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Experimental Study of Energy Absorption Efficiency (EAE) of Warp-Knitted Spacer Fabric Reinforced Foam (WKSFRF) Under Low-Velocity Impact

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Abstract : Using fabrics to reinforce composites considerably leads to improved mechanical properties, including resistance to the impact load and the energy absorption of composites. Warp-knitted spacer fabrics (WKSF) are fabrics consisting of two layers of warp-knitted fabric connected by pile yarns. These connections create a space between the layers filled by pile yarns and give the fabric a three-dimensional shape. Today because of the unique properties of spacer fabrics, they are widely used in the transportation, construction, and sports industries. Polyurethane (PU) foams are commonly used as energy absorbers, but WKSF has much better properties in moisture transfer, compressive properties, and lower heat resistance than PU foam. It seems that the use of warp-knitted spacer fabric reinforced PU foam (WKSFRF) can lead to the production and use of composite, which has better properties in terms of energy absorption from the foam, its mold formation is enhanced, and its mechanical properties have been improved. In this paper, the energy absorption efficiency (EAE) of WKSFRF under low-velocity impact is investigated experimentally. The contribution of the effect of each of the structural parameters of the WKSF on the absorption of impact energy has also been investigated. For this purpose, WKSF with different structures such as two different thicknesses, small and large mesh sizes, and position of the meshes facing each other and not facing each other were produced. Then 6 types of composite samples with different structural parameters were fabricated. The physical properties of samples like weight per unit area and fiber volume fraction of composite were measured for 3 samples of any type of composites. Low-velocity impact with an initial energy of 5 J was carried out on 3 samples of any type of composite. The output of the low-velocity impact test is acceleration-time (A-T) graph with a lot deviation point, in order to achieve the appropriate results, these points were removed using the FILTFILT function of MATLAB R2018a. Using Newtonian laws of physics force-displacement (F-D) graph was drawn from an A-T graph. We know that the amount of energy absorbed is equal to the area under the F-D curve. Determination shows the maximum energy absorption is 2.858 J which is related to the samples reinforced with fabric with large mesh, high thickness, and not facing of the meshes relative to each other. An index called energy absorption efficiency was defined, which means absorption energy of any kind of our composite divided by its fiber volume fraction. With using this index, the best EAE between the samples is 21.6 that occurs in the sample with large mesh, high thickness, and meshes facing each other. Also, the EAE of this sample is 15.6% better than the average EAE of other composite samples. Generally, the energy absorption on average has been increased 21.2% by increasing the thickness, 9.5% by increasing the size of the meshes from small to big, and 47.3% by changing the position of the meshes from facing to non-facing.

Keywords : composites, energy absorption efficiency, foam, geometrical parameters, low-velocity impact, warp-knitted spacer fabric
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