Porous modelling of AGRs pod boilers with *Code_Saturne*.

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Context

Life extension of AGRs in the framework of target 0/9/65:

- 0 harm;
- 9 years life extension;
- 65 TWh/y generated within the life extension.
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Critical components for life extension:

- graphite bricks in nuclear reactors;
- pod boilers.
Context - Pod Boilers

Critical aspects:

- temperatures at material transitions welds
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- temperatures of 9% Cr tubes fin tips
Critical aspects:

- temperatures at material transitions welds
- temperatures of 9% Cr tubes fin tips
- steam superheat temperature difference
Objectives

Development of a simplified 3D model of the gas side AGRs Pod Boilers.

Information provided by the model:

- fluid flow and heat transfer;
Objectives

Development of a simplified 3D model of the gas side AGRs Pod Boilers.

Information provided by the model:

- fluid flow and heat transfer;
- temperature distribution in the Pod Boiler;
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- fluid flow and heat transfer;
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- investigation of boiler spine thermocouples;
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Information provided by the model:

- fluid flow and heat transfer;
- temperature distribution in the Pod Boiler;
- investigation of boiler spine thermocouples;
- effect of modifications to original configuration.
Methodology

Very complex geometry, direct CFD simulation non viable
($\gg 10^9$ cells, months of CPU time on supercomputer)
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Porous model of the whole Pod Boiler
($\approx 10^5$ cells, hours of CPU time on desktop machine)
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Structure of the model:

- general modelling with Code Saturne;
- mesh and porosity information from plant data;
- correlations and detailed CFD submodels for drag coefficients and heat transfer;
- coupling between Code Saturne and NUMEL for heat exchange.
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the domain is divided into homogeneous regions;
Coupling with NUMEL - What is NUMEL?

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each point must be given a gas temperature as a thermal boundary condition.
Coupling with NUMEL - Locating the tubes
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The coupling on the Code Saturne consists in:

- reading the profiles of temperatures given by NUMEL, tube by tube;
- interpolate the temperatures and impose them in the cells touched by the tube;
- impose heat sinks proportional to the difference of temperature in the cells;
- compute temperatures to be used as gas boundary condition in NUMEL.
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Boiler Spine
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Heat conduction model with thermal radiation in SYRTHES;
Boiler spine

- Heat conduction model with thermal radiation in SYRTHERS;
- Coupling of the porous model with a heat conduction model in SYRTHERS.
Boiler spine

- Heat conduction model with thermal radiation in SYRTHES;
- coupling of the porous model with a heat conduction model in SYRTHES.
- inclusion of an explicit CFD model of the spine gap.
Main results

Cold plume effect:

hot main flow from the reactor;
cold side flow from the bottom of the boiler;

(Boundary conditions here used are not representative of the real conditions of the boilers)
Main results

**Cold plume effect:**

liner flow entrained by main flow into Reheater;

colder gas up to the 4th row of the Reheater;

(Boundary conditions here used are not representative of the real conditions of the boilers)
Main results

**Cold plume effect:**

Cold plume dependent on the parameters of the model;

(Boundary conditions here used are not representative of the real conditions of the boilers)
Main results

limited impact of cold plume on the spine;

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Main results

spine flow important also at the bottom of the gap;

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Conclusions

- equivalent 3D model of complex geometry;
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- results in hours rather than weeks or months;
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- results in hours rather than weeks or months;
- double coupling of Code_Saturne with NUMEL and SYRTHES;
Prospects

- full analyses of the pod boiler;
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- extension to dynamic stability analyses or transient analysis;
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- analyses of modifications of the pod boiler;
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- extension to dynamic stability analyses or transient analysis;
- analyses of modifications of the pod boiler;
- extension of the model to other boiler configurations.
thank you