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Integral Smart Plant Model Developed for the System Thermal Hydraulic Code Trace for Transient Analysis

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ABSTRACT

The interest in small modular reactors (SMR) is increasing worldwide for electricity generation in remote regions, to be integrated in the grid with renewables or for water desalination. Hence, a reevaluation of the economics and technical potentials are being done in USA and also Europe. Many SMR-designs based on light water reactors (PWR, BWR), HTR and liquid metal cooled are being developed worldwide e.g. the SMART design in Korea, the Na-cooled PRISM-design of GE Hitachi (Na-cooled), VBER-300 design of OKBM in Russia, etc. Since the reactor pressure vessel (RPV) of the SMART includes a lot of components such as the in-vessel heat exchangers, the pumps and in the upper part the pressurizer, the modeling of the flow inside the RPV is very challenging for the system thermal hydraulic codes. This paper describes the investigations performed at KIT to develop an integral plant model of the SMART design including all in-vessel components and the heat removal systems using 3D thermal components (Cartesian and Cylindrical Vessel of TRACE) and to check the prediction capability by comparing the simulation results with reference data and finally to identify possibilities for code improvements. A very detailed 3D model of the RPV and also of safety systems was developed for TRACE. Simulations of the stationary plant conditions using the developed plant model have showed that TRACE is appropriate to simulate the stationary plant conditions of the SMART reactor. Further work will follow to perform the analysis of transients using the integral model developed for TRACE.

KEYWORDS

Small Modular Reactor, SMART, TRACE, PLANT MODEL

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1. INTRODUCTION

The constant evolution of nuclear technologies provides a great variety of technological choices for future deployment, including nuclear power plants with very different designs and sizes. Besides the development of large-scale commercial LWR of generations III, “small modular reactors” with an electrical power output below 300 MWe are being developed in many countries in order to provide both electricity and heat in isolated regions of large countries such as Argentina, Canada, Russia, etc. where the national grids do not expand everywhere in the country. Some designs are e.g. the light water reactor such as the Korean SMART and the Russina VBER-300 designs, HTR and liquid metal cooled such as the Na-cooled PRISM-design of GE Hitachi (Na-cooled). It is also worth to note that some SMR are already in operation in China and India and others are being constructed in China (ACPR-50S, HTR-PM), Russia (KLT-40S) and Argentina (CAREM). During the last decade, a re-evaluation of the potentials, economic and technical feasibility of these reactors is being carried out in the USA and Europe while in other countries such as Russia, Argentina and China, different SMR-types are under construction. SMRs are a safer and more versatile alternative to large-scale nuclear power plants. The SMR-developments include reactors cooled by water, by gas and by liquid metals. But the majority of them are of PWR-type for example the Korean System-Integrated Modular Advanced Reactor (SMART) being developed by the Korean Atomic Energy Research Institute (KAERI). The main goals of the SMART design is to produce electricity with high safety standards, to be build in short construction process in a modular manner and to have the possibility for coupling with a desalination as well as with a district heating system. Because of it, they are an promising alternative to large nuclear power plants with high capital construction costs. SMRs are a attractive solution to regions cut off from the central national electrical grid with the potential for co-generation and desalination of see water. Hence, SMRs are considered as inherently safe reactors by its system-integrated design feature equipped with passive safety and heat removal systems. Many emerging and developing countries such as Saudi Arabia, Jordan, Turkey, etc. are interested in the assessment and feasibility studies of SMR-concepts such as the South Korea SMART complementary to the other energy generation options. At KIT , research activities were initiated to assess the safety-related features of SMRs using the multi-physics tools and the system thermal hydraulic as well as severe accident tools being validated and evaluated at KIT in the frame of master or doctoral thesis [1]. For this purpose, a thoroughly evaluation of the safety features of the SMR-reactors for both design basis accidents and beyond design basis accidents is of primordial importance. This paper presents the first step for the safety-related investigations of the SMART using the system thermal hydraulic code TRACE. This steps is the development of an integral plant model of SMART for TRACE able to predict the stationary plant conditions in an acceptable manner. Later on, this model will be extended for the analysis of different classes of transients and accidents using also the coupled TRACE/PARCS code system. In the first chapter, the peculiarities of the SAMRT reactor is described while in the second chapter, the approach followed at KIT to develop the integral plant model for TRACE is discussed. Then, the main results obtained with TRACE for the stationary plant conditions using the integral plant model are shortly discussed. Finally, the main conclusions and an outlook are given.

2. SHORT DESCRIPTION OF THE SMART REACTOR

2.1. Short description of the SMART reactor peculiarities

The System-Integrated Modular Advanced Reactor (SMART) is a small modular pressurized water reactor developed by the Korean Atomic Energy Research Institute (KAERI) for both electricity production and coupling with a desalination system. In addition, it can be also used to provide process heat for district heating. This integral PWR design has a thermal power of 330 MWth (100 MWe) and is designed a lifetime of 60 years. This reactor is also able to generate potable water (~ 40 tousand tones per day). The SMART consists of the following main systems: Reactor Pressure Vessel (RPV), Reactor Coolant System, Shutdown Cooling System, Passive Residual Heat Removal System, Safety Injection System, Chemical and Volume Control System, innovative heat exchangers located within the RPV, see Fig. 1. Due to the integrated design, the SMART reactor relies on a passive safety concept that is characterized e.g. by a great amount of coolant inventory in the pressurizer helping to maintain the reactor pressure at an acceptable value during any design basis accident. At the top of the RPV a semi-passive pressurizer is located. The steam generators are located above the core to favour the establishment of natural convection in case of an accident. Four canned motor pumps are also placed inside the reactor pressure vessel. The vessel penetrations have a maximal diameter of ~5 cm reducing the break size for potential LOCAs. In addition, the inclusion of an once-trough the steam generators with helical coils inside the RPV excludes the possibility of a LBLOCA and the canned pumps inhbits the possibility of a SBLOCA-scenario in the pump seals e.g. during a Station Blackout (SBO) accident. Finally, the core is characterized by low power density and negative reactivity feedback coefficient.

The secondary side consists of steam lines and feedwater lines including the turbine, condenser, feedwater pumps, pre-heaters, etc. For desalination purposes, steam can be directly extracted from the turbine. The steam generated in the innovative heat exchangers flows directly to the trbine for electricity generation. This reactor is also equipped with a chemical and volume control system, a letdown and charging system. Like the AP-1000, the SMART containment is hosting a water tank (IWRST). It is located at the lower part around the bio-shield andthe pressurizer safety valves are connected to it. As one can see in Fig. 1, the SMART is equipped with different safety systems as listed such as a) safety injection system consists of piping systems and safety injection pumps, b) passive residual heat removal system that consists of a emergency cooling tank and a passive heat exchanger which is connected to the hot (upper part) and cold (lower part) legs of the secondary circuit and c) a containment spray system that consists of pumps, valves and sprays [2]. In Fig. 2 the SMART RPV with the main components such as the core, the innovative heat exchangers, the canned pumps, the guide tubes, and the pressuriver are shown. The coolant flows through the core upwards to the helical steam generators where it gives off heat. The cooled water flows through the downcomer back to the lower inlet of the core.

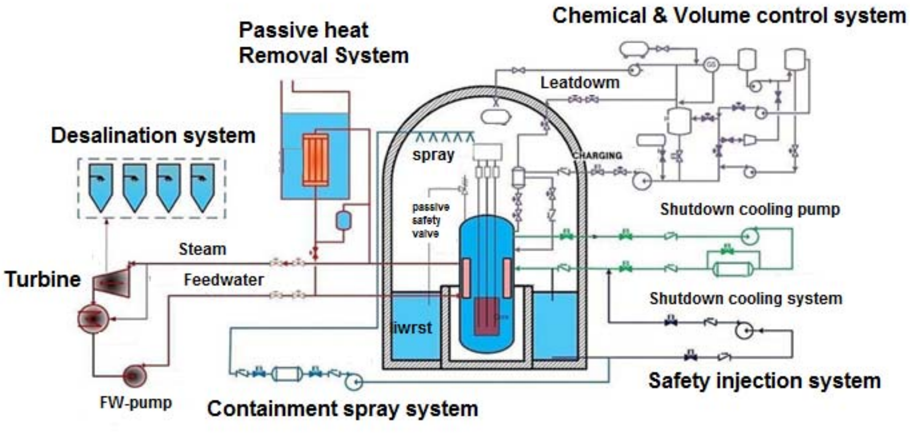


Fig. 1 General view of the SMART plant layout *[2]*

The SMART core contains 57 PWR fuel assemblies of standard design FA17x17 made of ceramic $U0_2$ fuel but with a reduced height of only two meters active length compared to a conventional large PWR. The core loading is formed by three fuel assembly types which differs from each other in the number of burnable poison rods. Three types of fuel assemblies (FA) are used: 8 FA of type A , 28 of type B and 21 of type C. In Fig. 3, the radial arrangement of the different FA-types is shown [3].

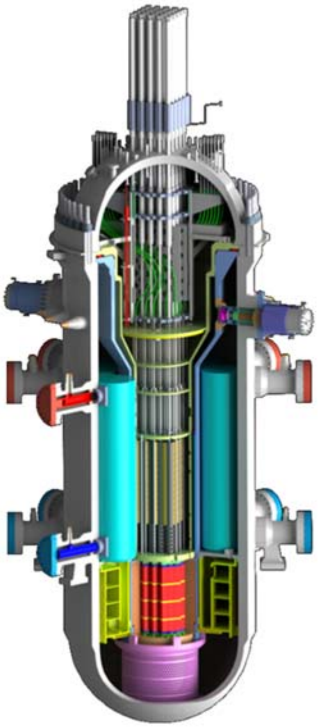
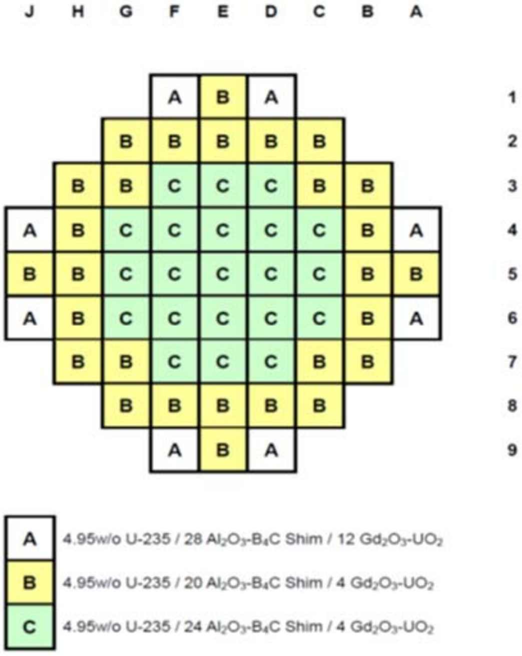


Fig. 2 The SMART RPV with internals *[4]*



	J	H	G	F	E	D	C	B	A
1				A	B	A			
2			B	B	B	B	B		
3		B	B	C	C	C	B	B	
4	A	B	C	C	C	C	C	B	A
5	B	B	C	C	C	C	C	B	B
6	A	B	C	C	C	C	C	B	A
7		B	B	C	C	C	B	B	
8			B	B	B	B	B		
9				A	B	A			

A	4.95w/o U-235 / 28 Al_2O_3-B_4C Shim / 12 Gd_2O_3-UO_2
B	4.95w/o U-235 / 20 Al_2O_3-B_4C Shim / 4 Gd_2O_3-UO_2
C	4.95w/o U-235 / 24 Al_2O_3-B_4C Shim / 4 Gd_2O_3-UO_2

Fig. 3 The SMART core with the radial distribution of the different FA-types and information about the einrichment and number of Gd-rods and controls rods *[5]*

2.2. Approach followed to collect data for SMART modeling with TRACE

To develop a integral plant model of the SMART reactor, a systematic data collection found in the open literature was done in Excel-sheets where the main data needed by TRACE as input e.g. geometry, dimensions, heated and wetted perimeters, flow areas, materials of the solid structures as well as their dimensions were derived. The documentation found is mainly from KAERI reports and articles, but also from some other papers of conferences such as NURETH 14 & 15 have been studied. In those cases in which discrepancies have been found between different papers for the same piece of data, the data from the KAERI related paper has been taken. In the case that both papers are KAERI related, the newest one has been taken as the correct one. The complete list of references is included in an Excel database; here the most important references used for each part of the model are listed: a) Core [3], [6] and [7] b) Vessel: [8], [5] c) Steam Generators:[4], [9], [10], and [11] d) Pumps & Pressurizer: [5] and [12] e) Containment: [10] and f) PRHRS: [13], [14], *and* [15].
On the basis of a study of open literature about SMART plants, and the collection of the needed plant data for the development of the TRACE model, an Excel database has been created. In this database, thermal-hydraulic values, geometrical values (form loss coefficients, surface roughness and material properties needed by TRACE) and some pictures and schemes (for a better understanding of a certain matter) are included. In Fig. *4*, the database structure - *SMART Data.xlsx- is shown.*

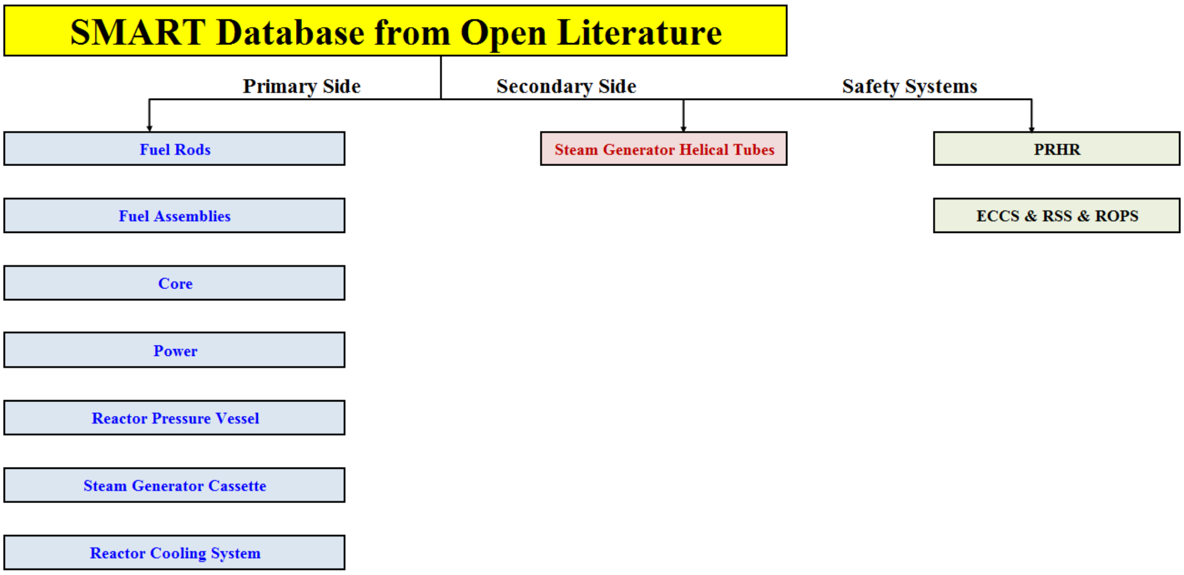


Fig. 4 The SMART data base structure on the basis of open literature

In [16], the details of the collected information about all the SMART systems modelled in the TRACE integral plan model can be found..

3. APPROACH FOLLOWED FOR THE MODELLING OF THE SMART REACTOR

In order to develop an thermal hydraulic model of the SMART plant for the system thermal hydraulic code TRACEV5.0Patch4, the following approach was followed:

- Development of a simplified reactor core in the Cartesian geometry (Cartesian Core Model)
- Development of a detailed and larger Cartesian model for the downcomer, lower and upper plenums (Cartesian Vessel Model)
- Development of a detailed reactor core with a cylindrical and more appropriate one Vessel model and adding the additional pieces to model the RPV-model such as the pressurizer and the primary and secondary circuit of the eight steam generators (SGs).
- Adding to the previous model, the containment and the passive residual heat removal systems (PRHRS) even tough they are not needed for the simulation of the stationary plant conditions but they are needed for further accident analysis of the SMART reactor.

For this purpose, first of all the SMART main components have to be identified and the TRACE-components to represent them were selected which was a straight forward task since TRACE has different components to represent a PWR. But the design peculiarities of the integrated SMART-design where many components are located inside the RPV, were additional challenges and required decisions and reasoning from the analyst developing the TRACE model, see [16] for more details. Hereafter, selected modelling issues of the SMART reactor will be described which are representative for all other components and for the way the complete SMART plant was modelled in TRACE.

3.1. Simplified Cartesian core model

The SMART core and the region below and above the core are represented by a 3D Cartesian VESSEL, PIPES, HEAT STRUCTURES, FILL and BREAK components used to fuel assemblies, the by-pass flow, the fuel rods, and the boundary conditions at the core inlet and outlet. The 3D Cartesian VESSEL TRACE component is nodalized in 12 axial levels and a square radial matrix of 9x9, with the sizee of each node equal to the SMART fuel assembly pitch. Each channel in the vessel represents a fuel assembly except from those that are not needed to represent the core, which are axially and radially blocked therefore avoiding the coolant to flow through them and not taking any part in the simulation. A total of 57 out of 81 channels in the matrix receive coolant flow, thus serving as fuel assemblies from axial level 2 to 11. Those levels account only for the active heat transfer height of the core (2 meters), as that is all what is needed to effectively check the heat exchange in the core. Two extra axial levels above and below the fuel assemblies are added to represent the volumes at the core inlet and outlet. These volumes are initialized with the corresponding thermal hydraulic parameters e.g. initial liquid temperature and pressure in all 3D nodes (568,85 K) and a pressure of 1.5E7 Pa. The vessel geometry and nodalization can be observed in Fig. 5. The nodalization was done following the recommendations of the US NRC [17]. The heat active height is divided in 10 axial nodes with 0.2 m each, while both axial levels dedicated to flow homogenization are 1 m high. Once the geometry of the vessel has been introduced in the VESSEL component and the nodalization of the vessel has been chosen attending to standard simplifications, the process continues with the input of the axial and radial flow areas for each channel. Each vessel channel represents a fuel assembly, so the axial flow area of each channel is established depending of the axial flow area of the fuel assembly located at that position. Even though every fuel assembly of SMART presents a matrix of 17x17 pin rods, there are three types of fuel assembly in SMART and each one has a different flow area.

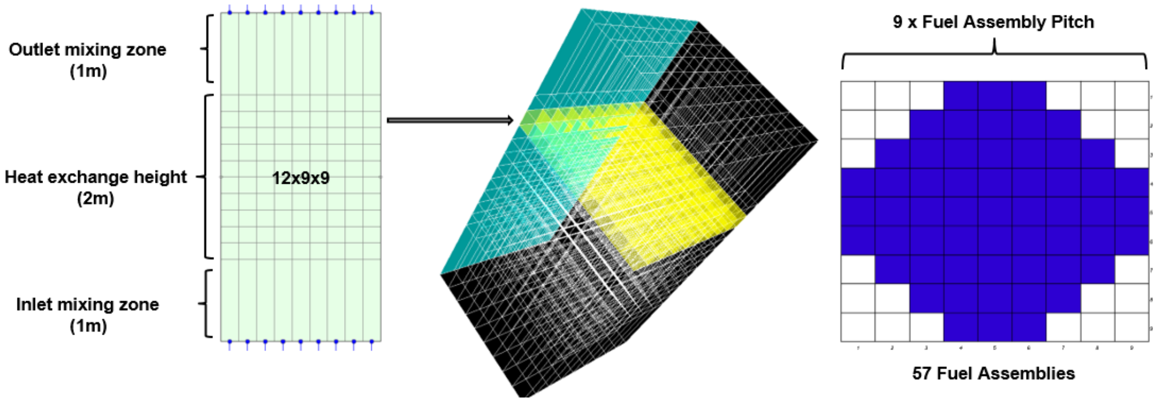
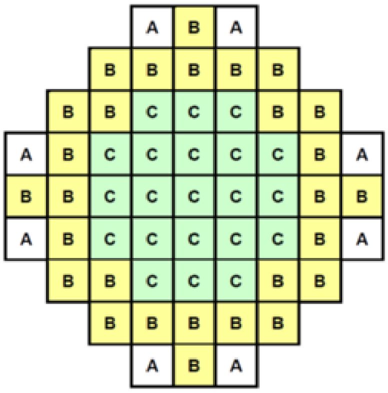


Fig. 5 Core vessel geometry and nodalization.

Coolant flows from bottom to top of the vessel through the channels, but these channels are also connected between each other allowing horizontal coolant flow. For this purpose, the horizontal flow area fraction of those sides where fuel assemblies are faced is established as 1 in the TRACE input. At the outlet and inlet flow mixing zones, the horizontal flow is also allowed completely. In Fig. 6 the fuel assembly distribution and the characteristics of each fuel assembly, which serve as input for TRACE, is exhibited. The SMART fuel assembly is equipped with four spacer grids spread along the 2 meters of active fuel height. These spacer grids are intended to improve the flow mixing and homogenization inside the fuel assemblies. They create a disruption in the vertical flow that must be taken into account in the model. The effect of the spacer grids is considered in the TRACE model as pressure loss represented by a K-factor added axially at the location of each spacer grid, [17]. After the flow area and hydraulic diameter of the channels have been set for vertical and horizontal directions, the fuel assemblies themselves are to be modelled and connected with their respective channel. Hence, 57 HEAT STRUCTURE (TRACE components) with the same axial levels than the ones of the vessel channels were created. For it, the dimensions of a pin rod and the number of pins present in the fuel assembly are given. Doing so, th proper heat transfer area per fuel assembly is defined. In order to define the core power, the POWER component is added to the model where an axial power profile is also given (cosine shaped). Normally this power profile is predicted by a 3D core simulator.

FA-A channel area	m²	0,027844
FA-A channel hydraulic diameter	m	1,1503E-02
FA-B channel area	m²	0,027749
FA-B channel hydraulic diameter	m	1,1438E-02
FA-C channel area	m²	0,027796
FA-C channel hydraulic diameter	m	1,1471E-02



			A	B	A			
		B	B	B	B	B		
	B	B	C	C	C	B	B	
A	B	C	C	C	C	C	B	A
B	B	C	C	C	C	C	B	B
A	B	C	C	C	C	C	B	A
	B	B	C	C	C	B	B	
		B	B	B	B	B		
			A	B	A			

Fig. 6 Fuel assembly distribution and parameters.

3.2. Cylindrical VESSEL model development

In order to represent the reactor pressure vessel and the main components inside e.g. pumps, steam generators, pressurizer, a new data base was developed, see Fig. 7.

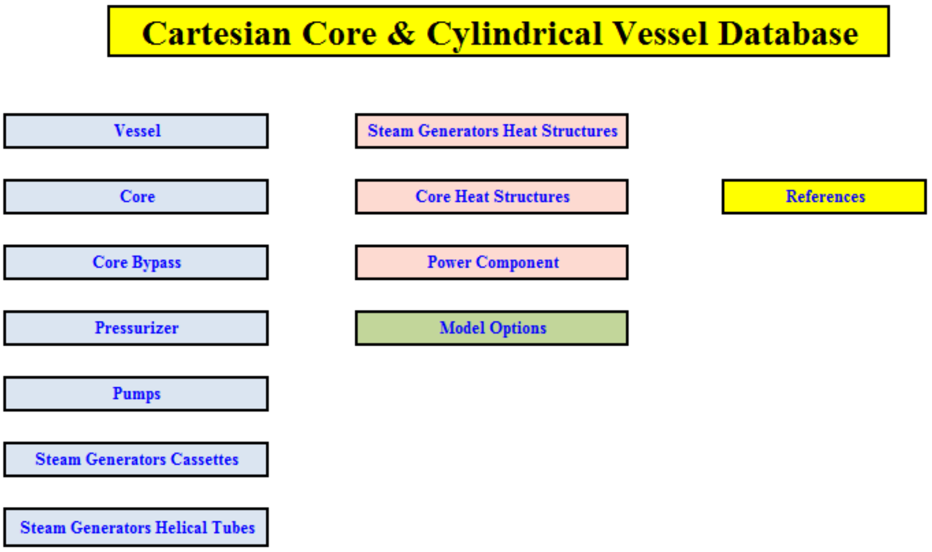


Fig. 7: Data base for the cylindrical vessel including in-vessel components.

A similar approach as described in the previous chapter was followed to develop a TRACE model for each of the components, one after another. First of all each model was testes as stand-alone model and later on, all models were integrated into the cylindrical vessel model of the whole RPV. The VESSEL component is subdivided in five rings, eight azimuthal and 21 axial levels, see Fig. 8, where also the flow paths are indicated.

3.3. The integral SMART TRACE model

The models described before were merged in order to represent the SMART plant using the components available in the system code TRACE. In Fig. *10*, the primary circuit of the SMART reactor is shown. It includes the RPV, where the Cartesian core, the core bypass, the pumps, the steam generators and the pressurizer are located, and the containment. As one can observe there, the SMART RPV fits in the first four axial levels of the containment model. The eight steam generators located around the core (component numbers; 20, 21, 22, 23, 24, 25, 26, and 27) are also shown. They are located in the fouth ring of the VESSEL component (number 100). The pressurizer is a part of the vessel in the SMART reactor and it is presented by a PIPE TRACE component with the type PRESSURIZER (component 80). It is connected with the IWRST and also the safety valves (ORV and SRV) are included in the model. Finally, also four pumps are modelled in TRACE (number 41, 42, 43 and 44). Since the coolant takes a 90° turn during its pass though the canned pumps and, to represent this turn, the pumps are modelled to take the coolant from a positive radial direction and unload it with a negative axial direction at axial level 20.

In order to model the turn, the second pump cell has a vertical orientation. K-factors are included for the turn and the edges with a change in flow area as predicted in [16].

Axial Levels	Unit	Value
21	m	0.5
20		1,25
19		0,6
18		0,6
17		0,6
16		0,6
15		0,6
14		0,6
13		0,6
12		0,6
11		0,6
10		0,6
9		0,16
8		0,6
7		0,6
6		0,6
5		0,6
4		0,16
3		0,7
2		0,7
1		0,7
Radial levels	**Unit**	**Value**
1	m	1,02
2		0,15
3		0,6
4		0,446
5		0,6
Azimutal Levels	**Unit**	**Value**
1	o	45
2		45
3		45
4		45
5		45
6		45
7		45
8		45

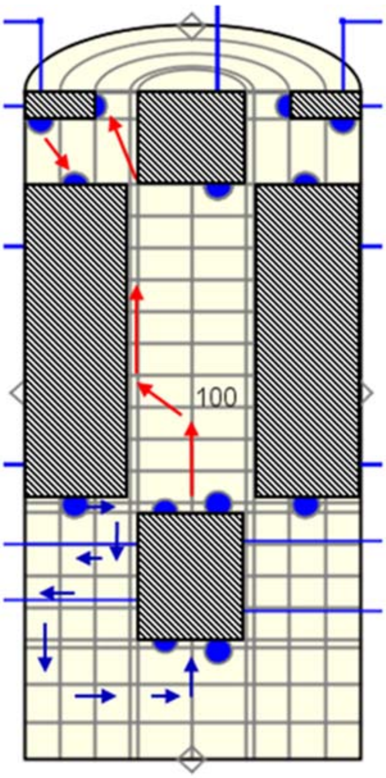


Fig. 8 Details of the axial nodes of the cylindrical VESSEL indicating the position of key components

In [16], the details of the modelling of all this components are included. In the next subchanpter, the final TRACE integral model of the SMART including the Containment will be described.

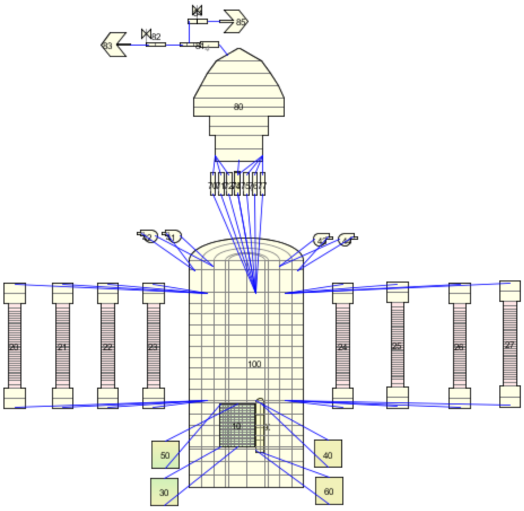


Fig. 9 Details of the axial nodes of the cylindrical VESSEL indicating the connection with the different In-vessel components of the SMART reactor

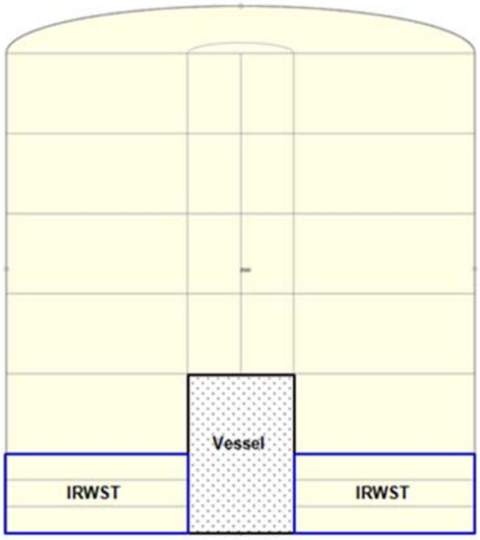


Fig. 10:Integral SMART model with the containment as modelled in TRACE

The SMART secondary side represents mainly the SG-secondary circuit with the steam header and the PRHRS. At the inlet and outlet of the steam generator coil, a valve is connected, with its correspondent

K-factor of 2.78 since it is open during normal operation. This valve permits the connection of the PRHRS pipes with an angle of 90º. The steam header consists of a pipe divided into 10 nodes where the flow area is growing in the first three nodes until the area of the pipe is equal to the total flow area of all helical coils. All helical coils are connected to the first node of the steam header for better simulation results. The chosen progressive grow in flow area is an imitation of other PWR-models and its length is approximated so the steam keeps superheated conditions until the BREAK, which simulates the turbine at a pressure of 5.2 MPa, see Fig. *11*.

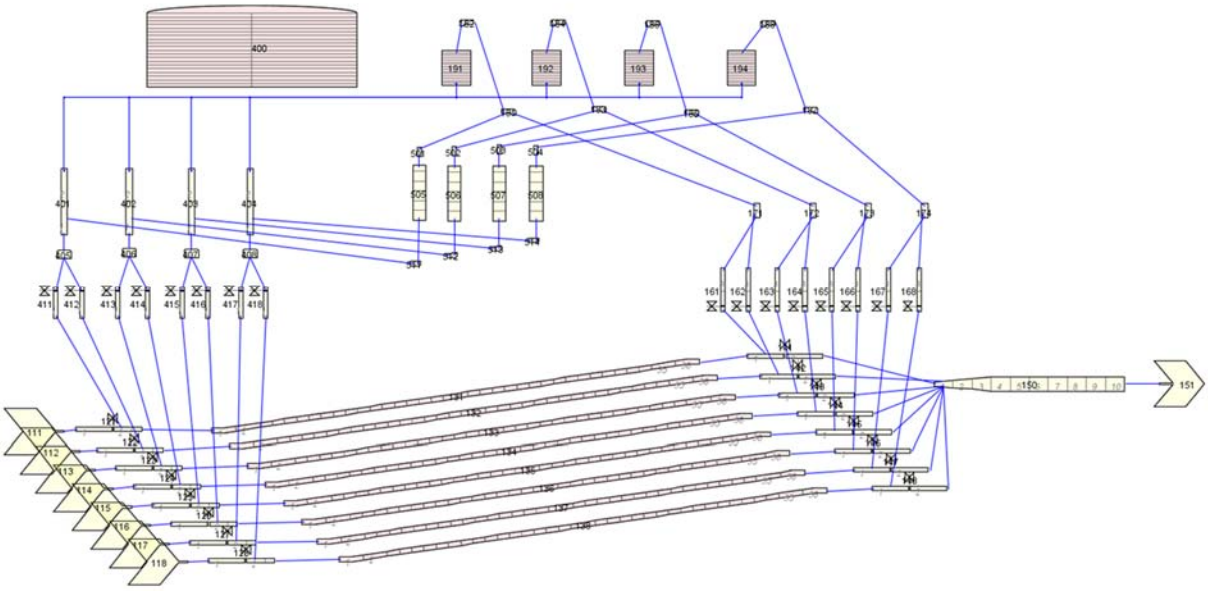


Fig. 11 TRACE modeling of the SMART secondary side

4. TRACE SIMULATION OF THE STATIONARY PLANT CONDITIONS

4.1. Short description of the system thermal hydraulic code TRACE

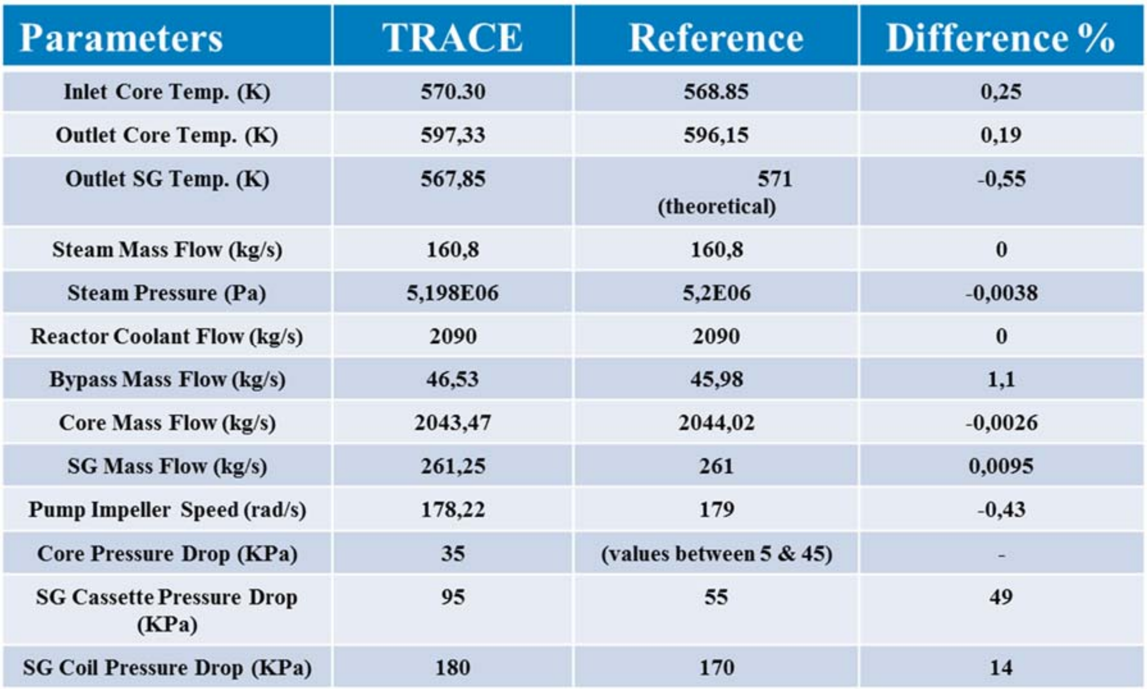
TRACE is the reference system thermal hydraulic code of the US NRC for the simulation of design basis accidents of Light Water Reactors. It solves a system of six mass, momentum and energy equations for a two-fluid problem in both one and three (VESSEL component) dimensions. The unknown terms in these equations are defined by a set of constitutive equations for both vertical and horizontal flow regimes and for the wall-fluid as well as interface mass and heat transfer. In addition, relations for the wall and interface friction are provided so that the system of equations is uniquely solvable. A sufficient number of components such as PIPE, VALVE, PUMP, HEATSTRUCTURE, VESSEL, POWER, etc. are part of TRACE which facilitate the representation of a any nuclear power plant (NPP) or experimental facility. Moreover, Signals, Trips, and controls are also part of TRACE that are used to define control systems, operator actions and the activation or shutdown of a component e.g. a PUMP, [18]. TRACE can be run either by DOS command line or from the Pre-and Postprocesor named Symboly Nuclear Plant Analyzer(SNAP) that allows to develop input decks from scratch using a graphical interface; it is very useful to check the model definition and surely it shortens the time for develop complex plant models.

4.2. Selected results of the steady state TRACE simulation

Since the integral plant model was developed step-wise, different TRACE steady state simulations were performed to check each part of the integral model, e.g. the core model, the RPV model, one primary/secondary loop model, etc. before they were integrated ino the integral SMART plant model. For example it was checked it the TRACE 3D Cartesian core model predicts the correct heat-up over the core for the stationary plant conditions given e.g. system pressure, inlet core temperature and core inlet mass flow rate and also to assure that the models converge in an acceptable time. Finally, TRACE simulations using the integral plant model were done to compare the calculated main parameters with the ones found in the open literature for the SMART design. A maximum timestep of 1.0 and a minimum one of 1.0E-9 was used in the simulations. The convergence criteria were set to 1.0E-4 for the key thermal hydraulic parameters. These final results were obtained after a certain number of simualtions were the input deck was continuously checked and improved. Finally, the TRACE version 5 Patch 4 steady-state simulations converged after 262 sec simulation time and seven minutes of calculation time.

In Table 1 a comparison of the main thermal hydraulic plant parameters predicted by TRACE with the ones found in the literature is shown. The values listed in the column "Reference" are the SMART-data taken from the references listed in this paper. It can seen, that the differences between them are acceptable. The large deviations were found for the pressure drop over the SG-Cassette but all other parameters are close to the reference values.

Table 1: Comparison of main parameters predicted by TRACE and the reference data



Parameters	TRACE	Reference	Difference %
Inlet Core Temp. (K)	570.30	568.85	0,25
Outlet Core Temp. (K)	597,33	596,15	0,19
Outlet SG Temp. (K)	567,85	571 (theoretical)	-0,55
Steam Mass Flow (kg/s)	160,8	160,8	0
Steam Pressure (Pa)	5,198E06	5,2E06	-0,0038
Reactor Coolant Flow (kg/s)	2090	2090	0
Bypass Mass Flow (kg/s)	46,53	45,98	1,1
Core Mass Flow (kg/s)	2043,47	2044,02	-0,0026
SG Mass Flow (kg/s)	261,25	261	0,0095
Pump Impeller Speed (rad/s)	178,22	179	-0,43
Core Pressure Drop (KPa)	35	(values between 5 & 45)	-
SG Cassette Pressure Drop (KPa)	95	55	49
SG Coil Pressure Drop (KPa)	180	170	14

The core inlet and outlet temperatures are little bit higher than the ones of the literature but still within acceptable limits. The steam temperature leaving the helical coils of the steam generator is a bit lower than the one of the reference. It is important to mention that this value is considered as a theoretical one. In many reviewed documents including studies of the heat exchange in the steam generators using experimental facilities the steam temperature is clearly lower than 571 K, sometimes as much as 8 degrees [10], [19]. In terms of steam mass flow and steam pressure at the outlet of the steam generators, the results are almost the exact value as the reference data. The mass flow through the SG cassettes (primary side) is satisfactory and just a 0.0095% higher than the bibliographical value. These results prove that the reduction carried out in SG-volume in comparison with the reference data helped in calculating a better steady state simulation.

The pump impeller rotational speed is the adjusted value in the constrained steady state simulation and its obtained value is close to the expected value, which demonstrates that the model is obtaining the proper mass flows in the primary system with a normal pump operation.The pressure drops have been the most difficult value to adjust in the model even after several simulation tryouts. In the case of the core pressure drop, even KAERI reports fail to obtain a unanimous value. 27 KPa [7], 9.53KPa [20] or 5.88 KPa [8] are all reported values. In the KAERI report [21] a value close to 27.25 KPa is mention to be the closest one to the desired value in a range in between 27 and 29 KPa. Hence, the value obtained of 35 KPa being in the range of the reports (as in previous models in this document) and close to the desired value is considered a successful result. The secondary SG-pressure drop is much better simulated than the one of the primary circuit. Despite several attempts have been carried out to further reduce the SG-Cassette pressure drop, it was almost impossible to obtain better results than the ones reported here without fatal consequences for the integral model e.g. failing to get stationary conditions at all.

In Fig. 12, a visualization of the primary system showing the cladding temperature and the coolant temperature in the unrolled cylindrical vessel is exhibited. It helps to understand the coolant path, the temperatures at different parts of the VESSEL and the inertias existing in the reactor. This SNAP visualization is very useful to check the mass flow rates and to identify any problem in the plotted parameters. There, one can see dfferent core axial layers showing a symmetrical behaviour as expected of different parameters in the core (fuel rods) and the increase in coolant temperature along the core height.

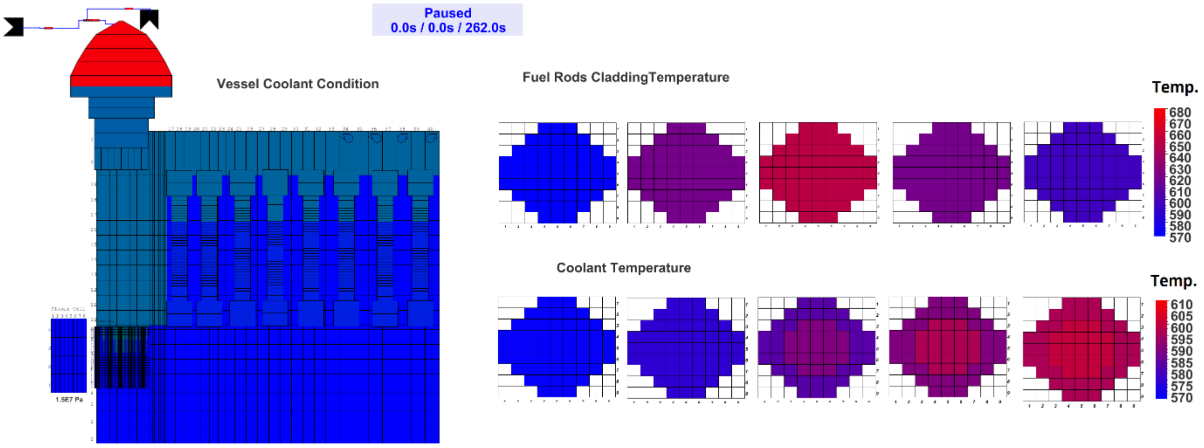


Fig. 12 Final animation model for the primary circuit.

5. CONCLUSIONS AND OUTLOOK

A integral plant model of the SMART reactor design was developed for TRACE where all internal components of this peculiar reactor were considered and the RPV was modelled in a 3D VESSEL component. It was shown that TRACE predicted the stationary conditions with acceptable accuracy after only seven minutes where a converged solution was found. For this, a systematica and exhaustive evaluation of the open literature was performed an all data were collected in an Excel Database for the SMART reactor which can be used to check or modify the model according to further needs. It could be demonstrated that TRACE is capable to determine the thermal-hydraulic behaviour of the SMART plant. The simulations showed also that small oscillations in the liquid level of the thin tubes had an impact on the convergence of the model which could be solved by reducing the nodalization of the SG-secondary side. In total, three models were created during the progressive work: a Cartesian core simplified model, a Cartesian vessel model for the lower part of the RPV and Cartesian core and cylindrical vessel model. In the near future, this TRACE model will be extended to perform the analysis of design basis accidents for using the coupled code TRACE/PARCS. In addition, the severe accident code ASTEC will be used to analyse the SMART-behavior under severe accident conditions.

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