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Effect of different whiskers on the physical and tribological properties of non-metallic friction materials

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ABSTRACT

Potassium titanate, magnesium borate and calcium sulfate whisker modified non-metallic friction materials (designated as P, M and C) were prepared by compression moulding process. Results of physical test showed that the addition of whisker greatly improved mechanical properties and slightly increased thermal stability. Particularly, M exhibited the highest tensile strength and C showed the best thermal stability. The tribology properties were investigated against a special counterpart of wire rope under dry and grease lubrication conditions. Results showed that potassium titanate whisker improved the wear-resistance most, and calcium sulfate whisker increased the value and stability of friction coefficient most at high sliding speed.

1. Introduction

Friction materials have been widely used in moving automobiles and hoisting device. For the extremely importance of safety, friction materials has been considered as one of the key components which determine the friction and wear characteristics of system. The friction materials normally contain multiple ingredients, and they are classified as binders, friction modified fillers and modified fibers according to their roles in determining the properties of composite. In general, organic binders are used to hold all ingredients together and phenolic resin is the most commonly used with synthetic rubber added to improve the flexibility of binder. Small quantities of fillers are added to optimize the properties. In order to strengthen the binders, reinforced fibers are included for their superior mechanical properties and heat-resistance [1–3]. During these years, a great deal of effort has been given to the development of friction materials in automotive brake system considering various issues such as organic fibers [4,5], abrasive fillers [6] and modified resin [7,8]. However, most of them cannot be directly used in hoisting device because the strong abrasive ingredients such as steel wool, metallic swarfs and some metal oxides in brake materials will make damage to the couple part such as wire rope. Therefore, it's necessary to find some new substituted reinforcers to improve the properties of non-metallic friction materials.

Among the numerous reinforcers, whiskers have been considered as one of the most attractive options. Owing to their perfect crystal structure, whiskers possess high thermal stability and tensile strength which is close to the binding force of adjacent atoms [9,10]. However, the expensive cost of some whiskers becomes an obstacle for their application. As the development of fabrication technology, some cheaper whiskers such as potassium titanate whisker ($K_2O{\cdot}6TiO_2$) have been developed and applied in reinforced composites including brake materials [11–14]. Additionally, previous researchers have demonstrated that magnesium borate whisker ($Mg_2B_2O_5$) and calcium sulfate whisker ($CaSO_4$) which are much cheaper possess excellent reinforcing effect in polymer [15–17] and metal [18] as well. However, they have been barely used in friction materials till now.

In the present study, the raw friction materials were modified with different whiskers, viz., potassium titanate whisker (PTW), magnesium borate whisker (MBW) and calcium sulfate whisker (CSW), respectively. The influence of selected whiskers on the physical properties was investigated. Tribological performance of the friction materials was emphatically evaluated under different lubrication and speed conditions in friction lining/wire rope pattern, which is the actual contact pattern in hoisting device.

2. Experiment details

2.1. Materials fabrication

The friction compositions were designed based on a fixed master batch consisting of nitrile butadiene rubber (NBR) modified phenolic resin, friction modified fillers and rubber agents (vulcanizing agent, plasticizer and anti-aging agent) as shown in Table 1. In the modified friction materials, 10 wt.% of friction modified fillers were substituted by PTW (Shanghai Jingxu Compound Materials Manufacture CO., Ltd.), MBW (Amwest Technology CO.,) and CSW (Shanghai Fuhua Industrial CO., Ltd.), respectively. The

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