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Analyses of a leaking styrene-acrylonitrile water-filter housing

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ABSTRACT

Fatigue cracks were found in water-filter housings made of styrene-acrylonitrile. These cracks initiated on the external surface, along the sharp corner between the wall of the housing and the vertical external ribs or at a pre-existing crack in the base of the water-filter housing. The reason for the crack was the high stress concentration due to an inappropriate design or the poor quality of the filter housing in combination with water-pressure impacts during the operation of an electromagnetic water valve and taps.

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1. Introduction

Several cases of water leaking from filter housings have been reported by the residents of homes in Slovenia. One common feature is that all the leaky housings have external vertical ribs. In one incident there was extensive damage to the property, because the water flooded the rooms in a house. As a result of a lawsuit (the owner of the house took legal action against the company that fitted the water filter), it was necessary to find the cause of the water leaking from the styrene-acrylonitrile water-filter housing.

Styrene-acrylonitrile belongs to the group of amorphous thermoplastics. It is a copolymer of styrene with the addition of 10–30% acrylonitrile. This means that styrene-acrylonitrile has (in comparison with polystyrene) an improved strength, impact toughness [1–3], fatigue resistance [4], resistance to thermal shock and resistance to non-polar media, e.g., oil and its derivatives [2,3]. Among all the styrene-polymers, styrene-acrylonitrile has the highest modulus of elasticity [1–3]. It also has a high hardness and, thus, a good resistance to the formation of surface scratches. However, such a fracture surface always tends to be brittle [3,5,6]. Styrene-acrylonitrile has a transparent, high-gloss surface, but it is sensitive to UV radiation. Nevertheless, because it is physiologically harmless, it is used for a variety of household products [2,3], including water-filter housings. These housings are directly threaded or screwed through a threaded sleeve to the filter head. The water-filter housing has a cylindrical shape, either with or without some external vertical ribs. These ribs allow a better grip and, therefore, easier tightening and loosening; they also increase the rigidity of the housing.

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2. Experimental

2.1. Samples

In order to find the source of the leaks, the company delivered eight water-filter housings for the investigation. The water-filter housing has a cylindrical shape with eight vertical external ribs (Fig. 1). The colour of the housing is a transparent blue. The internal surface of the upper part of the filter housing is threaded, which allows the housing to be screwed to the filter head. The radius of the transition between the ribs and the wall of the filter housing is $r = 0.2$ mm (Fig. 1, detail A). The thickness of the walls varies with the height (Fig. 1, detail B).

The technical characteristics of the water filter, as provided by the manufacturer, are as follows: destructive pressure $p_d \geq 32$ bar, working pressure $p_w \leq 8$ bar, working water temperature $T \leq 50$ °C. Three of the water-filter housings were delivered in an unused condition; five were taken from existing applications (all the filters had been installed in a cold-water system). Two of the five filter housings that had already seen some use also showed signs of leaking. One of them had been leaking from almost the entire length of one of the external vertical ribs, while the other was leaking from the central part of the base.

2.2. Methods

First, a visual inspection was made of all the delivered samples (with the naked eye and with a 5× magnifying glass). Various inhomogeneities in the walls of the filter housings (e.g., damage that occurs during manufacture, mechanical surface damage that may arise during transport or during the mounting of the filter to the water system, and cracks) were searched for. The shape of the water-filter housing was analysed. From pieces that were cut out and subsequently ground, the wall thickness according to a vertical cross-section and the radius of the transition between the ribs and the wall of the filter housing were measured. Additional measurements were made with a calliper (Garant absolute) and an optical dimensional measuring tool (Mitutoyo CS-3000 profile projector with a magnification of 10×). Both of these measuring instruments had calibration certificates. The fracture surfaces were examined with a scanning electron microscope (SEM JEOL JSM-561). Before the examination with the SEM, the samples were sputtered with a thin layer of gold. A destructive water-pressure test was made on one of the new, unused filter housings (a calibrated water manometer with a measuring range of 0–50 bar was used). A tensile test of the filter-housing material was performed with a

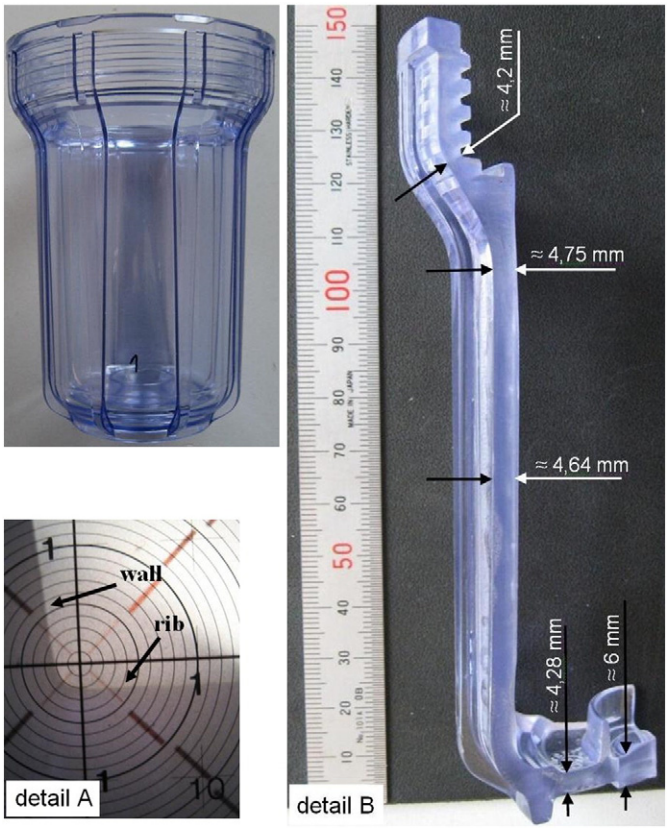

Fig. 1. The shape (a) and some dimensional characteristics (b, c) of the water-filter housing.

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