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ORIGINAL ARTICLE

Experimental study of the dynamic behaviour of loaded polyurethane foam free fall investigation and evaluation of microstructure

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Abstract
We aim to maintain as much control over the microstructure development during the manufacture of polyurethane foam with a specific density. As a result, the finished product contains the shock absorber's required characteristics. That is why polyurethane foam loaded with zinc oxide and silica must sustain the cellular structure and strengthen it. First, mechanical characterization was carried out utilizing a dynamic drop impact test conducted on locally developed and constructed equipment. Polyurethane foams' mechanical properties rely on their density, cell structure (size and shape), and the fraction of open or closed cells. Within the cell structure, the foam may be directed preferentially. Following that, Raman spectroscopy and SEM investigation to visualize the semi-opened cells of the cellular polymer. The cellular polymer appears to possess permanent, regular cellular structures with a high degree of reversibility in terms of overlap.

Keywords Polyurethane foams · Shock absorber · Drop impact · Raman spectroscopy · SEM

1 Introduction

Polymer foam is a two-phase structure with randomly scattered gas bubbles in a polymer matrix. This structure has several advantages, the most essential being base density, as reduced weight is becoming increasingly important in many enterprises due to new environmental constraints [1, 2]. Polymer foams also provide excellent thermal and acoustic insulation, along with superior energy dissipation and impact absorption [3]. For instance, in automobiles, the control panel and side panels generally contain a significant amount of polymeric foam to protect individuals in case of accidents [4]. Packaging is also an important sector, where substances with sufficient impact dampening ability are necessary to prevent product damage during travel [5]. Aside from the above industries, polymer foam is used in sports equipment such as apparel and sports matting. For instance, polymer foam shoe soles reduce stress on runners' knee joints [6, 7], and racing protection gear could save lives. Jumping, martial arts, and gymnastics also use polymer foam sports mats to reduce the impact on the player when landing to avoid sports injuries [8]. The most generally used testing for polymeric foam impact damping is dropping testing for the influence of weight, in which an object of a certain mass and form is fallen out of a height around with a test sample to estimate the product's impact energy and dampening capabilities from the collision force or velocity [9]. A solid support is utilized when the weight bounces off the sample, whereas hole support is used when the weight penetrates the specimen [10]. The decent support test is more relevant in manufacturing athletic products and packaging because the pressures on the foams better reflect actual use.

This form of drop weight experimental study is represented on the cushioning curve in use by package designers [11]. Several sport-specific criteria require such a rating [12]. As a result, it is impossible to compare goods for different applications because the conditions for each activity vary. Beyond the test circumstances, the falling weight's form impacts the test outcomes. On closed-cell PMI (polymethacrylimide) foam with a specific density of 51 and 111 kg/m^3, Flores-Johnson and Li [13] demonstrated this in their experiments [14]. They prove that different foams provide complete protection.

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