The Boiling Water Reactor Design and Analysis Impact That Operates On Stability Conditions Behavior

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ABSTRACT:

It is well known that the boiling water reactor could face unwanted power Oscillations. When such basic stability occurs it may fluctuate in two different Media (in the stage of development and stage configuration). In the late 1990s and stability The index was created using the stability data obtained from experiments in Swedish Nuclear Power Plant of Ringhals-1. Data were collected from 14 sessions, 15, 16 and 17. Later, it was to use this data to validate the various models and Symbols in order to predict non-basic stability behavior and understanding The players these oscillations. The current trend of increasing power reactor The intensity and dependence of natural circulation can have a basic cooling effect The stability of modern BWR designs. The objective of this study is to find the Most of the important parameters that influence the stability proposal and the BWR Alternative stability maps. This TRACE / PARCS model with the purpose Ringhals-1 NPP will be used. After the range of possible parameters and It will be to the dimensions of the numbers to study their impact on stability. Once these They are found in the parameters that will be included in the maps to make them more stable flour

INTRODUCTION

1.1 Motivation and objective

Since the beginning of the BWR technology development there was an important concern about nuclear-coupled stability. The first experimental BWRs weren't big enough to present instability and the first commercial BWR were designed in way to avoid instability issues. However, after many years of exploitation, many of those power plants suffered fuel modifications and/or power

upgrades. After that, the first indications of stability problems came in the late 70's and during the 80's [1]. Moreover, the actual trend of increasing the reactor power density and to rely on natural circulation for more extensive core cooling will have major repercussion for the stability of advanced BWR designs.[2] In prevision of the increasing importance of the instability matter inside the new BWR plant design this work pretend to find new tools of understanding and methods that will help to predict and avoid instability related shutdowns. For that purpose thermal hydraulics and neutronics simulation tools will be used to extract real plant data from a NPP model. And this data will be analyzed and used to predict the plant stability behavior.

1.2 BWR Instability issue

1.2.1 Types of Instabilities

In BWRs, thermal power is removed by boiling water in a vertical channel, this may\ cause instability during the operation due to density changes and thermal-hydraulic feedback mechanisms. Taking into account that the coolant is also a moderator, if\ the core void content is oscillating it will affect the neutron flux and the power generated. Those, in return, will affect the void fraction. Due to that, inside a BWR we can

identify and classify purely thermal-hydraulic instabilities or coupled neutronic-thermal-hydraulic instabilities. [2]

1. Thermal-hydraulic instabilities.

Thermal-hydraulic instabilities can be classified into two categories: static instabilities and dynamic instabilities. The static instabilities found in the reactor are: the flow excursion, the flow pattern relaxation and the geysering. These instabilities follows the steady state laws while the dynamic instabilities follows the dynamic conservation equations. Some dynamic instabilities are: the density wave oscillation (DWO), the acoustic oscillation and the pressure drop oscillation. From the previous mentioned instabilities, the DWO is the most common one in BWRs. The DWO takes places when, given a flow perturbation, a wave of voids travels upwards through the channel producing a pressure drop that is delayed with respect the original perturbation. In channel-thermal-hydraulic instability there are two different modes of oscillation: parallel-channel or out-of-phase instabilities and single-channel or in-phase instability. In out-of-phase instability the flow in one channel increase while the flow in other channel decrease. The channel void fraction follows opposite trends to those of the flows while

the pressure drop is the same across both channels

METHODOLOGY The main objective of this work is to do a study on BWR instability and its causes. For that purpose we collect as much relevant data as we can with the aim to find relations between this data and the stability behavior of the plant. This will be done using coupled thermal-hydraulic and neutronic code simulating a real BWR, specifically the Swedish plant of Ringhals-1. To reach this goals we need a way to quantify the stability of the core, this is done using the DR and the NF which are detailed below.

2.1 Quantification of Instability: Decay Ratio and Natural Frequency During normal operation of a nuclear reactor it is important to determine if it is inside the stable regime. Using the neutronics power signals obtained from APRM and LPRM we can determine the DR. If the value of the DR is between 0 and 1 , the reactor is stable because the oscillations are damping. But if the DR is over 1 the reactor is unstable because the oscillations are growing The NF is the oscillation frequency of the reactor power signal. [3]

STABILITYRELATED PARAMETERS.

With the aim of study the causes of instabilities in BWR we need to collect as much relevant data as we can. Moreover, we attempt to draw the different stability maps typical of BWR plants. With the help of the literature available on this topic ([1] and [2]) we were able to collect different thermal-hydraulic and neutronic parameters affecting the stability behavior of the BWR. Some of those parameters are listed and described below. Mass flow rate: an increase of the mass flow rate will make the reactor more stable. Inlet subcooling: an increase of the inlet subcooling will increase the stability at high subcoolings. Pressure: an increase in the system pressure will increase the stability. Inlet and exit pressure drop: an increase in those pressure drops will make the reactor less stable. Length of the channel: longer channels destabilizes the flow significantly. Core power: the higher the power is, the more susceptible the core becomes to instability. Axial power shape: it affects instability, a bottom peaked power shape appears to induce instability. Void reactivity coefficient: A more negative void reactivity coefficient increases neutronics feedback directly and destabilizes the core. The void reactivity coefficient depends upon fuel design parameters (burnup, enrichment, ratio between moderator and fuel atom density). Radial power shape: High radial power shape decreases stability. Xe concentration: affects the stability and in

particular de DR. The redistribution of the Xe concentration following a large scale power change apparently may cause a decrease of the DR. In addition to those previous listed parameters we chose to collect other thermalhydraulic and neutronic properties and dimensionless numbers which could have a relation with the stability behavior.

CONCLUSIONS:

BWR instability events have long been a concern in the nuclear industry. The study and understating of this phenomena needs knowledge in various fields of nuclear sciences as neutronics, thermal-hydraulics but also mathematics and computational sciences, which makes this a challenging multidisciplinary research area. In this work we have experienced the difficulties of treating with this subject. Thanks to the neutronics-thermal-hydraulic simulation tools and data analysis software we have been able to find the most stability related parameters from the Ringhals-1 benchmark experiments and we have been able to plot new stability graphs. We have found different regressions with an R-square accuracy higher than 90% using the plant data from the Ringhals-1 benchmark. It has to be noticed that this equations are valid only between the boundary values of core

flow and core power simulated during the benchmark. We compare the relation between those parameters and the DR from the literature with the relation found thanks to the multiple linear regression models. Both relations follows the same trends. The results are consistent. After this study we can highlight the importance of the following parameters: the power shape, the core mass flow, the core power, the neutronics feedback (TPC) and the inlet subcooling as the important actors in the stability response. In the models found in this thesis the axial power shape and the radial peaking factor were the main parameters capable to predict the DR of the oscillations after the control rod perturbation. Neutronic influenced instabilities have to been taking into account when new fuel elements and core fuel configurations are designed. To be able to improve the quality of the predictions made in this thesis, a bigger data population is needed. This could be achieved with more transient simulations using, as we did, validated plant models which have proved to be a reliable tool

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