# Proposal of Particle Size Distribution for Debris Coolability Research

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## 1. Introduction

Pre-flooding of the reactor cavity [1] is considered as an option of SAMG to mitigate the molten core concrete interaction. The pre-flooding accompanies the production of particulate debris of the molten corium in the reactor cavity. The coolability of the particulate debris bed in the reactor depends on the properties such as particle size distribution, porosity, and bed geometry [2]. Accordingly, the characteristics of debris produced by the prototypic corium-water interaction would be very useful in evaluating the coolability of the debris particle bed. The corium debris characteristics by fuel-coolant Interaction were observed [3].

This paper summarizes of these debris characteristics and proposes the particulate debris size distribution for coolability research of corium debris.

## 2. Methods and Results

The effect of injected melt mass into water and other minor experimental parameters were not in detail considered for the analysis of debris characteristics because the TROI experiments are generally carried out with similar experimental conditions except for the free fall of the molten corium.

### *2.1 Debris Size Distribution (PSD)*

**Non-Explosion Cases**: The PSD of the non-explosion cases is in the Fig.1. In all cases except for the TROI-61 and TROI-62 where free fall is 1 m, the free fall is over 3m. The fraction of particles less than 1 mm took up 10-20% in TROI. This PSD is similar to the FARO experimental cases [4].

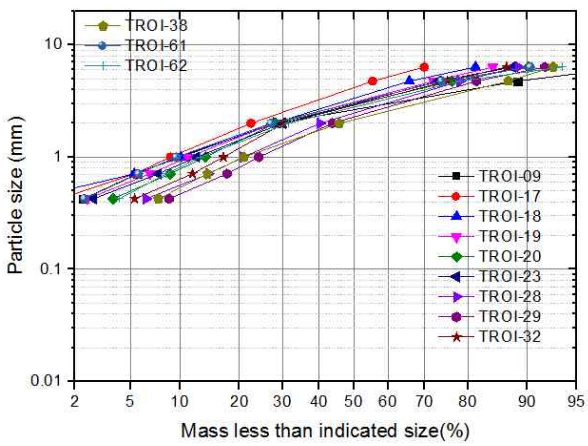


Fig. 1 PSD in TROI Non-explosion cases

**Steam Spike Cases:** The fraction of particles less than 1 mm for the cases of non-explosion comprised 20% at the maximum, as shown in Fig. 1. In the steam spike case, as shown in Fig. 2, about 20% was less than 1 mm; accordingly, the smaller particles in the steam spike were produced.

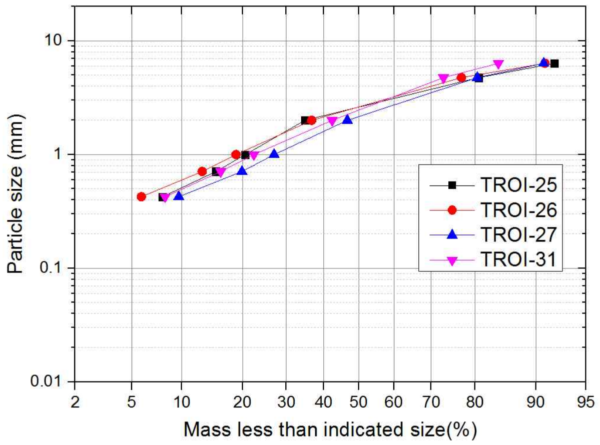


Fig. 2 PSD in TROI steam spike cases

**Free Fall Effect:** In the cases with ~ 3 m free fall, the fraction of particles less than 1 mm took up 10%-20%, as shown in Fig. 1. Meanwhile, in the cases with ~ 1m free fall, as seen in Fig. 3, the fraction of particles less than 1 mm took up 10% in maximum. Accordingly, generally the case with a high fall produced many more small particles even though the detail experimental conditions between two cases were not compared in detail

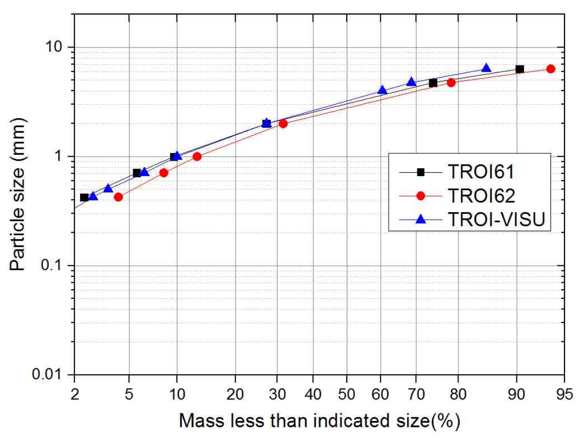


Fig. 3 PSD in TROI 1 m free fall cases

**Cases of Cavity Partially Flooded and Reactor Submerged:** TROI-61, 62 and VISU show the particle size distribution for a partially flooded cavity conditions, and TROI-79, 80 and 81 shows the shows the particle size distribution for reactor submerged conditions. As shown in Fig. 4, there was no a change of particle size distribution depending on conditions of a partially flooded cavity and reactor submerged condition even though the generation mechanism of the particle would be different [5].

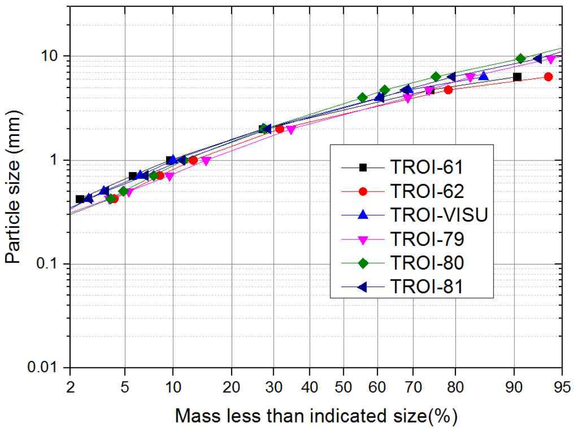


Fig. 4 PSD in 1m free fall and w/o free fall

### *2.2 Mass Mean Diameter (MMD) and Porosities*

As shown in Test No. 09 to 62 of Fig. 5, MMD ranged from 2.5mm to 3.5mm. There was no a difference of the MMD depending on the free fall length. The MMD with a steam spike, Test No. 09 to 31 of Fig. 5, had relatively smaller values than the values of the non-explosion cases. There was no clear difference in the MMD depending on the conditions of a partially flooded cavity and the reactor submerged, Test No. 79 to 81 of Fig. 5. For the steam spike case, the porosity of the debris was 39%. It was about 41 to 46% for non-explosion cases.

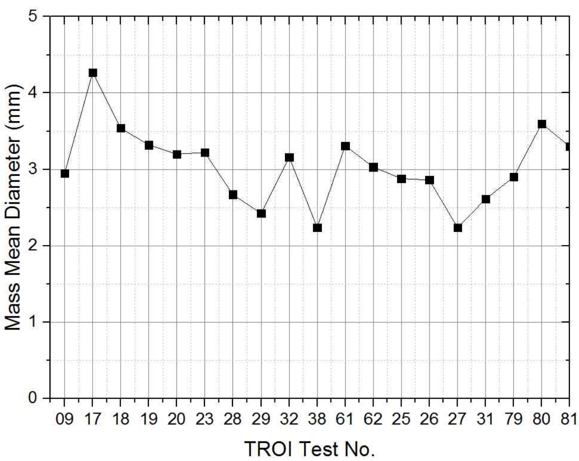


Fig. 5 MMD in non-explosion cases

### *2.3 PSD for Corium Debris Coolability Research*

From all data with non-explosion cases of TROI, the size distribution based on the mean values was proposed in Table 1. The other way to propose the size distribution of particles is derived from the conservative case which the fraction with small particles is highest. This particle distribution is shown in the right of Table 1. Fig. 6 shows the PSD of Table 1 compared with the TROI non-explosion cases of Fig.1 As shown in Fig. 6, the mean PSD proposed is located in the center of TROI non-explosion cases and the conservative PSD is located to the right-had of in the TROI non-explosion cases. Therefore it is thought that the proposed PSD of Table 1 is considered reasonably the mean and conservative cases. The mass mean diameters for PDF of Table 1 are 2.95 and 2.3mm, respectively, as shown in Fig. 7. The proposed PSD can cover all other cases such as 1 mm free fall cases, the cases with and without a free fall condition because the proposed PSD are relatively shift to the smaller size than these cases.

Table 1 Mean and Lowest PSD in TROI

| Particle Size(mm) | Accumulated Mass Fraction | |
|---|---|---|
| | Mean Distribution | Conservative Distribution |
| 7 | 100 | 100 |
| 5 | 80 | 87 |
| 2 | 36 | 46 |
| 1 | 17 | 21 |
| 0.5 | 5 | 8 |

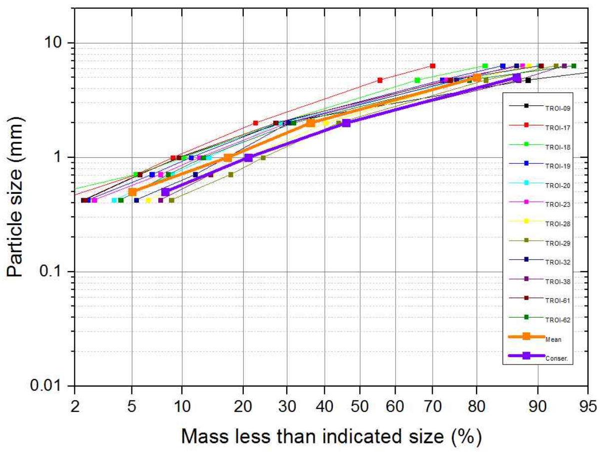


Fig. 6 Proposed PSD to Non-explosion cases

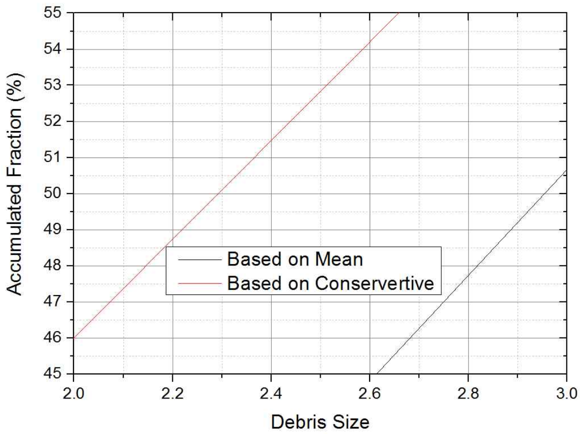


Fig. 7 MMD of Proposed PSD

The suggestion for this PSDs would extensible to the relatively large scale experiment, FARO, because the PSD from above session was not deviated largely from PSD of FARO experiment in which much more amount of molten mass was used. The PSD comparison results between FARO and TROI are in the paper [3]. However, conclusion for the extensibility to the reactor scale should be made carefully because the other many factors to be considered in reactor case exist. In addition, the current proposed PSD are derived based on non-explosion cases of TROI FCI experiment where the interaction of molten corium with water is processed during very short time within about 1 sec for a limited molten corium mass required explosion experiments. However, the interaction process of molten with water could be lasted for several ten seconds in postulated accidents, and it is highly possible that the large vapor column will be generated in the mixing zone, resulting in limiting the break-up of jet except initial interaction and accumulated on the floor of cake forms. To promote debris coolability, the scattering method of large melt jet releasing from the reactor vessel in addition to the long-term fuel coolant interaction has to be firstly developed.

### 3. Conclusions

The PSD were proposed in two ways to understand the thermal hydraulic characteristics of prototypic corium using TROI experimental data. These PSD would be useful to develop experimentally the pressure drop of the molten corium particles using simulant particles. The correlation of PSD for the modeling of pressure drop in the debris bed will be next proposed.

### ACKNOWLEDGEMANTS

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