The p-h Interpolator

Cliff Davis

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A new set of p-h interpolator coding makes RELAP5-3D thermodynamic properties to users and programs that need properties in terms of pressure and enthalpy.

Background

RELAP5-3D contains more than twenty five working fluids, including light and heavy water, several gases, liquid metals, molten salts, and other miscellaneous fluids. Each working fluid contains a full set of thermodynamic and transport properties as a function of two independent thermodynamic variables for the saturation line, subcooled liquid, superheated gas, and supercritical fluid. The thermodynamic properties are obtained from an equation of state, while the transport properties are obtained from correlations.

For purposes of code run speed, the equation of state is not evaluated at every state point encountered during its calculations. Rather, interpolation between exact fluid properties at thermodynamic grid points is used to quickly obtain approximate thermodynamic properties at any state point. The equation of state is used to generate "exact" fluid properties at developer-specified independent thermodynamic variables that define the thermodynamic grid allowed by the code. The subroutines that perform the interpolations are generally referred to as interpolators.

The exact fluid properties from the equation of states are contained in external files that are generated when RELAP5-3D is installed and are read into memory at the beginning of each run. The external files are referred to as thermal property files (*tpf*). For example, file *tpfh2* contains data for hydrogen. The *tpf* files are machine-independent binary files written in XDR format. They are portable across different computer platforms.

RELAP5-3D uses three different equations of state to calculate fluid properties for light water. These equations of state correspond to the 1967 steam tables, the 1984 steam tables, and the 1995 steam tables. These three versions of light water are referred to as *h2o*, *h2on*, and *h2o95*. The corresponding *tpf* files are *tpfh2o*, *tpfh2on*, and *tpfh2o9*5. RELAP5-3D contains four sets of interpolators, one for *h2o*, one for *d2o*, one for *h2on*, and one for all the other fluids.

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The combination of a large number of working fluids, the portable *tpf* files, and the fast-running interpolators means that the property data used by RELAP5 would be very useful to engineers or other computer codes if they were readily available. An easily accessible library that contains all of the property information used by RELAP5-3D and driver programs that accesses the library to determine fluid properties were created. The library and driver programs can be used to easily determine properties for any of the working fluids simulated by RELAP5-3D. Two driver programs were developed during this task. The first driver program, which is called *polate*, is used for interactive operation. Thus, an engineer can use *polate* to easily determine fluid properties at a given state. The second driver program, which is called *polated*, is used to perform automatic testing and plotting of results during installation. Testing was performed for four working fluids, the three light waters and one refrigerant.

The second driver program calls *polates*, which is similar to *polate* except that it functions as a subroutine rather than as a main program. The subroutine *polates* is included in the library and can be accessed by other computer codes. Some of the other codes that will access the library use pressure and specific enthalpy as independent thermodynamic variables. Almost all of the *tpf* files used by RELAP5-3D use pressure and temperature as independent thermodynamic variables. The one exception is fluid *h2on*, which uses pressure and specific internal energy as independent variables. Fluid *h2on* is also unique in its treatment of metastable states. Fluid properties for metastable states are contained within file *tpfh2on*, whereas metastable properties are calculated inside RELAP5-3D for all other working fluids. The computer codes will require derivatives of certain state properties as a function of pressure or specific enthalpy. The required derivatives are also calculated by *polate*.

Existing RELAP5-3D interpolators can access the library with independent variables of pressure and specific enthalpy except for the metastable states of fluid h2on. Therefore, a new interpolating subroutine was written to access the metastable states of h2on as part of this work.