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硕士学位论文

离子交换以及表面镀膜对玻璃强度影响的研究

Study on the Influence of Glass Strength by
Ion Exchanging and Surface Coating

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摘 要

高铁产业的迅速发展推动着相关材料和技术的不创造革新，车窗玻璃作为高速列车的重要安全构件，提高抗冲击能力，是高铁玻璃的研究前沿和焦点。玻璃的表面压应力、压应力厚度、中心张应力、表面微裂纹等因素，对玻璃抗冲击能力有重要影响。化学钢化，是已知的传统玻璃增强工艺，可大幅提高玻璃的表面压应力，但高铁玻璃，不仅要求表面压应力达到900 MPa以上，而且同时要求压应力厚度达到50 μm 以上，目前的化学钢化工艺无法满足要求。另一方面，表面镀膜增强，虽已有研究，但是，缺乏系统性，特别是缺乏膜厚影响因素的系统研究。本文，聚焦高铁玻璃的应用领域，针对高铁玻璃对化学钢化提出了新的工艺课题，同时，结合表面镀膜增强相关系统性研究的新课题，开展了两方面的研究：（1）以普通钠钙硅玻璃为主要研究对象，通过设计正交实验，采用FSM-6000LE表面应力仪及EDS能谱分析等测试方法，探究了熔盐添加剂对化学钢化玻璃的表面压应力以及应力层厚度的影响，得到了化学钢化添加剂配方；（2）采用微米级硅溶胶喷涂工艺，系统研究了膜层厚度以及不同冲击面镀膜对玻璃抗弯曲强度的影响。

本文主要研究内容和结论如下：

- 1、在传统化学钢化工艺基础上，通过设计正交试验，探究了新的熔盐添加剂配方，有效地提高了玻璃表面应力强度，与此同时，利用双环测试的结果比较了新、老熔盐配方在玻璃抗弯曲性能方面的表现，结果发现新配方相比旧配方，在抗弯曲强度上提高了将近100 Mpa。
- 2、实验主要采用空气枪喷涂工艺将微米级硅溶胶均匀的喷涂在玻璃表面，通过控制喷涂工艺来改变膜层厚度。分别利用SEM和膜厚仪检测膜层与玻璃的粘接情况和磨层的均匀性，结果表明，微米级硅溶胶和玻璃表面结合非常紧密，几乎没有空隙和孔洞；膜层厚度偏差很小，整体的均匀性很好。
- 3、通过微米级硅溶胶涂覆增强玻璃表面强度和抗弯曲性能，分别比较了三种膜厚对玻璃抗弯曲强度的影响，研究发现：玻璃表面的抗弯曲强度随着膜层厚度的增加而增加；通过改变玻璃表面膜层的放置方向发现，膜层背向冲击面的抗弯曲效果优于膜层面向冲击面。玻璃受冲击时，背向冲击的玻璃表面受张应力作用。微米级硅

溶胶能有渗透修复微裂纹，因此起到增强玻璃强度的效果。

关键词：熔盐添加剂；表面应力；硅溶胶；微米级镀膜；膜层厚度；抗弯曲强度

厦门大学博硕士论文摘要库

Abstract

The rapid developments of high-speed train industry promote the relevant materials and technology to create constant innovation. As an important safety component of high-speed train, the improvement of impact resistance is the focus of the research of high speed train's window glass. Many factors of glass surface, such as surface compressive stress, depth of compressive stress layer, center tension, surface micro-cracks, have an important impact on the impact resistance of glass. Chemical tempering, a well-known glass reinforced technology, can greatly improve the surface compressive stress of glass, however, high-speed train's window glass not only requires the surface compressive stress to be 900 MPa or more, but also requires the depth of compressive stress layer to be 50 μm or more, the current chemical tempering process is unable to fulfill the requirements. On the other hand, the strengthening technology of glass surface coating, although a few works had been reported, is still lack of systematic research, especially lack of the systematic study of the influence of surface coating thickness on glass strength. This article, under the application background of high-speed train's window glass and around the topics of (1) new processing of chemical tempering and (2) systematic study of surface coating enhancement, carried out the following two aspects of the study. (1) The effects of molten salt additives on the surface compressive stress and the thickness of the stress layer were investigated by orthogonal experiment, using ordinary soda lime silicate glass as raw materials and using FSM-6000LE surface stress meter, EDS energy spectrum analysis and other test methods. As a result, the additive formulation was obtained. (2) The influence of film thickness and the coating of different impact surfaces on the bending strength of the glass was studied by using the micron-scale silica coating and sol spraying process.

The main contents and conclusions of this paper are as follows:

1. On the basis of traditional chemical tempering technology, the new molten salt additive formula was explored through a design of orthogonal test, and the stress intensity of the glass surface is effectively improved according to the results of bicyclic test. The results show that the new formula increases glass anti-bending strength by nearly 100 MPa when comparing to the old formula.
2. The air gun spraying technology was used to spray silica sol on glass surface, and the micron-scale silica coating thickness was controlled by spraying processing. The interface adhesion between the film and glass, and the thickness uniformity of the coating were measured by SEM and optical interferometer, respectively. Results show that the micron-scale silica coating bonds with glass surface very closely without no voids and pores on the interface. The coating thickness deviation is small, showing the overall uniformity is good.
3. The surface strength and bending strength of glass were enhanced by micron-scale silica coating and the effects of three kinds of film thickness on the bending strength of glass were compared. Results show that glass bending strength increases with the increase of the coating thickness. By changing the coating orientation of glass surface, it was found that the bending strength of glass with film backing to the impact is significantly greater than that with film facing up to the impact. The glass surface of backing to the impact becomes a fragile surface due to suffering a tensile stress when being impacted. The cracks caused by tensile stress on glass surface can be healed by the SiO₂ coating, resulting the orientation effect of improving the bending strength.

Keywords: molten salt additive, surface stress, silica solmicron-grade coating film thicknessbending strength

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