IMPACT PROPERTIES OF MATERIALS DURING DROP TESTING

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INTRODUCTION

This study investigated the impact characteristics of materials typically used in helmets and protective sport equipment to a series of impacts. The materials included several foams (Vinylnitriles) and one each of a Expanded Polypropolene (EPP) and a Expanded Polystyrene (EPS). The purpose was to determine whether the attenuating properties of the materials were consistent after a series of impacts. Certain helmets are designed to withstand single impacts (e.g., bicycle and motorcycle) these typically use EPS and EPP liners, the latter are assumed to be more durable; others helmets are intended for repeated impacts (e.g., football) these use Vinylnitrile.

METHODS

A 5-kg load was dropped down a tube from 10, 20 and 30 cm onto an anvil with an imbedded uniaxial piezoelectric force transducer (ICP force ring, model 203B, PCB Piezotronics). The impact area was a 5.04 cm diameter circle. Each material had the same impact area had the same thickness of 2.54 cm. A photo-optical timer measured the velocity of the load prior to impact. Force data were collected at 20 kHz to determine the peak impact force and time to peak force. Each material was tested with a maximum of five repeated trials to observe the changes in the peak impact force and time.

RESULTS AND DISCUSSION

Figure 1 shows a relatively compliant material after only four drops from a height of 20 cm. Notice that trial 1 had a different force profile from trials 3 and 4. The material after the first drop yielded a peak force of only 900 N but two trials later the peak had risen to almost 1400 N.

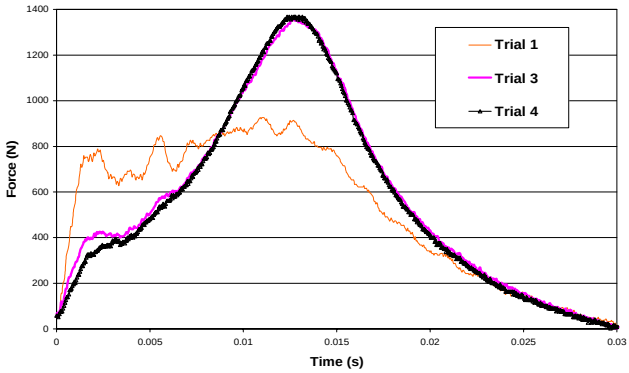

Figure 1: Impact histories of trials 1, 3 and 4 of a compliant foam material (VN600) for a drop height of 20 cm.

Figure 2 shows the results for a stiffer material (R3953V) for a reduced drop height of 10 cm. In this case, the material performed poorly on the initial drop but improved its performance for the second and third drops. The peak force for the first drop was over 2500 N but reduced to 1700 N and 1300 N for drops 2 and 3.

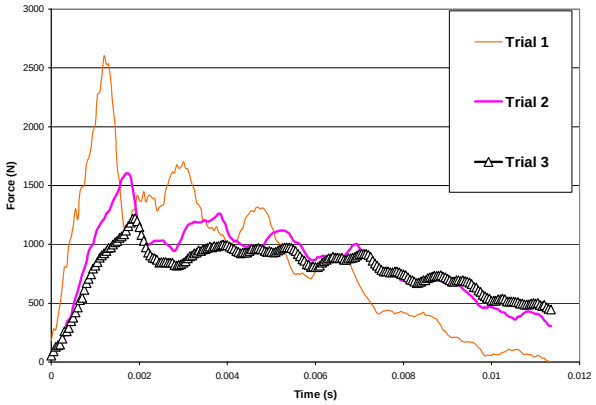

Figure 2: Force histories of trials 1, 2 and 3 of a stiff foam material (R3953V) for a drop height of 10 cm.

Figure 3 shows the average force histories (four trials each) for a 10 cm drop height. Notice that the foam materials (R313V, R326V, VN600) had lower peak forces due to a rapid early rises and by spreading the impact forces out over time while the EPS and EPP materials had slower rise times and consequently delivered higher peak forces.

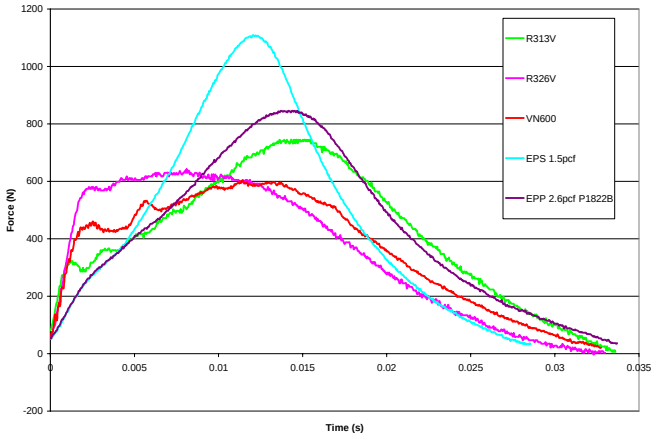

Figure 3: Average force histories of five different materials for a drop height of 10 cm.

SUMMARY

Unexpectedly materials that were assumed to be durable but did not maintain their force attenuation properties even after one impact. Stiffer materials appear to perform better after an initial impact but further tests have shown that their performance also degrades after repeated impacts. One must therefore expect to change helmet liners frequently after severe impacts.

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