PARALLEL CHANNEL FLOW EXCURSIONS (U)

by

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An invited paper proposed for presentation at
VPI in Blacksburg, VA on
January 22, 1990
(WSRC 1989-1990 Traveling Lecturer Program)

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PARALLEL CHANNEL FLOW EXCURSIONS (U)*

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Among the many known types of vapor–liquid flow instability is the flow excursion which may occur in heated parallel channels. Under certain conditions, the pressure drop requirement in a heated channel may increase with decreases in flow rate. This leads to an excursive reduction in flow. For channels heated by electricity or nuclear fission, this can result in overheating and damage to the channel. In the design of any parallel channel device, flow excursion limits should be established.

After a review of parallel channel behavior and analysis, a conservative criterion will be proposed for avoiding excursions. In support of this criterion, recent experimental work on boiling in downward flow will be described.

* The information contained in this article was developed during the course of work done under Contract No. DE–AC09–88SR18035 with the U. S. Department of Energy.
Parallel Channel Flow Excursions

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2-phase Natural Circulation

Simple Analysis

\[
\rho = \frac{\rho_1 \rho_2}{\rho_1 + \rho_2} \quad \text{mixture density}
\]

\[
z = \frac{\rho - \rho_1}{\rho_2 - \rho_1} \quad \text{quality}
\]

\[
\frac{dP}{dx} = \frac{dP_1}{dx} + \frac{dP_2}{dx} \quad \text{pressure gradient}
\]

Model Predictions

What Happened...
Parallel Channel Flow Excursions

Flow Patterns

Instabilities in Vapor-Liquid Flow

- Dynamic: Transient Analysis Required
  - Density wave
  - Pressure wave
  - Thermal nonequilibrium

- Static: Steady Description Sufficient
  - Flow regime transitions
  - Burnout and quenching
  - Flow excursions

Outline

- Review background information on flow excursions in parallel channels
- Propose a conservative criterion for avoiding their occurrence
- Describe results of an experimental study on boiling in downward flow

Background — 1

Parallel Channel Flow Loop

Supply Curve
Parallel Channel Flow Excursions

Demand Curve

Supply and Demand

Effect of Throttling

Power Limits

Background -- 2

OSV

P. Saha and N. Naber, 5th Intl Heat Transfer Conference, Tokyo, Sept 1974

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Parallel Channel Flow Excursions

Proposal

- Set power limits to avoid flow excursions
- Use OSV as an indicator of flow excursions
- Get conditions for OSV from accepted correlations
- Calculate these conditions with thermo-hydraulic code

OSV in Limits Calculation

Experimental Study

- Generate demand curves for steady flow in a heated annulus
- Cover a range of heat flux and inlet temperature
- Compare the demand curve minima to criteria for OSV

Findings

- For conditions studied, OSV is a good predictor of flow excursion
  but...
  - OSV correlation needs to be modified for downward flow at low velocity

Equipment

Data
Parallel Channel Flow Excursions

Results

In Conclusion

* Expect FE at minimum of demand curve.
* Use OSV as conservative predictor.

however...

○ Need a special OSV correlation for restricted geometry?
○ Is the steady analysis appropriate for rapid change in pressure?