RELAP5-3D Reported Problems and Requested Improvements

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Introduction

- Reported problems usually fall into the categories of installation problem, input processing failure, code execution failure, restart/renodalization failure, and unphysical result.
- Requested improvements are new capabilities.
- This presentation will discuss some of the more recent generic code problems and improvements for RELAP5-3D.

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Eliminate Time-Step Sensitivity in Critical Flow

- RELAP5-3D utilizes an underrelaxation algorithm (old-time weighted) to smooth changes in critical flow.
- The algorithm produced different results for different time step sizes for a simple 3 volume and 2 junction input deck because the underrelaxation weight factors are constants.
- The algorithm used on the interphase heat transfer and interphase drag coefficients is, in general, time step independent.
- The weighting factor for this is $\eta = \exp(-\Delta t/\tau)$.

Eliminate Time-Step Sensitivity in Critical Flow (continued)

- Implemented a time step independent methodology (similar to the interphase coefficients) into the critical flow models for the intermediate velocities.
- Did this for the Ransom-Trapp and Henry-Fauske critical flow models.
- Verification using the simple 3 volume and 2 junction input deck (dt = 0.0125 s and 0.00625 s) shows that the time-step sensitivity has been removed for the Henry-Fauske model but has not been removed for the Ransom-Trapp model.

Eliminate Time-Step Sensitivity in Critical Flow (continued)

- The Ransom-Trapp model is still time-step sensitive due to the presence of constants to underrelax other variables.
- The use of constants to underrelax other variables will be removed and the full Ransom-Trapp model implemented with proper transitions (current task).

Eliminate Time-Step Sensitivity in Critical Flow (continued)

- Validation was carried out using legacy cases (Edwards pipe, GE level swell, Marviken, LOFT-Wyle, LOBI, LOFT, TYPPWR).
- Validation using Henry-Fauske model showed that no significant differences between base code and modified code (except LOFT L3-7, where both codes fail to choke for most of calculation).
- Validation using Ransom-Trapp model showed that the code changes have not materially affected the performance of the code.

Henry-Fauske Critical Flow Model Flag

- There is a need to use the Ransom-Trapp critical flow model at internal valves and the Henry-Fauske critical flow model at the break.
- Moved the Henry-Fauske model from Card 1 status (Option 53) to junction control flag status (c = 2).
- Modified input-level subroutines (junction control flag and labels for discharge coefficients/nonequilibrium constant) and output-level subroutines (junction control flag).
- Modified Volume II, Appendix A of the RELAP5-3D manual to indicate how to turn on the model.

Henry-Fauske Critical Flow Model Flag (continued)

- Reviewed RELAP5/MOD3.3 theory/implementation manual and RELAP5-3D model coding.
- Volume IV of the RELAP5-3D manual was changed to use the RELAP5/MOD3.3 theory/implementation manual description with following changes: more background info in the derivation of equations, use nomenclature consistent with other sections of the manuals, and remove inconsistencies in the throat pressure iteration loop.
- RELAP5-3D model coding was modified to remove inconsistencies in the throat pressure iteration loop.

Fix Fuel Rupture Model for Reflood

- Previously, differences were seen in the fuel rupture model when the reflood model was on versus when the reflood model is off.
- Error was found in the reflood heat structure material properties (thermal conductivity and volumetric heat capacity) subroutine MDATA2.
- Changed subroutine MDATA2 to test on the rupture flag (variable ‘imw’ bit 10) rather than the loss flag (variable ‘imw’ bit 11).
- Now, the fuel rupture model behaves similarly when the reflood model is on or off.

Fixes to Input Processing

- Previously, there was no indication of the card number when a bad character is in column 1 of the input deck.
- Now, fixed; in subroutine INP, write out the card number (the message is before the listing of the input deck).
- Previously, if the initial value control flag in the control system was set to a value other than zero or one, the code did not indicate an input error.
- Now, fixed; in subroutine RCONVR, indicate an input error if the initial value control flag was set to a value other than zero or one.

Fixes to Input Processing (continued)

- Previously, the pump single phase homologous curve independent variables were not entered increasingly (this caused problems during the transient).
- Now, fixed; in subroutines RPUMP and RPMPMD, proper input checking was added to require the variables are entered increasingly (also, the manuals were modified to more correctly indicate the variables must be entered increasingly).

Fixes to Input Processing (continued)

- Previously, when a pipe junction diameter/ccfl data card was entered incorrectly, the error message only said ‘junction input data out of range’ (no indication of which card had the error).
- Now, fixed; in subroutine RPIPE, the error message was changed to say ‘junction diameter/ccfl input data out of range”.
- Previously, there was no warning message indicating additional left/right boundary heat structure cards are entered but are not needed.
- Now, fixed; in subroutine RHTCMP, a warning message is now printed.

Summary

- Implemented a time step independent methodology into the critical flow models for the intermediate velocities (ok for Henry-Fauske, not ok for Ransom-Trapp, working on full Ransom-Trapp).
- Can now activate Henry-Fauske critical flow model at a specific junction (junction control flag c = 2).
- Fuel rupture model fixed (reflood option now behaves similar to non-reflood option).

Summary (continued)

- Fixes to input processing:
  - error message indicates card number for bad character in in column 1.
  - error message if control variable initial value control flag set to value other than zero or one.
  - proper input checking added to require pump single phase homologous curve independent variables are entered increasingly.
  - error message for incorrect pipe junction diameter/ccfl data card.
  - warning message indicating additional left/right boundary heat structure cards entered but not needed.