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SUNNYVALE, CALIFORNIA

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by

J. P. Wei

To analyze thermal-hydraulic behavior in a wire-wrapped fuel or blanket assembly, it is necessary to evaluate the coolant flow field in the rod bundle. Evaluation of the coolant flow phenomenon in the wire-wrapped assembly becomes even more important when the bundle has a low pitch-to-diameter ratio or a wire-wrap configuration different from the current reference straight-start design or the assembly is located in a high radial power gradient region in a reactor. Subchannel analysis method (FULMIX-II)[1] was developed to specifically treat the complex coolant transfer process within a wire-wrapped assembly and to determine the coolant temperature field accordingly.

In a wire-wrapped rod bundle, coolant mixing caused by wire wraps, subchannel coolant flow area changes due to the presence and absence of wires, and circumferential swirl flow at the peripheral of the assembly all play important roles in redistributing coolant flow between subchannels. The redistribution of coolant flow, in turn, causes a redistribution of energy. The coolant mixing through the gaps between rods is the result of natural turbulent flow exchange, directed sweeping crossflow due to the helical wire wrap, and pressure-induced crossflow. The pressure-induced crossflow, which accounts for momentum changes associated with changes in subchannel velocity, is largely due to the change of net subchannel coolant flow area.

Based on the mechanics of mixing discussed above, an appropriate set of governing equations is set up for all the subchannels in the assembly. The coolant flow equations are first solved as a two-point boundary value problem. The computational method used is an iterative one. In solving the conservation equations of momentum, FULMIX-II utilizes the turbulent flow exchange, the sweeping crossflow and the step subchannel flow area change due to the presence and absence of wire as forcing functions. In other words, calculation of the changes in subchannel velocity is first made as a result of the turbulent flow exchange, wire sweeping crossflow and the step subchannel flow area change at the beginning of an iterative flow calculation for each axial section. The measured wire sweeping data are applied only at the gaps where wire sweeps through. The pressure-induced crossflows caused by unbalanced pressures between two adjacent subchannels due to changes in subchannel velocity are then calculated. From then on, during the iteration for the same axial section, it is assumed that the pressure-induced crossflow can be superimposed upon the turbulent flow exchange and the directed sweeping flow at the gaps. As a result, the solution converges without introducing any artifical restrictions on the crossflows and swirl flow factor for the peripheral flow. The flow solution provides both the pressure and velocity fields for the axial section.

The FULMIX-II code has been compared with the French 19-pin water flow test[2] on the transverse velocity in the peripheral region[3]. The agreement between the experimental data and the FULMIX-II prediction is very good. Since detailed information on pressure distribution of flow fields in a 61-pin wire-wrapped rod bundle was made available by MIT[4], a FULMIX-II model of the MIT water test geometry was set up for the purpose of comparison. Figure 1 was developed to show the computed edge subchannel pressure distribution and the pressure data along the length of the bundle with 6-inch wire-wrap pitch. Both of the results of the FULMIX-II code and the test data indicate that the axial pressure gradient is highly non-uniform and periodic with the same period as the wire-wrap pitch. Although, there are some point-by-point differences on the pressure distribution along the length, the overall pressure distribution prediction by the FULMIX-II code is in good agreement with the test data. Based upon the previous velocity comparison with the French data and the present pressure comparison with the MIT data, it is concluded that the FULMIX-II code is capable of predicting a reasonable pressure and velocity field of coolant flow in a wire-wrapped rod bundle.

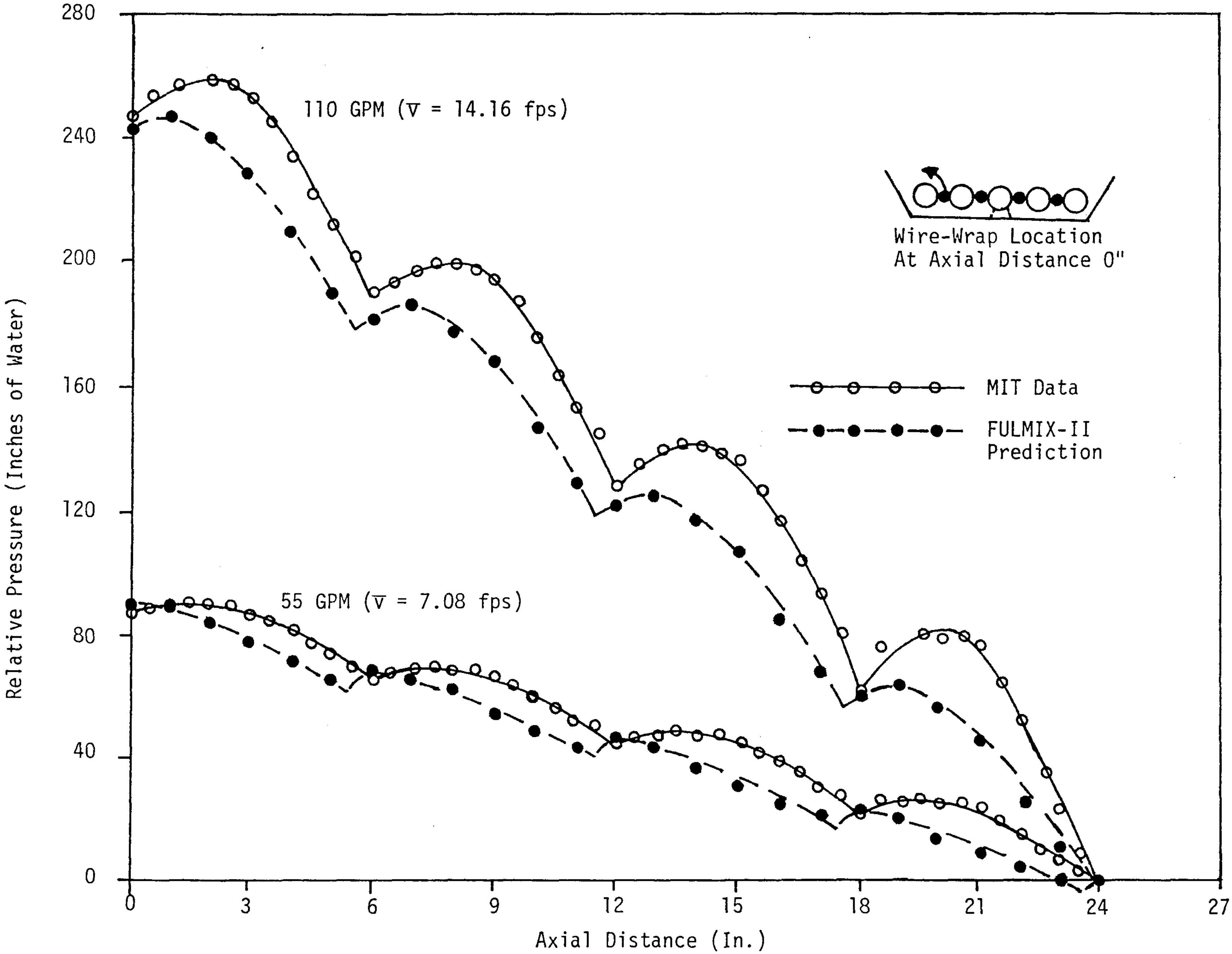

Figure 1. Pressure in an Edge Subchannel of the 6-Inch Wire-Wrap Pitch Bundle

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