*Transactions of the Korean Nuclear Society Spring Meeting*
*Jeju, Korea, May 10-11, 2007*

# A Steam Explosion Experiment with Partially Oxidized Corium in the TROI Facility

Jong-Hwan Kim,a B. T. Min,a S. H. Hong,a I. K. Park,a S. W. Hong,a H. D. Kim a
*a Thermal Hydraulics Safety Research Division, Korea Atomic Energy Research Institute, 150 Dukjin-dong, Yuseong-gu, Taejon, 305-353, kimjh@kaeri.re.kr*

## 1. Introduction

A steam explosion experiment (TROI-51) was performed in the TROI facility by using partially oxidized molten corium (core material) which is produced during a postulated core melt accident in a nuclear reactor. Since the prototypic molten core material is composed of fuel ($UO_2$), oxidized cladding material ($ZrO_2$), unoxidized cladding material (Zr metal) and structural material (stainless steel – SS), it extracts uranium metal through a chemical reaction [1], which could enhance the explosivity of corium because of a burning of the hydrogen generated from the uranium-water interaction. Therefore, it is necessary to perform steam explosion experiments using partially oxidized corium to find the explosivity of the prototypic corium. A triggered steam explosion occurred in this test. The dynamic pressure and the dynamic load measured in this experiment show a stronger explosion that those performed previously with oxidic corium.

## 2. Experimental Results

The experimental facility for TROI-51 is shown in Fig.1 and the instrumentations are described in Ref. 2. The melt temperature was measured by a two-color pyrometer and it was corrected after a compensation for the viewing tempered glass as shown in Ref. 2.

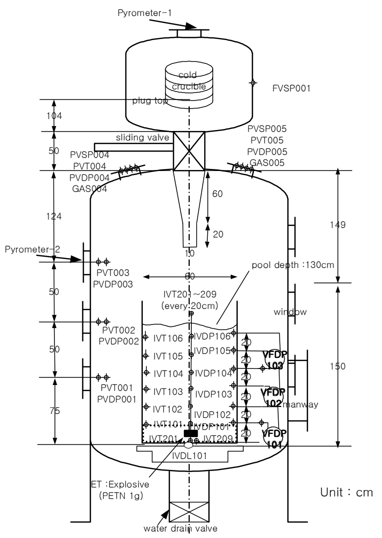


Figure 1. Schematic diagram of TROI-51.

### *2.1 TROI-51 Test*

This test was carried out to induce a triggered steam explosion with partially oxidized corium. Since the partially oxidized corium extracted a metal layer, the effect of the extracted metal on the energetics of a triggered steam explosion was examined. The test section of 0.6 m in diameter was filled with 1.3 m deep water, which was at room temperature and almost an atmospheric pressure. An external trigger was applied at 1.35 s in this test, but the error range of the trigger unit and DAS produced a slight time difference.

The mixture of $UO_2$, $ZrO_2$, Zr and stainless steel was charged into the crucible at a weight percent of 62.8, 13.5, 12.6 and 11.1 %, respectively. This percentage was referred to from the MASCA project [1]. Then the mixture was melted and the molten corium was delivered into the water in the interaction vessel.

During the melt delivery, the melt temperature was measured at the exit of a guide funnel, and it is presented in Fig.2. The maximum melt temperature measured through a tempered glass window was 3420 K. The corrected temperature was 3141 K after a compensation for the glass window.

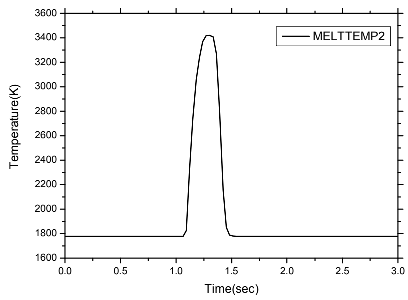


Figure 2. Melt temperature during delivery in TROI-51.

When the melt jet penetrated the water in the interaction vessel, an external trigger occurred at 1.35 seconds after the initiation of the melt delivery which is the time of a puncher actuation.

Fig.3 shows the dynamic pressures in the water measured by wall-mounted pressure sensors. It shows two peaks at about 1.327 s and 1.329 s. The first peak shows a propagation of the pressure waves from the bottom (IVDP101) to the top (IVDP104). This peak is caused by an external trigger which was located at the bottom. The second peak shows another propagation from the top to the bottom. It is believed that a steam explosion was induced by the external trigger when the melt front was still at the top of the water. The magnitude of the pressure by the steam explosion was

32 MPa, which is higher than those (~ 20 MPa) from the previous tests with oxidic corium.

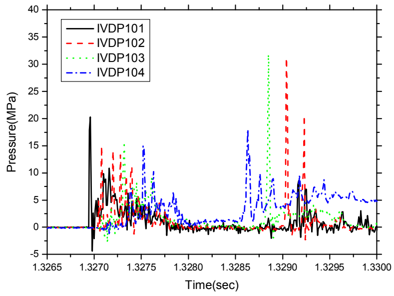


Figure 3. Dynamic pressures from wall-mounted sensors in TROI-51.

Fig.4 shows the dynamic pressures in the water measured by under-water sensors. It shows a similar pattern with those from the wall-mounted sensors. However, the magnitude was much smaller. This is probably caused by the movement of the sensors at the time of the explosions since the sensors were not fixed. The duration was 1.1 ms similar to the signals from the wall-mounted sensors.

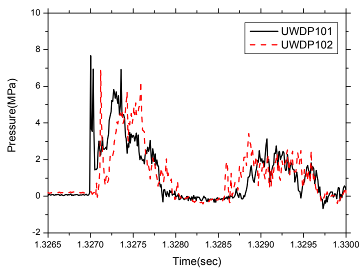


Figure 4. Dynamic pressures from under-water sensors in TROI-51.

Fig.5 shows the dynamic load on the bottom of the interaction vessel. The maximum value was quite high at 580 kN. From this figure, the external triggering was initiated at 1.327 seconds from the puncher actuation. The duration of the steam explosion was 11 ms which is similar to the previous steam explosion tests. From this signal, a triggered steam explosion is believed to have occurred.

Fig.6 shows the debris size distribution after the TROI-51 test. This figure shows that the mass fraction of the fine particles smaller than 0.425 mm is 27.5 %. This is a big amount when compared with non-explosive tests (less than 10 %). Furthermore, the mass mean diameter is as small as 1.2 mm.

From these facts, a steam explosion was triggered in this test, by fragmenting the molten corium into fine particles, which led to a rapid pressure increase due to an explosive steam generation.

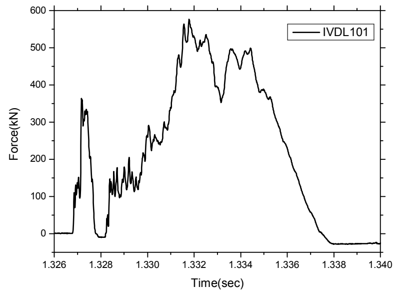


Figure 5. Dynamic load in TROI-51.

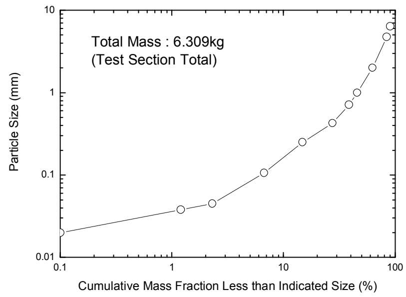


Figure 6. Debris size distribution in TROI-51.

## 3. Conclusion

A TROI steam explosion test has been performed by using partially oxidized corium melt. This test led to a strong steam explosion by applying an external trigger. With a sufficiently high melt temperature, the melt was finely fragmented and steam was explosively generated. The explosivity of the partially oxidized corium was higher than oxidic corium. The partially oxidized corium could enhance the strength of a steam explosion, so its material effect should be included during the reactor design. More steam explosion tests with partially oxidized corium need to be performed to confirm its high explosivity.

## ACKNOWLEDGEMENTS

This study has been carried out under the nuclear R&D program by the Korean Ministry of Science and Technology.

## REFERENCES

[1] V. Asmolov and V. Strizhov, Overview of the progress in the OECD MASCA project, CSARP Meeting, Washington DC, USA, 2004.

[2] J. H. Kim, I. K. Park, S. W. Hong, B. T. Min, S. H. Hong, J. H. Hong and H. D. Kim, Steam Explosion Experiments Using Nuclear Reactor Materials in the TROI Facility, NTHAS5, Jeju, Korea, Nov. 26-29, 2006.