基于模态振型优化的真空凝壳炉减振设计方法 *

高昕星[1],刘 鑫[1],张瑞宇[1],刘时兵[2],李心可[3]

(1.国机集团科学技术研究院有限公司工程振动控制技术研究中心,北京 100080;
2.中国机械总院集团沈阳铸造研究所有限公司,辽宁 沈阳 110022;
3.沈阳真空技术研究所有限公司,辽宁 沈阳 110002)

摘 要:真空电弧凝壳炉属于特种材料铸造装备,离心浇铸过程中可能受到周期性激振力以及外部设备振动影响而诱发自身壳体共振,不仅影响铸件质量,而且会造成安全隐患。本文对某型真空电弧凝壳炉进行了模态分析,查明了局部设计不足是导致出现低阶局部振型的原因。通过补强结构,将一阶模态的频率从贴近工频频率的 56.786Hz 提升到较为安全的 77.610Hz,振幅从 3.540mm 降低至 0.323mm,模态振型优化方法实现了较好的减振设计效果。

关 键 词:真空电弧凝壳炉;模态分析;振型优化;振动控制;减振设计
中图分类号:X966 **文献标识码**:B **文章编号**:1002-0322(2023)03-0076-04
doi:10.13385/j.cnki.vacuum.2023.03.13

Vibration Reduction Design Method of Vacuum Arc Skull Furnace Based on Mode Shape Optimization

GAO Xin-xing[1], LIU Xin[1], ZHANG Rui-yu[1], LIU Shi-bing[2], LI Xin-ke[3]

(1. SINOMACH Engineering Vibration Control Technology Research Center, SINOMACH Academy of Science and Technology Co., Ltd., Beijing 100080, China; 2. Shenyang Research Institute of Foundry Co., Ltd. CAM, Shenyang 110022, China; 3. Shenyang Vacuum Technology Institute Co., Ltd., Shenyang 110042,China)

Abstract: Vacuum arc skull furnace is a special material casting equipment. In the process of centrifugal casting, it may be affected by periodic excitation force and vibration of external equipment, which will induce resonance of its own shell. In consequence, shell resonancereduces the casting quality and formssecurity risk. In this paper, the modal analysis of avacuum arc furnace is carried out, and it is found that the local design deficiency is the cause of the low-order local mode. By reinforcing the structure, the first-order mode frequency is increased from 56.786Hz (close to the power frequency) to 77.610Hz(relatively safe), and the amplitude is reduced from 3.540mm to 0.323mm. In conclusion, modal shape optimization method has achieved a good effect of vibration reduction design.

Key words: vacuum arc furnace; modal analysis; mode optimization; vibration control; vibration reduction design

真空电弧凝壳炉(简称“真空凝壳炉”)可在真空环境下熔炼和铸造具有高熔点、高活性、高腐蚀性等性能的特殊材料(如钛、锆等),对我国高端制造和国防工业有着重要意义[1-3]。为提高铸件成型质量,常采用离心浇铸工艺进行铸造,即将铸型安装在凝壳炉内部底端的离心盘上,在水平旋转中完成铸造。由于制造误差和铸型动平衡等因素,离心浇铸过程中总是伴生周期性激振力,引起凝壳炉的整体振动。当激振力频率与凝壳炉低阶模态耦合时将诱发炉体的强烈振动,该振动不仅影响铸件成型质量,而且对结构安全形成隐患。部分学者借助动力学计算中的模态分析,对动力机械以及建筑结构进行优化,实现了较好的抑振效果[4-9],该方法未见于熔炼铸造装备。本文以模态振型优化为基础,对凝壳炉进行了结构优化。

收稿日期:2022-06-22
作者简介:高昕星(1989-),男,内蒙古赤峰市人,工学博士,工程师。
* **基金项目**:国机集团重大科技专项(SINOMACH-ZDZX-2020-03);工信部高质量发展专项 *** 项目。