Triggered Steam Explosions in a Narrow Interaction Vessel in the TROI Facility

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1. Introduction

Since the TMI accident, many studies have been performed worldwide on a steam explosion[1,2]. However, there are only a few tests using real reactor material. So the TROI steam explosion experiments have been carried out to evaluate the explosivity of corium. In the previous TROI tests, the effects of the water depth, corium composition and an external trigger with a wide interaction vessel on the occurrence of a steam explosion were studied[3,4,5,6]. In this paper, the results of two TROI (test No. 38 and 39) tests with a narrow interaction vessel using 80 : 20 corium(UO_2 : ZrO_2) with or without applying an external trigger are presented.

2. Instrumentations

The instrumentations of the TROI-39 experiment are shown in Figure 1. The instrumentations are almost the same as the previous test except for the interaction vessel. Compared with the previous tests[6], the diameter of the interaction vessel was changed from 60cm to 30cm. The aim of this study is to observe a steam explosion in a narrow interaction vessel with or without an external trigger. An explosive (PETN 1g) was used as the external trigger.

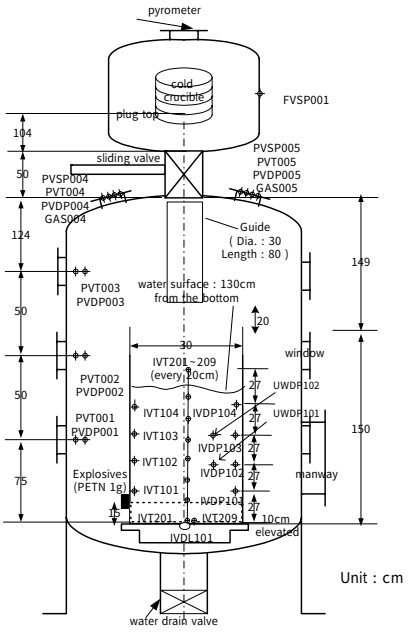

Figure 1. Instrumentations of the TROI-39 experiment.

3. Test Results

The TROI-38 and TROI-39 tests have been performed using 80 : 20 corium with or without an external trigger, respectively. The initial conditions and test results are presented in Table 1. In both cases, no steam explosions occurred. The dynamic pressure and load for the TROI-39 test in Table 1 are caused by the external trigger.

Table 1. Initial conditions and test results

	TROI test number	Unit	38	39
Melt	Initial Composition UO2 / ZrO2 /Zr	[w/o]	79/20/1	79/20/1
	Temperature	[K]	3650	3730
	Charged mass	[kg]	17.520	18.965
	Initiator mass	[kg]	0.15	0.15
	Released mass	[kg]	5.325	3.405
	Plug/puncher diameter	[cm]	8.0/6.5	8.0/6.5
	Initial jet diameter	[cm]	8.0	6.0
	Free fall in gas	[m]	3.1	3.1
Test Section	Water mass	[kg]	92	92
	Initial height	[cm]	130	130
	Final height	[cm]	88	90
	Cross section	[m2]	0.071	0.071
	Initial temperature	[K]	288	285
	Sub-cooling	[K]	85	88
Pressure Vessel	Initial pressure(air)	[MPa]	0.105	0.106
	Initial temperature	[K]	292	291
	Free volume	[m3]	8.023	8.023
Results	Maximum PV pressurization	[MPa]	0.031	0.051
	Time to reach peak	[sec]	2.5	2.0
	Maximum PV heat-up	[K]	57	56
	Time to stabilize	[sec]	4	7
	Maximum water heat-up	[K]	31	18
	Time to stabilize	[sec]	25	10
	Steam explosion		NO	NO
	Dynamic pressure peak	[MPa]	-	16.1
	Duration	msec	-	0.5
	Impulse	kN	-	260
	Duration	msec	-	9

3.1 TROI-38 Test

In the TROI-38 test, 17.520kg of 80 : 20 corium (UO_2 : ZrO_2) was charged into the crucible and melted. Then 5.325kg of the molten corium was delivered into a 130cm deep and 30cm wide water pool. The corium of this

composition did not lead to a spontaneous steam explosion in a wide interaction vessel(60cm in diameter) in the previous test[4,5]. Similar to the previous tests, no spontaneous steam explosion occurred.

3.2 TROI-39 Test

In the TROI-39 test, 3.405kg of the molten corium was delivered into a 130cm deep and 30cm wide water pool. The external trigger was exploded by the time of the melt–bottom contact (~1.55seconds after the melt delivery). However, no triggered steam explosion occurred which is different from the previous TROI-37 test performed with a wide interaction vessel using corium of the same composition[6]. This fact is deduced from the history of the dynamic pressures shown in Figure 2 and Figure 3.

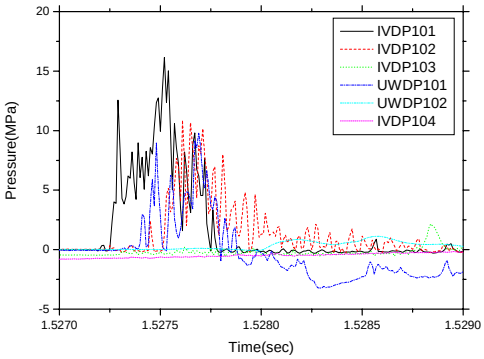

Figure 2. Dynamic pressures in the TROI-39 test

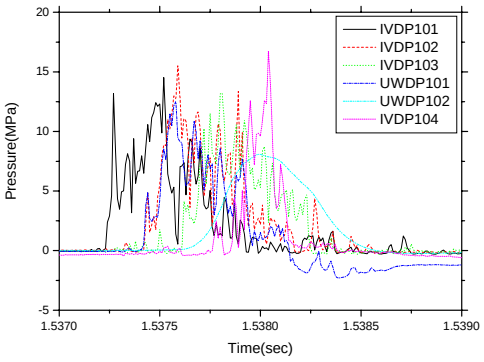

Figure 3. Dynamic pressures in the explosive calibration test

Figure 2 shows the dynamic pressure in the TROI-39 test and Figure 3 shows the dynamic pressure in the calibration test. The calibration test was performed without a melt delivery so the dynamic pressure was caused only by the external trigger(explosive). The magnitude and duration of the dynamic pressure in the TROI-39 test are 16.1MPa and 0.5ms, respectively, which are similar to those in the calibration test. This means that the pressure signal was produced by only the external trigger. The reason for no occurrence of a triggered steam explosion in the TROI-39 test is thought to be the high void fraction generated by the hot melt in the narrow interaction vessel. A steam explosion could not propagate to the nearby water due to a water depletion caused by the high steam generation.

4. Conclusion

Two steam explosion experiments in a narrow interaction vessel with or without an external trigger have been performed. In both cases, no steam explosions occurred. Compared with the previous test with a wide interaction vessel in which a triggered steam explosion had occurred, it did not occur in this test(TROI-39). The reason is thought to be that the high void fraction in the narrow interaction vessel prevented a steam explosion from any propagation to the nearby water due to water depletion. More triggered steam explosion experiments need to be carried out in a narrow interaction vessel with spontaneously explosive 70 : 30 corium to clarify the effect of the geometry of the interaction vessel.

ACKNOWLEDGMENTS

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