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THE TRANSIT-HYDRO TRANSITION PHASE ACCIDENT ANALYSIS CODE:
AN OVERVIEW AND RECENT IMPROVEMENTS*

by

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The TRANSIT-HYDRO computer code is being developed to provide a tool for assessing the consequences of transition phase events in a hypothetical core disruptive accident in an LMFBR.¹ The TRANSIT-HYDRO code incorporates detailed geometric modeling on a subassembly-by-subassembly basis and detailed modeling of reactor material behavior and thermal and hydrodynamic phenomena. The purpose of this summary is to give a brief overview of the code and to describe recent improvements to the code, particularly the addition of new phenomenological models. Sample results with these new models are also described.

The TRANSIT-HYDRO code is constructed on a modular basis, which allows models to be added or changed readily. The major code modules in TRANSIT-HYDRO include the steady-state and prevoiding stage; the subassembly voiding stage; the point kinetics, decay heat and reactivity feedback models; the primary loop model; the canwall failure model; and the disrupted subassembly model. The modular structure of TRANSIT-HYDRO allows it to be used either as an independent code or as a continuation of initiating phase calculations performed with another code, such as SAS4A.² When TRANSIT-HYDRO is used independently, simplified initiating phase calculations are performed which give good agreement with the general features of more sophisticated calculations, such as the initial voiding of the core. The TRANSIT-HYDRO code can be used for problems involving any number of subassemblies, from one to a whole core simulation, with each subassembly having different characteristics, if desired. Arrangements for various core symmetries are also included, reducing the computing requirements for those cases.

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In this summary, the emphasis is on the disrupted subassembly module, which is used once the fuel pin inside the subassembly start to disrupt. The disrupted subassembly module in the TRANSIT-HYDRO code uses a multi-phase, multi-component treatment of the continuity, momentum and energy equations. While the details of this equation system are too involved to be reviewed here, these equations account for the transfer mechanisms involving phase changes, and interphase and intercomponent exchange of momentum and energy. The set of equations is solved using an implicit Eulerian scheme, which is basically a modified ICE technique.³

By modeling the core on a subassembly-by-subassembly basis, it is possible to use one-dimensional modeling inside the subassemblies. The differences between subassemblies retains a three-dimensionality in the formulation which accounts for spatial inhomogeneities across the core. It also facilitates the modeling of intersubassembly effects, such as heat transfer between subassemblies and material motions after the subassembly walls have failed. The present canwall failure model accounts for the condition of each wall of the subassembly, and each wall fails independently, in general. Once a canwall has been failed, material from inside the subassembly can move out into the intersubassembly gap and contact the outer surface of the adjacent subassembly. The motion of material from one subassembly to another has already been modeled. In the near future, it is planned that models for intersubassembly gap penetration will be developed as well.

Another area of the code that has been improved recently is the modeling of vapor/liquid momentum exchange.⁴ Of several scenarios proposed for the LMFBR transition phase, one of the possibilities is for forming subassembly-size on multiple subassembly pools of molten oxide fuel and stainless steel following initial fuel pin disruption. Subsequent events were characterized by material vaporization and relocation with relatively low accelerations. The mechanism of pool boilup was suggested as a means of keeping the molten material in a subcritical configuration, even at decay heat levels where the vaporization rate is low. In order to model such a situation, the vapor/liquid momentum exchange models in TRANSIT-HYDRO were improved.

The new models were developed based on physical principles and previously developed and tested models. The liquid/vapor momentum exchange models are

functions of void fraction, flow regime, and bubble or drop size. Four flow regimes are used: bubbly flow, churn-turbulent flow, drop/annular flow, and a special case of slug flow. Different correlations are used depending on the flow regime and particle size. The models are not specific to any particular material, and are applicable to both simulant and real reactor materials.

These models have been tested against experimental data with good results. As an example, the accompanying figure shows the comparison between the TRANSIT-HYDRO calculations and a set of experimental data taken from a bubbling column experiment, in which nitrogen was injected into a column of water. The only input data required by the code for this calculation is an estimate of the bubble size. The flow regime modeling incorporated into the code needs no additional input, although the transition from one flow regime to the next can be easily adjusted by input, if desired.

Using these improved vapor/liquid momentum exchange models, calculations have been done for a single subassembly with real materials. These calculations showed that there was considerable vaporization of steel, even at decay heat levels, and that the vaporization rate was sufficient to carry the molten fuel/steel mixture upward and out of the subassembly. While these calculations were carried out using the most favorable boundary conditions, the consequences of varying the boundary conditions is being investigated, such as greater heat transfer to the wall and restricted flow out of the subassembly.

This example demonstrates how the development of these models for the TRANSIT-HYDRO code allows some questions regarding particular accident scenarios to be addressed. Using models already available in TRANSIT-HYDRO, areas being investigated at present, or in the near future, are the possibility of dispersing molten fuel material in a closed subassembly by boiling steel vapor, the possibility of removing fuel from the core by such boiling, the role of heat losses in affecting the boilup of molten reactor materials, and the reactivity implications of these results.

The TRANSIT-HYDRO code is also being evaluated for its suitability for metal fuel calculations, since this is an area of renewed interest for reactor designers. Based on the range of anticipated accident conditions, and due to the general nature of the modeling already included, most of the modeling in TRANSIT-HYDRO will be directly applicable to metal fuel calculations. Some

new modeling needs to be done, especially on the physical properties of metal fuel and alloy formation with other reactor materials. The modular structure of the TRANSIT-HYDRO code makes such changes relatively easy.

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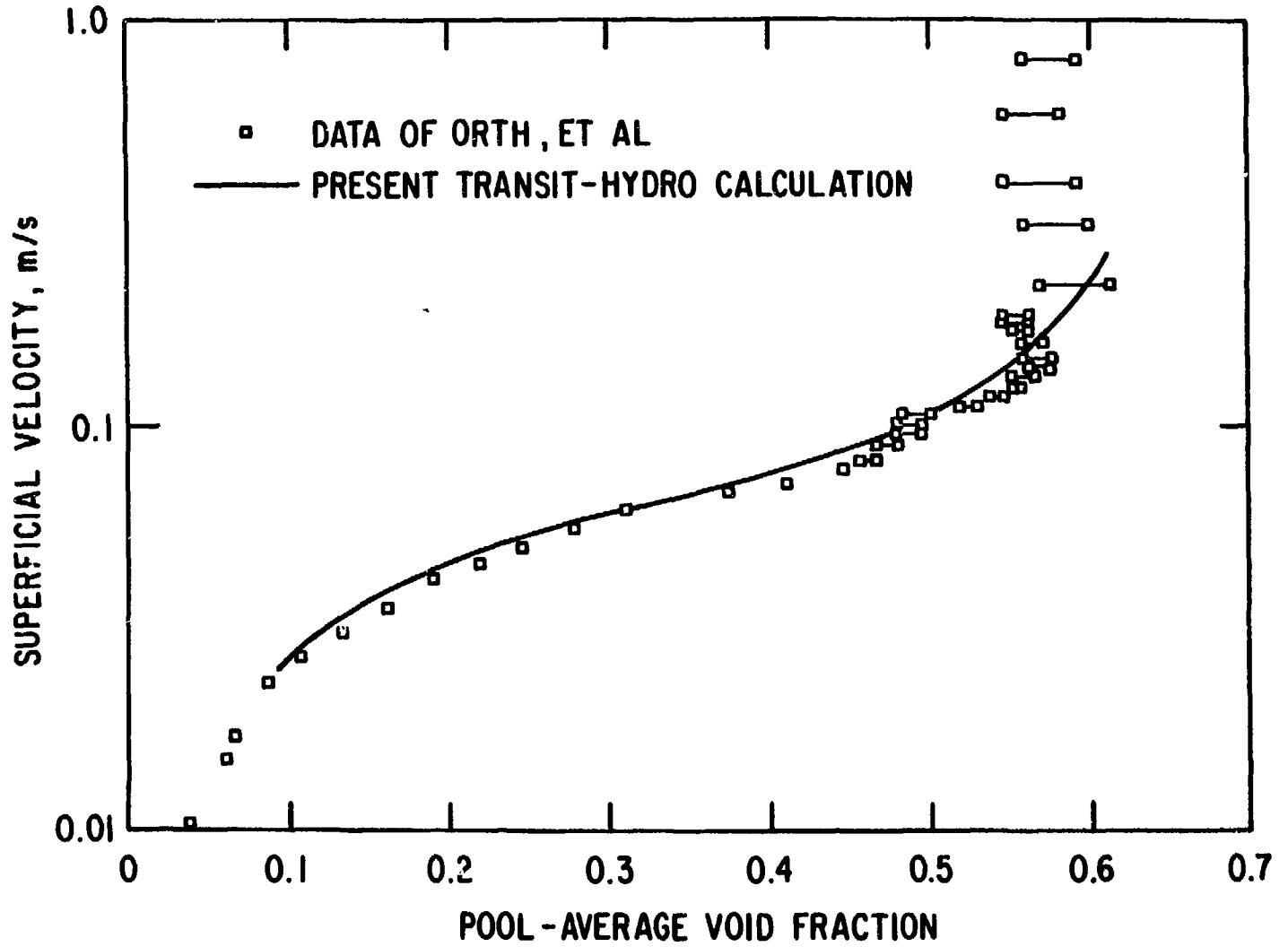


Fig. 1. Superficial Velocity vs. Average Void Fraction in the Pool