

燃煤电站锅炉塌灰落渣引发灭火的爆燃机理分析

(华北电力大学) 阎维平
(华北电力科学研究院) 高宝桐

[摘要] 对于某些燃用高挥发份、高灰份且易结渣煤的电站锅炉,在正常运行中,频繁发生因炉膛上部较大体积的掉渣或塌灰而造成锅炉瞬间灭火事故,在排除其它可能的因素外,提出了炉膛下部发生可燃气体爆燃的推测,并结合锅炉的实际运行工况对发生爆燃引发灭火的机理进行了初步分析。能够比较合理地解释灭火的原因,并具有新颖的理论价值,对采取相应的解决措施有比较重要的参考价值。

关键词: 电站锅炉; 爆燃; 机理分析

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1 前言

对华北地区某些燃煤粉电站锅炉实际运行情况的调查研究表明,因掉渣或塌灰而造成锅炉瞬间灭火事故较为常见。譬如,北京某热电厂的四台国产200 MW 燃煤机组,四角切圆燃烧,固态排渣,燃用大同混煤。长期以来,该厂锅炉在正常运行的工况下频繁发生锅炉塌灰落渣灭火事故,每年累计达30余次。又如,山西某电厂的两台500 MW 塔型布置燃高灰份烟煤的锅炉,经常发生炉膛顶部受热面塌灰造成灭火的事故。类似事故还发生在河北南网某电厂的几台200 MW 燃煤锅炉。

据调查分析,发生此类锅炉灭火具有以下共同的特点:

1.1 燃用高灰份、易结渣且挥发份较高的煤种;无吹灰和清渣装置或不能正常运行,使灰渣在炉膛上部发生累积。

1.2 因掉渣或塌灰而造成的灭火大部分发生在锅炉满负荷运行且燃烧正常的工况下,无任何先兆;均为塌灰落渣对燃烧过程突然造成某种瞬间的强烈

扰动而使锅炉灭火保护突然动作导致锅炉自动甩负荷。

1.3 据对北京某热电厂200 MW 锅炉发生塌灰落渣灭火时的数据记录和运行人员的观察,锅炉灭火瞬间总伴随着炉膛压力反正,炉膛正压的数值大致为1000~1500 Pa。

由于此类锅炉灭火均发生在锅炉机组正常运行的工况下,极具偶然性,运行人员准备不足,因此,严重地影响了机组安全稳定运行与经济性,是某些电厂电力生产中一个急待解决的重大问题。所以,深入研究锅炉塌灰落渣灭火的原因并提出行之有效的技术措施是十分必要的。

近年来,有关科技人员曾对燃煤锅炉频繁发生塌灰落渣灭火的各种可能的原因进行过推测和分析。

譬如,一种观点认为,塌灰落渣在自炉膛上部下落的过程中瞬间切断火焰并遮挡灭火保护器的火焰探头,而使灭火保护动作,造成锅炉灭火。但是,锅炉灭火保护通常设定至少两个以上火焰探测装置同时测到灭火的情况下才导致保护动作,而同时在两个角以上的喷燃器根部发生塌灰落渣的概率之小与锅炉频繁灭火的现实不符合。

另一观点认为高温灰渣落入炉底冷灰斗内的渣池中,造成水急剧汽化上升而吹灭燃烧器的火焰,导致锅炉灭火。但是,水的汽化需要一定的过程和时间,并且瞬间强度也不会大到吹灭火焰而使锅炉灭火的程度。也有观点认为,灰渣下落过程中造成气流的强烈扰动而引发灭火。类似的各种推测均不能从灭火机理得出符合实际情况的合理解释,也未能被现场的工程技术人员所接受。所以,一直未能提出切实可行的解决措施。

2 锅炉塌灰落渣引发爆燃造成灭火的推测与机理分析

在锅炉运行中,沿整个炉膛的高度,不仅温度、而且烟气成份的分布均存在较大的变化。譬如,对氧气的含量来说,炉膛上部的氧量较高,一般达5%~6%左右或更高,而炉膛的下部氧含量较低,特别是在燃烧器以下区域,氧气的含量很小甚至为零。对可燃气体(如:CO,碳氢化合物等煤的热解产物)来说,在炉膛上部,由于氧量比较充分、混合强烈且温度高,所以,可燃气体迅速燃尽,到炉膛出口处可燃气体的含量应为零。但是,在炉膛下部的燃烧器以下区域,由于煤粉颗粒不同程度的沉积(由于下二次风配风不合理或煤粉颗粒粒度分布不均匀等原因)滞留以及合适的温度环境,因而发生煤粉的热解并释放出大量的挥发份。由于此区域不仅缺氧、混合较差而且温度较低,可燃气体的消耗较慢,在释放和消耗可燃气体达到一定的平衡后,其中的可燃性气体将在此区域形成较高的浓度氛围。

当锅炉的上部发生塌灰落渣时,将经历高温灰渣块从炉膛上部落至炉底的过程,在这一过程中,灰渣块的本身与其携带的气流尾迹(通常为其体积的2到3倍)将携带炉膛上部较高氧气浓度的烟气随之一起落至炉膛下部可燃气体浓度较高的区域。如果灰渣块体积较大,其热容量和所携带的氧气含量亦较大,此时,炉膛下部会出现满足可燃气

体混合物发生燃烧的必要条件(合适的可燃气体浓度、氧气浓度及较高的温度)。由于可燃气体混合物的湍流火焰传播速度极快,燃烧会在瞬间完成,不同程度地造成气体体积的急剧膨胀和快速扩散的压力波,取决于爆燃的强度,可能瞬间移位或吹灭煤粉气流的火焰(特别是下层燃烧器的火焰),导致灭火保护动作。该爆燃过程可能不至于造成爆炸声响或对炉体破坏,但造成对火焰的扰动而引发灭火是完全可能的。

3 结论

(1) 由于锅炉现场试验测试条件的限制,观测塌灰落渣的过程和检测炉膛下部的气体成份含量是十分困难的。但是,在条件许可的情况下,有必要测定炉内烟气沿炉膛高度的氧气含量和可燃气体(CO,碳氢化合物等)的浓度;同时长期实时在线监测炉膛内压力变化情况,捕捉几次灭火时压力实时瞬间变化的数据。

(2) 采取有效的锅炉吹灰和清渣技术措施,对避免塌灰落渣的发生是十分必要的。譬如山西某电厂在解决了炉顶受热面吹灰后,几乎不再发生由于塌灰而引发灭火的事故。

(3) 采取合理的配风技术措施,强化炉膛下部的扰动和混合,提供必要的氧气及减少煤粉沉积,以避免可燃气体的聚集。

(静 编)

石化工业应用的工业汽轮机

据“Turbomachinery International”1999年3—4月号报道,美国Diesser-Rand公司的能源系统分部在与其用户的研讨会上推出该公司的能源系统分部在与其用户的研讨会上推出该公司最新颖驱动离心式压缩机的汽轮机驱动装置,这些压缩机用来压缩用作制造甲醇和氨的原材料的合成气。该研探会包括参观该公司位于纽约州威尔士维莱市的工厂,这时新一代的驱动合成气压缩机的汽轮机装置正在试验中。

合成气服务的汽轮机通常是单汽缸结构。氨过程要求的转速范围为12000—14000r/min,平均输出功率为15MW,抽汽压力约为28.7kPag。对于甲醇过程,上述要求分别为8500—10000r/min,40MW和19.2kPag。通常汽轮机将在转子的每一端驱动一台压缩机。

该汽轮机是具有水平中分面的单缸结构,7个冲动式级,二级高压,五级低压。整圈围带的第1—5级动叶是不锈钢制造的,自由支承的第6—7级动叶是由钛合金制造的,静叶是由400系列不锈钢制造的。

转子是实心单件锻件。进口和出口由Kingsbury低损失前缘开槽的可倾瓦轴颈轴承支承。位于高压端的止推轴承是Kingsbury低损失前缘开槽式轴承。额定工作转速范围是8140到10617r/min。

汽缸的高压段是低合金铸钢制造的铸件,低压段是碳钢铸件。

汽轮机将驱动位于其每一端的一台DATUM多级离心式压缩机。每台压缩机各接受汽轮机输出的一半功率。二台压缩机均安装在汽轮机底板上。

由锅炉供给的进口蒸汽条件是74.2kPa压力和500℃温度。第二个高压级后压力为19.2kPag的抽汽用于过程。

该汽轮机外形尺寸为3430mm长×3050mm宽×3730mm高。总重量为40823kg。

(思娟 供稿)

化学水处理计算机监控系统=A Computer-based Monitoring System for a Chemical Water Treatment System [刊, 中] /Shi Jianping, Yun Ruitian (Harbin No. 703 Research Institute) //Journal of Engineering for Thermal Energy &Power. -1999, 14 (4). -

A brief description is given of a chemical water treatment system. The concrete implementation of a control system for the chemical water treatment is expounded in detail with some difficulties identified and their methods of resolution presented. **Key words:** chemical water treatment, computer-based control system

加热法测量湿度探针取样过程的数值模拟分析=Numerical Simulation and Analysis of the Sampling Process of Wetness Measurement Probe through the Use of a Heating Method [刊, 中] /Li Yanfeng, Wang Xinjun, Xu Tingxiang (Xi'an Jiaotong University) //Journal of Engineering for Thermal Energy &Power. -1999, 14 (4). -

A mathematical model has been set up for a region near the inlet of a heating method-based wetness measurement probe. By way of a numerical simulation an analysis was conducted of the measurement error due to a non-isokinetic sampling and an axial deviation in the steam flow direction. The results of such an analysis provide useful data for the design and engineering application of the heating method-based wetness measurement probes. **Key words:** isokinetic sampling, flow field simulation, porosity

SO₂ 气体的辐射特性=Radioactive Properties of SO₂ Gas [刊, 中] /Liu Linhua, Yan Youcai (Harbin Institute of Technology) //Journal of Engineering for Thermal Energy &Power. -1999, 14 (4). -

On the basis of the spectrum data given in HITRAN database proposed is a line-by-line integral method for the calculation of SO₂ gas spectrum radioactive properties. Relevant charts are given for calculating SO₂ emissivity within the range of the following parameters: total pressure 0. 1 MPa, temperature 200 ~2000 K, pressure range 0. 00006 ~ 1 MPa. **Key words:** radioactive property, SO₂ gas, line-by-line calculation method

燃用宽筛分煤循环流化床锅炉燃烧模拟计算=Numerical Simulation of the Combustion in a Large Mesh Size Coal-Fired Circulating Fluidized Bed Boiler [刊, 中] /Liu Wentie Li Bingxi, Zhao Guangbo, et al (Harbin Institute of Technology) //Journal of Engineering for Thermal Energy &Power. -1999, 14 (4). -

Described in this paper is a mathematical model of large mesh-size coal particle combustion and desulfurization reaction in a circulating fluidized bed boiler furnace. The model has taken into account such specific features as a dense-phase zone involving high particle size concentration at the furnace lower portion and a dilute-phase zone at the furnace upper portion dominated by low particle size concentration. As a result of simulation computations obtained are the flue gas temperature, heat flux and the axial distribution of various gas components (O₂, C₂O, CO, H₂O and S₂O). The trend as indicated by the results of the simulation calculation is found to be rational. **Key words:** circulating fluidized bed boiler, numerical simulation calculation, combustion

论 DZF 循环是又一个第二类永动机=DZF Cycle as a yet Another Perpetual Motion Machine of the Second Category [刊, 中] /Chou Qiaoli, Xu Guang, Li Xinqiu (Nuclear Science Research Institute Under the Qinghua University) //Journal of Engineering for Thermal Energy &Power. -1999, 14 (4). -

The thermodynamic analysis of an invention patent to be examined and evaluated for official publication ([刊, 中 21] application No. 96111171. 2 and entitled "Refrigeration-based electrical power generation by utilizing a low boiling point working medium and a refrigeration power station") has shown that this pertains to yet another doomed-to-fail perpetual motion machine of the second category due to its infraction of the second law of thermodynamics and an impossibility of its independent existence. **Key words:** second law of thermodynamics, perpetual motion machine of the second category, refrigeration cycle, thermodynamic cycle

燃煤电站锅炉塌灰落渣引发灭火的爆燃机理分析=An Analysis of the Mechanism of Flame Failure Triggered

by a Sudden Collapsing of Sizable Slag Blocks in Coal-fired Utility Boilers [刊, 中] /Yan Weiping, et al (North China Electrical Power University) //Journal of Engineering for Thermal Energy &Power. -1999, 14 (4). -

During the normal operation of utility boilers firing high-volatile, high-ash and slagging-prone coals there often occurs a sudden flameout triggered by the collapsing of sizable slag blocks at the upper portion of the boiler furnace. After ruling out other possible factors the authors suggest that there is a possibility of flammable gas explosion burning at the lower portion of the furnace. In connection with the actual operating conditions of a boiler a preliminary analysis has been conducted of the mechanism of flameout sparked by gas explosion burning. This analysis makes it possible to identify the cause of flame-out in a relatively rational way. From a new theoretical perspective a sound basis is provided for adopting proper measures to cope with the flameout problems. **Key words:** utility boiler, flammable gas explosion, analysis

燃机烧重油常见问题的分析与处理 = Analysis and Resolution of Commonly Occurring Problems Encountered by Heavy Oil-fired Gas Turbines [刊, 中] /Zhang Xiaohong, Lai Weicheng (Shenzhen Nanshan Cogeneration Co. Ltd.) //Journal of Engineering for Thermal Energy &Power. -1999, 14 (4). -

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避免端轴封无名磨擦事故 = Avoidance of Indefinable Friction-related Failures in End Shaft Seals [刊, 中] /Wang Jinming (Huaibei Thermal Power Plant) //Journal of Engineering for Thermal Energy &Power. -1999, 14 (4). -

催化裂化余热炉应用脉冲燃气吹灰器 = The Application of Impulse Gas-based Soot Blowers on a Catalytic Cracking Heat Recovery Boiler [刊, 中] /Deng Yunshan (Qian Guo Rendering Plant) //Journal of Engineering for Thermal Energy &Power. -1999, 14 (4). -

凝结水回收器的研制与应用 = Development and Application of Condensate Recovery Devices [刊, 中] /Li Shusheng (Beijing Water-condense Power Technologies Co. Ltd.) //Journal of Engineering for Thermal Energy &Power. -1999, 14 (4). -