Recycling components made of polyurethane foam

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Abstract. The paper studies the influence of recyclable materials and waste (that are sandwich structures of polyurethane foam products) on physical mechanical properties of polyurethane foam products. It was established that indentation load deflection changed by 11 percent, thermal conductivity coefficient - by 12.5 percent, and the strength of bond between face layer and flexible PU foam remains the same (0.3 N/mm) when compared with PU foam products.

1. Introduction

Today, polyurethane (PU) foam is widely used in construction and machine building industry. PU foam has a good usability: high sound absorption and heat insulation properties, possibility to manufacture parts of a complex shape, high adhesive capability, low manufacturing cost of end products. Advanced PU foam has a wide range of uses in production of interior parts for automotive industry: floor mats, sun visors, upholstery components of cabins, doors, roof, and seats, bunk mattresses, overhead consoles, heat and sound insulation, heat insulators [1-8].

Sandwich structures are used due to high hygroscopic properties of PU foam, for better product esthetics and soft feel, higher wearing properties during operation, UV protection. One of the significant challenges for flexible foam manufacturers is to recycle foam products and waste. Block cutting and fabrication waste can be up to 15 percent of total output [9]. Therefore, the paper proposes the concept of recycling flexible foam waste and investigation of products based on this technology in order to reduce environmental contamination with foam waste.

2. Body text

In order to investigate recyclability of PU foam waste, we studied the compounds based on PU foam sandwich structures of floor mat [8], including manufacturing waste such as PVC film and rigid PU foam; synthetic leather (vinyl synthetic leather, fancy, TR type) and rigid PU foam; synthetic leather (industrial PVC material for vehicles, VID NT, type 02, TU 8729-156-05790484-2001), flexible PU foam and corona-treated film; semi-rigid PU foam and non-woven fabric; metallized polyethylene terephthalate film; flexible PU foam.

It was established that synthetic leather and film were joined together by foam waste. Its size varies from 100x100 mm² to 300x700 mm², and its edges are irregular.

Waste is baled under hydraulic pressure, stored in a plant storage yard, and moved to a municipal solid waste landfill by vehicles. A landfill receives approximately 34 tons of above mentioned waste every month. So, manufacturers and industry as a whole are facing an acute problem of industrial waste utilization.
It has been established that milled PU foam waste can be refoamed using heating, pressure, and binder. Refoaming is widely used to manufacture anti-vibration sound absorbing carpets, flooring, gym mats, stuffing materials, and carpet supports.

Comminuted polyurethanes are used as a filler for production of PU foam and elastomers. When comminuted powder is used as a filler, it is added first to polyol component during production. Molded PU products such as car headrests can contain up to 20 percent of re-milled material without loss in quality and performance.

It has been established that milling should be very fine as air pockets formed in the porous structure would shrink at a higher pressure and tend to restore its earlier volume under normal conditions. Using coarse recyclable particles (larger than 20 mm) for production of PU foam without sifting showed that resulting products had a non-uniform hardness in terms of area. It was observed that there was layer separation and poor adhesion between PU foam layer and outer layers.

In order to study the influence of recyclable materials on physical mechanical properties of PU foam products, the key properties of the studied samples made from waste and initial products were subjected to comparative analysis according to the specification TU [10]. The results of studies are shown in Table 1.

Table 1. Results of comparative assessment of physical mechanical properties

| No | Property name                                                                 | Test results for initial products | Test results for products with added recyclable material | Reference for parts | Test methods |
|----|--------------------------------------------------------------------------------|----------------------------------|--------------------------------------------------------|----------------------|-------------|
| 1  | Strength of bond between face layer and flexible PU foam, kN/m                  | 0.30                             | 0.30                                                   | 0.25                 | GOST 17317 [11], paragraph 4.4 [10] |
| 2  | Heat resistance                                                               | No layer separation and blistering, no changes in front coating and changes in geometry less than 5 % | No layer separation and blistering, no changes in front coating and changes in geometry less than 5 % | No layer separation and blistering, no changes in front coating and changes in geometry more than 5 % are permissible | paragraph 4.6 [10] |
| 3  | Indentation load deflection, mm, minimum:- absolute indentation               | 1.64                             | 1.46                                                   | 1.20                 | GOST 11529 [12], paragraph 4.9 [10] |
The studied samples have the same appearance as the samples of the initial material. However, using recyclable materials in sandwich PU foam structures changes physical mechanical properties such as indentation load deflection (by 11 percent), thermal conductivity coefficient (by 12.5 percent), and the strength of bond between face layer and flexible PU foam remains the same (0.3 N/mm). It should be noted that the most significant properties (sound absorption (up to 1000 Hz) and thermal conductivity) changed only slightly. Therefore, PU foam products with added recyclable materials have satisfactory physical mechanical properties, and they can be used for production of vehicle components, resulting in better environmental aspect of production.

3. Conclusions Therefore, the paper showed that the coarse particles of flexible foam waste could be used in vehicle parts such as supports for floor mats or inserts for molded foam. It is necessary to perform further exploratory studies to define optimum size of waste particles, their quantity in a product, spatial distribution of shape-forming elements, optimization of process conditions using recyclable materials and PU foam production waste.

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