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RETENTION OF MOLTEN CORE DEBRIS POOLS IN COMPOSITE SACRIFICIAL BEDS+

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Passive core catchers have been proposed as a means for retaining the core debris following a hypothetical core disruptive accident in a fast reactor. The core debris which may be in the form of a molten pool is passively retained in a sacrificial bed of high melting temperature material placed inside or outside the reactor vessel. A stable pool configuration is reached when the decay heat generated in the pool is equal to the rate of heat dissipation to the surroundings by conduction through the bed and upward convection and radiation to overlaying sodium.

Recently, it has been suggested that "composite sacrificial beds" with a low-melting-temperature zone inside the main high-melting-temperature bed may be more effective in retaining the pool than simple beds. It was argued that the inner zone would quickly melt and dilute the pool so that further growth into the main bed would be slowed. Hence, the main objective of this work has been to examine the composite bed concept to ascertain its efficacy vis-á-vis simple sacrificial beds.

The test cell used in this investigation has been described elsewhere (1). The main bed is simulated using Carbowax 1540 with a melting temperature T^+ of 43°C while the inner zone is simulated using Carbowax 1000 ($T^+ = 37$ °C). Different amounts of ammonium bicarbonate which decomposes at nearly 45 °C have been mixed with the main bed to simulate possible noncondensable gas release. An aqueous solution of potassium iodide and zinc bromide is used to simulate the core debris pool. The pool is bounded from the top by a nearly-isothermal, water-cooled copper plate.

Power is applied to the pool and maintained constant throughout the experiment. The pool is photographed at known intervals to obtain its dimensions. Experiments have been conducted at different values of power input, initial pool density, and gas release rate for both simple and composite beds.

Typical results showing the pool dimensions L and W, reduced by their initial values L_o and W_o, as functions of time for simple and composite beds without gas release are given in Fig. 1. These results show that initially the pool grows in the composite bed at a faster rate than in the simple bed until the inner, low-melting-temperature zone is completely melted. Beyond that point, the pool growth rates, as indicated by the slopes in Fig. 1, are nearly equal in both cases so that pools growing in composite beds will be larger than those in simple beds at all times during the transient. This result is reasonable since, for the same power input, the internal Rayleigh number which is the governing parameter for this system will always be larger for a pool growing in a composite bed than that for a simple bed so that the heat transfer rates to the pool boundaries would be increased.

Results similar to those shown in Fig. 1 for gas-releasing beds are given in Fig. 2. These results show that initially the pool grows in the composite bed faster than in the simple bed. However, after the inner zone is completely melted the pool growth rate in the composite bed becomes slower than in the simple bed. These results are reasonable since for gas-releasing beds the heat transfer rates at the pool boundaries are independent of the internal Rayleigh number and depend primarily on the superficial gas velocity (2).

The results of this investigation indicate that composite core catchers will be more effective in retaining the debris pool only if significant amounts of noncondensable gas are released by the main bed material.

REFERENCES

(1) D.K. Felde, Z. Musicki, and S.I. Abdel-Khalik,"Growth of Volumetrically-Heated Pools in Miscible Gas-Releasing Solid Beds," Presented at Post Accident Heat Removal Meeting, Ispra (Nov. 1978).

(2) D.K. Felde, H.S. Kim, and S.I. Abdel-Khalik,"Convective Heat Transfer Correlations for Molten Core Debris Pools Growing in Cincrete," Trans. ANS, 0, 00 (Nov. 1979).

Fig.1. Variation of pool dimensions with time for simple and composite beds with no gas release (double arrow indicates melting of inner zone).

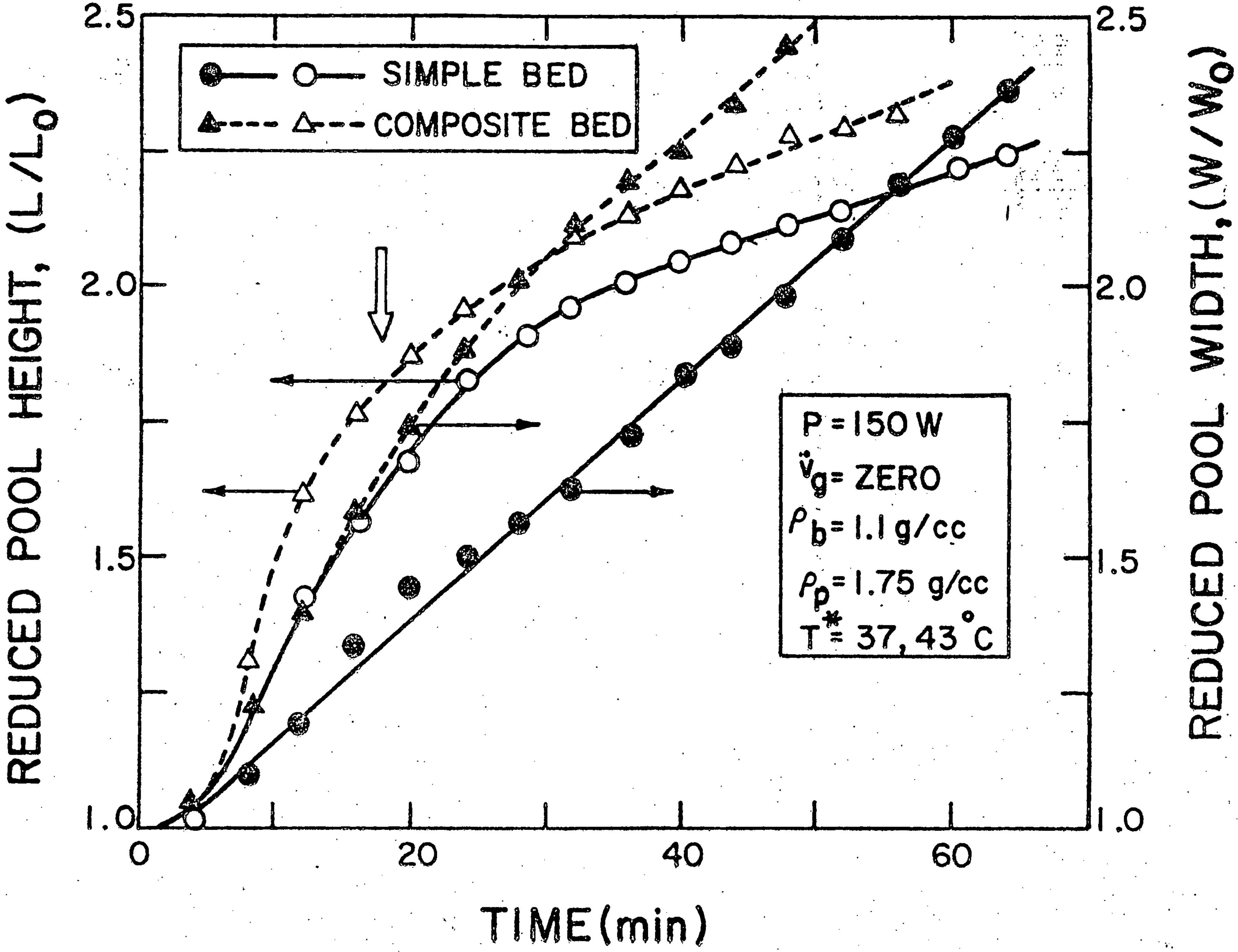

Fig. 2. Variation of pool dimensions with time for simple and composite beds with gas release (double arrow indicates complete melting of inner zone).