浮空器囊体热合区域透氦率性能研究

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摘 要:浮空器实际使用中氦气渗漏量远超理论计算值而极大地影响自身驻空性能。本文基于漏氦量误差产生原因,探讨了囊体热合缝部位的漏氦机理,通过热合区域透氦率试验,提出了改进思路和方法。针对长航时浮空器设计,研究了不同热合缝结构形式和工艺方法对漏氦率的影响以优选出低漏氦的浮空器囊体的成型技术。结果表明:通过优化囊体结构形式和工艺方法,如在囊体热合缝外侧热合或胶黏有保护性质的外热合条、尽量选用热合工艺加工等方式来有效提高囊体的阻隔、保型能力,可以提高浮空器的驻空时间。

关 键 词:浮空器;长航时;囊体热合技术;漏氦率试验

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Research of Leakage Properties for Aerostat Envelope Welding Area

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Abstract: In actual use, the helium leakage of the aerostat is much larger than the theoretical value, which greatly affects the standing performance of the aerostat. In this paper, the mechanism of helium leakage at the envelope welding area was discussed based on the errors between the calculated and actual helium leakage values. Helium permeability tests in the envelope welding area were conducted, and improvement ideas and methods were proposed. Aiming at the design of the long-endurance aerostat, the forming technology of the low helium aerostat capsule was optimized by studying the influence of different structural forms and technological methods of the envelope welding on the helium leakage rate. The results show that optimizing the structural form and processing methods of the airship envelope, such as applying protective outer heat-sealing strips on the outside of the envelope heat-sealing seams, or using heat-sealing processes as much as possible, the barrier and shape retention capabilities of the envelope can be effectively improved, and the standing time of the aerostat can be increased.

Key words: aerostat; long endurance; envelope welding technology; leakage rate test

浮空器是以浮升气体(氦气)为载体,携带任务载荷,升空到一定高度工作的飞行器[1-3]。近年来,如平流层飞艇等应用,要求浮空器能在特定高度上停留长达6个月以上,具备类似地球同步轨道卫星的能力[4-5]。较长的驻空时间使得浮空器不得不面临很多挑战,如强紫外线、很大的昼夜温差等。气囊内的气体(如氦气)也会透过飞艇表皮向飞艇内外渗漏,从而导致飞艇内部气体纯度降低,总物质的量下降,质量上升,压差降低[6]。

氦气渗漏造成的压差下降是限制浮空器航时最重要的原因之一。因为浮空器需要一个最低压差来抵抗风力及其所携带载荷引起的变形,而随着浮空器主气囊内的氦气量和纯度在渗漏过程中逐渐下降,同时由于空气密度远大于氦气,浮空器的总重会相应增加。因此,浮空器必须在氦气渗漏不可避免的情况下,通过维持重力、浮力平衡来保持高度。在浮空器一次能携带的抛重物有限的情况下,渗漏和排空气都会导致浮空器内部气体总物质的量下降,浮空器内外压差相应降低[7]。浮空器压差降低到安全值(最小可用压差)的时间即是浮空器的最长航时。

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