 升温速率: 0.1~40 ℃/min; 天平灵敏度: 1 μg; 样品容量: 最大试样质量是 2 g; 试验气氛: 均采用压缩空气。

试验所采用样品的粒径为 0~0.2 mm; 升温速率取 20 ℃/min; 载气流量: 120 mL/min。

1.2 实验样品

试验所采用样品为吉林省梅河口市海龙化肥厂造气炉渣 S1及生产该造气炉渣所使用的辽宁本溪的无烟煤 S2。燃料的工业分析数据如表 1所示。由表可知, 造气炉渣是一种挥发分低、灰分高、含碳低、热值很低的劣质燃料。造气炉渣与无烟煤混合比例及编号如表 2所示。

表 1 燃料的工业分析

样品	工业分析 /%				
	M_{ad}	V_{daf}	A_{ad}	FC_{ad}	$Q_{net,ar}$/kJ·kg^{-1}
S1	0.29	4.09	76.71	22.06	5 327
S2	1.49	5.87	14.66	78.93	28 918

表 2 造气炉渣与无烟煤混合比例及编号

编 号	渣∶煤
S2	0∶10
SC1	1∶9
SC2	2∶8
SC3	3∶7
SC4	4∶6
SC5	5∶5
SC6	6∶4
SC7	7∶3
SC8	8∶2
SC9	9∶1
S1	10∶0

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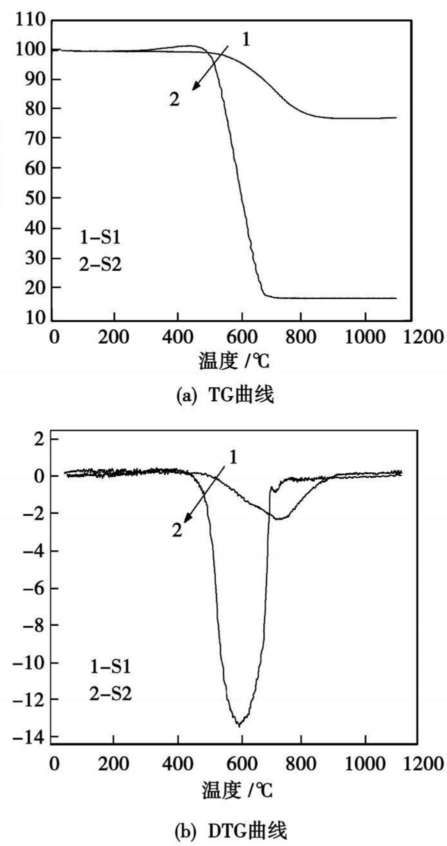
2 实验结果及分析

2.1 燃烧过程

2.1.1 造气炉渣和无烟煤热重曲线比较

图 1为 S1与 S2的 TG和 DTG曲线。从 TG曲线中可以看出,从室温到 320 ℃左右, S1和 S2曲线几乎没有失重现象。主要是因为 S1与 S2所含的水分和挥发分比较低。 S1的 TG曲线很平滑;而 S2的 TG曲线很陡。结合 DTG曲线, S2的最大失重速率远远大于 S1。一方面是因为造气炉渣的含碳量只有 22%,远远小于无烟煤含炭量 78%。另一方面,造气炉渣是高灰分难燃的炉渣;造气炉渣燃烧过程中易在表面逐渐形成灰壳,灰分含量越高,灰壳越厚。灰壳的存在有碍于氧分子的扩散,使得灰壳内所包含的未燃尽碳粒表面的氧浓度降低;灰壳还增加了空气气氛与未燃尽碳粒之间的传热热阻,使得碳粒和空气气氛之间的温差增大,结果表现为燃烧反应速率比无烟煤小得多。



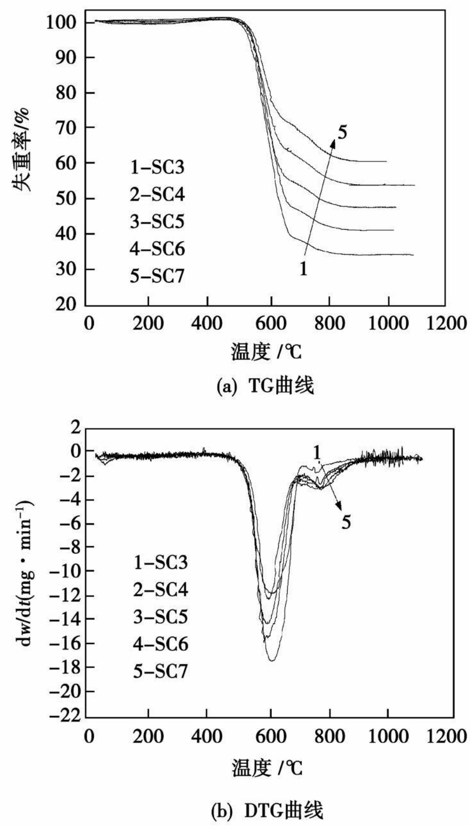
(a) TG曲线

(b) DTG曲线

图 1　S1和 S2的 TG、DTG曲线

2.1.2 不同混合比造气炉渣与无烟煤混合燃料的热重曲线

从图 2中曲线可以看出,造气炉渣与无烟煤混合燃料燃烧过程分为燃烧前期(550~680 ℃)、燃烧后期(680~850 ℃)两个阶段。随着无烟煤在混煤中所占比例的增大,混煤失重也随之增加,这主要是因为无烟煤中碳含量很大。燃烧前期主要是混合燃料中的碳的燃烧,反应比较剧烈,相对应的 DTG曲线上的最大失重速率比燃烧后期的最大失重率大,燃烧后期主要是无烟煤中的碳酸盐的分解和残碳的燃烧,碳酸盐的含量比较少。



(a) TG曲线

(b) DTG曲线

图 2　不同混合比的造气炉渣与无烟煤混合燃料的 TG、DTG曲线

2.2 着火点的确定及燃烧特性参数

采用 TG-DTG法确定造气炉渣与煤混合燃料的着火温度。其步骤是:在 DTG曲线上,过峰值点 A作垂线与 TG曲线交于一点 B,过 B点作 TG曲线的切线,该切线与失重开始时平行线的交点 C所对应的温度定义为着火温度[2],如图 3所示。

用 TG-DTG法确定造气炉渣与无烟煤混合燃料在不同混合比时的着火温度,如图 4所示。造气炉渣的着火温度为 612 ℃,无烟煤的着火温度为 544 ℃。造气炉渣与无烟煤的混合燃料着火温度比较接

近于无烟煤的着火温度,随着渣煤比增大,混煤的着火温度变化不大。可见,混合比对混煤的着火温度影响不大,混煤着火温度主要取决于无烟煤。

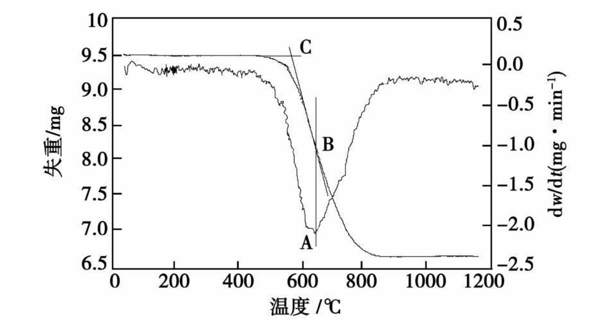


图 3　TG-DTG法确定造气炉渣的着火温度

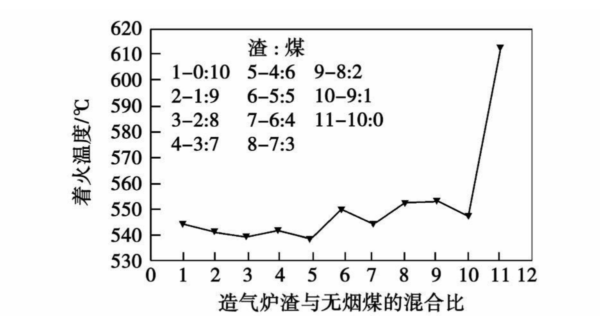


图 4　造气炉渣与无烟煤不同混合比的着火温度

2.3　燃烧特性指数 S

为了全面评价混合燃料的燃烧情况,引用燃烧特性指数对燃烧进行描述[3]

$$S=\frac{(dw/dt)_{max}\cdot(dw/dt)_{mean}}{t_i^2\cdot t_h}\qquad(1)$$

式中:$(dw/dt)_{max}$—最大燃烧速度, mg/min; $(dw/dt)_{mean}$—平均燃烧速度, mg/min; t_h—燃尽温度,℃; t_i—着火温度,℃。

燃烧特性指数 S是造气炉渣着火和燃尽的综合特性指标, S值越大,表明造气炉渣燃尽越快,燃烧特性越好。造气炉渣与煤混合燃料的燃烧特性指数 S如表 3所示。造气炉渣和煤混合燃料的燃烧特性指数随着渣煤比的增大,燃烧特性指数先减小、再增大、再减小。当渣煤比达到 4∶6时,燃烧特性指数最大,说明更有利于燃烧。当渣煤比达到 5∶5时,燃烧特性指数仅次于渣煤比 4∶6的情况。造气炉渣没有掺混时,燃烧特性指数很小, S1燃烧特性指数只有 0.549,当掺混时,燃烧特性指数大得多。

表 3　造气炉渣与无烟煤混合燃料的燃烧特性指数

样　品	S(× 10⁻⁸)
S2	12.6
SC1	9.96
SC2	9.66
SC3	7.74
SC4	15.5
SC5	12.6
SC6	9.54
SC7	7.41
SC8	5.33
SC9	2.15
S1	0.549

3　结　论

(1)造气炉渣是一种挥发分低、灰分高、含碳低、热值很低的劣质燃料。

(2)造气炉渣和无烟煤不掺混时,只有一个燃烧阶段。当掺混时,分为燃烧前期(550~680 ℃)和燃烧后期(680~850 ℃)两个阶段。

(3)造气炉渣的着火温度为 612 ℃,无烟煤的着火温度为 544 ℃。造气炉渣与无烟煤的混合燃料着火温度比较接近于无烟煤的着火温度,随着渣煤比增大,混煤的着火温度变化不大。可见,混合比对混煤的着火温度影响不大,混煤着火温度主要取决于无烟煤。

(4)造气炉渣和无烟煤混合燃料的燃烧特性指数 S随着渣煤比的增大,燃烧特性指数先减小、再增大、再减小。当渣煤比达到 4∶6时,燃烧特性指数 S最大,渣煤比为 5∶5时,燃烧特性指数 S仅次于渣煤比 4∶6的情况。造气炉渣没有掺混时,燃烧特性指数 S很小;当掺混时,燃烧特性指数 S大得多。所得数据如表 3所示。

参考文献:

[1]　李惠峰,刘建军,宋健林.改造循环流化床锅炉掺烧造气炉渣[J].节能技术, 1999, 17(3): 46-47.

[2]　聂其红,孙绍增,李争起.褐煤混煤燃烧特征的热重分析法研究[J].燃烧科学与技术, 2001, 7(1): 72-76.

[3]　王文选,王凤君,李　鹏.石油焦与煤混合燃料热重分析研究[J].燃料化学学报, 2004, 32(5): 522-525.

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overall dimensions of the combustor and the opening hole dimensions of the flame tube were determined. On this basis, a performance test of the combustor was conducted to a certain extent. The test and application results show that the combustor thus designed features a safe and reliable operation, a simple structure, as well as a high space utilization rate, a quick temperature rise speed and a clean exhaust gas. In the whole operation range, the combustion efficiency can reach 0.95 ~0.97 and the non-uniformity of the temperature field at the outlet is lower than 0.09, thus meeting the design requirements. Key words: gas turbine, high temperature rise, evaporation type, combustor

余热电站热力系统建模及蒸汽参数优化 = Modeling and Steam Parameter Optimization for the Thermodynamic System of a Waste Heat Power Plant[刊, 汉] / ZHAO Bin, XU Hong, ZHANG Cai-juan (Education Ministry Key Laboratory on Power Plant Equipment Condition Monitoring and Control, North China University of Electric Power, Beijing, China, Post Code: 102206), LU Xiao-wen (Hebei Provincial Key Laboratory on Modern Metallurgical Technologies, Hebei University of Science and Technology, Tangshan, China, Post Code: 063009) // Journal of Engineering for Thermal Energy & Power. — 2010, 25(4). —389 ~393

The choice of a thermodynamic system and its steam parameters is the most important basic work for designing a waste heat power plant. With the dual pressure system in a sintering waste heat power plant in Jinan Iron and Steel Works serving as an example, established was a model for calculating a thermodynamic system and optimizing its steam pressures with a maximum net power output serving as the target function. In addition, a program was designed and the correctness of the model was verified through calculations. The main factors influencing the optimization of the main steam pressure were analyzed, and the law governing the change of net power output with the main steam pressure was studied. The research results show that the optimum main steam pressure of a case calculation is 2.2 MPa, 0.14 MPa higher than the main steam design pressure of the power plant. The research findings can offer a relatively scientific basis for the optimized design and operation of low pressure waste heat power plants. Key words: waste heat power plant, thermodynamic system, mathematical model, program computation, main steam pressure optimization

Ω型惯性气液分离器性能研究 = Performance Study of a Ω Type Inertia Gas-liquid Separator[刊, 汉] / LUAN Yi-gang, SUN Hai-ou, WANG Song, et al (College of Power and Energy Source Engineering, Harbin Engineering University, Harbin, China, Post Code: 150001) // Journal of Engineering for Thermal Energy & Power. — 2010, 25(4). —394 ~398

With the help of a numerical simulation method, predicted was the status of the flow field inside a Ω type gas-liquid separator. In the calculation, the two-dimensional Reynolds time-averaged N— S equation was adopted, and the standard model has been used as the turbulent flow model to obtain and understand the distribution characteristics of the flow field inside the separator. Moreover, the performance of the separator with different clearances was studied and a model was fabricated to conduct a test in a wind tunnel. The theoretical calculation results were verified, and the resistance and efficiency characteristics of the separator, obtained. It has been found that the separator has a relatively high gas-liquid separation efficiency and the blade spacing exercises a very big influence on the separation efficiency. When the Ω type blade spacing is 18.2 mm, the average separation efficiency can reach over 90%. Key words: Ω type gas-liquid separator, numerical simulation, model test, drag force, separation efficiency

造气炉渣与无烟煤混合燃料燃烧特性分析 = Analysis of Combustion Characteristics of a Gas Production Slag and Anthracite Mixed Fuel[刊, 汉] / GAO Yu-fen, WANG Peng, LI Hong-jun (Engineering Project Installation Team, Department of Combined Service Forces, Shenyang Military Region, Liaoyuan, China, Post Code:

136300)// Journal of Engineering for Thermal Energy & Power. —2010, 25(4). —399~401

A combustion test was performed of a gas production slag and anthracite mixed fuel by using a high temperature trace thermal scale. TG (thermogravimetric) and DTG (derivative thermogravimetric) curves at different mixing ratios of the gas production slag and anthracite were obtained and the influence of different mixing ratios on the mixed combustion of the gas production slag and anthracite was analyzed with the ignition temperatures and combustion characteristic indexes of the combustion of the mixed fuel being acquired. The research results show that the combustion characteristic indexes of the mixed combustion of the mixed fuel will first decrease, then increase and finally decrease with an increase of the slag-coal ratio. When the slag/coal ratio is 4:6, the combustion characteristic index will reach its maximal value. When the slag/coal ratio is 5:5, the combustion characteristic index will be only inferior to that of the slag/coal ratio being 4:6. When the slag and coal are not mixed and diluted, the combustion characteristic index will be very small. When the slag and coal are mixed and diluted, the combustion characteristic index will be much greater. Key words: coal-gas production slag, thermogravimetric analysis, combustion, loss-on-ignition

对火电厂循环冷却水浓缩倍率的分析研究 = Analysis and Study of the Concentration Rate of the Circulating Cooling Water in a Thermal Power Plant[刊,汉] / WANG Rong, SHEN Bing-yun, LIU Wen-chao (College of Energy Source and Power Engineering, Inner Mongolia Polytechnic University, Huhhot, China, Post Code: 010051)// Journal of Engineering for Thermal Energy & Power. —2010, 25(4). —402~405

When the circulating cooling water system of a thermal power plant in Inner Mongolia was in actual operation, its concentration rate would be only 1.9. As a result, a chemical agent replacement test was performed. When a chemical agent sifting test was being performed, a static simulation test was first performed of two kinds of chemical agent. It has been determined that when the dosages of the two chemical agents are 10 mg/L, the fouling resistance effectiveness will attain its best. Through a dynamic simulation test, it has been verified that the fouling-resistance etching-retarding performance of JD~211A chemical agent is superior to that of JD~211B chemical agent. When no acid is added, the safe concentration rate can reach 2.5. Therefore, to use JD~211A chemical agent can save a large amount of makeup water. Finally, the cost effectiveness by replacing the chemical agent was calculated. It has been verified that to enhance the concentration rate can bring about an economic benefit of more than RMB 1.24 million yuan each year to an enterprise. Key words: circulating and cooling water, concentration rate, steam condenser

四角切圆煤粉锅炉燃烧工况评判方法研究 = Study of Methods for Evaluating and Judging the Combustion Conditions of a Tangentially Corner-fired Boiler[刊,汉] / LI Jun, YAN Wei-ping (Education Ministry Key Laboratory on Power Plant Equipment Condition Monitoring and Control, North China University of Electric Power, Baoding, China, Post Code: 071003), LI Chun (Dispatchment Station, Xinzhou Power Supply Company, Xinzhou, China, Post Code: 036000)// Journal of Engineering for Thermal Energy & Power. —2010, 25(4). —406~409

In the light of the actual situation that the currently available methods for evaluating and judging the combustion conditions of a boiler are insufficient and in combination with the actual operating conditions of a 300 MW tangentially corner-fired pulverized coal boiler, a main component analytic method was used to extract correlative factors after a relatively strong correlation has been confirmed being present among various influencing factors. Subsequently, the factors were weighted as per their mean square deviation contribution rates and added up to calculate the scores. Factor variables were used to replace the original variables for evaluating the magnitudes of the roles played by various influencing factors. The comprehensive evaluation results thus obtained can correctly reflect the actual