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Comparison of Several RANS Modelling for the Pavia TRIGA Mark II Research Reactor

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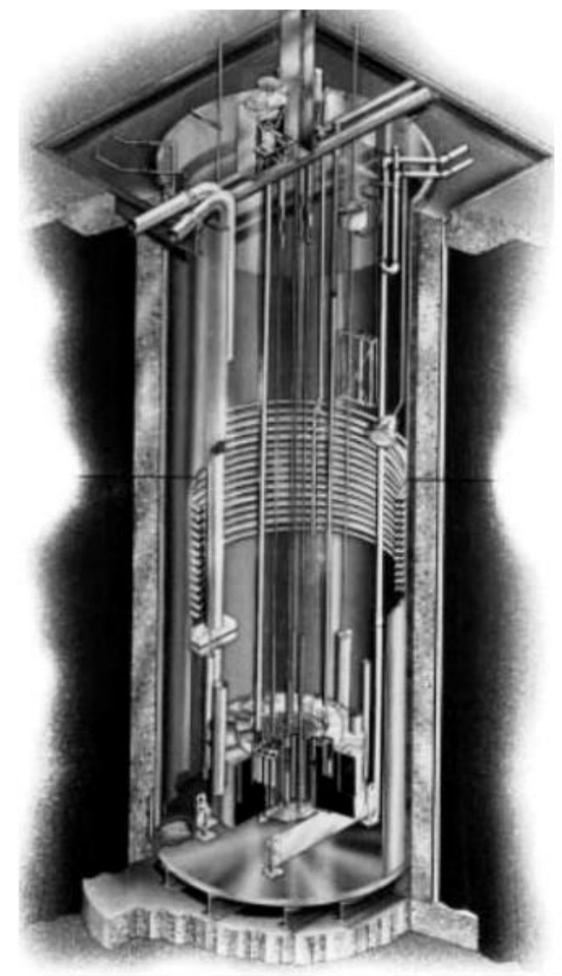


SUMMARY

In this study, a detailed analysis of the turbulent regime within the core of the Pavia TRIGA Mark II reactor is perfomed by means of an in-depth **comparison** of the **RAS** (Reynolds-Averaged Simulation) turbulence models implemented in **OpenFOAM**. Aim of this analysis is to give some important information with respect to the **flow regime** within the **core**. The performance of the various models is tested against a **LES** (Large Eddy Simulation) of the **innermost channel.**

TURBULENCE MODELLING

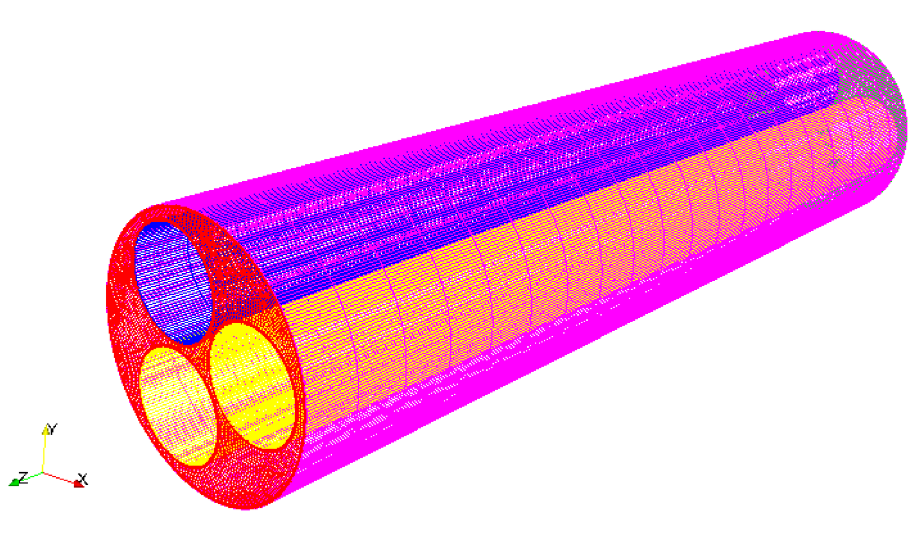
Reynolds-Averages Simulation (**RAS**) models focus on the **mean** flow and the effect of **turbulence** on its properties, by resolving only the **largest** eddies that characterise turbulence and without entering into details about the **smallest scales** and **local effects**.

Seven models have been tested:

- RMS (Reynold Stress Model) LRR and RSM-SSG
- Standard k-ε, Renormalised k-ε, and Shih-Quadratic k-ε
- k-ω SST and k-ω SST-SAS

For investigation the behaviour of the quantities of interest near the wall, a **Low-Reynolds Number** (LRN) approach has been chosen. The fluid flow is modelled as Netwonian, **incompressible**, **turbulent,** and it is considered in **steady state**.

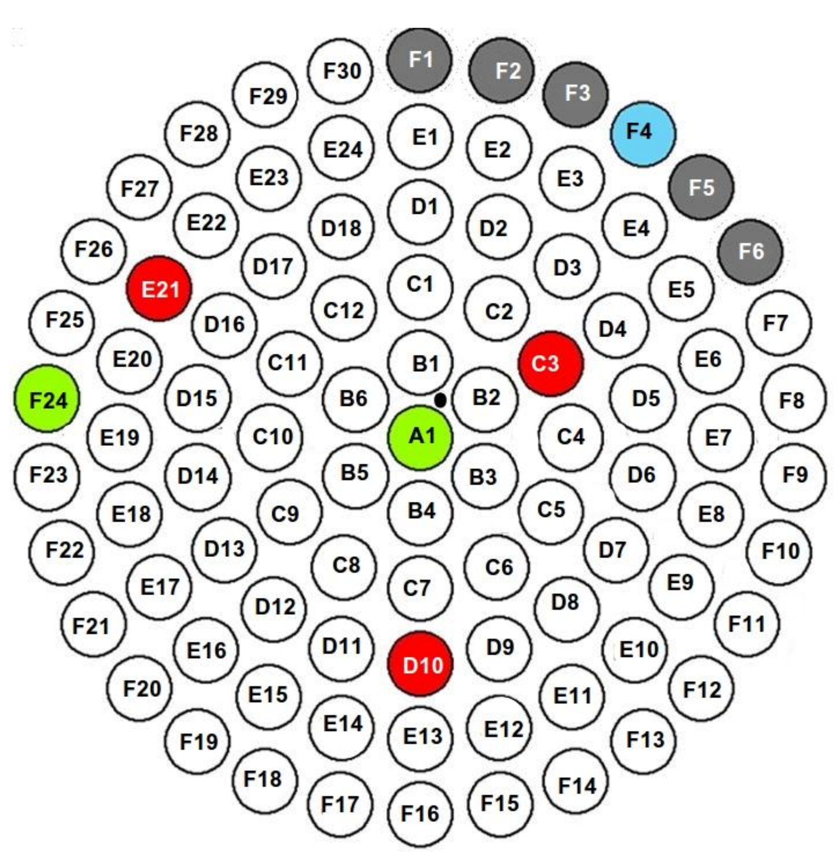
NUMERICAL MODEL



Detail of the adopted axial direction division for the mesh. The different boundaries are identified by the different colours: red (outlet), green (inlet, not shown), yellow (fuel elements B1 and B2), blue (irradiation channel A1), purple (domain boundaries)

Elements	Maximum non-Ortho	Maximum Skew	Average y^+	Axial Elements	Inflation Layers
352895	45.47	0.62	3.29	35	7

Main characteristics of the employed discrete grid



Reactor core configuration. White elements are the fuel elements, red ones are the control rods, green elements are the irradiation channels, grey ones are the graphite elements, the blue one is the neutron source, and the black dot is the analysed channel

Channel boundary conditions

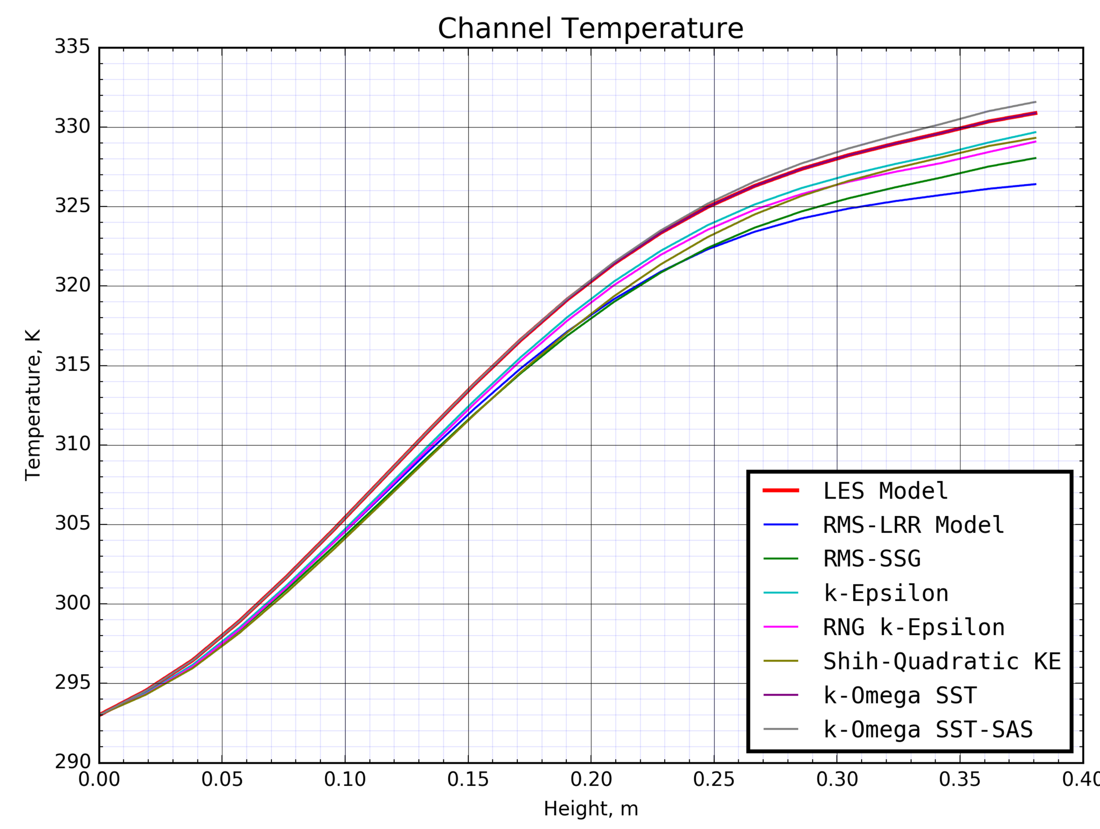
	Inlet	Outlet	Fuel	Boundary
Pressure	Zero-Gradient	1.5 bar	Zero-Gradient	Zero-Gradient
Velocity	(0, 0, 0.264)	Zero-Gradient	No-Slip	No-Slip
Temperature	293 K	Zero-Gradient	Sinusoidal Gradient	Zero-Gradient
Turbulence	Free-Stream Values	Zero-Gradient	Placeholder Wall Function	Placeholder Wall Function

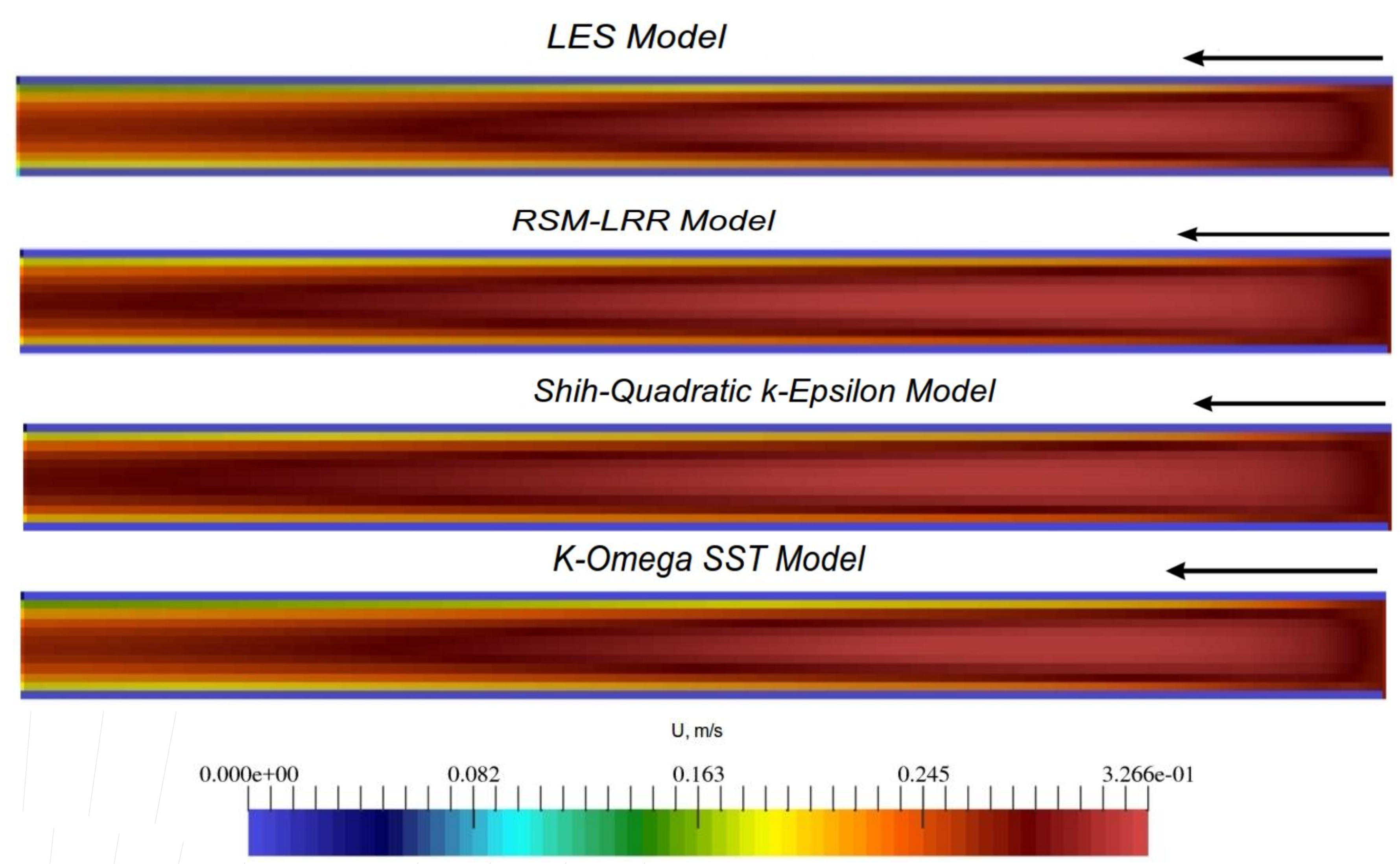
The power produced by the fuel elements was taken as input data for each element. For the LRN approach for wall treatment, the use of placeholder wall functions allow the evaluation of the wall distance y^+

CONCLUSIONS

Overall, the k-ω SST model shows the best agreement with the LES simulation, while being less time consuming. This can be explained with its inherent structure, designed to be accurate both for near-wall and free-stream regions. This models offers the best compromise between accuracy and computational requirements, and may be suitable even for a full core simulation.

NUMERICAL RESULTS





	LES	LRR	SSG	k-ε	RNG k-ε	SQ k-ε	k-ω SST	k-ω SAS
Convergence times	1902	1404	1200	1167	1146	1353	1200	1204

Convergence times for the compared models