基于流导法的G-M制冷机低温泵抽速测试与分析*

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摘 要：抽气速率是衡量低温泵产品抽真空性能优劣的重要指标之一。除国内企业常用的流量法外，流导法亦是测量低温泵抽速的重要方法。本文依据现行标准中所规定的基于流导法原理测试真空泵气体抽速的方法，对ZD-200口径G-M制冷机低温泵对不同气体抽速测试进行了详细介绍。结果表明：流导法测得低温泵对N_2和Ar的抽速分别为2 410 L/s、1 884 L/s，明显优于国内外同类产品指标；低温泵对H_2抽速为2 577 L/s，与国内外产品公开技术指标处于相同水平。依照流导法获得的测试结果具有较高的准确度和可信度。

关 键 词：G-M制冷机低温泵；流导法；抽速测试；性能分析

中图分类号：TB752+.53 **文献标识码：**A **文章编号：**1002-0322(2024)03-0020-06

doi：10.13385/j.cnki.vacuum.2024.03.04

Measurement and Analysis of Pumping Speed of G-M Refrigerator Cryopump Based on the Orifice Method

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Abstract: Pumping speed is an important index to measure the pumping performance of cryopump. The throughput method is generally used to measure the pumping speed of cryopump in China. In addition, the orifice method is also an important method for measuring the cryopump pumping speed. In this paper, detailed introduction of pumping speed test for different gases of ZD-200 caliber cryopump was conducted based on the orifice method specified in the current standards. The results show that the pumping speed of cryopump for N_2 and Ar are 2 410 L/s and 1 884 L/s respectively, which are significantly better than the indicators of similar products at home and abroad. The pumping speed of cryopump for H_2 is 2 577 L/s, which is at the same level as the technical indicators of domestic and foreign products. The test results obtained by the orifice method have high accuracy and credibility.

Key words: G-M refrigerator cryopump; the orifice method; pumping speed measure; performance analysis

低温真空泵，简称“低温泵”，是获得和维持高真空或超高真空的设备，又常被称为深冷泵、冷冻泵或冷凝泵[1]。G-M制冷机低温泵是基于回热式低温制冷技术的一种低温泵，它利用G-M制冷机获得低温表面，对密闭腔体内的各类气体分子产生快速低温吸附、冷凝和捕集作用，从而实现超高真空环境。G-M制冷机低温泵因具有气体抽速大、真空腔内无运动部件、环境清洁、极限真空度高等优点而得到了越来越多的商业化应用，被广泛用于半导体和显示器制造设备等领域[2-3]。

G-M制冷机低温泵由壳体、80K挡板、80K防辐射屏蔽罩、G-M制冷机和压缩机等单元组成。G-M制冷机的循环介质为氦气，一级冷头温度可达到40～80 K，用于冷凝水蒸气、二氧化碳以及对其他气体进行预冷；二级冷头温度可达到8～20 K，用于冷凝和捕集氮、氧和氩等气体。在与二级冷头相连的冷伞阵列内表面用低温胶黏粘了椰壳活性炭颗粒，利用高比表面积(800～2500 m^2/g)的活性炭在低温条件下对氦、氖和氢有很强吸附能力的特性，实现对这些非冷凝气体的吸附[4-7]。

收稿日期：2023-06-25

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* **基金项目：**广东省重点领域研发计划项目(2021B0101300004)。