IMPACT-FATIGUE BEHAVIOUR OF CARBON/PEI COMPOSITE MATERIALS

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Carbon fiber reinforced PEI composite is used in mechanical engineering applications where machine parts are subjected to impact loading. In fact, most of the machine parts are subjected to impact loading repeatedly during their service life. This study is aimed to investigate the repeated impact behavior and the crack initiation and propagation mechanism of the Carbon PEI (C/PEI) composites.

Hot pressed, 14 ply unidirectional carbon fiber reinforced PEI composite was kindly supplied by CETEX. Instrumented Izod impact tests were performed on a Ceast pendulum type tester (Resil 25). A charpy hammer, having a strike range of 1.08 kN was used. Hammer length and mass were 0.327 m and 1.254 kg, respectively. Sampling time was 8 μsec. At a falling angle of 40°, impact velocity was 0.93 m/s, and maximum available energy was 0.54 J. Impact test samples were prepared according to ISO 180 standard. For each parameter, 10 experiments were performed and the average is reported. Preliminary experiments were performed in order to find the appropriate falling angle, which was chosen to be 40^o in order to reduce the inertial oscillations in the contact load between striker and sample. Figure 1 illustrates the force-time curve of the material. Before discussing the results, it is important to understand the approach used in the analysis of force-time curves, which is critical in determining the impact characteristics of materials. Upon impact of the pendulum the force rises sharply to a maximum value (F_{max}) and then gradually falls to zero due to catastrophic failure. The total area under a force-time curve gives the impact energy for the system (E_{max}). This curve can be divided into two regions. These regions give the energies of crack initiation (E_i) and crack propagation (E_p). The first region is the crack initiation region, which extends up to F_{max} in the force –time curve. The second region is the crack propagation region, which starts from F_{max} and ends at the fracture of the sample. The spikes seen in the first region are due to inertial oscillations of the sample.

The samples were placed into the instrumented impact tester and struck with the pendulum hammer, at small falling angles. These falling angles were not big enough to fracture the samples but they were big enough to cause elasto-plastic deformation in the material. The falling angles of izod hammer were chosen as 5,10,15,20,22,25,30 and 35^o. The hammer struck each sample only one time. The samples were preserved from additional strikes of the hammer. These samples were called "previously impacted samples" and their force-time and energy-time curves were carefully investigated. It was observed that there was remarkable crack propagation at 35^o which was the maximum falling angle used for these samples.

Up to a falling angle of 20^o, crack initiation in the material was not observed. The amount of crack propagation and total fracture energy increased with the increase of falling angle.

Finally, all of the previously impacted samples were put into the impact tester and fractured by the izod hammer, at a falling angle of 40°. This impact was called the "final impact". Data for both previous impacts and final impact at each falling angle will be given. The effects of previous impacts result in a decreasing in F_{max}, E_i and E_p values at final impacts. The result of changes at F_{max} after the final impact can be seen in Fig 2.

On the other hand we performed another group of experiments which can be called as an impact-fatigue experiment. Between the falling angle of 5 and 35° we strike the samples repeatedly at each angle till fracture. The hammer struck each sample only one time at each stage. The samples were preserved from additional strikes of the hammer. These samples "impact-fatigue samples" and their force-time and energy-time curves were carefully investigated. It was observed that as a function of strike number there was remarkable decreasing in F_{max}, E_i and E_p values at the same falling angles. The result of changes at F_{max} along the impact-fatigue test as a function of impact number can be seen in Fig 3.

After impact tests, the fracture surfaces of the specimens were examined by using scanning electron microscope (SEM) to find out the effect of impact-fatigue on the fracture morphology. All the fracture surfaces were coated with a thin film of gold to avoid the charging effect during SEM observation.

It is observed that as a result of impact-fatigue experiments there is a remarkable morphological change in the material.

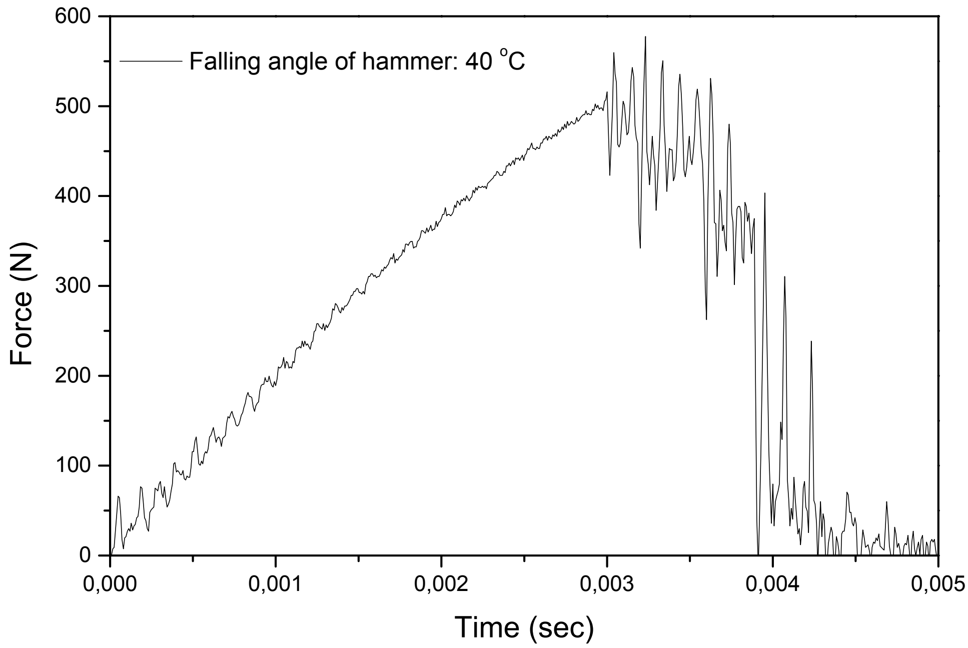

Fig 1. Force-time curve of impact test, which is performed under falling angle of 40°

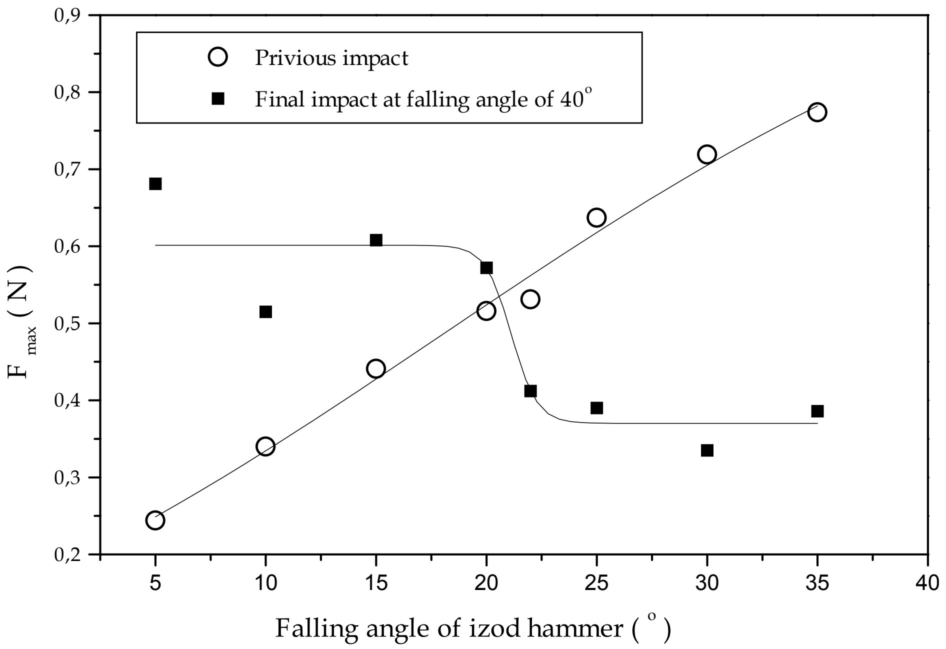

Fig 2. Previous impact effects on F_{max} values.

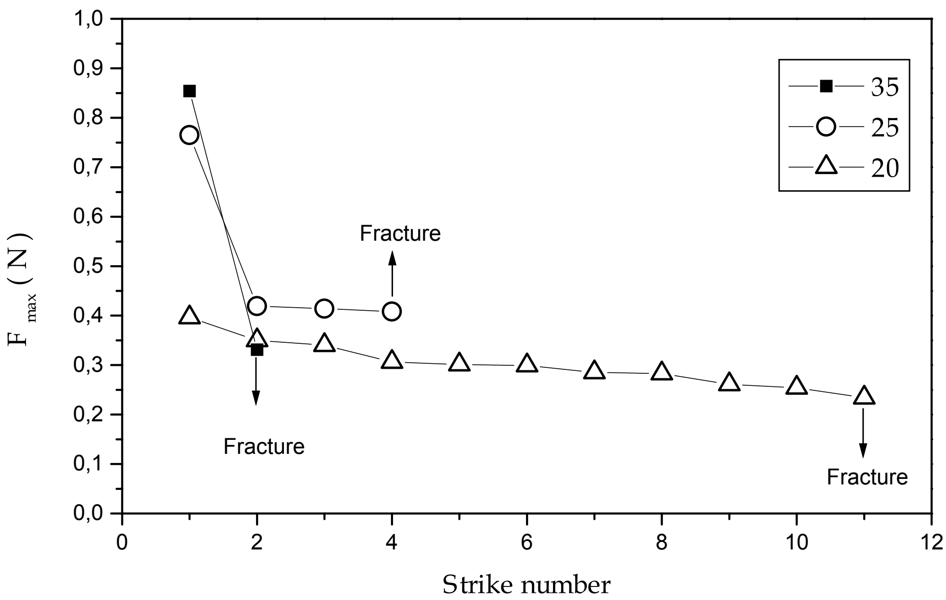

Fig 3. F_{max} values changes along the fatigue-impact tests.

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