燃料化学学报
JOURNAL OF FUEL CHEMISTRY AND TECHNOLOGY
ISSN 0253-2409
CN 14-1140/TQ

燃料化学学报 » 2014, Vol. 42 » Issue (04): 408-413 DOI:

增压O_2/CO_2气氛下煤燃烧特性实验研究

胡海华, 段伦博, 陈晓平, 韩冬, 潘玄

东南大学能源与环境学院 能源热转换及其过程测控教育部重点实验室, 江苏 南京 210096

Experimental investigation on pressurized coal combustion characteristics under O_2/CO_2 atmosphere

HU Hai-hua, DUAN Lun-bo, CHEN Xiao-ping, HAN Dong, PAN Xuan

Key Laboratory of Energy Thermal Conversion and Control of Ministry of Education, School of Energy and Environment, Southeast University, Nanjing 210096, China

摘要 增压O_2/CO_2燃烧是一种可高效分离回收CO_2的新兴燃烧技术，其燃烧机理与常压空气、常压O_2/CO_2燃烧存在较大差异。在加压热重分析仪上研究了增压条件下总压、氧浓度、气氛及粒径等反应参数对美国烟煤和淮北无烟煤燃烧特性的影响，确定了煤的着火温度，并对其进行燃烧动力学分析。结果表明，增压O_2/CO_2气氛下，随着压力或氧浓度的增加，DTG曲线向低温区移动，煤样整体燃烧速率加快。压力提升、氧浓度增加及煤粉细化均可改善O_2/CO_2气氛下煤样的着火特性。常压O_2/CO_2气氛下煤粉燃烧基本属于一级反应；增压O_2/CO_2气氛下，低温区属于0.5级反应，而高温区属于1.5级反应。

关键词： O_2/CO_2 燃烧特性 压力 热重分析 动力学

Abstract: The pressurized O_2/CO_2 combustion is a potential technique, which makes CO_2 separation and recovery more efficient. However, it has a notably different mechanism from the air combustion and the O_2/CO_2 combustion under atmospheric pressure. The combustion characteristics of an American bituminous coal and a Huaibei anthracite coal under O_2/CO_2 atmosphere were studied employing the thermo-gravimetric analyzer at various pressures (p=0.1~1.5 MPa). The influences of pressure, oxygen concentration, atmosphere and particle size on the coal combustion characteristics were inspected, and the ignition temperature was obtained. Also, the combustion kinetic parameters were calculated. The results indicate that as the total pressure or oxygen concentration increases, DTG curves move to the low temperature zone and the overall combustion rate of coal samples is accelerated under pressurized O_2/CO_2 atmosphere. The ignition characteristics of pulverized coal could be improved through the pressure enhancement, the increase of oxygen concentration and the reduction of particle size. The pulverized coal combustion under atmospheric pressure is basically a first order reaction. For pressurized oxy-fuel combustion, the reaction order is 0.5 under the low temperature zone, while the reaction order becomes 1.5 under the high temperature zone.

Key words: O_2/CO_2 combustion characteristics pressure thermo-gravimetric analysis kinetics

收稿日期: 2013-10-09;

基金资助:

国家重点基础研究发展规划（973计划，2011CB707301）。

通讯作者: 段伦博（1982-），男，Tel：025-83790147，Fax：025-83790147，E-mail：duanlunbo@seu.edu.cn。

E-mail: duanlunbo@seu.edu.cn

引用本文:

胡海华,段伦博,陈晓平等. 增压O_2/CO_2气氛下煤燃烧特性实验研究[J]. 燃料化学学报, 2014, 42(04): 408-413.

HU Hai-hua,DUAN Lun-bo,CHEN Xiao-ping et al. Experimental investigation on pressurized coal combustion characteristics under O_2/CO_2 atmosphere [J]. J Fuel Chem Technol, 2014, 42(04): 408-413.

链接本文:

http://rlhxxb.sxicc.ac.cn/CN/ 或 http://rlhxxb.sxicc.ac.cn/CN/Y2014/V42/I04/408

[1] CHEN L, YONG S Z, GHONIEM. Oxy-fuel combustion of pulverized coal: Characterization, fundamentals, stabilization and CFD modeling [J]. Prog Energy Combust Sci, 2012, 38(2): 156-214.

[2] TOFTEGAARD M B, JACOB B, JENSEN P A, GLARBORG P, JENSEN A D. Oxy-fuel combustion of solid fuels[J]. Prog Energy Combust Sci, 2010, 36(5): 581-625.

[3] WANG Y, ZHAO Y, ZHANG J Y, ZHENG C G. Technical-economic evaluation of O_2/CO_2 recycle combustion power plant based on life-cycle[J]. Sci China Technol Sci, 2010, 53(12): 3284-3293.

[4] 孔红兵, 柳朝晖, 陈胜, 张倩, 郑楚光. 600MW富氧燃烧系统过程建模及优化[J]. 中国电机工程学报, 2012, 32(2): 53-60. (KONG Hong-bing, LIU Chao-hui, CHEN Sheng, ZHANG Qian, ZHENG Chu-guang. Process simulation and optimization of a 600MW O_2/CO_2 power plant[J]. Proceedings of the CSEE, 2012, 32(2): 53-60.)

[5] 曹阳, 林鹏云, 罗永浩, 陈楠, 肖琨, 陈飞, 郑路. 燃煤电站锅炉富氧燃烧技术研究进展综述[J]. 锅炉技术, 2012, 43(1): 45-48. (CAO Yang, LIN Peng-yun, LUO Yong-hao, CHEN Nan, XIAO Kun, CHEN Fei, ZHENG Lu. Research process of oxy-fuel combustion for coal-fired utility boilers[J]. Boiler Technology, 2012, 43(1): 45-48.)

[6] 阎维平. 洁净煤发电技术的发展前景分析[J]. 华北电力大学学报(自然科学版), 2008, 35(6): 67-71. (YAN Wei-ping. Reviews on prospects of clean coal power generation technology[J]. Journal of North China Electric Power University, 2008, 35(6): 67-71.)

[7] FASSBENDER A. Pressurized oxy-fuel combustion for multi-pollutant capture[C]//The Proceedings of the 30th International Technical Conference on Coal Utilization and Fuel Systems. Coal Technology Association, 2005.

[8] HONG J, CHAUDHRY G, BRISSON J G, FIELD R, GAZZINO M. Analysis of oxy-fuel combustion power cycle utilizing a pressurized coal combustor[J]. Energy, 2009, 34(9): 1332-1340.

[9] 阎维平, 董静兰, 任海锋. 增压富氧燃烧与捕集CO_2电站的经济性分析[J]. 动力工程学报, 2012, 32(9): 712-717. (YAN Wei-ping, DONG Jing-lan, REN Hai-feng. Economic analysis of the power station with pressurized oxy-fuel combustion and CO_2 capture[J]. Journal of Chinese Society of Power Engineering, 2012, 32(9): 712-717.)

[10] 段伦博. O_2/CO_2气氛下循环流化床煤燃烧及SO_2/NO排放特性研究[D]. 南京: 东南大学, 2010. (DUAN Lun-bo. Coal combustion and SO_2/NO emission characteristics in circulated fluidized bed combustion under O_2/CO_2 atmosphere[D]. Nanjing: Southeast University, 2010.)

[11] 雷鸣, 王春波, 阎维平, 王松岭. 大同烟煤增压富氧燃烧的热重实验研究[J]. 中国电机工程学报, 2012, 32(5): 21-26. (LEI Ming, WANG Chun-bo, YAN Wei-ping, WANG Song-ling. Thermo-gravimetric research on the pressurized oxy-fuel combustion of Datong bituminous coal[J]. Proceedings of the CSEE, 2012, 32(5): 21-26.)

[12] SAASTAMOINEN J J, AHO M J, HAMALAINEN J P. Pressurized pulverized fuel combustion in different concentrations of oxygen and carbon dioxide[J]. Energy Fuels, 1996, 10(1): 121-133.

[13] MACNEIL S, BASU P. Effect of pressure on char combustion in a pressurized circulating fluidized bed boiler[J]. Fuel, 1998, 77(4): 269-275.

[14] LI Q Z, ZHAO C S, CHEN X P, WU W F, LI Y J. Comparison of pulverized coal combustion in air and in O_2/CO_2 mixtures by thermo-gravimetric analysis[J]. J Anal Appl Pyrolysis, 2009, 85(1/2): 521-528.

[15] 杨海平, 陈汉平, 鞠付栋, 王静, 王贤华, 张世红. 典型煤种加压热解与气化实验研究[J]. 中国电机工程学报, 2007, 27(26): 18-22. (YANG Hai-ping, CHEN Han-ping, JU Fu-dong, WANG Jing, WANG Xian-hua, ZHANG Shi-hong. Study on pressurized pyrolysis and gasification of Chinese typical coal samples[J]. Proceedings of the CSEE, 2007, 27(26): 18-22.)

[16] 孙学信. 燃煤锅炉燃烧试验技术与方法[M]. 北京: 中国电力出版社, 2002. (SUN Xue-xin. Technology and method of combustion experiments of pulverized coal furnace[M]. Beijing: China Electric Power Press, 2002.)

[17] SUN C L, ZHANG M Y. Ignition of coal particles at high pressure in a thermogravimetric analyzer[J]. Combust Flame, 1998, 115(1/2): 267-274.

[18] 谷小兵. 半焦加压燃烧特性研究[D]. 南京: 东南大学, 2003. (GU Xiao-bing. Investigation on the combustion characteristics of semi-coke at elevated pressure[D]. Nanjing: Southeast University, 2003.)

[19] 李庆钊, 赵长遂. O_2/CO_2气氛煤粉燃烧特性试验研究[J]. 中国电机工程学报, 2007, 27(35): 39-43. (LI Qing-zhao, ZHAO Chang-sui. Investigation on the characteristics of pulverized coal combustion in O_2/CO_2 mixtures[J]. Proceedings of the CSEE, 2007, 27(35): 39-43.)

[20] 陈镜泓, 李传儒. 热分析方法及应用[M]. 北京: 科学出版社, 1985: 120-136. (CHEN Jing-hong, LI Chuan-ru. Thermal analysis method and application[M]. Beijing: Science Press, 1985: 120-136.)

[21] 段伦博, 赵长遂, 李庆钊, 李英杰, 陈晓平. O_2/CO_2气氛下煤焦燃烧实验研究[J]. 燃料化学学报, 2009, 37(6): 654-658. (DUAN Lun-bo, ZHAO Chang-sui, LI Qing-zhao, LI Ying-jie, CHEN Xiao-ping. Experimental investigation on coal and char combustion in O_2/CO_2 mixture[J]. Journal of Fuel Chemistry and Technology, 2009, 37(6): 654-658.)

[22] 李庆钊, 赵长遂, 武卫芳, 李英杰, 段伦博. O_2/CO_2气氛下煤粉燃烧反应动力学的试验研究[J]. 动力工程, 2008, 28(3): 447-452. (LI Qing-zhao, ZHAO Chang-sui, WU Wei-fang, LI Ying-jie, DUAN Lun-bo. Kinetics of pulverized coal combustion under mixed O_2/CO_2 atmospheres[J]. Journal of Power Engineering, 2008, 28(3): 447-452.)

[1] 赵煜, 马彦, 李婷, 薄晓, 王俊文, 李鹏, 钟丽萍, 孙彦平. 生物燃料电池处理生活污水同步产电特性研究[J]. 燃料化学学报, 2014, 42(04): 481-486.

[2] 李伟伟, 李克忠, 康守国, 郑岩, 张荣, 毕继诚. 煤催化气化中非均相反应动力学的研究[J]. 燃料化学学报, 2014, 42(03): 290-296.

[3] 陈菲菲, 刘庆敬, 孙学文, 许志明, 赵锁奇. 大港沥青对正戊烷溶剂中卟啉钒化合物的吸附动力学研究[J]. 燃料化学学报, 2014, 42(02): 193-199.

[4] 柏静儒, 李晓航, 张亮, 贾春霞, 王擎. 柳树河油页岩微波干燥及其对热解特性的影响[J]. 燃料化学学报, 2014, 42(01): 37-42.

[5] 武景丽, 陈天举, 罗希韬, 杨静, 王志奇, 吴晋沪, 孙立. 典型城市固体废弃物热解动力学机理研究[J]. 燃料化学学报, 2014, 42(01): 43-47.

[6] 景旭亮, 王志青, 张乾, 房倚天. 流化床气化炉半焦细粉的燃烧特性及其动力学研究[J]. 燃料化学学报, 2014, 42(01): 13-21.
[7] 韩奎华, 齐建荟, 李辉, 刘洪涛, 路春美. 木醋调质石灰石用于O_2/CO_2燃煤同时脱硫脱硝性能[J]. 燃料化学学报, 2013, 41(11): 1378-1383.
[8] 王西明, 王兴军, 陈凡敏, 刘海峰, 于广锁, 王辅臣. 水蒸气气氛煤中温催化气化动力学研究[J]. 燃料化学学报, 2013, 41(10): 1166-1172.
[9] 李国娜, 李春迎, 王渭娜, 沈文, 吕剑, 王文亮. 吸热型碳氢燃料正癸烷热裂解机理、热沉及产物分布的理论研究[J]. 燃料化学学报, 2013, 41(09): 1136-1145.
[10] 熊绍武, 张守玉, 吴巧美, 郭熙, 董爱霞, 陈川, 郑红俊, 邓文祥, 刘大海, 唐文蛟. 生物质炭燃烧特性与动力学分析[J]. 燃料化学学报, 2013, 41(08): 958-965.
[11] 屈成锐, 徐斌, 吴健, 刘建新, 王学涛. 流化床O_2/CO_2气氛下添加石灰石对燃煤$PM_{2.5}$的控制[J]. 燃料化学学报, 2013, 41(08): 1020-1024.
[12] 陈川, 张守玉, 刘大海, 郭熙, 董爱霞, 熊绍武, 施大钟, 吕俊复. 新疆高钠煤中钠的赋存形态及其对燃烧过程的影响[J]. 燃料化学学报, 2013, 41(07): 832-838.
[13] 帅超, 宾谊沅, 胡松, 向军, 孙路石, 苏胜, 许凯, 徐朝芬. 煤焦水蒸气气化动力学模型及参数敏感性研究[J]. 燃料化学学报, 2013, 41(05): 558-564.
[14] 熊志波, 郭东旭, 路春美, 张信莉. 铁铈复合氧化物催化剂SCR脱硝反应动力学研究[J]. 燃料化学学报, 2013, 41(04): 506-512.
[15] 相建华, 曾凡桂, 李彬, 张莉, 李美芬, 梁虎珍. 成庄无烟煤大分子结构模型及其分子模拟[J]. 燃料化学学报, 2013, 41(04): 391-399.