# Supplemental information: Description of the THEFIS Experiments

A series of THEFIS (THErmite Freezing In Structures) experiments has been performed at KfK later reorganized KIT in 1980s [11][12]. The blockage formation of solid-liquid flow with freezing has been simulated reasonably in this experiment.

Figure S 1 shows the THEFIS experimental apparatus and procedures. This experimental apparatus consisted of a pressure vessel, a silica crucible and a testing tube made of quartz glass. The testing tube was fixed at the top of the pressure vessel. Aluminum and iron oxide thermite was contained in the silica crucible initially. 200K superheated alumina (Al2O3) melt was generated through the thermite process after electrical ignition. Alumina and iron melts separated rapidly due to their density difference. After the alumina melt generation, the silica crucible moved upward and the air was supplied to the pressure vessel. Then, penetration of the alumina melt is driven by pressure difference of 0.1 MPa between the pressure vessel and the upper end of the testing tube that was open to the atmosphere.

Sets of alumina particles were given different placements of position arranged in all testing tubes for “THEFIS with particle” experiment as shown in Figure S 2 and Table S 1. The alumina particles had non-spherical shape in the equivalent diameter range of 0.5 – 2.5 mm. An approximate packing fraction of the particle deposit was 0.45. The particle deposit and the testing tube were room temperature initially.

There were three cases of the particles fixing in the testing tube as shown in Figure S 2. The experimental condition of each case is summarized in Table S 1. In the experimental Runs #2 – #6, the alumina particles are accumulated on aluminum foil of 0.1 mm thickness at the lower end of the testing tube. The particles formed solid-liquid mixture flow together with the alumina melt. In the experimental Runs #8 and #9, the particle deposits were positioned at 0.31 and 0.38 m, respectively, above the lower end of the testing tube. The particle deposit was fully fixed by two spacers.

The penetration length of the alumina melt in the testing tube was measured by means of flow visualization through the quartz glass tube. The measurement result is shown in Table S 1.

Table S 1. Experimental parameter and result for each run [12]

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Series | Run # | Particle-deposit lower position (m) | Particle-deposit height (mm) | Melt penetration depth (m) | Comment |
| (I)  Aluminum foil | 1 | - | - | 1.35 | Reference for #2 – #6 |
| 2 | 0 | 25 | 0.99 | Particles  lifted up |
| 3 | 0 | 30 | 1.05 | Particles  lifted up |
| 4 | 0 | 50 | 0.03 | Plug inside particles |
| 5 | 0 | 40 | 0.04 | Plug inside particles |
| 6 | 0 | 80 | 0.05 | Plug inside particles |
| (II)  2 spacers | 7 | - | - | 1.26 | Reference for #8 – #10 |
| 8 | 0.31 | 16 | 0.34 | Melt stopped shortly above particles |
| 9 | 0.38 | 80 | 0.45 | Plug inside particles |



Figure S 1. THEFIS experimental apparatus and procedures



Figure S 2. Testing tube in the THEFIS with particle experiment