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英文题名	Vibration Investigation on Bracket of Zhouning Hydropower Station
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中文文摘	摘 要稳定性是水轮发电机组长期安全运行的重要保证。随着设计、制造技术水平的不断提高，机组容量增大，结构却向轻型化发展，导致许多机组出现机架的振动超标问题。因此快速有效地消除各种可能的振源，对机组的安全稳定运行有着重要的现实意义。论文首先介绍了周宁电站机组上机架水平振动严重超标的状况，即使通过传统的超速动平衡方法也解决不了这种状况，由此认为机架有共振的可能。为了确定并消除振源，在现场开展了机架的固有频率测试工作，但由于机架的尺寸太大，没有能够激励机架的明显振动，仅测得了高频成分，因此通过有限元计算各相关部件的固有频率成为一种可行的方法。接着本文介绍了结构模态分析和转子动力学的研究现状和有限元分析原理。针对现场测试到的可能共振频率，对机架和轴系的相关部件进行了模态分析，计算了上机架和定子机座整体结构及下机架的前几阶固有频率，得出了轴系的弯振、扭振、垂振的固有频率及临界转速。计算结果表明，上机架和定子机座整体结构的 1 阶固有频率与可能共振频率吻合，振型为水平摆动，也与现场情况完全符合；而下机架和轴系的固有频率与可能共振频率相差较大，由此确定机架振动严重超标的原因为激励引起的上机架和定子机座整体结构的 1 阶共振。确定振源后，优化目标为提高上机架和定子机座整体结构的 1 阶固有频率至 13 Hz 左右。结合现场情况，进行了四个方案的分析比较，分析了定子机座上部立筋数、千斤顶碟簧刚度系数和千斤顶位置对整体结构的 1 阶固有频率的影响。最终确定了一个经济快速的改造方案，该改造方案最终实施，过速试验结果表明，机架和定子机座的水平振幅大大降低，减振效果非常明显。本文运用有限元方法对机架和轴系的动力特性进行了较为系统的分析，为从有限元角度分析水力机械的机组稳定性积累了一些经验，并可为其它水轮机组的机架改造提供借鉴和参考。
外文文摘	AbstractA good stability ensures a safe long-term operation of hydroelectric generating unit. With the development of design and manufacture technology, the unit capacity increases while the structure weight declines, which brings about the excessive vibration problem of many unit brackets. Thus, eliminating every possible vibration resource is of great practical importance to the safe operation of unit.Firstly, the seriously excessive vibration situation of the upper bracket of Zhouning hydropower plant was introduced. This problem could not be fixed even by the traditional method of overspeed dynamic balance. Therefore, the resonance of the upper bracket might be responsible for this problem. In order to identify and eliminate the vibration resources, the measurement of natural frequency of the bracket was taken in the field. However, because the size of the bracket was too large, the expected severe vibration could not be excited and only the high-frequency components were acquired. Consequently, calculating the natural frequency of the related parts through FEM became a practical method.Afterward, the FEM theory and the current advance of study on structural modal analysis and rotor dynamics were introduced. According to the possible resonance frequency measured in the field, the modal analysis of the bracket and the related parts of the shaft system were conducted. The integrated structure of the upper bracket and the stator frame and the first several natural frequency of the lower bracket were calculated, and also the natural frequency of bending, torsional and vertical vibration of the shaft system and the critical rotational speed. The calculation result indicated that: the 1st order natural frequency of the integrated structure of the upper bracket and the stator frame probably accorded with the resonance frequency; the vibration mode was horizontal oscillation, which completely accorded with the actualities; however, the natural frequency of the lower bracket and shaft system diverged much from the possible resonance frequency. Thus, the 1st order resonance of the integrated structure of the upper bracket and the stator frame was assigned as the cause

	of the seriously excessive vibration.After the identification of the vibration resource, the optimization objective became increasing the 1st order natural frequency of the integrated structure of the upper bracket and the stator frame to approximately 13 Hz. According to the actualities, four plans were compared, the effect of the amount of the vertical steel bar and the stiffness coefficient and the position of the jack disc springs on the 1st order natural frequency of the integrated structure were investigated, and an economical plan was finally determined. After the implementation of this plan, an overspeed test was conducted and the result indicated that the horizontal vibration amplitude of the bracket and the stator frame was reduced greatly.FEM was employed to carry out a systematic analysis of the dynamic characteristics of the brackets and the shaft system, some experience in analyzing the operating stability of hydraulic unit from the angle of FEM was presented, and a reference for the brackets reform of other hydroelectric units was offered.
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