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国产 600 MW 超临界机组直流锅炉启动系统

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摘　要: 上海锅炉厂有限公司首次引进美国 ALSTOM 公司技术生产 600 MW 超临界直流锅炉, 超临界锅炉与亚临界锅炉在启动过程中有很大区别, 超临界锅炉在国内的现有运行机组中为数不多, 且大多数采用的是外置式汽水分离器。本文通过对该直流锅炉启动系统的结构特点的简要介绍, 阐述了 600 MW 锅炉启动系统的工作过程, 分析了锅炉启动系统中工况疏水的调整原则, 对同类型机组在调试和运行方面将有一定的借鉴作用。

关　键　词: 直流锅炉; 超临界参数; 启动系统

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1　超临界压力 600 MW 锅炉的整体布置

太仓港四期工程为 2×600 MW 燃煤汽轮发电机组, 锅炉采用超临界参数变压运行螺旋管圈直流炉, 单炉膛、一次中间再热、采用四角切圆燃烧方式、平衡通风、固态排渣、全钢悬吊结构Ⅱ型露天布置煤粉锅炉。

炉膛由膜式壁组成。从炉膛冷灰斗进口到标高 48 840 mm 处炉膛四周采用螺旋管圈, 在此上方为垂直管圈。炉膛上部布置有分隔屏过热器和后屏过热器, 水平烟道依次布置高温再热器和高温过热器, 尾部烟道布置有低温再热器和省煤器。

锅炉燃烧系统采用中速磨直吹式制粉系统。直流式燃烧器分 6 层布置于炉膛下部四角, 煤粉和空气从四角送入, 在炉膛中呈切圆方式燃烧。过热器汽温通过煤水比调节和两级喷水来控制。再热器汽温采用燃烧器摆动调节, 再热器进口连接管道上设置事故喷水。

整台锅炉炉前沿宽度方向垂直布置两个规格为 Φ812.3×104.8 的汽水分离器, 其长度为 19 900 mm。

该启动系统设置两级旁路系统, 该系统旁路的主要功能是实现快速启动和工质回收, 旁路采用液压控制方式。

2　600 MW 锅炉启动系统的主要特点

机组在启动时, 锅炉负荷低于最低直流负荷 35%B-MCR 时, 蒸发受热面出口的介质流经分离器进行汽水分离, 蒸汽通过分离器上部管接头进入炉顶过热器, 而水则通过两根内径为 Φ324 mm 疏水管道引至一个储水箱, 储水箱下方设有两根管道分别通至除氧器和大气式疏水扩容器, 每根管道上设有调节阀、截止阀、逆止阀及节流孔板等。可根据不同状况控制分离器水位, 并能够对工质和热量进行回收。在大气式疏水扩容器中, 蒸汽通过管道在炉顶上方排向大气; 水进入扩容器水箱内, 经疏水泵回送到凝汽器。至除氧器一路主要作用是利用启动初期蒸汽对除氧器进行加热, 改善蒸汽品质, 虽然经济性较明显, 但由于汽水分离器压力高, 对除氧器存在一定潜在威胁, 故一些机组有弃置不用的情况, 这样在启动初期除氧器的加热就只能由机组辅汽供给。

锅炉启动循环系统由汽水分离器、储水箱、大气式疏水扩容器和水位控制阀等组成。锅炉启动及低负荷运行阶段, 送至省煤器的给水途经水冷壁加热后, 进入汽水分离器, 在汽水分离器内分离成水和饱和蒸汽。在机组启动初期, 严重不合格的水经排污阀排至地沟, 随着启动过程的深入, 相对合格的水在汽水分离器储水箱水位控制阀的控制下, 经锅炉大气式疏水扩容器返至凝汽器以回收工质, 然后经过化学精处理装置处理后, 再通过给水系统送至炉内循环。当分离器内的水质参数达到要求后, 分离出来的含热合格水, 可经除氧器送入给水系统进行再循环, 从而减少热损失, 提高机组效率。

启动分离器汽水混合物入口的位置、角度和流速的选取均应有利于汽水分离, 汽和水的引出方向与汽水引入管的旋转方向相一致, 以减少阻力。分离器内设有阻水装置和消旋器。

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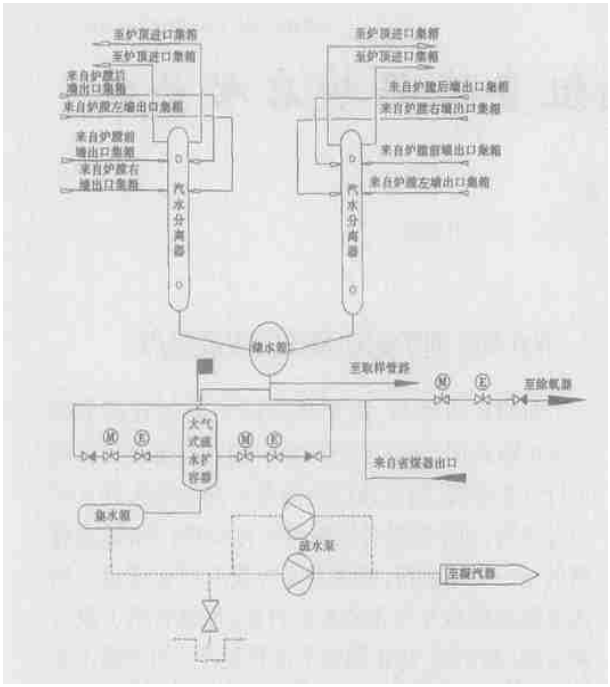

图 1 600 MW 超临界锅炉启动系统图

3 600 MW 锅炉启动系统的工作过程

3.1 点火启动时的工作过程

锅炉启动时,汽水分离器建立水位,汽压为零,点火后,锅水被加热并逐渐开始蒸发产生蒸汽,机组起压,压力由汽机旁路开度来维持和控制,水位由分离器排水阀控制,汽水分离器的高度可以满足水位的较大波动,其排水系统的阀门,在启动阶段依照程序根据水位及时投入自动调整。当机组启动并网后,锅炉达到最低直流运行工况 35%B-MCR 时,调节煤水比,使分离器的进水量逐渐减少,直至达到全饱和状态,水位消失,排水阀门全部关闭,分离器处于"干态"下运行,锅炉进入纯直流运行状态。

3.2 分离器的作用

启动系统中最主要的部件是汽水分离器,其进出口分别与水冷壁和炉顶过热器相连接。每个分离器筒身上方切向布置 4 根不同管径的进口管接头、2 根内径为 Φ225.4 mm 至炉顶过热器管接头和一根内径为 Φ225.4 mm 疏水管接头。作用类似汽包,将汽水混合物进行分离,并建立水位,防止锅水冲入过热器系统,也防止蒸汽带到水侧的系统中。在最低直流工况 35%BMCR 以上运行时,进入分离器的介质,可以达到干饱和状态,使分离器从有水位(湿态)切换到无水位(干态)运行。一旦锅炉启动结束,该系统就失去原来作用而作为连接水冷壁与过热器之间的汽水通道。该分离器被称为内置式汽水分离器。

3.3 机组甩负荷时的工作过程

本机组机侧配有 35%两级旁路,炉侧过热系统配置 2× 250+4× 380 t/h,共 6 只安全阀,过热蒸汽管道上配置 2× 160 t/h 电磁泄放阀(PCV),安全阀排放容量共 2 020 t/h。在机组甩负荷时,锅炉出口的主蒸汽通过快速启动旁路排至凝汽器,当甩负荷过大时,旁路容量不足,此时,电磁泄放阀(PCV)将动作,加上运行人员快速调整,力争做到停机不停炉。再热器系统入口配置 4 台安全阀排汽量 4× 307 t/h,出口配置 2 台安全阀排汽量 2× 232 t/h,以保护再热器。

3.4 停机时的工作过程

带有内置式汽水分离器与外置式汽水分离器的直流锅炉正常停机过程有很大区别。原进口的机组有很多是带外置式汽水分离器,带有内置闸阀。其正常停机过程最显著的特点是内置闸阀前锅炉的通路暂时被切断,内置闸阀之后的过热蒸汽管道和中间再热系统中无蒸汽通过。而内置式汽水分离器与汽水系统无隔离阀门,正常运行时只作为连接水冷壁与过热器之间的汽水通道。其正常停机过程是按运行规程逐渐减小给水量和燃烧量。在锅炉熄火前应始终保持一定流量的给水。锅炉熄火后终止向锅炉给水,完成停炉过程,可打开旁路阀,把过热器管路通过快速旁路与凝汽器连接起来。这样,过热器中的凝结水就可通过快速旁路直接被排放掉,过热器和再热器疏水也可通过其系统疏水阀将凝结水排出,以利于锅炉防腐和下次锅炉点火。

4 结束语

国产超临界 600 MW 机组为国内新产品,尚无投运的业绩。对其特性还有待于进一步在生产实践中探索,不断进行优化设计,制订合情合理的操作规范,从而保证机组的安全稳定经济运行。

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ing valve, thus controlling the entrainment quantity of hot flue gases and achieving a stable ignition by adapting to various ranks of coal. By using the combustion system under discussion the retrofitting of a 150 t/h pulverized coal-fired boiler at the Thermal Power Plant of Dandong Chemical Fiber Co. Ltd. was implemented and operating tests at 10 different working conditions performed. Test results indicate that the combustion system can adapt well to various ranks of coal and to load variations. Under various operating conditions a stable combustion and high combustion efficiency can be attained. **Key words**: concentration, preheating, combustion system

船用增压锅炉热力计算方法有关问题分析=**A Study of Some Issues Related to the Thermodynamic Calculation of a Supercharged Marine Boiler** [刊, 汉] / LI Yan-jun, JIANG Ren-qiu, SUN Bao-zhi (College of Power and Nuclear Energy Engineering under the Harbin Engineering University, Harbin, China, Post Code: 150001) // Journal of Engineering for Thermal Energy & Power. — 2005, 20(1). —93 ~ 96

Concerning some key issues encountered in the thermodynamic calculation of supercharged marine boilers an in-depth theoretical study was carried out, and some calculation formulas and methods presented. This has in a certain sense offered a theoretical basis for the final establishment of a thermodynamic calculation method for supercharged marine boilers. By making use of the research results thermodynamic calculations of supercharged marine boilers made in the former Soviet Union were conducted and the results of calculation can relatively well meet boiler performance requirements. **Key words**: supercharged boiler, thermal balance, supercharged combustion, thermodynamic calculation

错动炉排套管式节能热水锅炉(2.8 MW)的研制=**Research and Development of an Energy-saving Hot Water Boiler** (2.8 **MW**) **Equipped with Staggered Grates and Casing Pipes** [刊, 汉] / DING Li-qun, WANG Wen-yu (College of Municipal Environmental Engineering under the Harbin Institute of Technology, Harbin, China, Post Code: 150001) // Journal of Engineering for Thermal Energy & Power. — 2005, 20(1). —97 ~ 98

The development process and experience of a 2.8 MW hot-water boiler equipped with staggered grates is described along with the presentation of two items of patented technology, namely staggered grates and cashing-pipe convection heating surfaces. A new product among small-sized heating boilers, the recommended boiler features a packaged construction. The casing-pipe type convection heating surfaces can bring about a 1/3 economy in space requirements. A safe and reliable operation of the boiler is secured by the use of natural circulation-based radiation heating surfaces. The boiler with a high thermal efficiency and full steam output can operate on lean coal of low calorific value, formed coal and shell-like refuse. **Key words**: boiler, staggered grate, casing pipe, energy saving

国产 600 MW 超临界机组直流锅炉启动系统=**Start-up System of a Chinese-made** 600 **MW Supercritical Once-through Boiler** [刊, 汉] / DUAN Yong-cheng (Taicanggang Environment-protection Power Generation Co. Ltd., Taicang, Jiangsu Province, China, Post Code: 215433) // Journal of Engineering for Thermal Energy & Power. — 2005, 20(1). —99 ~ 100

Shanghai Boiler Co. Ltd. in China has for the first time imported the manufacturing technology of 600 MW supercritical once-through boilers from Alstom Co. of USA. A major difference exists between the start-up process of a supercritical boiler and that of a subcritical one. There are few supercritical boilers presently in operation in China and in the majority of cases external steam-water separators are used. Through a brief account of the construction features of a once-through boiler start-up system the author has analyzed the adjustment principle of drainage employed in the boiler start-up system. This can serve as a guide and resource of useful information for other analogous units. **Key words**: supercritical parameter, once-through boiler, start-up system