锅炉装置计算机监测优化控制系统

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[摘要]本文介绍了用计算机对锅炉装置进行在线监测、优化控制的技术。

关键词　计算机监测　优化控制
分类号　TK223.7

1　前言

锅炉装置的安全、可靠、稳定运行是工厂各生产过程正常运行的必要保证。黑龙江省计算机开发中心与浙江炼油厂早在 1989 年就共同研制开发“锅炉装置计算机监测优化控制系统”,该系统由监测和优化控制两个子系统组成,不同于当前大多数锅炉多个单回路 PID 控制方法。

2　控制系统硬件结构

锅炉装置计算机监测优化控制系统的硬件结构如图 1。

锅炉装置现场信号(油压、瓦斯压力、进风量、液位等)经过一次仪表检测、变送器转换后送入工业控制计算机(简称工控机)输入接口,转换成数字信号,送给工控机进行数字处理、图形显示和计算控制量优化值等软件处理,经过工控机的接口输出控制信号,控制电动调节阀阀位,从而达到自动控制的目的。锅炉点火燃烧期间,由手操器控制电动调节阀进行手动控制,当燃烧过程趋于平稳后,计算机控制系统进行无扰动切换,转入自动控制状态。

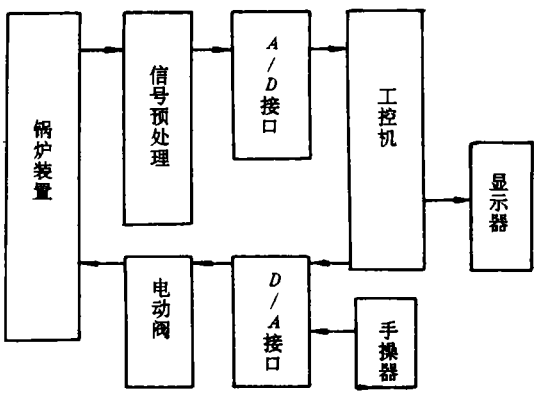

图 1　控制系统硬件结构图

3　计算机监测子系统

锅炉装置计算机监测系统是对现场三台锅炉生产过程的全部工艺参数进行现代化管理,其功能如下:

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3.1 装置的各种工艺参数实时在线显示，工艺流程图显示。

3.2 工艺参数曲线组态。

3.3 工艺参数数据存储(一个月)，以便于装置故障分析。

3.4 工艺参数上下限设定，超限报警，超限参数统计。

3.5 监测系统故障自诊断。

3.6 各电动调节阀阀位显示，以便于特殊情况处理。

监测系统软件采用模块化程序设计技术，现场操作人员通过人——机对话模块软件，利用键盘的各种功能键可简单方便地操作监测系统，进行锅炉装置的现代化管理。

4 优化控制子系统

根据锅炉燃烧过程既操作运行平稳又节能的要求，提出用蒸汽压人工智能控制和燃烧热效率在线自寻最优控制相结合的方法，构成适合锅炉燃烧特性的控制策略。

4.1 蒸汽压人工智能控制

结构图如图 2。

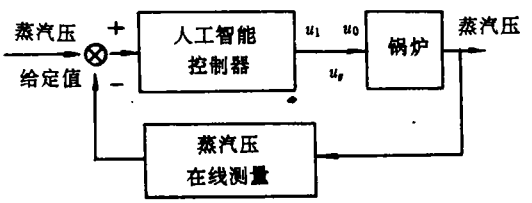

图 2 人工智能控制结构图

u_0— 油压 u_g— 瓦斯压力 u_1 —进风量

蒸汽压控制是属于三输入(进风量、油压、瓦斯压力)、一输出(蒸汽压)控制系统。经过现场调研，决定采用人工智能控制，将现场操作人员的操作经验和经验公式归纳总结，建立知识库，根据蒸汽压的波动情况和特殊情况，由推理机进行逻辑推理，给出控制值进行控制。

这种基于知识的控制器既包含算法又包含逻辑，在这种情况下按算法和逻辑分离进行构造。系统最低层是简单的 PID 算法，然后将这种算法配上自校正、增益自动调度。系统根据一些实用的经验规则和启发性的知识，使不同功能的算法都能正常运行。该系统的数值算法是由一系列控制算法和估计算法构成，例如：变形 PID、递推最小二乘估计算法等，由专家系统来协调所有的算法，利用贮存的专家经验，决定什么时候使用什么参数启用什么算法。

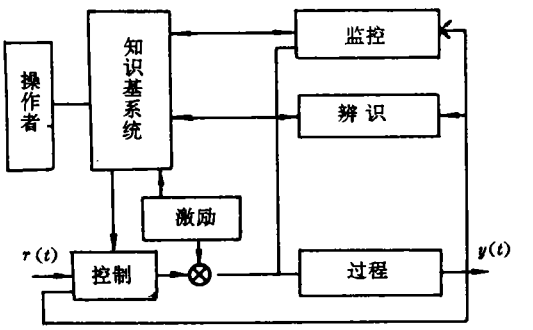

图 3 蒸汽压人工智能控制示意

4.2 燃烧热效率自寻最优控制

热效率的曲线表示了过剩空气与热效率的关系，周知存在一个合适的 α_0，此时燃料能完全燃烧，排烟损失又最小，在其它条件不变的情况下，锅炉的热效率达到最大。

锅炉瞬时热效率 η 根据燃烧过程的热平衡求得：

$$\eta = \frac{Q_1}{BE_f}\% = \frac{Q_1}{B_{油}E_{f油} + B_{气}E_{f气}}\%$$

式中 $B_{油}$ —— 燃油流量，

$B_{气}$ —— 瓦斯气流量，

$E_{f油}$ —— 燃油热值，

$E_{f气}$ —— 瓦斯气热值，

Q_1 —— 被加热热媒的吸收热量，

$Q_l = Q_{out} - Q_{in} = Q_t(C_{out}\,T_{out} - C_{in}\,T_{in})$

Q_t—— 被加热热媒流量　(kg/h)，

T—— 被加热热媒温度，

C—— 被加热热媒比热。

控制结构图见图 4。

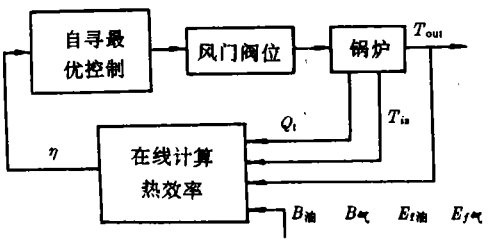

图 4

热效率在线自寻最优控制，它在线实时测量数据，计算锅炉热效率作为燃烧过程的目标函数，以热效率最高(不管工况和燃料性质变化如何) 为目的。根据自寻最优控制原理细调进风阀门开度，以实现最佳过剩空气系数下的经济燃烧，它是一种软件实现的控制算法。

燃烧系统是控制的关键。其目的是使燃料发送热量适应蒸汽负荷的需要，既要保证经济燃烧，又要保证锅炉安全运行，主要措施是保证燃烧过程中燃料和空气具有适当的比值，它的描述是：

$$X = f(t, x_0, u_1, u_2)$$

t—— 时间，x_0—— 燃料燃烧值，u_1—— 燃料量，u_2—— 空气量，X—— 燃烧效率，f 是根据具体装置的函数，指标泛函数为：

$$J = \frac{1}{2}X^T(T)X(T) + \frac{1}{2}\int_0^T (X^TQX + U^TRU)\mathrm{d}t$$

Q、R 是正定常数矩阵，由此可以求出每一时刻 X 和 $U = \{u_1, u_2\}$。

控制算法上采用位置型 PID 算法，为使微分项对控制过程有一段持续的影响，提高调节品质，采用了不完全微分算式，减少积分项超调，采用了变速积分算式。

由于燃烧过程的复杂性，对于同时影响蒸汽压和热效率控制品质的进风量，我们采用了“效益从优的原则”。即当两个回路有明显的矛盾时，可根据生产的实际情况来处理，生产时蒸汽压要求很刻苛时，取控制蒸汽压的进风量优化值，而放弃热效率的优化。反之，当蒸汽压要求不高时，采用优化热效率的优化进风量。

由于计算机技术的迅速发展，使得控制系统的设计工作能够方便地利用计算机来进行，在燃烧效率的最优控制设计中采用了我们参加研制的中国控制系统计算机辅助设计软件系统(CADCSC)[1]。从理论上讲最优程序控制问题可用极大值原理或动态规划来求解，但从数值计算角度来看，它们并不是好方法，我们实际用的是将共轭梯度法的推广来实现的[2]。

五　结束语

本系统是为生产需要而研制的，整个系统力求稳定、可靠、控制安全、实时性强，方便锅控人员操作。该系统在浙江炼油厂 20 吨锅炉运行过程中，经不断的改进，实现了以上的目标，控制效果良好，经过长期的运行起到了节能降耗、提高效率及蒸汽质量的作用。

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(李乡复　编辑)

(CWM) of High Concentration and Its Effect on Flow Characteristics in Pipes [刊,中]/Meng LingJie (Shandong Polytechnical University), Zhang Mingyao (Southeastern University)//Journal of Engineering for Thermal Energy & Power. -1996,11(2):85～88

By combining theoretical analysis with experimental research discussed is the slip phenomenon of coal water mixture (CWM) of high concentration flowing in pipes. An analysis is given of the effect of "slip layer" on the flow characteristics of the CWM in pipes. The authors have also come up with a new method for correcting the wall slip of CWM. flowing in pipes and obtaining a true rheoligical model of the CWM. **Key words**: coal water mixture, slip phenomenon, flow properties

流化床煤燃烧中氮氧化物的生成机理=A study on the Generation Mechanism of Nitrogen-Oxygen Compound Puring the Process of Fluidized Bed Coal Combustion[刊,中]/Feng Bo, Lin Zhijie, Yuan Jianwei, Cai Xuejun, Liu Dechang (Middle China University of Technology)//Journal of Engineering for Thermal Energy & Power. -1996,11(2):89～94

The generation mechanism of N_2O and NOx during the process of fluidized bed coal combustion is studied in a fluidized bed reactor and a fixed bed reactor. N_2O and NOx in the fluidized bed coal combustion are found to come mainly from the nitrogen in the coal, i. e. volatilization nitrogen and coke nitrogen, and NOx is partly from the N_2 in the air. The volatilization nitrogen is mainly in the form of HCN and NH_3 to generate N_2O and NOx by means of equal phase reaction, and the resultant of N_2O and NOx from the coke nitrogen is by multi-phase reaction. The removing mechanism of N_2O is different from that of NOx. The removal of N_2O is by means of the reduction reaction between the hydrogen atom and the oxygen atom, the catalysis-reduction of the solid state substance in the bed layer and self thermal decomposition, and the removal of NOx is by means of the reaction with CO_2 H_2 NH_3 and coke under the catalysis of solid state substance. **Key words**: Fluidized Bed Reactor, Fluibized Bed Combustion, Nitrogen-Oxygen Compound

内循环流化床锅炉技术及发展前景=Internal Cycle Fluidized Bed Boiler Technology and Its Development Prospects [刊,中]/Wang Huaibin, Zhang Zidong, Dong Yong (Harbin Institute of Technology)//Journal of Engineering for Thermal Energy & Power. -1996,11(2):95～100

A definition is given of the internal cycle fluidized bed boiler along with an overview of the major contributions made by experts at home and abroad involved in the development of the said boiler. The authors hold that the above mentioned boiler will eventually be listed as a predominant product among industrial boilers. **Key words**: boiler, internal cycle, fluidized bed, overview

燃机应用于商船的现状和展望=The Present Status and Future Prospects of the Application of Gas Turbines for Merchant Ships [刊,中]/Zhang Hui(Harbin 703 Research Institute)//Journal of Engineering for Thermal Energy & Power. -1996,11(2):101～104

A general review is given of the developments and present status of marine gas turbines employed on board merchant ships. In this connection the merits of the gas turbines as against diesels are described. The prospects of the use of gas turbines for merchant vessels have also been briefly dealt with. **Key words**: gas turbine, power plant, merchant ship application

锅炉装置计算机监测优化控制系统=A Computer-based Monitoring and Optimized Control System for a Boiler Unit

[刊,中]/Zhang Mingbo(Applied Mathematics Institute of Heilongjiang University)//Journal of Engineering for Thermal Energy & Power.-1996,11(2):105～107

This paper deals with a computer-based system for the on-line monitoring and optimized control of a boiler unit. Key words: computer-based monitoring, optimized control

BHW35 钢电渣焊后亚温淬火=Sub-temperature Quench of BHW35 Steel after Electroslag welding[刊,中]/Liu Ying, Xiao Yueling, Chang Fanghua, You Mo (Harbin Boiler Ltd Company), Cui Yuexian (Harbin Institute of Technology)//Journal of Engineering for Thermal Energy & Power.-1996,11(2):108～111

The treatment of normalizing, sub-temperature quenching and tempering to BHW35 steel after electroslag welding can improve the impact toughness of the welding contacts and the mother steel, with the high strength being maitained. The problem of low impact toughness of electroslag welding seam of BHW steel has been therefor resolved. Key words: BHW35 Steel. Welding, Impact Toughness, Quench

用锰砂除地下深井水中铁、锰离子的工艺设计及运行控制=The Technological Design & Operation Control of the Clearance of Iron & manganese Ion from Deep-Well Water by Manganese Sand[刊,中]/Shao Yanqiu, Liu Yangfang, Gao shujun, Liu Li(Harbin Labour Bureau Boiler Compressure Vessel Inspection Institute)//Journal of Engineering for Thermal Energy & Power.-1996,11(2):112～116

Key words: underground water, manganese sand, Iron and Manganese Ion, Technology Design,Control.

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