FRAPCON for RAST-K

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FRAPCON Physical Models

Fuel rod thermal response

- PWR, BWR or HBWR cores
- Uranium or MOX fuel
- Decay models: ANS-5.1 (2005)

Fuel rod mechanical response

- Solvers: FDM (code FRACAS-I) and FEM (code FEA)
- Relocation models: FRAPCON 3.4 and 3.5

Internal gas pressure response

- Models: ANS-5.4 (1952), ANS-5.4 (2011), Forsberg-Massih and FRAPFRG
- Gases: fission products (Kr, He, Xe) + Nitrogen release

Corrosion and Hydrogen pickup

- Claddings: Zircaloy-2, Zircaloy-4, M5, ZIKLO and optimized ZKLO
- Optional: zircaloy vintage (prior 1998)
- Creep simulation: conservative or best estimated

Code usage example

```
PROGRAM
USE fpn4rastk, ONLY : INIT, STP0, NEXT, SET, GET
   INIT(m,n,dx,rf,rg,rc,pitch,den,enrch)
DO i = 1, N
   SET("linear power, W/cm", power)
   ...
   SET("coolant temperature, C", tcool)
   IF (i == 1) STP0()
   IF (i > 1) NEXT(dtime)
ENDDO
   GET("axial fuel temperature, C", tfuel)
   ...
   GET("bulk coolant temperature, C", bulk)
 END PROGRAM
```

use fpn4rastk, only : init, next, get, set, stp0

Initialization: `init(<arguments>)`

- `m, n` : number of radial and axial segments
- `dx` : axial node thickness, cm
- `rfuel, rgap, rclad` : radius of fuel, gap and cladding, cm
- `pitch` : fuel rod pitch, cm
- `den` : as-fabricated apparent fuel density, %
- `enrch` : initial fuel enrichment, %

Running calculations: Settings of parameters

Set variables : `set(key, value)`

- `key` : name of the variable
- `value` : value of the variable

List of the available parameters

- linear power distribution, $\frac{W}{cm}$
- coolant temperature distribution, $^{\circ}C$
- coolant pressure distribution, MPa
- coolant mass flux, $\frac{kg}{s \cdot m^2}$

Running calculations: Time step

Very first time step: `stp0()`

The first time step is needed in order to stabilize the time-integration scheme

Next time step: `next(dtime)`

- `dtime` : time step, *day*

Running Calculations: Output Data

Get variables: `get(key, value)`

- `key` : name of the variable
- `value` : value of the variable

List of the available parameters

- axial fuel temperature, $^{\circ}C$
- bulk coolant temperature, $^{\circ}C$
- gap conductance, $\frac{W}{m^2 \cdot K}$
- thermal gap thickness, μm
- mechanical gap thickness, μm

- gap pressure, MPa
- cladding hoop strain, %
- cladding hoop stress, MPa
- cladding axial stress, MPa
- cladding radial stress, MPa
- cladding radial stress, MPa
- axial mesh, cm

Test Example

- Uranium fuel rod with the initial enrichment 3.42 %
- Transient during 40 days with the time step 5 days
- Steady-state input parameters
- Average linear heat rating is 14.6 kW/m
- Coolant inlet temperature is 569 K
- Coolant mass flux is 3857 $\frac{kg}{s \cdot m^2}$
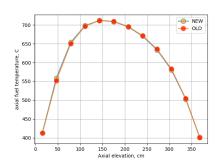
Figure 1: Axial fuel temperature
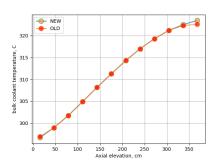
Figure 2: Bulk coolant temperature
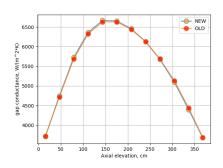
Figure 3: Gap conductance
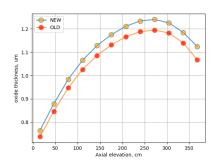
Figure 4: Oxide thickness
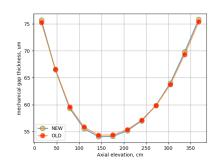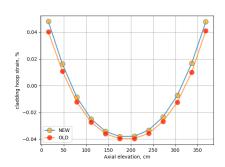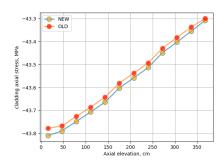
Figure 5: Mechanical gap thickness

Figure 6: Gap pressure
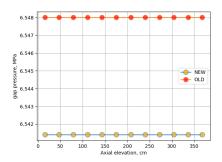
Figure 7: Cladding hoop strain

Figure 8: Cladding axial stress