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直控式液粘调速器的开发

李福尚[1], 魏建华[2]
(1. 山东电力研究院 热能所, 山东　济南　250002;
2. 浙江大学 国家电液工程技术研究中心, 浙江　杭州　310027)

摘　要: 针对液粘调速器存在的问题, 研制出一种将控制精度、动态响应与工作可靠性有机结合的直控式液粘调速器。现场运行表明, 直控式液粘调速器工作可靠、运行平稳、节能效果显著, 具有工程应用价值。

关　键　词: 液粘调速器; 直控式; 电液执行机构

中图分类号: TK325　　文献标识码: B

1　引　言

液体粘性调速器是国外 20 世纪 70 年代开发的新型高效调速装置, 技术已经成熟, 并且形成了系列化产品, 现在美、德、日等国已在各行业广泛应用这种产品实施水泵、风机调速运行。国外代表产品主要有日本奥米伽液粘调速器和美国压力伺服型液粘调速器, 这两种液粘调速器的特点是均具有快速的动态响应及良好的静态特性(如: 分辨率高、滞环小、线性度好等)。其缺点是设备转速控制系统中电液执行机构(如奥米伽阀或压力伺服阀)的加工精度高、工艺要求严格、成本高, 对油质要求高, 易卡涩。我国从 20 世纪 80 年代开始研制液粘调速器, 研制的 TL 及 YT 等系列产品, 其转速控制系统和美国液体粘性调速器的转速控制系统相类似, 只是用先导式电液比例溢流阀取代压力伺服阀来调节油缸的压力从而达到调速的目的。先导式比例溢流阀能降低对油质的要求, 但其控制特性不够好, 如死区过大、滞环过大、超调较大, 动态响应较慢的问题, 影响了设备的使用范围, 而且由于先导式比例溢流阀的先导阀油口较小, 对油液污染仍然敏感。因此, 新型节能调速装置在我国并没有得到广泛的应用。为此作者开发了一种将控制精度、动态响应与工作可靠性有机结合的直控式液粘调速器。

2　直控式液粘调速器的研制

2.1　直控式电液执行机构的工作原理

直控式比例阀具有控制环节少, 重复精度高, 滞环小, 死区小、响应速度快, 动态超调小的特点, 但输出功率小、带载能力差。本研究突破现有比例阀结构原理和设计准则, 使用内反馈原理、耐高压比例电磁铁和电子校正等手段, 提高直控阀的输出流量、输出功率, 增强阀的带载能力, 实现小功率信号对大功率输出的控制, 研制出一种直控式电液执行机构——电液比例压力控制阀, 其结构如图 1 所示。

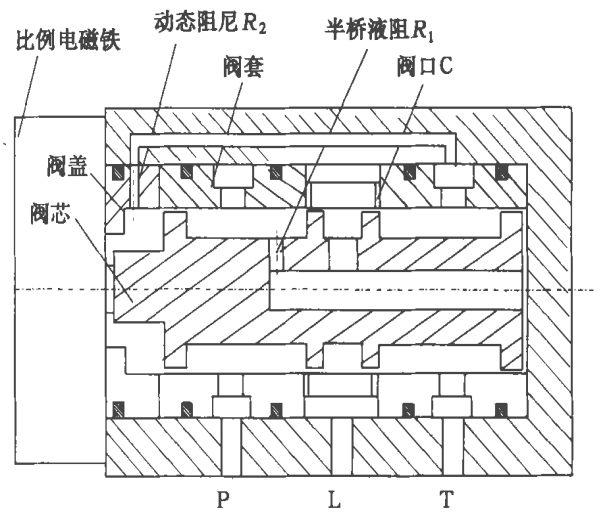

图 1　电液比例压力控制阀结构示意图

比例电磁铁由电子控制器的电流信号转化为成比例的电磁力, 作用在阀芯的一端, 阀芯的另一端作

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作者简介: 李福尚(1968－), 男, 山东成武人, 山东电力研究院高级工程师, 博士.

用着一反馈液压力。反馈压力来自负载口, 经液阻进入反馈腔。阀芯依靠电磁力与负载口的液压力平衡定位。阀套的外圆柱面上开有四个环形槽, 两端两个环形槽通过阀体上的通孔均与回油口相连, 另外两个分别是进油口及负载口。当阀芯处于图示位置时, 阀芯上的台肩正好遮盖了阀套上的阀口 C, P 口、L 口及 T 口均不通, 负载腔没有油液进出, 负载腔压力不变。当比例压力控制阀的给定信号增加时, 比例电磁铁的输出电磁力增加, 阀芯向右移动, 电液比例压力控制阀的 P 口通过阀套上的阀口 C 与负载 L 相通, 压力油进入负载腔, 负载腔的压力升高; 随着负载腔的压力升高, 反馈容腔的压力随之升高, 阀芯在液压力作用下返回, 直到在新的位置上电磁力与液压力重新平衡, 阀口 C 重新被阀芯上的台肩所遮盖, 电液比例压力控制阀达到新的平衡。当电液比例压力控制阀的给定信号减小时, 由于作用在阀芯上的液压反馈力大于电磁力, 阀芯在液压力的作用下向左移动, 负载口通过阀套上的阀口 C 与回油口 T 相通, 导致负载腔的压力降低, 反馈腔压力随之减小, 直到液压力与电磁力达到新的平衡。

表 1　直控式液粘调速器与国内外产品的比较

	可靠性		能量损失	控制精度
	加工精度	抗油液污染能力		
直控式液粘调速器	一般	强(< 25μm)	很小	较高
美国压力伺服型液粘调速器	很高	差(3 ~ 10μm)	高(1/3)	高
日本奥米伽液粘调速器	高	差(3 ~ 10μm)	较高	较高
国产先导比例溢流型液粘调速器	高	较差(< 15μm)	较高	低

2.2　直控式液粘调速器调速特性性能测试

液粘调速器的转矩 T、控制油压力 p、输出转速 n_2 和转速比 i 的关系称为调速特性, 这是液粘调速器最重要的特性之一。该特性为台架试验测试所得, 动力为直流测功电机, 负载为水力测功计, 先给予足够的控制油压使液粘调速器在额定转速下保持同步工况, 加载至额定转矩, 然后调节控制油压力, 即可测得不同的 n_2、i、p 和 T, 绘制出调速特性曲线(见图 2)。

3　直控式液粘调速器在电厂中的应用实例

山东聊城热电有限责任公司 1 号炉甲、乙两台送风机一直采用节流挡板进行风量调节, 2002 年 5 月甲侧送风机采用直控式液粘调速器进行转速自动调节, 运行稳定可靠, 为了解 1 号炉甲送风机调速节能改造效果, 进行了如下风机试验:

试验采取甲或乙单台送风机运行, 电负荷为 30 MW, 35 MW, 40 MW。运行甲送风机时, 停止乙送风机, 将甲送风机入口挡板开至最大, 根据负荷高低, 调整甲送风机转速, 保持锅炉氧量 3.8±0.2%, 稳定后进行抄表。运行乙送风机时, 停止甲送风机, 根据负荷高低, 调整乙送风机入口挡板, 保持锅炉氧量 3.8±0.2%, 稳定后进行抄表。

通过试验结果进行同负荷下甲送风机与乙送风机耗电比较, 40 MW 时少耗电 2.95 kW, 35 MW 时少耗电 8 kW, 当机组负荷 30 MW 时, 甲送风机与乙送风机少耗电 32.5 kW, 节电效率约为 20%。

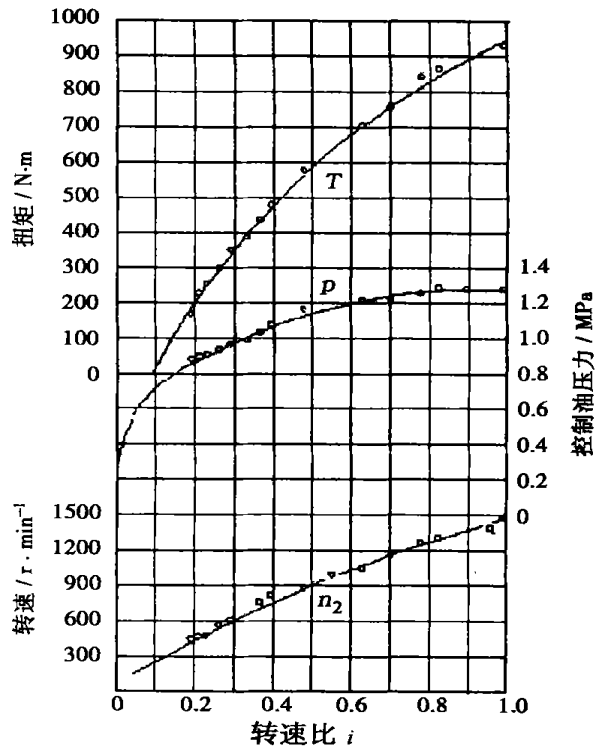

图 2　直控式液粘调速器的调速特性

1 号炉甲送风机调速节能改造前, 为运行安全起见, 通常同时运行甲、乙两台风机, 因而两台风机负荷率均偏低, 由此造成的节流损失远比单独运行一台风机要大, 所以调速节能改造后的效果也就越显著。

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用于动力设备的纳米镍基合金微观结构及耐磨性研究

徐向东[1], 孟繁娟[1], 惠文华[2], 刘家俊[3]
(1. 清华大学 热能工程系, 北京　100084; 2. 美国 3S 公司 NJ 08618;
3. 清华大学 机械工程系, 北京　100084)

摘　要: 阀门是核电站应用最多的一种设备, 因材料耐磨性不足导致阀门失效是核电站事故的主要原因之一。文中提出在阀门零件的关键密封表面镀上一层纳米镍基合金, 可以大大提高阀门的耐磨性, 是减少核电站事故的有力手段。应用 X 射线衍射、TEM 研究了纳米镍基合金的组织结构及相结构, 陈述了这种结构为什么具有优异耐磨性的机理。

关　键　词: 动力设备; 阀门; 纳米材料; 微观结构; 耐磨性

中图分类号: TM623. 4　　文献标识码: A

1　前　言

阀门是核电站中应用最多的一种设备, 一座 600 MW 压水堆核电站需使用各类阀门约 1 万多个, 占整个核电站设备投资的 10%左右。核阀在工作中可能由于表面耐磨性不足等原因而导致多种形式的失效, 如工作面塑性变形、疲劳剥落和磨损等。据统计[1,2], 世界上核电站因阀门装置出故障而造成事故占 1/4。为了提高核阀密封面的耐磨性, 必须对其进行表面改性处理, 在其表面形成结合力好、强度高、耐磨性好、耐蚀性最佳的表面改性层。目前国内一般采用电弧, 火焰堆焊和等离子小喷焊等工艺熔焊核阀零件关键的密封面。然而, 传统工艺存在裂纹倾向大, 废品率高, 组织性能不均匀、生产工序繁多、熔层极不平整和加工量大等难以克服的缺点, 无法保证核阀的质量要求。

纳米材料由于晶粒细小, 产生高浓度晶界, 因而使纳米材料有许多不同于一般粗晶材料的性能, 如 1.8% C－Fe 合金, 在粗晶时断裂强度为 490 MPa, 而纳米化后可达 5. 88 GPa, 提高了一个数量级, 而且塑性良好。所以在核阀零件的关键密封表面镀一层纳米材料, 例如镍基合金, 这是解决目前阀门零件耐磨性的有力手段。

本文对纳米镍基合金的组织结构及相结构进行了研究, 并论述了其优异耐磨性的机理。

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作者简介: 徐向东(1947－), 男, 江西南昌人, 清华大学教授, 博导.

4　结　语

直控式液粘调速器的研制成功, 解决了液粘调速器高品质的控制精度、动态响应与工作可靠性有机结合的关键性技术难题, 设计合理、性能稳定, 制造成本低, 易于系列化, 维护费用低, 自动化程度高, 而且抗油液污染能力强, 工作可靠性得以提高, 能够满足绝大部分工程控制的要求, 比国外产品有更广泛的应用领域和更强的竞争力。现场实际运行表明, 采用这种新型液粘调速器启动及运行平稳, 调速灵敏, 闭锁性能好, 操作简便, 安全可靠, 节能效果显著, 具有很大的推广价值。

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(何静芳　编辑)

基于粗糙集理论的汽轮机组回热系统故障诊断模型＝**Fault Diagnosis Model for the Regenerative Heating System of a Steam Turbine Unit Based on a Rough Set Theory** [刊, 汉] / WANG Wei-jie, HUANG Wen-tao, ZHAO Xue-zeng, et al (College of Mechanical Engineering under the Harbin Institute of Technology, Harbin, China, Post Code: 150001) // Journal of Engineering for Thermal Energy & Power. — 2003, 18(6). —618 ~622

After an analysis of the insufficiency of current fault diagnostic methods used for the regenerative heating system of a steam turbine to resolve the problem of redundant fault symptoms the authors have proposed a new fault diagnosis model based on a rough set theory. With the typical fault modes of a regenerating heating system being taken into account a fault diagnostic decision table was established through a discretization of continuous fault symptom attributes. A reduction of the fault symptom attributes was realized by making use of a genetic algorithm. An optimal selection stratagem of minimal reduction is proposed based on domain knowledge. Then, a decision rules base for fault diagnosis was set up through the basic principle of decreasing the given decision rules. When the proposed model is employed for fault diagnosis the discretized fault symptom attributes to be diagnosed are first matched with the diagnostic decision rules in the rules base. The returned diagnostic decision rules will undergo a comprehensive evaluation with a diagnostic conclusion being reached. The simulation of typical faults by a power plant simulator was performed to verify the fault diagnosis model. Engineering practice shows that the proposed model is highly effective in reducing redundant fault symptoms and credited with a good fault-diagnosis effect as well as a fair fault-tolerant capability. **Key words**: steam turbine unit, regenerative heating system, fault diagnosis, rough set theory, genetic algorithm

新型喷雾光学测量仪的研制＝**Development of an Innovative Mist-spray Optical Measuring Device** [刊, 汉] / WU Wei-liang, CHEN Han-ping, JIN Hao, et al (College of Machine and Power Engineering under the Shanghai Jiaotong University, Shanghai, China, Post Code: 200030) // Journal of Engineering for Thermal Energy & Power. — 2003, 18(6). — 623 ~626

To measure the water droplet diameter and concentration as well as their variation in a humidifier, the key element of a humid air turbine (HAT) cycle, has long been an intractable problem during relevant experimental tests. In view of this the authors have developed an innovative mist-spray optical system for measuring the water droplet diameter and its changes at various locations during the mist-spray process of a dual-fluid nozzle in air. Meanwhile, at proper locations and under identical operating conditions a contrast measurement of mist-spray characteristics was conducted with the use of a phase Doppler anemometer. The measurement results indicate that the recommended system can be used for measuring nozzle mist-spray particle diameter and is well suited for the measurement of water droplet parameters in a humidifier. **Key words**: mist-spray characteristics, mist spray measurement, humid air turbine cycle, humidifier, phase Doppler anemometer

直吹式制粉系统满足等离子点火浓度技术的应用＝**Technical Version of a Direct-fired System for Attaining the Pulverized-coal Concentration as Required by Plasma Ignition** [刊, 汉] / ZHANG Xiao-yong, ZHANG Yong-cai, ZHANG Shi-kai, et al (Yantai Longyuan Electric Power Technology Co. Ltd., Yantai, Shandong Province, China, Post Code: 264006), // Journal of Engineering for Thermal Energy & Power. — 2003, 18(6). — 627 ~629

Plasma ignition technology is applied to a dual-in dual-out direct-fired system, which satisfied pulverized-coal concentration requirements and practical operating conditions. The selection of a rational layout for a plasma burner and the proper adjustment of coal-mill operating mode have met the requirements of the temperature-rise and pressure-rise characteristics for the plasma ignition of a boiler. A detailed description is given of the use of an impact-type centrifugal separation-based concentration device for achieving the pulverized-coal concentration required by the plasma ignition. **Key words**: plasma burner, pulverized-coal concentration, ignition

直控式液粘调速器的开发＝**Research and Development of a Direct-controlled Hydro-viscous Variable Speed Driver** [刊, 汉] / LI Fu-shang (Shandong Electrical Power Research Institute, Jinan, China, Post Code: 250002),

WEI Jian-hua (State Research Center of Electro-hydraulic Engineering Technology, Hangzhou, China, Post Code: 310027) // Journal of Engineering for Thermal Energy & Power. — 2003, 18(6). — 630 ~ 631

To overcome the existing problems specific to a hydro-viscous speed regulator, the authors have developed a direct-controlled hydro-viscous variable speed driver (HVD), which features an organic integration of control precision, dynamic response and operation reliability. On-site operating experience indicates that the HVD has achieved a reliable and steady operation with significant energy-savings, and is well suited for engineering applications. **Key words**: hydro-viscous variable speed driver, direct controlled, electro-hydraulic actuator

用于动力设备的纳米镍基合金微观结构及耐磨性研究= **A Study of the Microstructure and Wear Resistance of a Nickel-base Nanometer Alloy for Use in Power Equipment** [刊, 汉] / XU Xiang-dong, MENG Fan-juan, LIU Jia-jun, et al (Department of Thermal Engineering, Tsinghua University, Beijing, China, Post Code: 100084) // Journal of Engineering for Thermal Energy & Power. — 2003, 18(6). — 632 ~ 635

One of the major causes of nuclear power station accidents can be attributed to the poor wear resistance of materials of valves, the most commonly used elements in nuclear power plants. The coating of a layer of nickel-base nanometer alloy on the key seal surface of a valve part may contribute to a significant enhancement of valve wear resistance and serves as an effective means for reducing the chances of nuclear plant failures. The microstructure and phase-structure of the nickel-base nanometer alloy is analyzed by the use of X-ray diffraction and transmission electron microscopy. The mechanism of the excellent wear resistance of the above-mentioned structure is also expounded. **Key words**: power equipment, valve nanometer material, microstructure, wear resistance

均热炉燃烧系统改造方案的数值模拟研究= **Numerical Simulation Investigation of the Combustion-system Modification Scheme for a Cell Pit Furnace** [刊, 汉] / SHU Zheng-chuan, ZHU Tong (College of Mechanical Engineering under the Tongji University, Shanghai, China, Post Code: 200092) // Journal of Engineering for Thermal Energy & Power. — 2003, 18(6). — 636 ~ 638

The technical modification of a cell pit furnace combustion system by introducing high-temperature air combustion (HiTAC) can lead to a reduction of gas consumption and an enhancement of temperature field uniformity. By way of numerical simulation tests the in-furnace flow field and temperature field of the cell pit furnace are investigated after the furnace has undergone a technical upgrading through the use of HiTAC. On this basis an optimum modification scheme was proposed. **Key words**: cell pit furnace, high-temperature air combustion technology, numerical simulation

基于 COM 技术的锅炉热力计算软件研究= **Research on Computer Technology-based Thermodynamic Calculation Software for Boilers** [刊, 汉] / HAN Mu-xing (Harbin No. 703 Research Institute, Harbin, China, Post Code: 150036), HUANG Bo (Harbin University of Science & Technology, Harbin, China, Post Code: 150040) // Journal of Engineering for Thermal Energy & Power. — 2003, 18(6). —639 ~ 641

Key words: boiler, thermodynamic calculation, computer

220 t/h 锅炉水冷壁角部断裂分析和改进措施= **Analysis of Water-wall Corner Cracking of a 220t/h Boiler and Measures Taken for Its Prevention** [刊, 汉] / XIE Ying (Baling Petrochemical Power Plant, Yueyang, Hunan Province, China, Post Code: 414003) // Journal of Engineering for Thermal Energy & Power. — 2003, 18(6). —642 ~ 644

Key words: water wall, cracking, analysis, improvement

一种绿色液体燃料——生物柴油= **Biological Diesel Oil - a Kind of Green Liquid Fuel** [刊, 汉] / FU Wei-bao (Department of Engineering Mechanics, Tsinghua University, Beijing, China, Post Code: 100084) // Journal of Engineering for Thermal Energy & Power. — 2003, 18(6). —645 ~ 646