Assessment of RELAP5-3D using NACOK Natural Circulation Data

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Outline

- Introduction
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Introduction

- The RELAP5-3D computer code is being improved for the analysis of very high temperature gas-cooled reactors (VHTGRs)
- Improvements include models for molecular diffusion and pressure drop across a pebble bed
- Assessment of the molecular diffusion model using data from an inverted U-tube was presented last year
- This paper describes the model for pressure loss across a pebble bed and the results of assessment calculations using data from the NACOK facility

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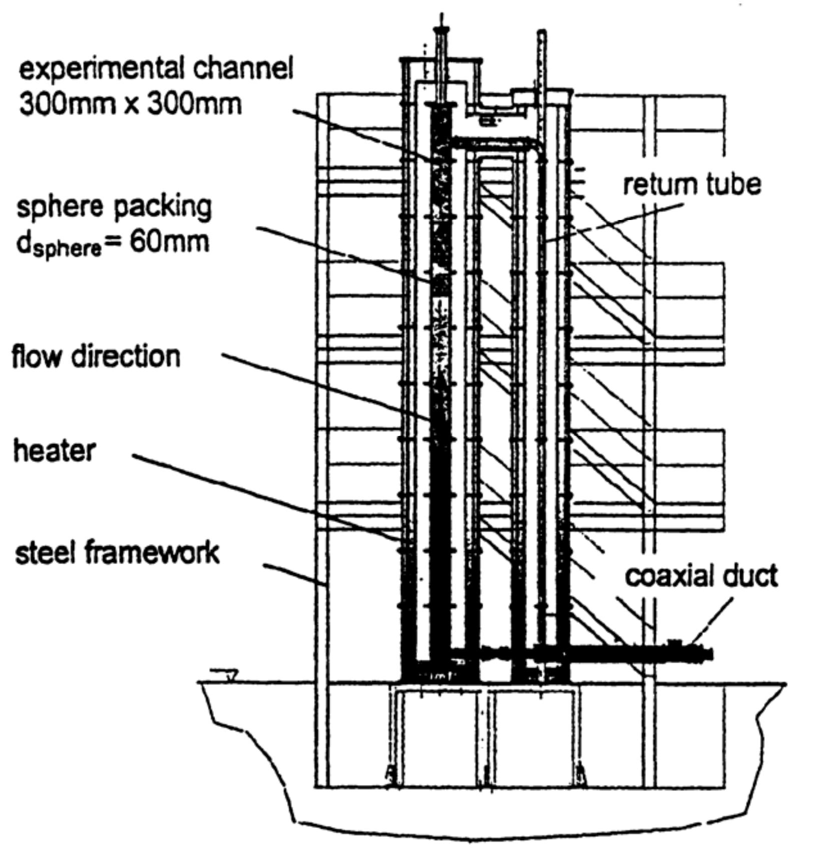
RELAP5-3D contains a model for pressure loss across a pebble bed

- **For single-phase flow, the model reduces to the Ergun equation, which is a function of superficial velocity, V_o, and porosity, ε**

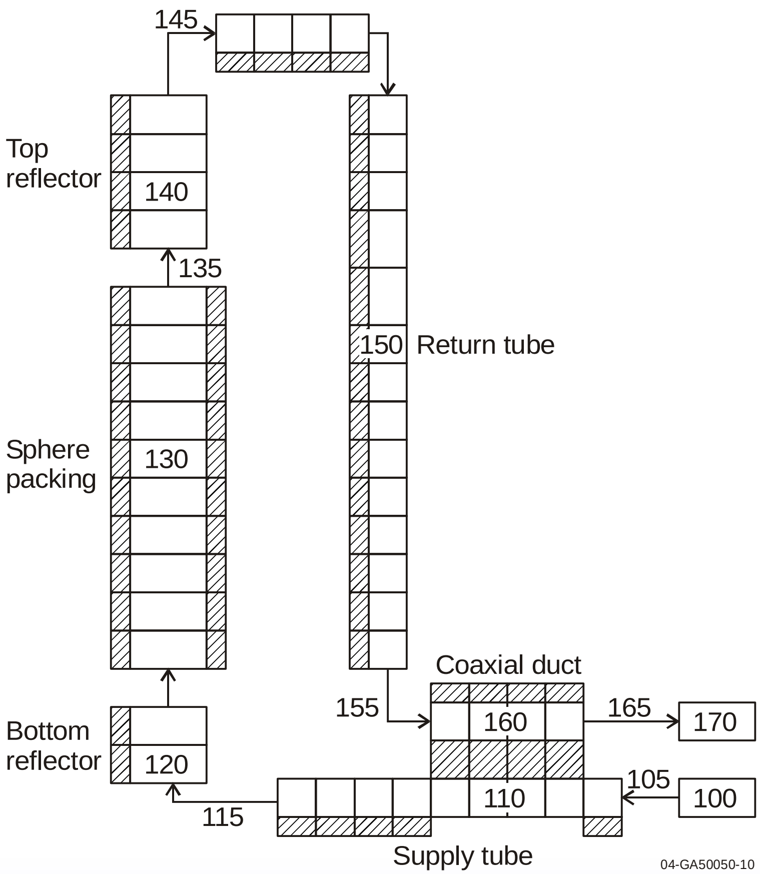
$$\Delta P = \rho V_o^{\,2} \left(\frac{150(1-\varepsilon)^2}{Re_o \varepsilon^3} + \frac{1.75(1-\varepsilon)}{\varepsilon^3} \right) \frac{L}{D_p}$$

The pressure loss model was assessed using data from the NACOK facility



- Natural circulation experiments from Kuhlmann (2002)
- Heating elements controlled wall temperatures of the experimental channel and the return tube
- The return tube temperature was varied between 200 and 800 °C.
- The experimental channel temperature was at least 50 °C higher.

RELAP5-3D model of the NACOK facility



- Boundary conditions of atmospheric pressure and temperature were applied in Components 100 and 170
- Wall temperatures were based on reported measurements, but measured values were not given for all structures

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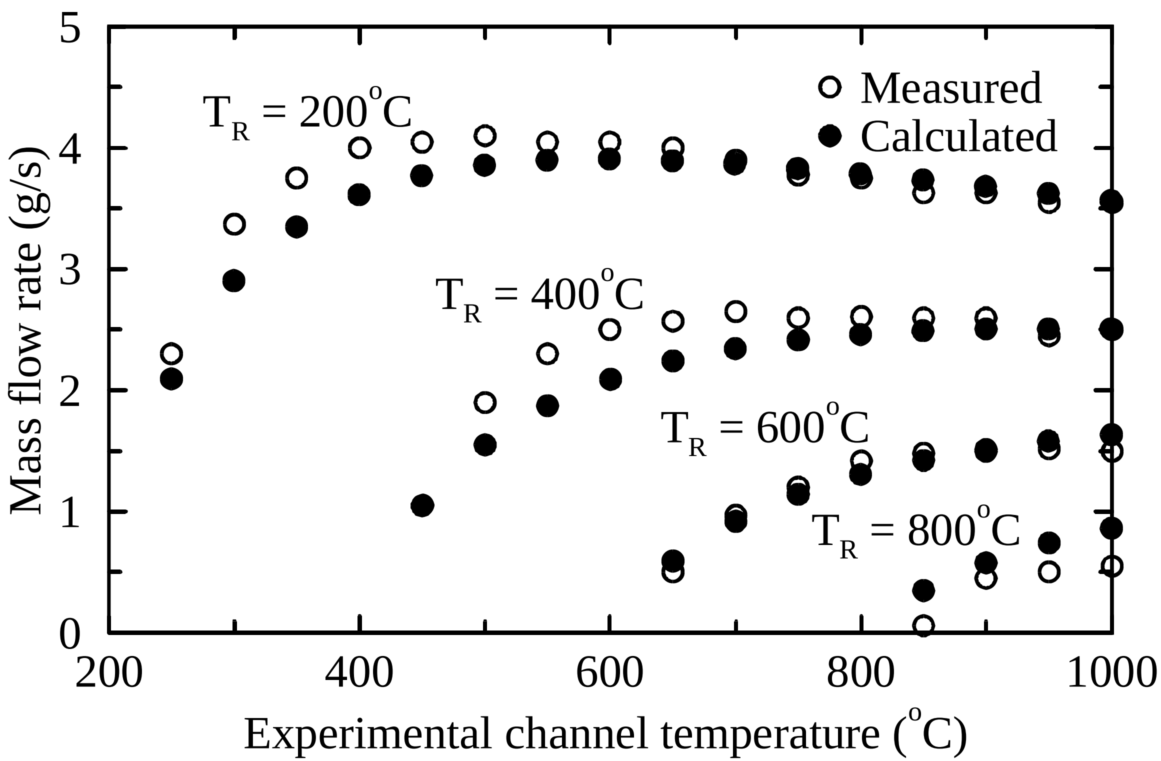
Calculated and measured results were in reasonable agreement



- A series of steady-state calculations was performed
- Trends were similar
- RMS error was about 0.21 g/s (5% of the maximum measured value)

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Calculated results were sensitive to the applied wall temperatures

- These wall temperatures affected the driving head for natural circulation
- Changing the wall temperatures in the horizontal leg at the top of the return tube from that of the experimental channel to that of the return tube increased the average flow rate by 0.26 g/s
- Reducing the wall temperatures in the bottom reflector and the last cell of the supply tube from that of the experimental channel to halfway between the experimental channel and ambient decreased the average flow rate by 0.23 g/s
- Both of these changes were significant compared to the RMS error of 0.21 g/s

Conclusions

- The calculated results were in reasonable agreement with the data from the NACOK experiments
  - Important trends were predicted
  - The pressure loss predicted by the Ergun equation was in reasonable agreement with the NACOK experiments