Chemical Engineering 512

Nuclear Reactor Transient Modeling

Lecture 2

Reactor Concepts

RELAP5-3D Introduction

Export Control Laws

Spiritual Thought

"To establish Zion in our homes, branches, wards, and stakes, we need to (1) become unified in one heart and one mind; (2) become holy people; and (3) care for the poor and needy. We cannot wait until Zion comes for these things to happen—Zion will come only as they happen."

-Elder D. Todd Christopherson

Objectives

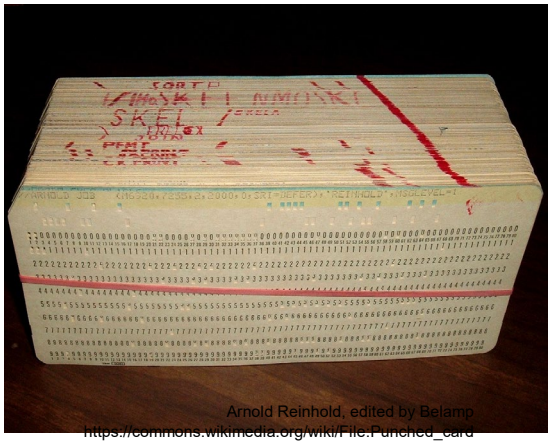
- Go over questions from DVDs
- Learn how to build an input deck
- Build a sample input deck

DVD Questions?

- RELAP Code Overview
- RELAP5-3D Code Overview
- Execution Procedures
- Input Description (Part 1)

Input Deck Information

- Use text editor
  - Really anything, Notepad ++ works well
- Files saved with ".i" extension
- 80 Character Length
- * or $ to comment
- Must end with a "."
- All lowercase unless in a name
- Do not use TABs
- All input word descriptions can be found in the Appendix



Arnold Reinhold, edited by Belamp
https://commons.wikimedia.org/wiki/File:Punched_card_program_deck.agr.jpg

Comment EVERYTHING

```
0750001          26
0750101       0.061977823      26
0750301       .076395          1
0750302       .153416          3
0750303       .153314          23
0750304       .153416          25
```

VS

```
*              name          type
0750000     "Ch1Q1"           pipe      * quadrant 1, channel 1 volume properties
*           nodes
0750001          26
*           FlowArea         vol#
0750101       0.061977823      26    * 2 assemblies  *
*           Node Length      vol#
0750301       .076395          1
*           Node Length      vol#
0750302       .153416          3
*           Node Length      vol#
0750303       .153314          23
*           Node Length      vol#
0750304       .153416          25
```

Custom Language in Notepad ++

- Language → User Defined Language → Define Your Language
- Create New → Name is whatever you'd like (RELAP)
- Ext. → .i
- Comment & Number → Comment Line Style → Open → *
- Comment & Number → Comment Style → Open → *
- Then use styler to choose what choose foreground color (text color)
- Exit
- Language tab → Select RELAP
- Now all your comments will be one color and your code will be black

Title Card

- = Title of Deck

Miscellaneous Control Cards (A2-12)

- 100 Problem Type Problem Option
- 101 INP-CHK/RUN
- 102 input units output units
- 105 time remaining 1 time remaining 2 (adv) CPU time allotted
- 110 noncondensable gas
- 120 ref. vol elevation fluid type system name

```
100 new stdy-st
*
102  british   si
105  5.0 6.0 5000.0
110 nitrogen
```

Time Step Control Cards (A3-1)

- 201 End Time min time step max time step ssdtt minor major restart

- ssdtt – time step options
- Minor*min time step = minor data point every ____ seconds
- Major*min time step = major data point every ____ seconds
- Restart*min time step = generate restart file every ____ seconds

```
201   10000.0   1.0-7    0.01    07003   100 50000    50000
```

Hydrodynamic Components

- Single Volume
  - Holds liquid or gas
- Single Junction
  - Connects two volumes
- Time Dependent Volume
  - Imposes a boundary condition
- Time Dependent Junction
  - Used to supply fluid and specific flow rate

Hydrodynamic Input Numbering

CCCXXNN

- CCC component number
- XX card type
- NN card number within card type

Single Volume (Appendix Page A7-1)

- Component Name and Type
  - CCC0000 name snglvol
- X-Coordinate Volume Data
  - CCC0101 X-area X-length X-volume
  - CCC0102 X-azim X-incl X-Δz
  - CCC0103 X-roughness X-D_h X-tlpvbfe
- Initial Conditions
  - CCC0200 εbt initial conditions

```
1060000   isglip    snglvol
1060101   28.550   0.0   149.43   0.0   49.   3.958   0.0   6.029 00
1060200   3   2233.   594.14
*
```

Single Volume (Appendix A7-1)

- Area, Length, and Volume
  - Only need 2, leave the other as 0.0
- Azimuthal Angle
  - Not used, enter 0.0
- Inclination Angle
  - 0 – horizontal
  - 90 – vertical upward
  - -90 – vertical downward
- Hydraulic diameter
  - Can be computed by hand
  - Input 0 to allow the computer to complete the calculation

Single Volume (Appendix A7-1)

- Volume Control Flags
  - t thermal front tracking
  - l mixture level tracking
  - p water packing
  - v vertical stratification
  - b interphase friction
  - f wall friction
  - e equilibrium/non-equilibrium
- If default enter 00 or do not input

ε

- 0 default fluid
- 1 H_2O
- 2 D_2O
- 3 H_2

b

- 0 no boron
- 1 boron

t

- 0 P, u_t, u_g, and α
- 1 T and X
- 2 P and X
- 3 P and T
- 4 P,T, and X_e
- 5 T,X, and X_{nc}
- 6 P, u_t, u_g, α, and X_{nc}

Single Volume Example

- Component Name and Type
  - CCC0000 name sngIvol
- X-Coordinate Volume Data
  - CCC0101 X-area X-length X-volume
  - CCC0102 X-azim X-incl X-Δz
  - CCC0103 X-roughness X-D_h X-tlpvbfe
- Initial Conditions
  - CCC0200 εbt initial conditions

- Create a single volume named “test” that starts out at a pressure of 3000Pa and 400K. This volume is perfectly smooth, has a downwards inclination of 5^o and a change in height of 0.7m. The length of “Test” is 5m and its volume is $25m^3$. You may assume all flags are set to default. Number this volume 105

Single Volume Results

```
*Answer
1050000          test    snglvol
1050101          0.0     5       25
1050102          0.0     -5      -0.7
1050103          0.0     0.0     00
1050200          3       3000    400
```

Single Junction (Appendix Page A7-17)

- Component Name and Type
  - CCC0000 name sngljun
- Geometry
  - CCC0101 from to area
  - CCC0102 A_F A_R jefvcahs
- Initial Conditions
  - CCC0201 vel/mfr liquid vapor interface

```
1070000   isglptu     sngljun
1070101   106010000   108000000   11.099   0.0   0.0   0100
1070201   1   9737.   0.0   0.0
```

Single Junction (Appendix Page A7-17)

- Connections
  - CCC000000 – inlet of CCC
  - CCC010000 – outlet of CCC
- Area
  - If 0, minimum adjoining area is used
- Input Conditions
  - Vel/mfr
    - 0 to input velocities
    - 1 to enter mass flow rates

Single Junction (Appendix Page A7-17)

- Junction Control Flags

  e modified PV term in energy equations

  f CCFL

  v horizontal stratification entrainment

  c choking

  a smooth/abrupt area change

Single Junction (Appendix Page A7-17)

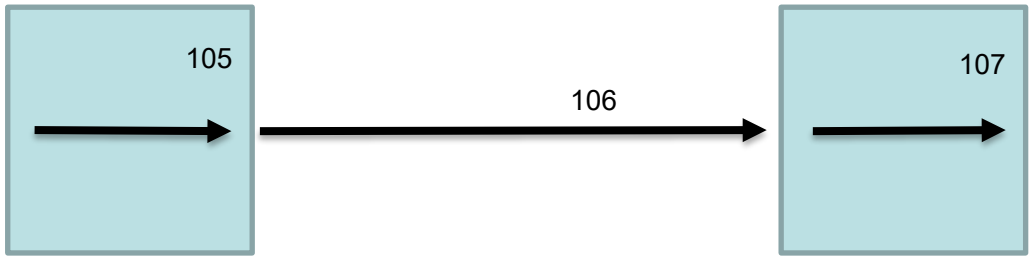
- Component Name and Type
  - CCC0000 name sngljun
- Geometry
  - CCC0101 from to area
  - CCC0102 A_F A_R jefvcahs
- Initial Conditions
  - CCC0201 vel/mfr liquid vapor interface

Create a single junction that connects from the outlet of volume 105 to the inlet of 107. Let the computer calculate the minimum area for this connection. You may assume loss coefficients are 0 and there are no flags. Name the junction “test2” and number it 106. Assume there is no gas in the junction and that the initial liquid mass flow rate is 2.11 kg/s.

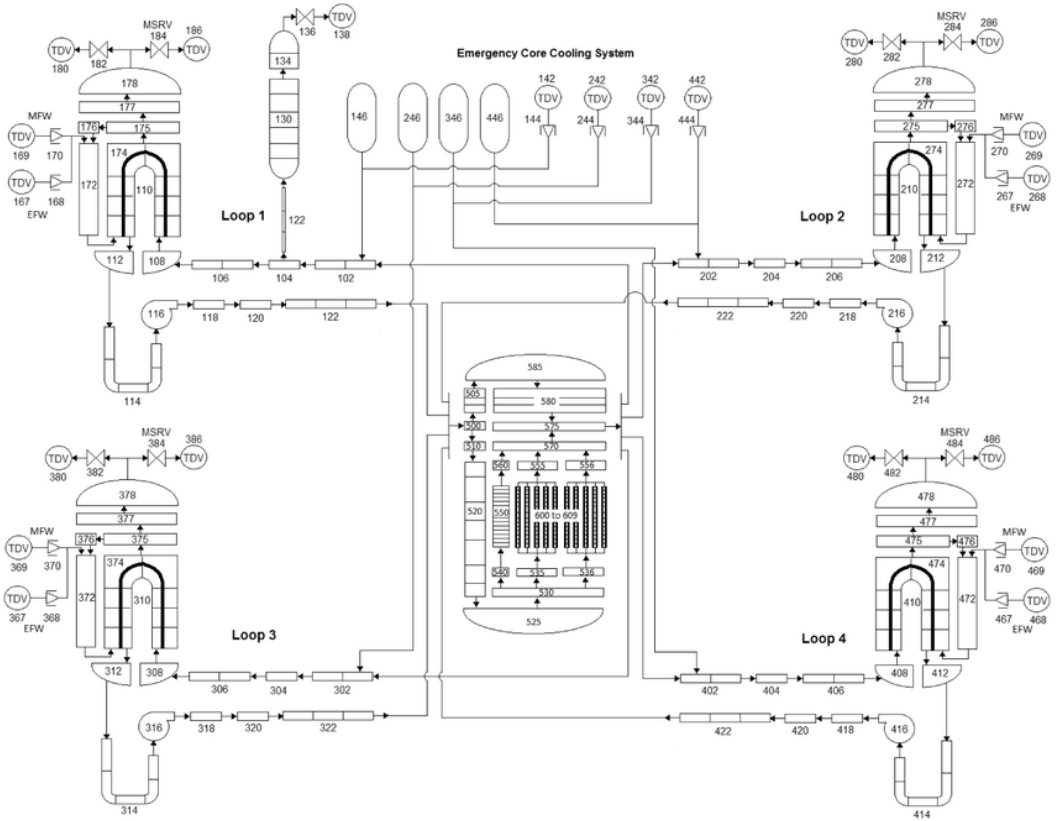
Single Junction (Appendix Page A7-17)

```
*Answer
1060000          test2              sngljun
1060101          105010000     107000000      0.0
1060102          0.0           0.0            00000000
1060201          1             2.11           0.0              0.0
```

What did we just do?



What is our goal?



Time Dependent Volume (A7-10)

- Component Name and Type
  - CCC0000 name sngIvol
- X-Coordinate Volume Data
  - CCC0101 X-area X-length
    X-volume
  - CCC0102 X-azim X-incl
    X-Δz
  - CCC0103 X-roughness X-D_h
    X-tlpvbfe
- Data Control
  - CCC0200 εbt trip #
    search variable
  - CCC0201 search variable data

```
* inj
7500000   injvol tmdpvol
7500101   1000. 1.0   0.0   0.0   0.0   0.0   0.0   0.0   00
7500200   2
7500201   0.0 2500. 0.
*
```

Time Dependent Volume (A7-10)

- Same as single volume but card 200 is different
- εbt is same as single volume
- Trip is optional
  - Don’t worry about this now
- If no search variable is entered, time is used
- Used where fluid is coming into the model at specific conditions

Time Dependent Junction (A7-22)

- Component Name and Type
  - CCC0000 name tmdpjun
- Geometry
  - CCC0101 from to area jefvcahs
- Data Control
  - CCC0200 vel/mfr trip # search variable
  - CCC0201 search variable liquid vapor interface

```
1810000   mnfeed1   tmdpjun
1810101   182000000   174000000   0.736
1810200   1     506
1810201  -1.0  968.25   0.0   0.0
1810202   0.0  968.25   0.0   0.0
1810203   20.  968.25   0.0   0.0
1810204   20.1 0.0      0.0   0.0
```

Time Dependent Junction (A7-22)

- Again, much like single junction
- Used to supply fluid as specified flow rate or velocity

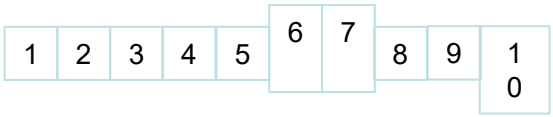
Pipe (A7-26)

- CCC0000 name pipe
- CCC0001 number of volumes
- CCC0101 X-area vol #
- CCC0301 X-length vol #
- CCC0601 X-incl vol #
- CCC0801 X-rough X-D_h vol #
- CCC1001 tlpvbfe vol #
- CCC1101 jefvcahs jun #
- CCC1201 εbt initial conditions vo
- CCC1300 vel/mfr
- CCC1301 liquid vapor interface jun#

```
1000000  ihll   pipe
1000001  2
1000101   5.14    1
1000102   4.587   2
1000301   3.339   1
1000302   4.362   2
1000601   0.0     2
1000801   0.0   2.558   1
1000802   0.0   2.417   2
1001001   00   2
1001101   0000  1
1001201   3   2233.  594.14   0.0   0 0 1
1001202   3   2233.  594.14   0.0   0 0 2
1001300   1
1001301   9737.   0.0   0.0   1
```

Pipe (A7-26)

- Annulus is same just put annulus as type
- Number of junctions
  - Number of volumes – 1
- Sequential Expansion Notation
  - 1000101 0.5 5
  - 1000102 0.75 7
  - 1000103 0.5 10



End of Deck Card

- .

- DO NOT FORGET THIS CARD!!!!!

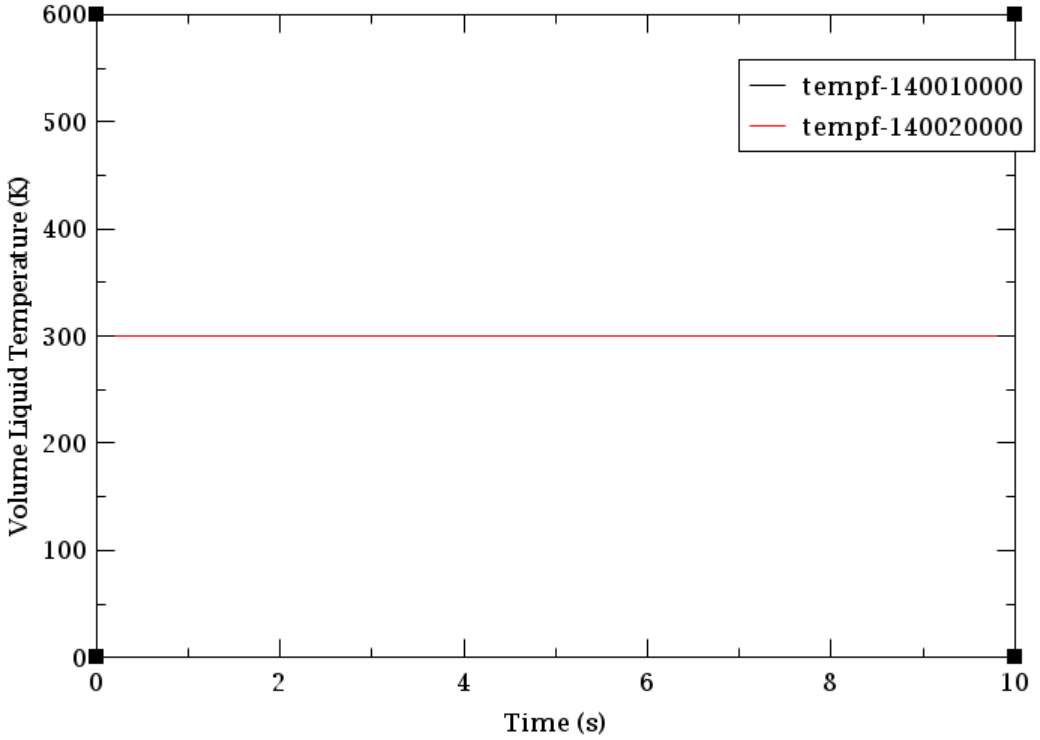
Lets Practice!

- Create and input deck for a 2-volume pipe of any size with an initial temperature and pressure of 300K and 100000Pa with the water being stagnant.

- Run the input deck for 10sec and generate a plot of the temperature of the fluid in that volume.

- What do we expect to happen?
- What did happen?

Results


tempf-140010000
tempf-140020000
Volume Liquid Temperature (K)
600
500
400
300
200
100
0
0
2
4
6
8
10
Time (s)

Assignment

- Before next class, watch sections 7 and 11 on DVDs
- Homework 2 is due Tuesday (9/19)