

高压给水泵 故障分析和检修技术改进

苏少林

(广州石油化工总厂检安公司, 广东 广州 510725)

[摘要] DG270-140B 高压给水泵为沈阳水泵厂早期定型产品, 是热电厂、供热厂热介质(水、汽)系统的核心, 在很多热电厂使用。由于特殊工况及设计上存在不足, 该产品经常出现密封填料泄漏、振动及推力瓦块烧熔等故障。对此, 介绍几种行之有效的检修改进技术。

[关键词] 高压给水泵; 故障分析; 密封填料; 泄漏; 振动; 推力瓦

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DG270-140B 高压给水泵主要技术参数:

表 1 DG270-140B 高压给水泵主要技术参数

项目	内容	项目	内容
级数	10	进口温度/℃	158
转速 $r \text{ min}^{-1}$	2 985	出口母管温度/℃	220
入口压力/MPa	0.8	效率/%	76
出口压力/MPa	15	电机型号	YK-2000-2/990
流量/ $\text{m}^3 \text{ h}^{-1}$	320	电机功率/kW	2 000
轴功率/kW	1 970	电压/V	6 000

DG-140B 高压给水泵是锅炉的重要辅机, 由于泵的入口介质温度高、压力高, 加上泵设计上的一些不足, 轴封系统经常漏水, 高温除氧水从填料函喷出并汽化, 严重影响现场安全。并且, 除氧水喷入轴承箱, 会造成润滑油乳化, 影响润滑, 甚至引起轴瓦、平衡盘、推力瓦很快磨损。此外, 给水泵检修后经常发生振动, 也困扰着生产和机组的安全运行。

为此, 经过反复实践, 采取了一系列针对性的技术改造方法及检修技术, 取得较好的效果。

1 给水泵轴封漏水故障分析

DG270-140B 给水泵原配材质为 3Cr13 的轴套, 较经济实惠, 但抽查发现, 经常有部分轴套淬硬层厚度

不均匀或硬度不足, 淬硬层薄的只有 0.2 mm, 硬度只有 HRC45~48, 而按要求, 轴套与盘根接触部分的硬度要在 HRC48~52 以上。所以按图纸要求定制或购买的轴套, 配普通碳纤维盘根作为密封填料, 使用寿命一般只有(600~1 600) h, 还发生过连续使用不足 200 h 情况。当出现严重漏水后, 检查发现轴套表面出现大量环型沟槽, 深者超过(2~3) mm, 以致轴套与盘根之间无法密封, 而运行中泵轴的轴向串动, 更使盘根与轴套完全脱离, 泄漏更加严重。所以, 提高轴套的抗磨性是克服轴封漏水的关键。

2 提高给水泵轴套抗磨性

提高轴套抗磨性可通过提高表面硬度来实现, 经实践采用了 2 种较为可行的办法。

2.1 热喷涂法

(1) 轴套制造时按图纸尺寸预留一定加工余量加工轴套毛坯。(2) 选用 Co 基强化喷涂粉末, 按专业厂制定的工艺进行热喷涂, 涂层厚度为 1.5 mm。(3) 粗车轴套内表面, 精磨外径再精车内径至图纸尺寸。

这样加工的轴套, 表面硬度可达 HRC58~63, 硬化层厚度非常均匀, 耐磨性好, 但造价相对较高。

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作者简介: 苏少林, (1969-), 男, 工程师, 毕业于四川大学, 从事电厂锅炉及发电设备检修技术工作。

2.2 激光局部相变淬硬法(图 1)

将原厂一批新轴套进行硬度抽检,对硬度不合格的轴套送专业激光修复公司进行表面局部淬火。由于激光局部加热迅速,加热后立即淬火冷却,工件整体温度变化小,轴套不变形,淬硬层硬度、深度容易控制且均匀可靠(一般淬硬后硬度可达 HRC52~56,淬硬层深度可均匀达到 1 mm);淬硬后不需要再加工,工艺简单,经济性好。

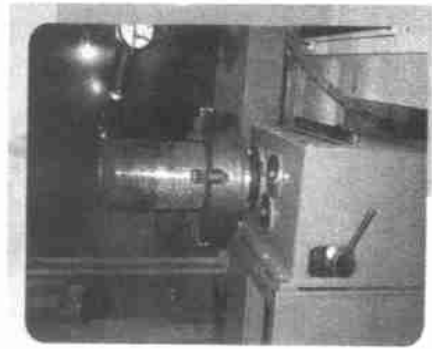


图 1 激光淬硬

2 种方法强化的轴套使用情况见表 1。

表 1 轴套和盘根更换周期

表面硬化方式	表面硬度	国产碳纤盘根		切斯顿黄金组合盘根		国产黄金组合盘根	
		更换盘根	更换轴套	更换盘根	更换轴套	更换盘根	更换轴套
热喷涂	HRC58	2 880	15 100	5 040	21 600	4 320	19 440
激光淬硬	HRC53	2 800	12 960	5 000	19 440	4 320	18 000

3 选择自润滑性好的密封填料

(1) 特殊密封填料,交错装配,减少对轴套磨损,延长轴套寿命,减少轴封泄漏。

该型给水泵一般选用碳纤维(碳纤)盘根作轴端密封填料,自润滑性不太理想,对轴套的磨损较严重,而单独使用全编织(不包心)纯石墨盘根摩擦小,因密封填料函较浅,只能装 4 条 17 mm × 17 mm 的盘根。此外,纯石墨盘根容易被水冲散,一旦稍微散开,渗漏便加剧。为此,经过反复试验,采用一种填料组合装配法,即被切斯顿(CHESTERTON)公司称为给水泵填料黄金组合,其中 477-1 为碳纤盘根,1400 为纯石墨盘根(图 2)。

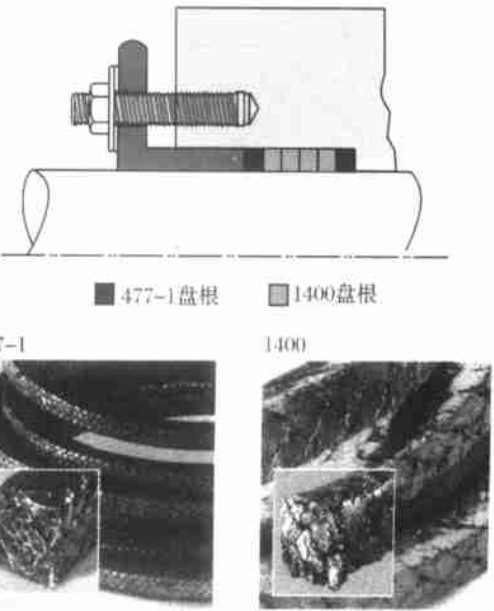


图 2 密封填料、组合示意

纯石墨的 1400 型盘根自润滑性能非常好,作为中间环可减少轴套的磨损,确保盘根和轴套持久良好接触。密封可靠、韧性较强的 477-1 型碳纤盘根作为端环,可避免少量泄漏,将 1400 型盘根冲走,主要起到固持作用。

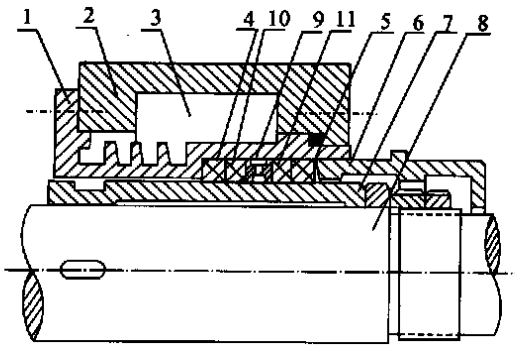
根据轴封处轴套外圆旋转线速度值选择不同型号的碳纤盘根和纯石墨盘根进行组合,如广州石化总厂给水泵轴套外圆旋转线速度为 18.7 m/s,试验中选用线速度大于 19 m/s 的相应型号碳纤盘根及纯石墨盘根。由于切斯顿公司的盘根较昂贵,考虑运行效果和性价比,目前选用国产的碳纤维盘根和国产 3A-TP550(碳纤及纯石墨混编)黄金组合盘根与激光淬硬轴套配套。组合使用效果更佳。

3 年来在 5 台给水泵上对不同盘根及不同组合方式

进行多次试验和统计证实,平均使用效果较佳(表 1)。

(2) 采用黄金组合密封填料,检修方便。

通常,给水泵 4 条盘根均采用碳纤盘根时(见图 3),由于碳纤盘根纤维非常坚韧,经常小股分离并挤压进冷却水环和填料函之间的间隙,使冷却水环无法取出,有时为了更换盘根,不得不拆出泵的首、尾盖。取出冷却水环后,再对泵进行重新找中心及对中,工作量大,且质量难以保证。使用黄金组合安装后,由于靠近冷却水环的 2 条盘根均为纯柔性石墨盘根,盘根柔软细滑易粉碎,不会出现冷却水环卡住取不出现象,更换盘根非常方便。



1—冷却水衬套 2—首、尾盖 3—冷却水室 4、5—碳纤维盘根 6—填料压盖 7—轴套 8—泵轴 9—冷却水环 10、11—柔性石墨盘根

图3 给水泵填料装配

4 止推瓦块瞬间烧熔原因分析及故障排除

给水泵为单吸多级离心泵，采用平衡盘、止推盘（推力盘）来共同平衡泵的轴向推力。在泵投用2年后，时常发生止推瓦块烧熔情况，进而造成平衡盘严重磨损，使泵强烈振动。

对几年中相关运行参数进行汇总分析发现，大多数情况下存在平衡室压力偏高现象。分析认为，泵经多年运行后，平衡套内孔与该处轴套磨损增大，平衡盘前的流通能力加大。同时，如果平衡盘与平衡板磨损或平行度较差时，大量流进平衡室的高压水来不及经平衡管及平衡管上的截止阀排回泵的入口，引起平衡室压力升高，乃至平衡盘前后压差不足，产生的平衡力远小于转子叶轮部分引起的正轴向推力，过大的正轴向力长时间作用在推力盘上，造成止推瓦块烧损，乃至平衡盘严重磨损。分析认为平衡管的尺寸可能偏小，管上的截止阀开度不足或堵塞，使平衡室压力升高，造成推力过大。因此，将平衡管从原来 $d38\text{ mm}$ 改成 $d52\text{ mm}$ ，并取消了截止阀，改为法兰直接连接。

经过上述改造，发生上推瓦块烧熔、平衡盘磨损等故障的次数大为减少，约降低了74%。

5 给水泵检修后频繁发生振动原因分析及故障排除

给水泵在检修后按厂家要求进行装配及调整，加装填料后进行对中。开机运行初期，振动值正常，填料也不漏水，运行不久，则振动增大，填料开始漏水，且情况急剧恶化无法运行。经检查，轴套无磨损，轴瓦正常，盘车确认转子不存在动静摩擦。装填填料后重新对中，运行(3~5)天后又发生振动和漏水情况。类似

情况频繁发生。经对给水泵振动频谱分析，认为可能存在动不平衡、对中不良、微量动静摩擦等因素。

后来经过现场多次测量对比分析发现，加装填料前、后，泵的对中值误差很大，径向对中误差在 0.4 mm 以上，端面对中误差在 0.2 mm 以上。究其原因，认为由于该泵的轴较为细长，刚性较差，大弧度小应变下很容易产生弯曲。加装填料前，转子在泵壳内由两端轴瓦承托，处于自然弧垂状态，对轮端稍微翘起，处于正常工作位置，此时进行对中调整，运行中转子对中值将不变且处于正常数值。加装填料后(图4)，由于盘根在轴套周围分布不均匀或硬度不一，压紧填料时，填料函处轴径被填料顶离自然中心，如果此时进行对中，泵投运后初期填料代替泵轴瓦的功能，转子对中正常，泵的运行状态良好。而运行一段时间后，由于填料磨损或被挤压开，泵轴慢慢恢复到由轴承支托，对中变差，泵的振动也随之逐渐加大，大的振动又引起轴套扫膛填料，转子将趋于全部由轴承支托，对中偏差更大，振动也加剧，最终振动和漏水情况急剧恶化，以至无法运行。

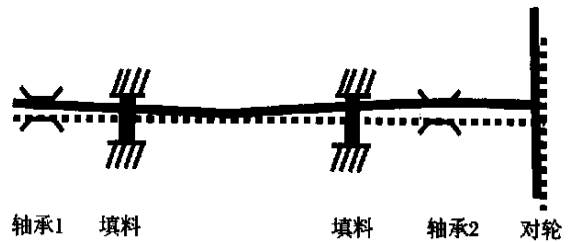


图4 转子在盘根作用下弯曲

因此，每次检修后，若需对给水泵重新进行对中，须将盘根彻底清理，对中完成后重新加装密封填料。采取这项措施后，高压给水泵的振动和密封填料能维持正常运行。

6 结 语

DG270-140B 高压给水泵由于设计和检修技术方面存在的不足之处，经常出现轴套磨损，轴封漏水，给水泵振动及推力瓦块烧熔等故障，频繁地发生强迫停机、停泵，严重威胁到石化总厂的稳定、安全生产。经过反复实践，改进检修技术，提高了轴套表面硬度，选择自润滑性良好的组合密封填料，采取放大平衡管直径以及合理的给水泵对中工艺等措施，消除了运行故障。5台给水泵每年总共需检修(包括换盘根)四五次，检修率降低了约52%，确保了电厂的安全、稳定生产，取得了很好的经济效益。

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The operational situation and troublesome problems existing in equipment and system for home-made 300MW turbine unit No. 3 of imported type after putting into operation at Sihong Power Plant have been briefly described, and the retrofitting measures for perfection of said unit and practical results after implementation of technical retrofitting being expounded. Through said retrofitting, the specific heat consumption has been relatively reduced by 333.45 kJ/(kWh), specific coal consumption for electric energy generation by 12.5 g/(kWh), having obvious retrofitting effectiveness.
- PRESENT SITUATION OF STUDYING THE TECHNIQUE TO BURN FUEL IN STEPS AND APPLICATION PROSPECTS THEREOF** Ling Ronghua et al (6)
The situation of studying the technique to burn fuel in steps at home and abroad has been presented, and the application prospects of said technique in our country being analysed from view points of natural resources, technical economy, and environmental protection policy of the state. It is considered from analysis that the said technique can effectively control NO_x emission, and its maturity in application, at the same time has remarkable competitive force in economic aspect. Along with the requirements of environmental protection are becoming increasingly higher, the application of said technique in our country will certainly be widened.
- DEVELOPMENT OF RECIRCULATING COOLING WATER TREATMENT TECHNIQUES IN THERMAL POWER PLANTS OF OUR COUNTRY** Luo Jianghe et al (9)
The main problems lying ahead of recirculating cooling water treatment techniques in thermal power plants of our country after reform of the power system and the development direction of said techniques in the future have been presented. Based on the practical demand and possibility at present, it is considered that the enrichment factor of circulatory water at each thermal power plant in the near future should be greater than three, and taking this factor as a control target. For this reason, eight points of recommendation have been put forward as follows: (1) perfection of external treatment method for circulatory water; (2) development of new stabilizing agents and high-effective complex prescrip-tion; (3) strengthening the research of anticorrosion technology for condenser tubes; (4) carrying out the study on technique of using urban sewage as recirculating water; (5) exploring application of other pesticides; (6) strengthening application of automatic control techniques; (7) carrying out the study of descaling technique during the time of operation; (8) assigning fixed points to produce agents used for circulatory water treatment.
- STUDY ON ADAPTABILITY OF LOW NO_x BURNERS TO VARIOUS COAL QUALITY** Huo Xuezhi et al (12)
Analysis and discussion have been made in the following aspects, namely the working principle of low NO_x burners, the relationship between quantity of NO_x formation during initial stage of combustion and the volatile of coal quality, the effect of technology to burn air in steps on coal of different quality, the situation of utilizing low NO_x burners in our country, as well as the adaptability of low NO_x burners to coal of various quality etc. Hence, some recommendations for developing and spreading low NO_x burners have been put forward.
- STUDY ON USING SUPERSONIC SPEED BOOSTING HEATER WITH STEAM-LIQUID TWO-PHASE FLOW IN DESALINATED WATER HEATING SYSTEM** Wang Xiaofeng et al (16)
The method of regulating the outlet flow rate of the boosting heater with supersonic speed steam-liquid two-phase flow has theoretically been studied, and a desalinated water heating system composed of four boosting heaters and a recirculating pipeline has been designed and built based on the said study. The said system can heat up the desalinated water to a given temperature while the outlet flow rate changing from 60t/h to 360t/h, and having boosting capability. Practical operation test shows that the operation of the said system is stable and reliable, satisfying completely the requirements of production process in thermal power plants.
- DESIGN AND REALIZATION OF CONSUMPTION DIFFERENCE ANALYSING SYSTEM FOR THERMAL POWER UNITS BASED ON WEB HYBRID MODE** Cheng Hongwei et al (20)
On the basis of information resources existing in the thermal power plants, a consumption difference analysing system for thermal power units has been developed based on the design idea of modularized structure by using computer technique. The C/S mode and the B/S mode have been analysed and compared, obtaining a realizing scheme of system based on a hybrid mode both of them. Directing against key problems such as data acquisition and data storage etc. in the system, OPC technical specifications and design idea of sharing the internal storage has been used, enhancing safety real-time nature of the said system. Application in the fields shows that the said system can effectively improve the operation level of operators and operation management level of the entire power plant.
- DESIGN OF ADAPTIVE CONTROLLER IN CONTROLLING SUPERHEATED STEAM TEMPERATURE AND REALIZATION OF ITS CONFIGURATION** Zhang Xilin et al (23)
In view of defects existing in conventional superheated steam temperature control, such as slow response speed, long transient time, and large overshoot magnitude etc., a design method of the controller based on adaptive regulations has been put forward, making parameters of the PID controller can automatically suit to the variation of object, achieving the purpose of optimal controlling. At the same time, the configuration of adaptive controller and the working principle of its every part have been given. The result of simulation shows that the quality of adaptive PID controller is much better than that of the conventional PID controlling.
- STUDY ON FAILURE MODE OF WELDED JOINTS FOR AUSTENITE STEEL WITH DISSIMILAR METALS ON HIGH-TEMPERATURE BOILER TUBES IN POWER PLANTS** Ren Ai et al (27)
The aging features, as well as creep rupture strength limit and persistent strength limit of welded joints for austenite steel (such as 304H and 347H stainless steel) with dissimilar metals (such as 2.25Cr-1Mo ferrite heat-resisting steel etc.) after long-term service have been tested and studied. The said heat-resisting steel has comparatively extensive utilization in our country. The causes leading to aging and failure of the said joints have been comprehensively analysed from several aspects, namely structure aging, performance variation, features of joint's configuration, carbon migration, and thermal expansion coefficient of materials etc.
- TESTING OF COAL PULVERIZING SYSTEM AS WELL AS ENERGY-SAVING AND CONSUMPTION-REDUCING THEREOF** Wang Hongyu et al (32)
Combined with optimization of adjusting and testing for the coal pulverizing system with intermediate storage bunker of a 410t/h boiler's ball mills in a power plant, the influence of various factors upon operating condition of the coal pulverizing system has been analysed. Through optimization of adjusting, the operating condition of said system becomes more reasonable, enhancing economic aspect, reducing the specific consumption of electricity for coal pulverizing more than 2.51 kWh/t.
- CAUSE ANALYSIS OF FAULTS OCCURRED ON HIGH-PRESSURE FEED-WATER PUMPS AND IMPROVEMENTS OF REPAIR TECHNIQUES** Su Shaolin (35)
DG 270-140B type high-pressure feed-water pumps are early typical products of Shenyang Water Pumps Factory, being widely used in many power plants. Due to special operating conditions and insufficiency existing in the design, such faults as seal packing leakage, vibration, and burn-melting of thrust bearing shoe etc. have frequently occurred. For this reason, several effective repair techniques are recommended.
- CAUSE ANALYSIS OF RADIATOR TUBE BUNDLES FROST-CRACK FOR INDIRECT AIR-COOLED SYSTEM WITH SURFACE CONDENSER** Wen Xingu et al (38)
Frost-crack of the radiator tube bundles during the period of winter in frigid area is a comparatively prominent problem for indirect air-cooled system with surface condenser, a cause analysis for the said problem has been carried out, taking emphatically the freeze-up mechanism as the point of departure. It is considered from said analysis that the short-circuit of intermediate partition plate is the main cause resulting in frost-crack of the said tube bundles, and corresponding technical measures for improvements have