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中文题名	小浪底水轮机组效率与稳定性测试关键技术应用研究
英文题名	Application of Key Technology for Xiaolangdi Turbine Units Efficiency and Stability Test
中文关键词	水力机械;现场测试;效率试验;稳定性试验;运行区
英文关键词	hydro-machinery;field test;efficiency test;stability test;operating regions
中文文摘	摘 要本文从水轮机效率和稳定性两个方面，结合黄河小浪底水电站实际工程问题，对水轮机组现场测试关键技术的应用进行了研究，并合理划分了机组的运行区域，为保证机组安全稳定运行提供了参考依据；也为其他类似电站水轮机组现场测试和运行区域划分提供了借鉴经验。本文首先分析了水轮机进行现场测试的必要性，并简要介绍了水力机械效率及稳定性现场测试方法的研究现状，包括各种主要测试方法及相应的优缺点。其次，结合黄河小浪底水电站 1 号机组现场绝对效率试验和机组稳定性试验研究，介绍了试验原理、方法及测点布置方案，并对试验结果进行了深入分析。在效率试验研究中，采用蜗壳压差法进行了流量测量，并通过压力—时间法对机组的蜗壳压差流量系数进行了率定。效率试验结果表明：在低负荷区域实测效率曲线与水轮机制造厂给出曲线相差较大。在稳定性试验研究中，先后对 1 号机组进行了 87m 水头下的开机过渡过程试验和 87m、99m、109m 及 121m 等四个水头下稳定运行工况的变负荷试验。其中，开机过渡过程试验结合频谱分析方法与轴心轨迹方法，通过对实测数据分析表明：转子存在质量不平衡；并且当转速达到约 22%额定转速时，上导、下导和水导的最大偏心距离远大于开机稳定后的最大偏心距离，其具体原因需结合多个水头的数据进一步深入分析。在四个水头下稳定运行工况的变负荷试验中，通过对 1 号机组在不同负荷工况下振动、摆度、水压脉动等实测数据的深入分析，得到各种曲线和成果，作为制定电厂经济安全运行、优化调度和节水节能的依据。根据效率及稳定性试验成果，通过深入分析蜗壳进口压力脉动、顶盖压力脉动和尾水管压力脉动的关系，确定压力脉动是振动的主要因素。因此，本文最后以尾水管进人门压力脉动的实测数据为主要参考因素，同时考虑尾水管进人门 1 m 处的噪声实测数据，及水导摆度、顶盖水平和垂直振动等因素的综合影响，对小浪底水轮发电机组运行区域进行划分，为电站安全稳定运行提供了依据。本文的研究工作将为其它电站机组划分运行区域提供借鉴。
外文文摘	AbstractThe application of key technologies of the field test for the actual project problems of the Xiaoliangdi hydro-power on the Yellow River was studied in this paper, the restricted operating regions of the hydroelectric unit determined according to efficiency and stability, a warrant provided for the safe and stable operating of the hydroelectric unit, and also experience of the field test and operating regions determination provided to other similar power stations.Firstly, the necessity of the field test was been analyzed in this paper, and the present research situation of efficiency and stability test methods introduced including the major kinds of test methods and their advantages and disadvantages.Secondly, the experiment principle, test method, measuring point layout scheme was elaborated and result was been analysis for the absolute efficiency test and unit stability test of No.1 unit in Xiaolangdi hydropower station. In the efficiency test, the volute pressure difference method was been used for the flow measurement, and the coefficient of volute pressure difference was calibrated by the pressure-time method The efficiency test result shows that in the low-load region the measured efficiency curve differs greatly from the one given by the turbine manufactory. In the stability test study, the start-up test under the head of 87 m and the load change tests of the steady operating condition under the heads of 87 m, 99 m, 109 m and 121 m were conducted. Through the combination of frequency spectrum analysis and axis orbit analysis in the start-up test, the data show that: the runner was of mass unbalance; when the rotation speed was approximately 22% of the rated one, the maxim eccentric distances of the upper guide bearing, lower guide bearing and turbine guide bearing were much bigger than the ones in the steady operating condition, the reason for which should be investigated further according to the data of several heads. In the load change tests of the steady operating condition under the four heads, for No.1 unit, all kinds of experiment curves and conclusions obtained through the analysis of the data of vibration,

	swing, pressure fluctuation, were regarded as the basis of plans for safe and economical operation, scheduling optimization and energy saving of hydro-power station.Finally, according to the results of the efficiency and stability test, through the analysis of the relations between the pressure fluctuations in different parts, the pressure fluctuation was been regarded as the main source of the vibration. Thus, the pressure fluctuation at the manhole of draft tube was taken as the main reference this paper, together with other factors such as the noise data measured 1 m away from the manhole, the swing of water guide bearing and the vertical and horizontal vibration of upper cover, to determine the restricted operating regions of the unit, which provides the basis of the safe and stable operation to Xiaolangdi hydro-power station. In addition, the work will be a reference of the restriction of operating regions for other stations.
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