

# 一种有效的船舶轴系安装新方法

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**摘 要:** 传统的轴系安装方法是先在船台安装轴系, 后下水通过调整主机位置进行轴系对中安装。大连造船厂承造的某型船舶由于其动力系统结构复杂, 设备及管路舾装周期很长。为确保总船的建造进度, 必须提前进行机舱设备的舾装工作, 因此需要先在船台定位安装主机, 后下水进坞安装轴系。为了保证轴系的安装质量, 需要开发一种有效的轴系安装技术, 以解决在这种安装方案下因船体水下变形可能造成的轴线偏移问题。针对这个问题, 设计人员提出了一种有效的轴系安装技术, 实船使用表明, 该技术不仅能够保证机舱的舾装进度, 其轴系安装精度也能满足技术要求。

**关 键 词:** 轴系; 对中; 安装技术

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## 1 前 言

大连造船重工有限公司承造的某型船采用的是蒸汽动力装置, 双机双轴双桨。两套装置分前后机舱布置, 分别通过两根多支点的轴系驱动螺旋桨。该船两根轴系长度分别为 78 mm 和 58 mm, 可当作长轴系结构。这种长轴系结构使得轴系的布置和安装非常困难, 而轴系设计的合理性及其安装的精度对轴系的运转性能影响很大。由于该船为首次建造, 其轴系安装没有可值得借鉴的数据。为了保证该船的建造进度, 需要提出一种有效的轴系安装方法, 既能确保轴系的安装精度, 又能大大缩短机舱管系和设备的舾装周期。由于国内目前还无此类似的安装方法进行借鉴, 船方组织了有关人员进行了专项研究, 最终研究出了一套有效的轴系安装技术解决了这个问题。

## 2 方案论证

### 2.1 拟用方案

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常规的轴系安装方法, 一般有以下三种方案:

第一种方案: 根据常见的保守方法, 在船台加工艉轴管, 在坞内安装艉轴及螺旋桨, 出坞后依艉轴为基准, 由后向前依次排轴, 最终定位主机和减速器。

第二种方案: 先安装定位主机, 即在船台按减速器输出轴中心为基准来定艉轴管, 在船台加工艉轴管成品, 下水后坞内安装艉轴和螺旋桨, 出坞后进行水上轴系校中定位。

第三种方案: 先定位主机, 在船台按减速器输出轴中心初步定位艉轴管, 下水后在坞内定位加工艉轴管并安装艉轴和螺旋桨, 水上进行轴系校中。

### 2.2 方案分析

第一种方案是大多数船厂常用的方法。该方法比较稳妥, 但是由于主机只能在水下后定位, 相关的设备和管系就无法定位安装, 使机舱的舾装工作严重滞后。另外, 由于该船的主机和齿轮箱体积庞大, 重量超常, 在机舱内很难进行主机和齿轮箱的安装和定位工作。因此, 这个方案势必会影响机舱的舾装进度, 从而难以保证按期交船。

第二种方案方法虽然简单, 但风险较大。因为当轴线的两端定死后, 即主机和艉轴管定位下水后, 主船体在水中会发生一定的变形, 由于轴线的变形值无法控制, 一旦变形值过大将造成艉轴管及艉轴支架的报废。

第三种方案方法复杂, 难度较大, 但风险较小, 既能保证轴系的安装精度, 又能确保全船的建造进度。此方案的关键是坞内艉轴管和前后艉轴架定位尺寸的确定。要确定该尺寸, 必须充分掌握船体在水上、船台、坞内三种状态下的变形值及其对轴线的影 响, 根据这些数据, 从而推出艉轴管和艉轴架在坞内的定位尺寸。

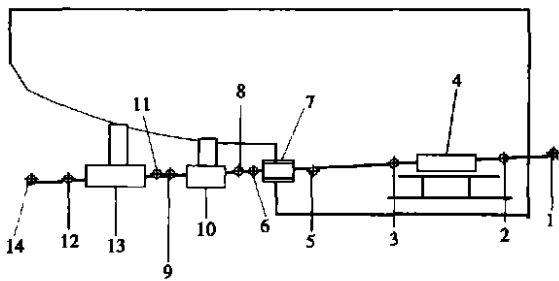
通过充分的论证, 第三种方案被采纳用来进行

本船的轴系对中工作。

### 3 轴系安装技术实施方案

#### 3.1 轴系首次照光

轴系首次照光的目的是通过确立轴线的首尾基点来确定轴线。其基本条件是主船体成形,相应的设备基本就位。当设备或上层建筑因某些特殊情况下无法安装时,可对其重量进行估算,并在其安装部位采用相当重量的压载铁进行压重,以对该重物所造成的变形进行补偿,力求此时轴线区域的受力状态等同于下水前的完整状态,确保第一次照光的精确性(见图1)。



1-轴线首基点; 2,3-减速器前后拉线光靶; 4-减速器; 5,6-艉轴管前后拉线光靶; 7-艉轴管; 8,9前轴架前后拉线光靶; 10-前轴架; 11,12后轴架前后拉线光靶; 13-后轴架; 14轴线艉基点

图1 轴系照光示意图

照光时,根据图纸计算的结果,得到机舱前部和船体尾部首尾基准点的定位数据,首尾基准点的中心连线即为理论轴线。该过程如图1所示。

#### 3.2 减速器船台安装定位

按照第三种轴系安装方案的要求,首次轴系照光完成后,将在船台对减速器按首次照光确定的轴线进行定位安装。具体过程如下:

(1) 轴系首次照光确定了首尾基点,根据这一首尾基准点,可在主机减速器前后端、前后艉轴架前后端以及艉轴管前后端共设置8个拉线支架,调整支架中心,使其与首尾基点、光学准直仪同心,这表明8个拉线支架的理论连线即为轴线,可定位点焊支架。

(2) 主机减速器基座定位。在焊好的主机减速器前后的支架间拉钢丝线,按理论的高度(考虑钢丝下垂量),确定基座面板的高度,并对面板进行定位焊接。

(3) 艉轴架的定位。对前后艉轴架支架进行拉

线,考虑钢丝的下垂量,在钢丝线上对前后艉轴架进行定位(按加工要求),然后对艉轴架进行焊接固定。

(4) 主机减速器基座面板的加工。确定主机基座的高度位置后,在基座面板前后位置设置基准块,使之面板的理论中心距离相等,并符合设计要求。根据基准块来调整专用铣床,对基座平面进行加工,使其座前后平面均平行于轴线;其它方位尺寸及表面粗糙度满足图纸要求。

(5) 减速器定位安装。用调整螺栓调整减速器的位置,首先将准直仪中心与减速器输出轴同心,调整减速器位置,使准直仪中心与前后艉轴架拉线支架中心以及尾基点同心,测量减速器基座垫块厚度并对基座面板钻孔,将垫块及松螺栓把紧,检查减速器中心是否与艉轴管及前后艉轴架同心,然后在基座铰孔,配制紧配螺栓并固定好减速器,最后再次复测减速器中心定位的精确性。

(6) 艉轴管初定位。以安装好的减速器输出轴中心为基准,在艉轴管前后拉线支架间拉钢丝线,对艉轴管进行初步定位(考虑钢丝线下垂量)并点焊定位。

#### (7) 中间轴承定位

中间轴承以轴线为基准在舱内进行定位。

### 3.3 轴系安装对中

(1) 艉轴管、前后艉轴架的坞内加工。船舶进坞48h后,进行轴系照光。从减速器输出轴用准直仪按各中心点同心法对艉轴管的中心进行精确定位,然后烧焊艉轴管。根据此次艉轴管和艉轴架中心的测量结果及船体变形值,确定艉轴管及前后尾支架的加工基准点,然后对艉轴管及艉轴架按加工基准点进行镗孔加工,在坞内安装螺旋桨和艉轴及轴系其它附件。

(2) 水上排轴。出坞48h后,从艉到首,用传统的对中方法进行轴系对中工作,对中时应考虑主机的热变形的轴承负荷对对中结果的影响。

### 3.4 艉支架和艉轴管加工基准的确定

为了掌握船体在水上、坞内两种状态下相对于船台状态下的变形规律,以便在坞内坐墩状态反推算出水上浮态轴线的状况,特制定一套可行的变形数据测量及分析方案。

(1) 艉轴管在船台初步定位后,下水前在两根轴线上部区域的两边通道内分别设置一排光靶,依次调整位置,用准直仪确保这排光靶中心位于同一根直线。

(2) 船舶下水后,用准直仪来测量光靶的变形量。

(3) 船舶进坞后,再用准直仪来测量光靶的变形量。

(4) 根据进坞和下水状态下相对于船台状态下的船体变形量,可得出坞内状态相对于水下状态的船体变形量。

其轴线变形测量如图 2 所示。

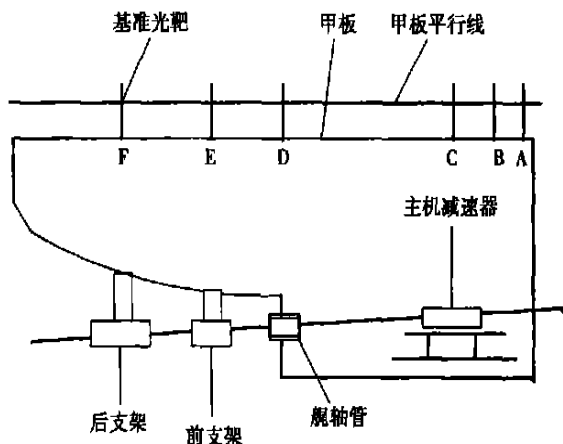


图 2 轴线变形测量方法示意图

表 1 轴线变形测量数据

	A	B	C	D	E	F
1	0.23	0.25	0.24	0.21	0.86	0.87
2	0.21	0.24	0.24	0.21	0.87	0.87

测量数据如表 1 所示,根据测量得出的变形数据,通过该型船底的结构形式和船底结构材料的机械性能,可以推算出水上状态相对于坞内状态下的船体变形量为:

$$Y = (x_1 \quad x_2 \quad x_3 \quad x_4 \quad x_5 \quad x_6)k - (0.03 \quad 0.03 \quad 0.03 \quad 0.03 \quad 0.072 \quad 0.209)$$

其中,  $x_1 \ x_2 \ x_3 \ x_4 \ x_5 \ x_6$  为下水后再次进坞时船体艉部主甲板处的变形量,即 A、B、C、D、E、F 处的

变形值。 $k$  为一  $1 \times 6$  的定量矩阵,根据经验公式和计算结果,可取  $k$  矩阵为:

0.3	0	0	0	0	0
0	0.3	0	0	0	0
0	0	0.3	0	0	0
0	0	0	0.3	0	0
0	0	0	0	0.7	0
0	0	0	0	0	0.7

根据计算结果,在进行前后艉支架和艉轴管的镗孔时,可把后艉支架镗孔的前后基准点从理论基准点处垂直向下移动 0.40 mm,使得后艉支架在坞内镗孔后的实际轴线将比理论轴线降低 0.40 mm。前艉支架加工的基准点则在理论加工基准点处垂直向下移动 0.53 mm。

艉支架、艉轴管坞内镗孔工作完后,开始在坞内穿轴。出坞后从尾向首进行排轴,轴系对中外圆  $< 0.10$  mm,缝差  $< 0.10$  mm/m 要求进行。考虑到主汽轮机组在满负荷状态下的热膨胀对机组中心的影响,在主轴系与减速器轴系进行对中时,将减速器轴线相对于轴线降低 0.3 mm。

### 4 结 论

轴系安装完成后,在后来的系泊试验以及 3 000 多海里的航行试验中,轴系上各中间轴承、主机减速器和推力轴承等所有设备在各工况下的工作性能稳定,振动小、噪音低,其性能得到了设计单位、船东及各方专家的认可。在采用这种轴系安装技术后,该船的机电设备舾装周期提前了 4 个月完成,确保了该船的总体建造进度,获得了可观的经济效益。

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# 欢 迎 订 阅

is given of the basic process of its implementation and, on this basis, an expanded and balanced combustion control system proposed. The above work can serve as an exemplary case and provide reference for control version optimization in other thermal power plants and for the full utilization of system resources. **Key words:** primary air, pulverized coal, on-line monitoring, Symphony, realization

煤粉与水煤浆焦炭颗粒燃烧速度的分析和比较 = **Analysis and Comparison of the Combustion Speed of Coal Water Slurry and Pulverized-coal Coke Particles** [刊, 汉] / YU Hai-miao, ZHAO Xiang, CAO Xin-Yu, HUANG Zhen-yu (Education Ministry Key Laboratory on Energy Clean Utilization and Environmental Engineering under the Thermal Power Engineering Institute of Zhejiang University, Hangzhou, China, Post Code: 310027) // Journal of Engineering for Thermal Energy & Power. — 2004, 19(6). — 631 ~ 633.

Through the full-load combustion tests of a coal water slurry-fired boiler No. 2 at Maoming Thermal Power Plant and a pulverized coal-fired boiler No. 5 at Banshan Power Plant an analysis and a comparison was conducted of the combustion speed of coal water slurry (CWS) and pulverized-coal coke particles. With the help of a scanning electron microscope and by way of a BET nitrogen adsorption test and by using a granularity analyzer the fly ash samples of the combustion test were studied and analyzed. This is followed by a discussion of the causes, which may have led to the divergence in combustion speed of CWS and pulverized-coal coke particles. **Key words:** pulverized coal, coal water slurry, coke particle, combustion speed

水煤浆代油改造技术在工业采暖锅炉中的应用 = **The Application for Industrial Heating Boilers of a Modification Technology Involving the Conversion from Oil firing to Coal Water Mixture Firing** [刊, 汉] / ZHAO Bao-cheng, ZHU Liu-juan, GU Bo-qin (College of Mechanical & Power Engineering under the Nanjing Polytechnical University, Nanjing, China, Post Code: 210009) // Journal of Engineering for Thermal Energy & Power. — 2004, 19(6). — 634 ~ 637.

The 14 MW heavy oil-fired industrial heating boiler of Beijing Yanshan Petrochemical Civilian Energy Sub-company has been converted to fire coal water mixture. In the light of the specific features of this conversion the authors have expounded the proper adjustment and modification of the boiler system under the condition of retaining the original facilities. The social economic benefits resulting from the above-cited modification are evaluated and analyzed. It can be shown that the coal water mixture as a kind of clean fuel enjoys a high potential of wide applications. **Key words:** industrial heating boiler, coal water mixture, modification

水煤浆技术在吉化炼油厂的应用 = **The Application of Coal Water Slurry Combustion Technology at Jihua Oil Refinery** [刊, 汉] / CAO Xian-bo, TAO Shu-cheng (Jihua Oil Refinery, Jilin, China, Post Code: 132000), LIU Jian-zhong, ZHOU Jun-hu (Zhejiang University, Hangzhou, China, Post Code: 310027) // Journal of Engineering for Thermal Energy & Power. — 2004, 19(6). — 638 ~ 641.

The conversion and modification of a 65 t/h oil-fired boiler at Jihua Refinery to fire coal water slurry is described along with a brief account of the latter's discharge, storage and transportation system, the boiler front system components, slag and dust removal system. Moreover, analyzed are the modified-boiler operating conditions, economic and social benefits achieved and future use prospects of such modifications. The actual results of conversion of the above-cited boiler indicate that its load can be higher than 60 t/h, combustion efficiency above 97% and thermal efficiency greater than 88.5%. **Key words:** coal water slurry, combustion, boiler, oil refinery

一种有效的船舶轴系安装新方法 = **A New Effective Method for Installing a Ship Shafting** [刊, 汉] / LI Nan (Mechanical Engineering Institute under the Dalian University of Science & Technology, Dalian, China, Post Code: 116023), NIU Ming-tian (Naval Representative Office Resident at Dalian Shipyard, Dalian, China, Post Code:

116005), Sun Jing-bo (Dalian Shipbuilding Heavy Industry Co. Ltd., Dalian, China, Post Code: 116005) //Journal of Engineering for Thermal Energy &Power. — 2004, 19(6). — 642 ~ 644.

Under a traditional installation method a shafting is first mounted on a shipway and after a launching, the shafting undergoes an alignment through the adjustment of a main machine location. A certain type of ship built by Dalian Shipyard due to its complicated structure of propulsion system the fitting-out cycle of the equipment and piping is very long. To ensure the building time schedule of the ship as a whole, it is necessary to conduct the fitting-out work of engine room equipment in advance. Hence, it is first necessary to fix a location at the shipway to install the main machine, and then install the shafting while in the dock. With a view to ensuring installation quality of the shafting, it is required to develop an effective technique of shafting installation, thereby resolving the problem of shaft line offset caused by the underwater deformation of the ship body under the present installation scheme. To cope with this problem, designers have proposed an effective method of shafting installation. The actual use experience on a ship indicates that the proposed technique can not only ensure the fitting-out time schedule of the engine room equipment, but also meet the technical requirements of the shafting installation precision. **Key words:** shafting, alignment, mounting technique.

**螺旋管换热器防止蒸汽随凝水排出的方案研究 = The Study of a Scheme for Preventing the Vent of Steam from Condensate in a Spiral-tube Heat Exchanger** [刊, 汉] / HAN Zhi-hang, SUN Feng-zhong, HAN Ji-tian, SHI Yue-tao (College of Energy and Power Engineering under the Shandong University, Jinan, China, Post Code: 250061) //Journal of Engineering for Thermal Energy &Power. — 2004, 19(6). — 645 ~ 647.

The spiral-tube heat exchanger represents a new type of high-efficiency heat exchanger. Loss of steam is a major factor impairing its heat exchange efficiency. The basic working principle and application of such heat exchangers are described and some technical schemes for preventing the vent of steam from condensate proposed. **Key words:** heat exchanger, spiral tube, heat exchange efficiency

**锅炉煤仓塞煤问题解决方案 = A Scheme for Resolving the Problem of Coal Plugging in a Boiler Coal Bunker** [刊, 汉] / SHI Shuai-jun (Shenma Nylon Chemical Engineering Co. Ltd., Pingdingshan, China, Post Code: 467013), LIU Kai-fu (Qinhuangdao City Huadian Measurement &Control Equipment Co. Ltd., Qinhuangdao, China, Post Code: 066000) //Journal of Engineering for Thermal Energy &Power. — 2004, 19(6). — 648 ~ 649.

**常压热水锅炉机械循环垂直式供暖系统分析 = The Design of a Mechanical-circulation and Vertical Type Heat Supply System for Constant-pressure Hot Water Boilers** [刊, 汉] / ZHENG Xin-wei (College of Power & Nuclear Energy Engineering under the Harbin Engineering University, Harbin, China, Post Code: 150001), LIU Chang-he (Harbin No.703 Research Institute, Harbin, China, Post Code: 150036), SONG Yan (Technical Quality Supervision Bureau of Heihe City, Heihe, China, Post Code: 164300), ZHANG Ai-ping (North China Oil Field Bazhou Municipal Constant-pressure Hot-water Boiler Co. Ltd., Bazhou, China, Post Code: 065703) //Journal of Engineering for Thermal Energy &Power. — 2004, 19(6). — 650 ~ 653.

The mechanical-circulation and vertical type heat supply system of constant-pressure hot water boilers pertains to a representative heat supply system widely used in China. Through the analysis and research of this heat supply system the authors have proposed for the above-mentioned heat supply system some pertinent schemes and a method of laying out its piping, valves and instrumentation. Meanwhile, some suggestions concerning the optimized design of a boiler-water heat supply system for the constant-pressure hot water boilers are proposed. They are of practical engineering value for heat supply system engineers. **Key words:** heat supply system of constant-pressure hot water boiler, form, design, proposal