Comparison of MCCI Analysis Results using the Newest MAAP5

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1. Introduction

After the Fukushima accident, EPRI has developed the MAAP5 that is expected to make up the limitation of MAAP4. The newest version of MAAP5 is known as the Ver.5.0.2 (Build 5.01.2182, simply called 502D) which is published in July this year for final beta testing. In this, it is expected that so many models should be upgraded such as the Lower head plenum model, Debris Coolability model, Molten Core Concrete Interaction, Spent Fuel Pool model and Containment Heat Sink model, etc.

During the severe accident progression, the molten corium ejected into the cavity reacted with the concrete in the cavity floor and the phenomenon is called MCCI (Molten Core Concrete Interaction). In the last KNS Spring Meeting, KHNP presented the MCCI analysis results according to the concrete composition using MAAP Ver. 5.0.2 (Build 5.01.1100, simply called 502B) published in April, 2012[1]. In that report, we pointed out that the results of MCCI for Basaltic concrete was too much conservative, so we raised the issues related the MCCI model in the MUG meeting.

In this study, we try to find the improvement in the newest MAAP5 MCCI model by comparing the results using the same sequence and the same condition those used in the previous paper.

2. Methods and Results

2.1 MAAP code

The newest MAAP5 was published in July 2013 for final beta testing. In this version, it is known that there is some fundamental improvement in MCCI model such as the Melt Eruption model and Debris Coolability. So, we compare the results generated by MAAP5 502D with the previous results generated by MAAP 4.0.8 and MAAP5 502B. And we used the Zion parameter file in the distribution package for each version.

2.2 Accident Scenario

We select the same accident scenario in the previous paper, Large LOCA accident sequence initiated by the Double Ended Guillotine Break in cold leg, for comparison of the results due to model improvement. In order to find the improvement in Debris Coolability, the AC Power is available and so, the ESF(Engineered Safety Features) function is operable. So, at the early stage of accident, the cavity is flooded.

2.3 Parameter Characteristics

In MAAP parameter file, the characteristics of concrete is classified into 2 categories; the first is the composition of concrete and the second is the liquidus and solidus temperature profiles of concrete. In addition to this, in MAAP5, the representative values for 3 types of concrete such as Basaltic, Limestone/Common Sand, and Limestone are given. [2] In the earlier version of MAAP, the limited Plant-Specific data that is sufficient to at least loosely quantify one or two key mass fraction variables in this group is an adequate basis for identifying the concrete category, as shown in Table 1.

Table 1. Concrete Characteristics in MAAP

Variable	Description	Basaltic	Limestone/ CommonSand	Limestone
MFCN(2)	Mass Fraction of CaO	<0.15	0.25-0.35	>0.35
MFCN(11)	Mass Fraction of CO_2	<0.05	0.15-0.25	>0.3

In the earlier version of MAAP, the liquidus and solidus temperature profiles for concrete should be obtained by the experiment. In MAAP5, the liquidus-solidus curve for representative 3 types of concrete is provided.

In the MAAP 502D, since the melt eruption model is included, we activated it by specifying the parameter IMLTERP = 1

2.4 Analysis Case

For the comparison of the model improvement, firstly we compare the results of MAAP4.0.8, MAAP502B, and MAAP502D using Zion plant parameter file given in the MAAP Distribution Package with the same accident scenario described above. In the next step, since the concrete type of Zion plant is Limestone common sand, we changed the parameters for the concrete type to Basaltic default values and Limestone default values.

And then, we changed the composition of concrete based on the Ulchin concrete composition which was obtained by chemical analysis of specimen. The analysis cases are shown in Table 2.

The selection of concrete type provided in MAAP5 for UCN concrete is some obscure. Because it may be the Limestone concrete from the view point of CaO mass fraction, but it may be the Basaltic concrete from the view point of CO_2 mass fraction as shown in Table 3.

Table 2. Analysis Case

Case	Composition	MAAP Ver.	Concrete
1	Zion	4.0.8	L/C Sand
2	Zion	5.0.2B	L/C Sand
3	Zion	5.0.2B	Basaltic
4	Zion	5.0.2B	Limestone
5	UCN	5.0.2B	L/C Sand
6	UCN	5.0.2B	Basaltic
7	UCN	5.0.2B	Limestone
8	Zion	5.0.2D	L/C Sand
9	Zion	5.0.2D	Basaltic
10	Zion	5.0.2D	Limestone
11	UCN	5.0.2D	L/C Sand
12	UCN	5.0.2D	Basaltic
13	UCN	5.0.2D	Limestone

Table 3. CaO and CO2 Mass Fraction

	L/C Sand	Basaltic	Limestone	Zion	UCN
MFCN(2)	3.13E-01	8.82E-02	4.54E-01	3.13E-01	2.27E-01
MFCN(11)	2.12E-01	1.50E-02	3.57E-01	2.12E-01	1.31E-02

2.4 Analysis Results

The representative major event occurrence time for each case are summarized in Table 4.

Table 4. Analysis Results Using MAAP Code

Case	Core Uncover (S)	RPV Failure (S)	CV Fail (S)	Eroded Depth (M)
1	12.096	6800	151797	3.6
2	1.261	13880	112620	2.6
3	1.261	13534	127168	3.9
4	1.261	13357	114910	2.49
5	1.261	12738	146820	2.55
6	1.261	13534	133834	3.57
7	1.261	13357	150117	2.39
8	1.261	12275	80629	1.41
9	1.261	12134	102049	2.07
10	1.261	12352	87907	0.81
11	1.261	12374	127930	2.22
12	1.261	12121	109848	2.31
13	1.261	12336	133075	2.16

Though there are so many parameters which can show the effect of MCCI model improvement, we select the XCNDB(1), concrete floor erosion depth in cavity, as the comparison factors

The results of comparison for the XCNDB(1) for each cases are shown in Fig1, 2 and 3

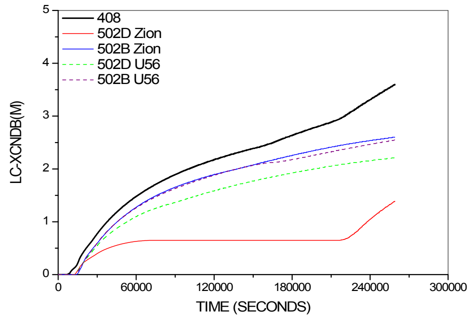

Fig 1. XCNDB(1) for L/C Sand Concrete

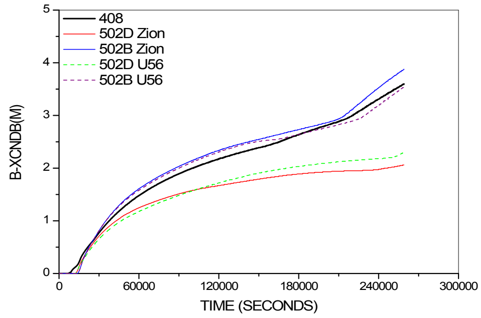

Fig 2. XCNDB(1) for Basaltic Concrete

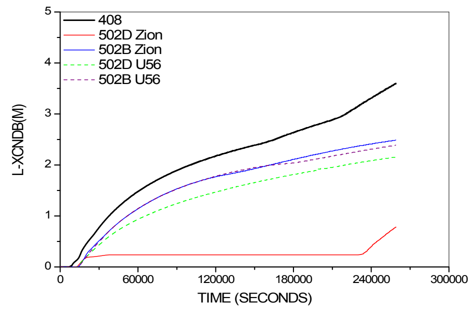

Fig 3. XCNDB(1) for Limestone Concrete

3. Conclusions

In this study, we can find that the problem which overestimated the concrete ablation for Basaltic concrete is somewhat resolved. And, in case that the cavity is flooded, it is confirmed that the debris coolability for Limestone and Limestone Common Sand concrete is maintained. But, in case of Basaltic concrete, though the interaction is somewhat inactive, but the debris Coolability is not maintained. We are planning to report these results to EPRI in order to confirm whether this phenomenon is appropriate.

REFERENCES

[1] Mi Ro Seo, Hyeong Taek Kim. Comparison of Severe Accident Phenomena according to the Concrete Composition, 2013 KNS Spring Meeting, May 2013
[2] Zion MAAP5 Parameter File , FAI, 2013