Thermal Test of a Model for FBR Irradiation Fuel Shipping Cask

S.Iwanaga [1], S.Uruwashi [1], K.Moritani [1], M.Usami [1], S.Takahashi [2], T.Nakatani [3] and M.Sawa [3]

[1] Power Reactor & Nuclear Fuel Development Corporation, Ibaraki Pre., Japan
[2] Atom Transport Service Ltd., Tokyo, Japan
[3] Hitachi Zosen Corporation, Osaka, Japan

INTRODUCTION

As one of the development programs of the cask for the post−irradiation examination of the FBR fuels, a thermal test was carried out using the full scale model of the upper portion of the cask. The objectives of the test are to demonstrate that the seals of the lid and the vent−valve of the cask maintain their tightness under the fire test conditions required for type BM packages and then to verify the thermal analysis method used in safety analyses by comparing test results with analysis results.

We carried out the test by using a large furnace heated up with gas fuel.

The full scale model consists of the upper portion of the cask including the upper shock absorber, the lid and the body flange.

This paper describes the test procedures, test results and their comparisons with analysis results.

SPECIMEN AND FACILITY

The specimen was the full scale model of the upper portion of the cask.
The model has a length of 3,000mm, a width of 2,200mm, a height of 2,575mm and a weight of 5.3 tons, and was provided with a hole in the shock absorber simulating the 1/2 scale model drop test results, in order to observe the effect of burning of balsa wood.
The specifications of the furnace are as follows:

1) Type	a large furnace with a cart
2) Dimensions of Interior	width 5.0m x height 4.5m x length 15.0m
3) Method of Opening and Shutting	sliding door to one side
4) Furnace Temperature Heated	normal 650 ℃
	maximum 900 ℃
5) Fuel	Mixing gas of butane and air

TEST PROCEDURES

The thermal test was performed with the following procedures:

1) The model was pre-heated so as to have the predicted temperature of the cask under the normal transport condition by micro-heater equipped in the model.
2) After the furnace was heated up to about 900 ℃, the door of the furnace was opened and then the model was inserted in the furnace by a cart.
3) The model was placed in the furnace for 30 minutes after the furnace re-heated up to 800 ℃.
4) The model taken out from the furnace was left on the floor outside. The test was continued until the burning of shock absorber material (balsa) was put out naturally and the specimen was cooled down to the atmospheric temperature.
5) The temperatures at 28 locations of the model were continuously measured by thermo-couples during the test.
6) Before and after the test, the leakage tests were performed at the seals of the lid and the vent-valve by the nitrogen gas pressurizing method, in order to confirm the tightness of the seals.
7) After the test, the lid and the vent-valve were taken off from the specimen and O-rings at seals and the inner surface of lid and flange were inspected.
8) The cover plate of the shock absorber was cut off and the situation of the burned balsa was observed.

TEST RESULTS

The temperature of the cover plate of the shock absorber rose in consistence with the temperature of atmosphere in the furnace. On the other hand, the temperature of the lid and body flange did not rise so highly and the maximum temperature of lid and vent-valve seals was 130 ℃, which is lower than 150 ℃

of the heat−resisting temperature of the rubber O−rings under normal operating condition. It was confirmed that the material of the O−rings was durable enough under the fire test conditions.
The leak rates measured in the leakage test before and after the test were comparatively less than the limit required for the cask design. Therefore, it was demonstrated that the tightness integrity of the seals were maintained under the fire test conditions.

Furthermore, no damage was observed in the O−rings by visual inspection after the lid and the valve were taken off and it was confirmed that the tightness ability of the seal material was not damaged.

The burning of balsa wood continued for a long time after the specimen taken out from the furnace, but it was observed that the temperatures in the cask body changed smoothly and downward. This showed that the effect of burning was limited into the shock absorber and its heat transfer to the cask body was negligible.

COMPARISON WITH ANALYSIS RESULTS

The thermal analysis was performed to simulate the test results, using the Finite Element Method Analysis Program 「NOHEAT」 for axisymmetric structures (Farhoomand and Wilson 1971). The analysis was performed for two cases: one gave the surface absorptivity coefficient of the specimen as 0.3 for non−oxidized surface of polished austenite stainless steel, the other as 0.8 specified in IAEA Safety Series No.6 Para. 628. The typical comparisons with test results are shown in Figure 1, which is the time−history plots of temperatures at the lid.

The following considerations are derived from this result:

1) As shown in Figure 1, the analysis case given 0.8 as the absorptivity coefficient indicated more conservative results compared with test results because of huge radiation heat input into the specimen. On the other hand, the analysis case given 0.3 as the absorptivity coefficient showed that the highest temperatures at typical positions in the specimen were well agreed with test results.
2) As most of the surface of the specimen was not observed to be oxidized after the test, the absorptivity coefficient of the surface was not considered to be changed in the furnace. This is the reason why the test results are close to

the analysis result using the value of 0.3.

3) The burning of balsa wood was not taken into account in the analysis model, but the analysis results gave higher temperatues than test results at important positions such as the lid, the vent−valve and seals. Therefore, it also showed from the analysis that the burning of balsa wood in shock absorber has negligible effect on the cask body.

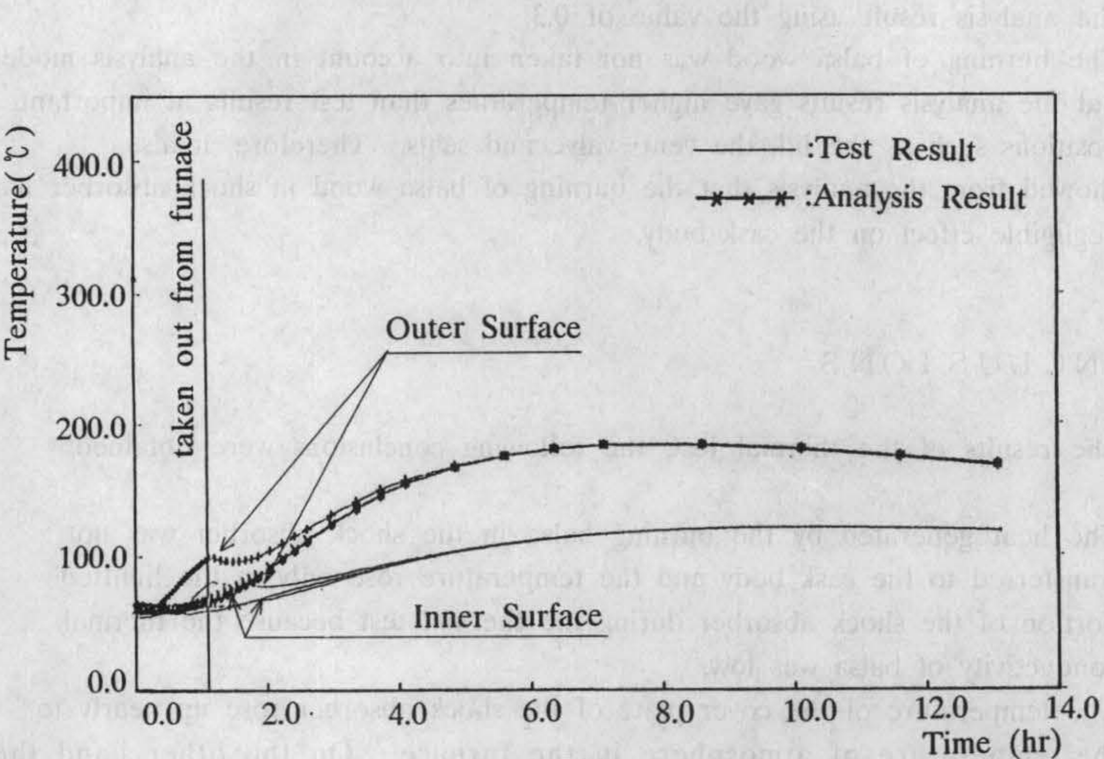
CONCLUSIONS

As the results of the thermal test, the following conclusions were obtained:

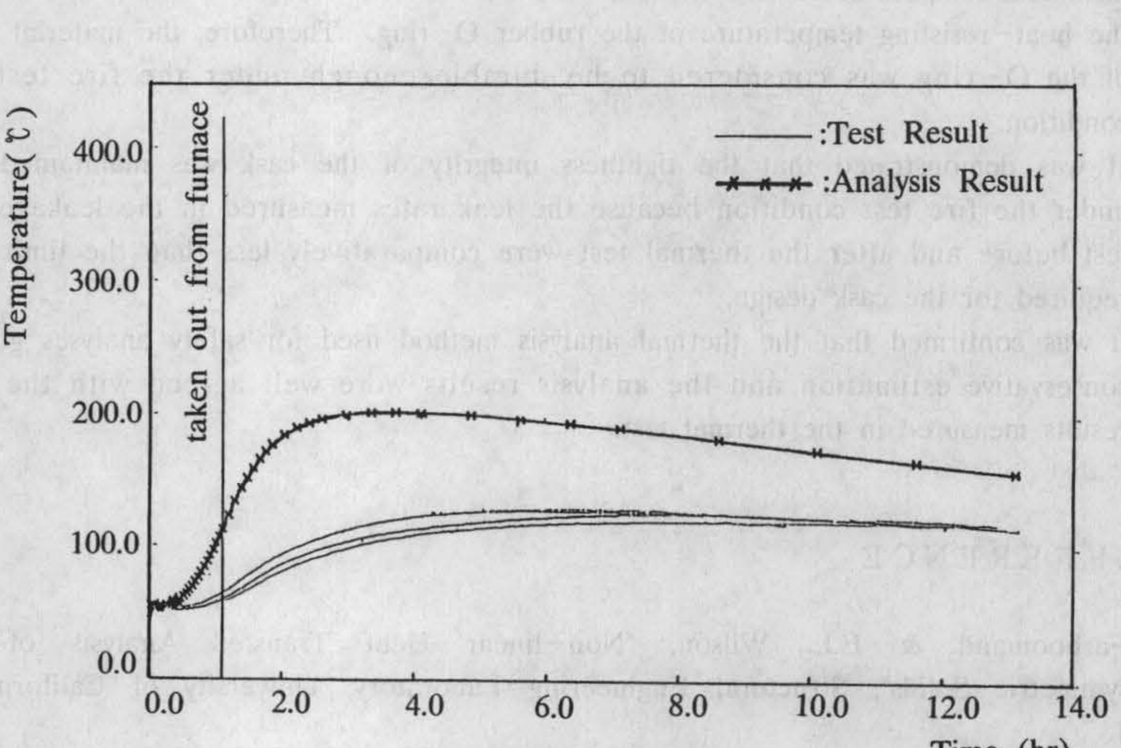
1) The heat generated by the burning balsa in the shock absorber was not transferred to the cask body and the temperature rose only in the limitted portion of the shock absorber during the thermal test because the thermal conductivity of balsa was low.
2) The temperature of the cover plate of the shock absorber rose up nearly to the temperature of atmosphere in the furnace. On the other hand the temperature of the lid and body flange did not rise up so highly and the maximum temperature at the lid and vent−valve seals was lower than 150 ℃ of the heat−resisting temperature of the rubber O−ring. Therefore, the material of the O−ring was considered to be durable enough under the fire test condition.
3) It was demonstrated that the tightness integrity of the cask was maintained under the fire test condition because the leak rates measured in the leakage test before and after the thermal test were comparatively less than the limit required for the cask design.
4) It was confirmed that the thermal analysis method used for safety analyses gave conservative estimation and the analysis results were well agreed with the results measured in the thermal test.

REFFERENCE

I. Farhoomand & E.L. Wilson, "Non−linear Heat Transfer Analysis of Axisymmetric Solids", Structural Engineering Laboratory, University of California, 1971.



(i) Lid



(ii) Lid Seal

Figure 1 Time History Plot of Temperatures at Lid (Surface Absorptivity Coef.=0.8)