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Drop Weight Device Fabrication and Tests for a Dynamic Material Property of Shock-Absorbing Material and Structure in Transportation Package

Jea-Eon Jeon[a], Sang-Hyeok Han[a], Woo-Seok Choi[a], Sang-Hoon Lee[a], Ki-Seok Seo[a]*
Korea Atomic Energy Research Institute
wschoi@kaeri.re.kr

1. Introduction

A radioactive material transportation package consists of canister and impact limiters. IAEA Safety Standard Series No. TS-R-1 recommends a drop test to evaluate the structural integrity of a transportation package under a hypothetical accident condition. The free drop test of a transportation package from 9 m height simulates one of accident conditions. The transportation package has a potential energy corresponding to 9 m drop height, and this energy changes to a kinetic energy when it impacts on the target. The energy is absorbed by a deformation of shock-absorbing material so that the minimum energy is transferred to canister. Accordingly, the shock-absorbing material is a very important part in transportation package design. Since the data for shock-absorbing material characteristics is acquired by a static test in general, it is quite different to that of dynamic characteristics. And the dynamic characteristics data is hardly found in literature. In this study, a drop weight facility was designed and fabricated which produces an impact speed like that of free drop of 9 m height. Several materials considered for an impact limiter and impact limiter structures were tested by a drop weight facility to acquire a dynamic material characteristics data.

2. Drop Weight Facility Fabrication and Dynamic Characteristics Test

2.1 Fabrication of Drop Weight Facility.

Drop weight facility is fabricated based on the ASTM E 208-06. The facility is changed to reduce the energy loss due to friction. And it is equipped with the spring to make a 9 m height free drop speed and energy. It is shown in Fig. 1.

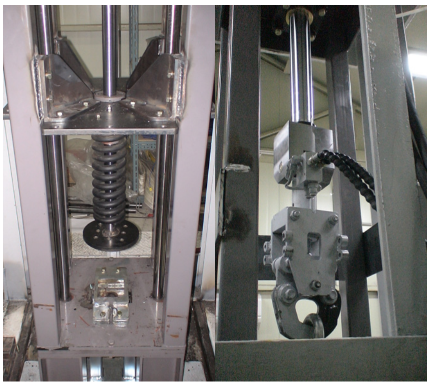

Fig. 1. Drop weight facility

2.2 Dynamic Characteristics Test of Shock-Absorbing Materials.

Shock-absorbing materials are tested in 9 m height accident condition. Materials which are used or considered as shock-absorbing materials are chosen as shown in Table I. The size of specimens shown in Fig. 2, is 100 mm × 100 mm × 50 mm. Stress - strain curves of materials are derived from acquired force profiles and deformation profiles. The results are shown in Fig. 3 and Fig. 4, respectively. The absorbed impact energy is expressed as the area under the stress and strain curve. The absorbed specific impact energy of each material is shown in Table II. A balsa wood (Axis) absorbs the largest impact energy.

Table I: Specimens for Drop Test

Material	Species
Urethane Foam	$150kgf/mm^3$
	$200kgf/mm^3$
	$250kgf/mm^3$
Balsa Wood	Axis
	Radial
Honeycomb	1/4 inch
	1/2 inch

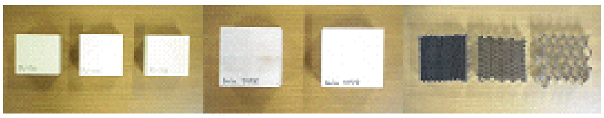

Fig. 2. Specimens for dynamic material characteristics

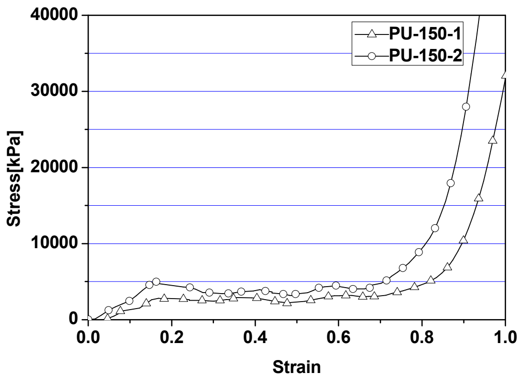

Fig. 3. Dynamic characteristics of polyurethane form ($150kgf/mm^3$)

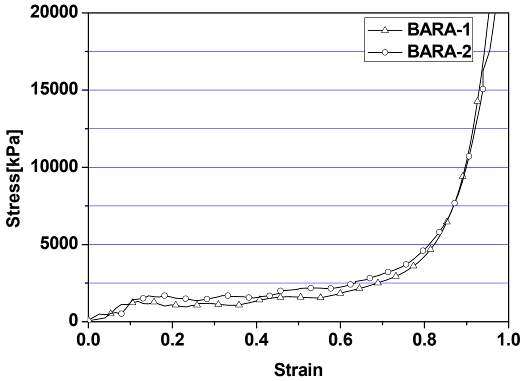

Fig. 4. Dynamic characteristics of balsa wood (Radial direction)

Table II: Absorbed Specific Impact Energy of each Material

Material property		Stress[kPa]	strain (m/m)	Specific energy (joule/m^3)
PU	150	2700	0.72	1,944,000
	200	3800	0.51	1,938,000
Balsa wood	Axis	3500	0.65	2,275,000
	Radial	2200	0.72	1,440,000
Honeycomb	1/4 inch	2500	0.72	1,800,000

3. Dynamic Characteristics Test of Impact Limiter Structure.

Since the impact limiter consists of an inner shock-absorbing material and outer stainless steel shell, it is difficult to estimate the shock-absorbing effect of impact limiter solely from the shock-absorbing material dynamic characteristics data. The structure specimen is tested to check the effect of stainless steel structure. Each specimen is the scaled model of an impact limiter used in a new developed transportation package in KAERI. The specimen is a cylinder with the diameter of 160 mm and the height of 50 mm that has a tested shock-absorbing material inside. Specimen is shown in Fig 5. Stress - strain curves of specimens are derived from acquired force profiles and displacement profiles. The results are shown in Fig. 6. The specimen with balsa wood absorbs the largest impact energy and has a large deformation.

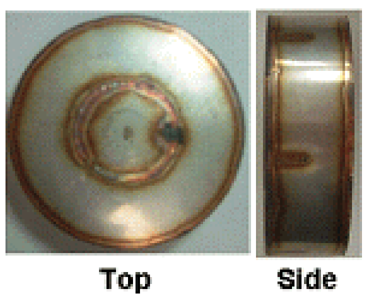

Fig. 5. Specimen of an impact limit structure

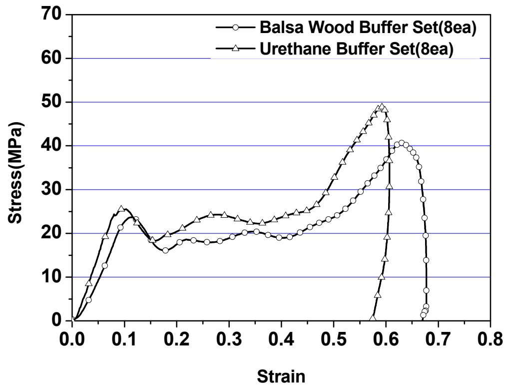

Fig. 6. Dynamic characteristics of impact limiter structure

4. Conclusions

The results in this study are as follows;

(1) A dynamic characteristics data of shock-absorbing materials was acquired by means of the drop weight facility, which simulates a free drop of 9 m height. The balsa wood absorbed the largest impact energy.

(2) Dynamic characteristics data of impact limiter structure was acquired. The specimen with balsa wood absorbed the largest impact energy and had a large deformation.

The acquired dynamic characteristics data is useful for the design of an impact limiter.

REFERENCES

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