**Nuclear Thermal Hydraulics**

**Analytical (Matlab) Pin and Channel Analysis**

## Objectives

This exercise is intended to

-reinforce and increase your understanding of channel analysis

-help familiarize you with typical values of the various thermal-hydraulic quantities

-allow you to investigate the concept and application of “departure from nucleate boiling”, and appreciate its limitations.

## a\_TFINTERACTIVE

a\_TFINTERACTIVE is a direct implementation of the equations presented in the notes on channel analysis.

a\_ TFINTERACTIVE comes with reactor types AGR, PWR and PW2 'built-in'. Additional types (eg RE1, RE2; they must have 3-character names) can readily be added; just examine the code and follow the same approach.

Run a\_TFINTERACTIVE simply by typing a\_TFINTERACTIVE at the Matlab prompt. (You will of course need to set your Matlab paths appropriately.

There is no documentation beyond internal comments and the text it writes to the screen; the code is heavily commented, and your lecture notes provide the mathematical / physics background.

The exercise is structured as a series of questions.

1. Basic model

Run a\_TF\_INTERACTIVE for the PWR and AGR cases provided. Comment on the thermal conditions predicted in comparison to those predicted for the AGR case provided.

1. Improved axial flux variation

Real reactors have axial flux variations significantly different from  .

A better model is



where *Le* is some ‘extrapolated length’ slightly greater than the channel length.

Modify a\_TFINTERACTIVE to model this. This will generate the need for an additional item of data; the extrapolated length. You can either add this using the same interactive approach as the other data, or simply add a hard-coded line, which is less elegant but easier to implement.

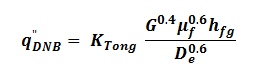
Comment on the changed thermal conditions.

1. Departure from nucleate boiling (‘Critical Heat Flux’)

Evaluate the “departure from nucleate boiling ratio” (DNBR) variation along your channel.

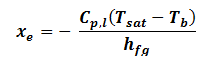
This will require you know what the departure from nucleate boiling is, and how it is predicted using correlations based on measurements. Learning this is one of the main outputs for you from this present exercise. The book by Tong (Tong, L. S. and Y. S. Tang (1997). Boiling Heat Transfer and Two-phase Flow, Taylor and Francis, Washington) gives a good introduction, as does the report by Hewitt & Walker. There are various correlations; ‘W3’ and Tong-68 are a good, general purpose ones.

The Tong-68 correlation predicts CHF as function of local bulk temperature, pressure and coolant mass flux:



where:





Notation:

|  |  |  |
| --- | --- | --- |
|  | kW/m^2 | critical heat flux |
| p | MPa | pressure |
|  |  | local quality |
|  | m | equivalent hydraulic diameter |
| G | Kg/m^2.s | mass flux |
| hfg | kJ/kg | Latent Heat of vaporization |

Reasonable values for PWR conditions (~150bar) are:

|  |  |  |
| --- | --- | --- |
| hfg | kJ/kg | 930.6 |
| TSAT | K | 619 |

The local quality depends on the local enthalpy and should be evaluated at every axial position.

The correlation above is for uniformly heated channels, but for sub-cooled conditions, as here it can be applied reasonably accurately to non-uniform heating cases. (Why?).

* Evaluate the Critical Heat Flux using the Tong correlation
* Evaluate the local DNB ratio (DNBR)