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# VVER-440 Steam Generator's Two-Phase Flow Analysis

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**Abstract:** The subject of this report is creation of three-dimensional thermal-hydraulic model of horizontal steam generator for Dukovany nuclear power plant. A procedure is presented for simulation and analysis of secondary side of PGV-440 steam generator for nominal and increased reactor power load. A two-fluid approach is applied for modeling physical processes inside the steam generator. Physical models were implemented in ANSYS Fluent CFD environment using User Defined Functions (UDFs). Results from this thermal-hydraulic numerical model can be used for various other subsequent nuclear power plant operations and safety analysis.

## Introduction

Steam generator (SG) is one of the most important components of nuclear power plant (NPP) with pressurized water reactors (PWR). The main purpose of this component is heat transfer from the radioactive primary side to the secondary side of SG where steam is generated. Therefore the service life of NPP is closely connected with service life of SG.

Corrosive impurities (iron oxides) concentrated in the secondary side are main problem of SG which decreases designed service life. As a result of thermal-hydraulic processes, the impurities are accumulated in so-called critical zones which are cause increased degradation of heat-transfer tubes (HTT) [1].

Removing these impurities is carried out by periodical and continual operated blowdown system. In order to achieve high blowdown efficiency, the location of critical zone must be known for designing blowdown circuit arrangements [2].

Due to complications related to the measurements of SG and lack of large experimental facilities it is very difficult to describe multi-phase flow on the secondary side. A detailed insight into two-phase flow on the secondary side can be obtained by a three-dimensional thermal-hydraulic numerical simulation.

## Methodology

There have been published several works dealing with thermal-hydraulic analysis of horizontal SG in the world. Every NPP with VVER-440 or VVER-1000 reactors has unique design of SG components, therefore it is necessary to create a specific numerical model for SG of Dukovany NPP.

This NPP is equipped by 6 PGV-440, with identical design for each of its four units. A two-fluid approach is applied to model two-phase flow on the secondary side of SG [3]. Certain simplifications, whose the most significant is the modeling of HTT as a porous media, are made.

Special multiphase flow model was developed and implemented in ANSYS Fluent CFD environment using UDFs for the accurate presentation of steam generation processes [4].

The governing equations are solved using six-equation model. This model is based on conservation equations of mass, momentum and energy at two-phase interfaces, as well as between two fluid phases and tube bundles. The two-phase flow interface transfer processes are completed

by closure laws. By using UDFs for mass, momentum and energy source terms, better convergence of numerical analysis was achieved [5].

## Results

Obtained data from thermal-hydraulic numerical model provide complete insight of velocity distributions and steam volume fraction (Fig. 1 and Fig. 2). These results can be used for detailed analysis of impurities concentration and obtained data are essential for improvement of blowdown efficiency.

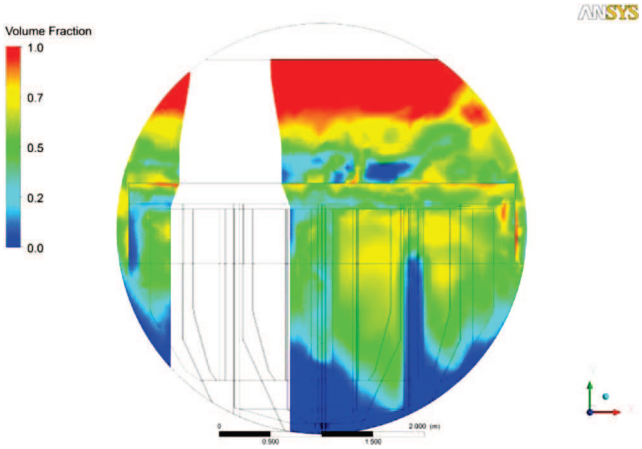


Fig. 1: SG cross section view with steam volume fraction

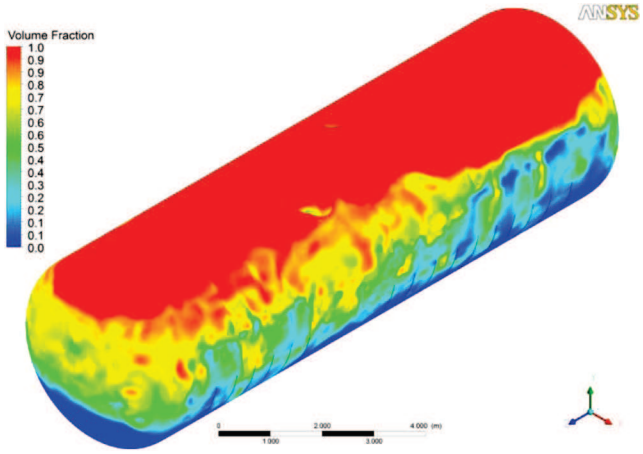


Fig. 2: SG isometric view with steam volume fraction

## Conclusions

This report deals with thermal-hydraulic analysis of horizontal steam generator of Dukovany nuclear power plant VVER-440. Due to accumulation of corrosive impurities it is important to know processes which occur on the secondary side of steam generator.

A two-fluid approach is applied for modeling of physical processes inside the steam generator. Physical models were implemented in ANSYS Fluent CFD environment using UDFs.

Results from numerical simulation of two-phase flow can be used in steam generator design, reconstruction, in nuclear power plant operation and safety analyses or for improvement of blowdown circuit and feed water arrangements.

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