# Lab #6: VIPRE subchannel analysis - PWR Core

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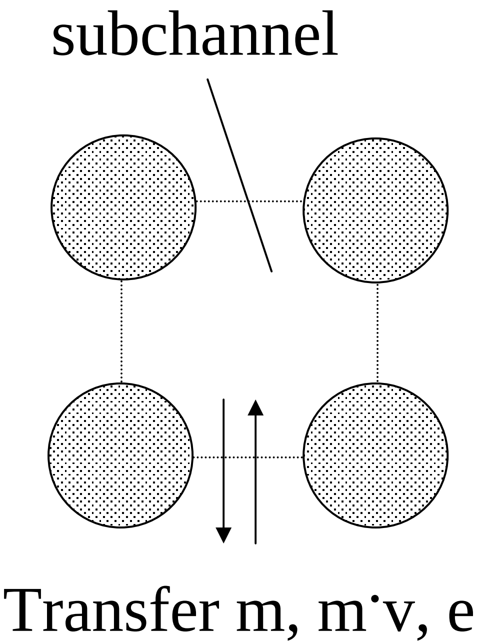
11/18/2005

# VIPRE Computer Code

- Predicts 3-D velocity, pressure and thermal energy fields in coolant
- + temperatures in fuel rods
- MDNBR – major output
- in PWR and BWR cores
- Steady state and transients

# Simplifications




- Control volume fixed
- Subchannel analysis
- Channel-averaged quantities

- lateral flow loses its sense of direction after leaving gap (not fully 3D as CFD)
- Incompressible, thermally expandable homogeneous flow

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See figures in Cuta, J. M., et al. "VIPRE-01 A Thermal-Hydraulic Code for Reactor Cores." *EPRI* 1-3 (1985): NP-2511-CCM.

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*EPRI* 1-3 (1985): NP-2511-CCM.

# Input data

- Geometry (A, Pw,Ph,pitch,gaps,L, nodalization)
- Coolant properties
- Correlations (dp, CHF, alpha, heat transfer)
- Grid specification (positions, losses)
- Mixing (mixing coefficient)
- Operational (p,q’, G, Tin)
- Computational control (solution method, print…)
- Fuel rods (peaking, fuel properties, dimensions)

# Turbulent mixing modeling

- Turbulent mixing important
- 1. mixing coefficient W*=**A** s G
  - Typically A=0.038
  - higher in current PWRs
  - need to be proven by experiments
- 2. Turbulent momentum factor FTM (0-1)
  - How efficiently the turbulent cross flow mixes momentum
  - VIPRE not very sensitive to FTM
  - typical representative value FMT=0.8

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* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                                     *
*   vipre-01, reference case of typical W PWR core - Pavel Hejzlar    *
*                                                                     *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
1,0,0                                                           *vipre.1
1/8 core single pass hot bundle analysis REFERENCE UO2 core     *vipre.2
*
*  channel geometry - 21 channels, 48 axial nodes
*
geom,21,21,48,0                                                 *geom.1
144.,?                                                          *geom.2
0.,2.          * default sl = 2.0                               *geom.2 (cont.)
*      channel dimensions
*   A      Pw     Ph Gaps g#  centroid dist, P
1,.0590,.6300,.4406,2,2,.068,.496,7,.122,.744                   *geom.4
2,.1180,1.260,0.8812,3,3,.068,.496,4,.122,.496,7,.122,.744      *geom.4
3,.0590,.6300,.4406,1,5,.122,.496                               *geom.4
4,.1362,1.175,1.175,3,5,.122,.496,7,.122,.744,8,.122,.496       *geom.4
5,.1362,1.175,1.175,2,6,.122,.496,9,.122,.496                   *geom.4
6,.0590,.6300,.4406,1,10,.068,.496                              *geom.4
7,1.2983,12.0465,10.7215,2,8,.122,.744,12,.19,1.984             *geom.4
8,.1180,1.260,0.8812,2,9,.068,.496,12,.068,.744                 *geom.4
9,.1180,1.260,0.8812,2,10,.122,.496,13,.068,.744                *geom.4
10,.1180,1.260,0.8812,2,11,.068,.496,13,.122,.744               *geom.4
11,.0590,.6300,.4406,1,13,.122,.744                             *geom.4
12,1.0103,8.9818,8.2247,2,13,.268,1.736,14,.366,2.976           *geom.4
13,1.4731,12.5688,12.1902,1,14,0.61,2.976                       *geom.4
14,9.527,87.01,77.55,2,15,1.054,3.968,16,1.054,4.464            *geom.4
15,9.527,87.01,77.55,2,16,1.054,6.448,17,1.054,6.448            *geom.4
16,19.05,174.,155.1,1,18,2.108,8.432                            *geom.4
17,19.05,174.,155.1,2,18,2.108,6.448,20,1.054,12.4              *geom.4
18,38.11,348.,310.2,2,19,2.108,8.432,20,2.108,12.4              *geom.4
19,19.05,174.,155.1,1,20,2.108,12.4                             *geom.4
20,266.8,2436.,2171.,1,21,9.486,20.83                           *geom.4
21,534.,4873.,4343.                                             *geom.4
*
prop,0,0,2,0       * internal EPRI functions                    *prop.1
*
drag,1,1,4     * #of axial, #of radial, lat drag opt.-page2-183 *drag.1
.184,-.2,0.,64.,-1.,0. * axial friction corr f=a*Re^b+c         *drag.2
.374,.496    * Rod OD, pitch                                    *drag.7
3.15,-.2,0.,  3.15,-.2,0. * lateral drag corr.  Kg=a*Re^b+c     *drag.8
*
grid,0,1       * 0-local, # of correlations, page2-192          *grid.1
.80                                                             *grid.2
-1,7           * all channels have same cd = .80                *grid.4
12.0,1,32.0,1,52.0,1,72.0,1,92.0,1,112.0,1,? * grid loc.        *grid.6
132.0,1,                                                        *grid.6
0,                                                              *grid.4
*
corr,1,1     *# of CHF corrs, 1-only to boiling point , page2-154
levy,homo,homo,none,     *subcool, bulk, 2-ph mult, hot wall    *corr.2
ditb,thsp,thsp,w-31   *correlations for boiling curve           *corr.6
w-31                * dnb analysis with w-31                    *corr.9
0.042,0.066,1.000  * w-31 input data  0.066-Weisman, p.484      *corr.11
*
mixx,0,0,1   * W=AsG, 2phase=1ph, each gap diff beta page2-176  *mixx.1
0.,.038        * Ftm, A  (beta)                                 *mixx.2
0.0380,0.0, 0.0250,0.0, 0.0380,0.0, 0.0380,0.0,                 *mixx.3
0.0250,0.0, 0.0380,0.0, 0.0250,0.0, 0.0380,0.0,                 *mixx.3
0.0380,0.0, 0.0380,0.0, 0.0380,0.0, 0.0380,0.0,                 *mixx.3
0.0250,0.0, 0.0095,0.0, 0.0380,0.0, 0.0250,0.0,                 *mixx.3
0.0380,0.0, 0.0250,0.0, 0.0380,0.0, 0.0250,0.0,                 *mixx.3
0.0250,0.0, 0.0109,0.0, 0.0063,0.0, 0.0063,0.0,                 *mixx.3
0.0048,0.0, 0.0042,0.0, 0.0029,0.0, 0.0029,0.0,                 *mixx.3
0.0022,0.0, 0.0029,0.0, 0.0015,0.0, 0.0029,0.0,                 *mixx.3
0.0015,0.0, 0.0015,0.0, 0.0009,0.0                              *mixx.3
*
oper,1,2,0,0,0,1,0, * unifTin,Mlbm/hr-ft2, see age 2-132        *oper.1
* no iteration on mdnbr, fcool=2.6,
0., 0., 2.6, 0.000                                              *oper.2
2250.0,562.46,2.613,6.5776,  * Poper,Tin,Gin,q'core-ave(kW/ft)  *oper.5
0                      * no forcing functions                   *oper.12
*
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cont        *computational control - see page 2-214                     *cont.1
0.,0,20,0,0,1          * direct upflow solution                         *cont.2
0.,0.,0.01,0.,0.,0.8                                                    *cont.3
0,5,6,3,5,0,1,1,0,0,0,1                                                 *cont.6
1000.,0.,0.,0.,0.,0.,                                                   *cont.7
2,3,4,5,6       * channels printed                                      *cont.8
3,4,6,7,10,11  * gaps printed                                           *cont.9
4,5,8             * rods printed                                        *cont.10
2,3,4,5,6       * dnb results printed                                   *cont.11
*
*   rod layout - mixed dummy and conduction rods
*
rods,1,23,1,2,0,0,0,0,   *1ax.profile,# of rod types,page2-63   *rods.1
*
0.0,0.0,0   *zheat=zbundle,zstart power prof., page2-67         *rods.2
*
-1           * enter chopped cosine                              *rods.3
*
1.55,  * cosine power shape with 1.55 peak                       *rods.5
*
* normal rod input for subchannel rods
*type peak,ax, channel#, fraction of power to channel
1,2,1.605,1, 1,.125,7,.375                                       *rods.9
2,2,1.641,1, 1,.25,2,.25,7,.5                                    *rods.9
3,2,1.607,1, 2,.25,4,.25,7,.5                                    *rods.9
4,2,1.650,1, 2,.25,3,.25,4,.25,5,.25                             *rods.9
5,2,1.631,1, 3,.125,5,.25,6,.125                                 *rods.9
6,2,1.603,1, 4,.25,7,.5,8,.25                                    *rods.9
7,2,1.648,1, 4,.25,5,.25,8,.25,9,.25                             *rods.9
8,2,1.650,1, 5,.25,6,.25,9,.25,10,.25                            *rods.9
9,1,1.617,1, 7,7.                                                *rods.9
10,2,1.620,1, 7,.25,8,.25,12,.5                                  *rods.9
11,2,1.624,1, 9,.25,10,.25,13,.5                                 *rods.9
12,2,1.601,1, 10,.25,11,.25,13,.5                                *rods.9
13,2,1.541,1, 11,.125,13,.375                                    *rods.9
14,1,1.557,1, 12,6.5                                             *rods.9
15,1,1.510,1, 13,9.0                                             *rods.9
16,1,1.578,1, 14,66.0                                            *rods.9
17,1,1.578,1, 15,66.0                                            *rods.9
18,1,1.578,1, 16,132.0                                           *rods.9
19,1,1.382,1, 17,132.0                                           *rods.9
20,1,1.261,1, 18,264.0                                           *rods.9
21,1,1.226,1, 19,132.0                                           *rods.9
22,1,0.94093,1, 20,1848.0                                        *rods.9
23,1,0.94268,1, 21,3696.0                                        *rods.9
0                                                                *rods.9
*       fuel geometry types
*        Dco   Dfo  # Dfi clad      page 2-112
1,dumy,0.374                  * rods 13 - 21 are dummy rods      *rods.68
2,nucl,0.374,0.3715,6,0.,0.022  * rods 1 - 12 nuclear            *rods.62
0,0,0,0,0,2000.,.94,0.                                           *rods.63
endd
*
* end of input file for reference pwr case
*
0     *terminate execution                                       *vipre.1
```