Ansys

INNOVATION CONFERENCE

2021

Automatic shell development with ANSYS WORKBENCH for fast & accurate thermal simulation on Dry transformers

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ABB Powergrids

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Auto-Thermo3D

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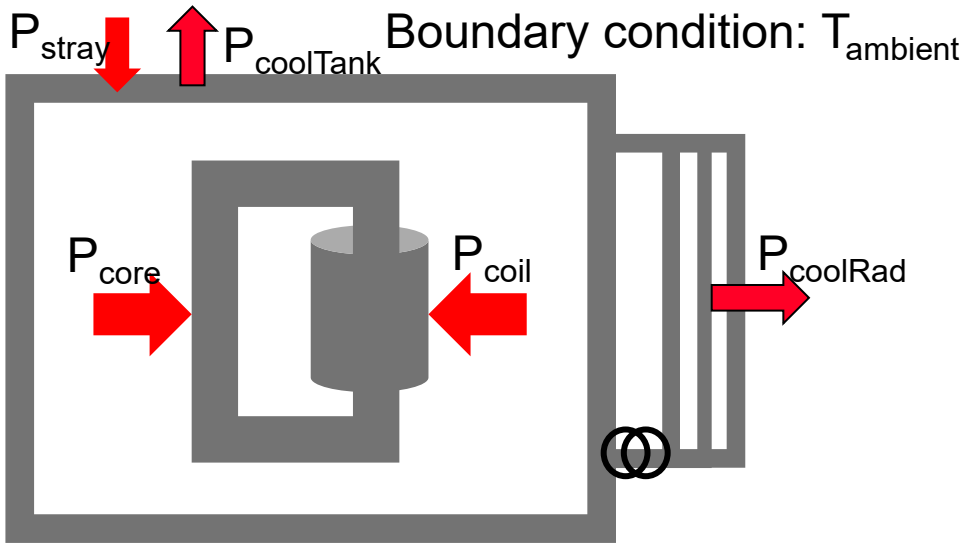
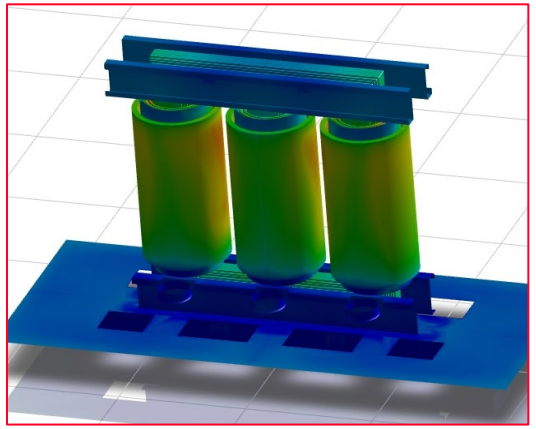
Backgrounds

- Transformer Cooling Problem Formulation. Solution methods: traditional, Network, CFD
- Traditional: Empirical-formulas-based method
- Network approach: Equivalent analog thermal network based, Spice solver
- CFD: Detailed physics-based calculation
- Elements included in calculation:
  - Windings+ insulation layers
  - Core
  - Cooling Duct
  - Cooling systems (AN, AN with enclosures, AF with fans, AFWF, etc)
- Calculation cost:
  - CFD: Several days for pre-processing, meshing + several hours for calculation and post-processing → higher accuracy

An automatic process could be developed to highly reduce CFD time from several days to several hours with higher accuracy and reliability.



Prototype

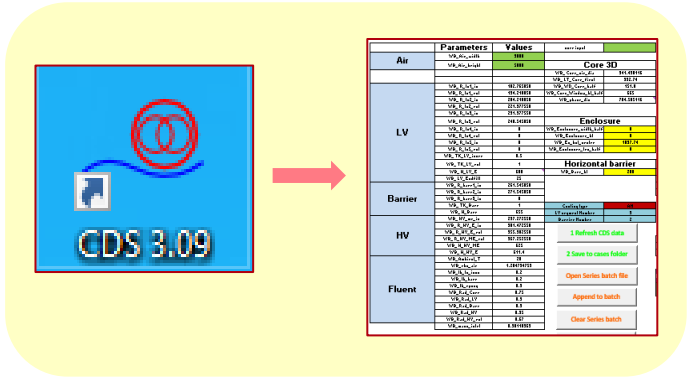


Simulation model

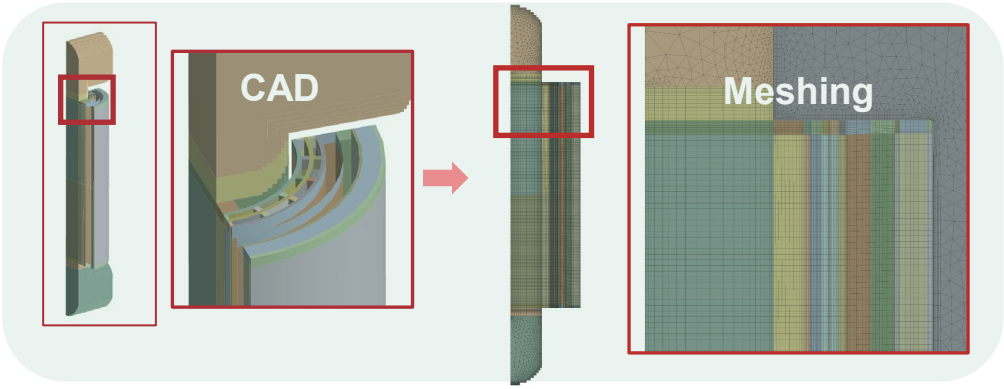
Auto-Thermo3D

Workflow

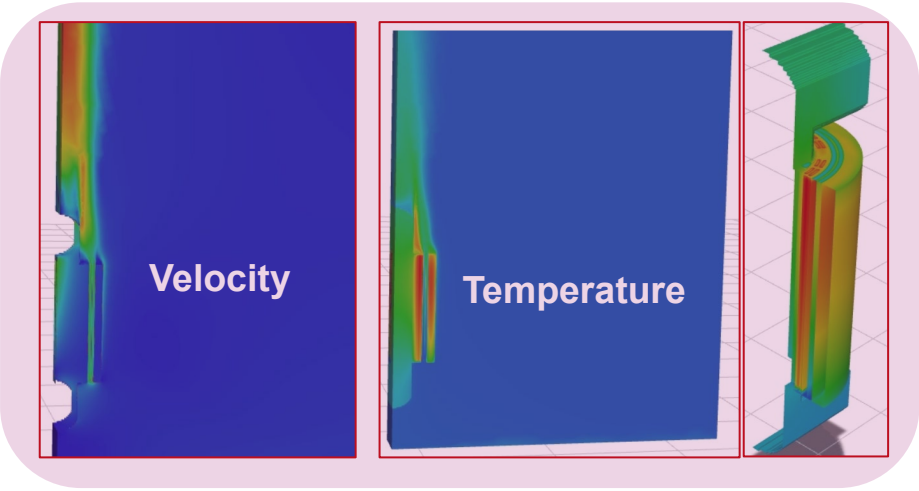
(1) Parameterized Common Design System



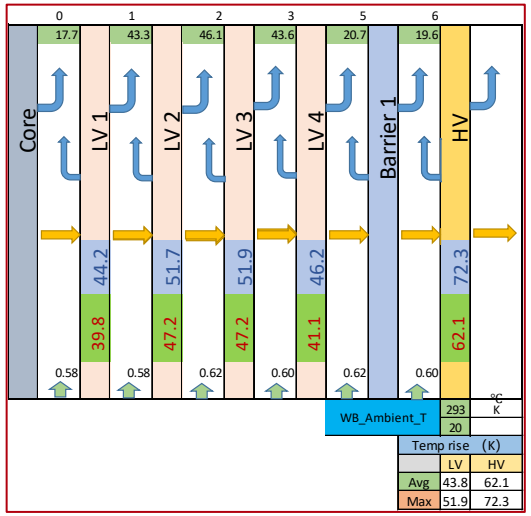
(2) Auto geometry modeling and meshing with ANSYS



(3) Auto CFD simulation with FLUENT



(4) Single case results summary

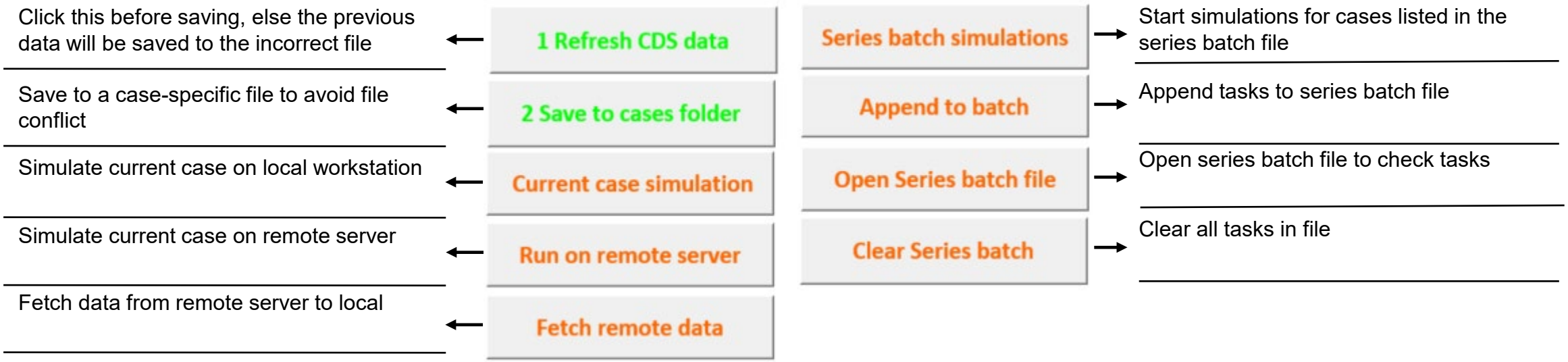


(5) Global summary & Static analysis

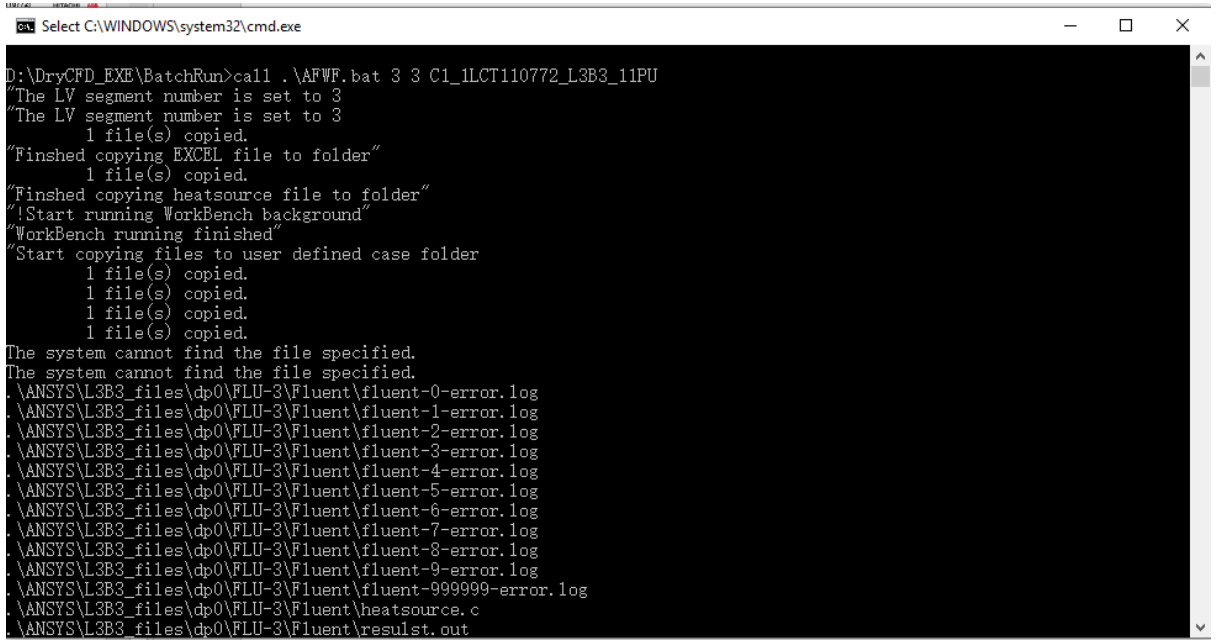
Update data | Append data | Clear Data | Importing results from CDF calculation files

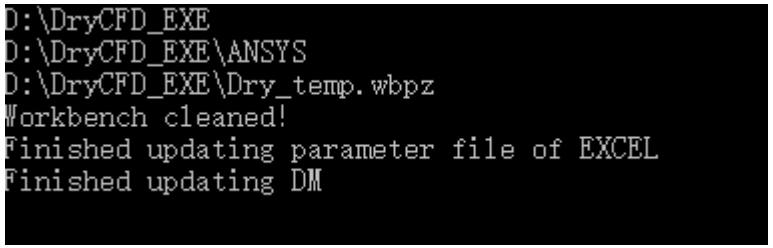
Case	Amb. Temp	Average		Maximum		Heat Source			Average			
ID	Avg	LV	HV	LV	HV	core	LV	HV	LV1	LV2	LV3	LV4
1LCT1029112CL_L3_B1	40.00	98.43	96.32	111.59	113.94	0.00	409.40	427.83	91.57	104.98	98.09	82.01
1LCT1030912CL_L3_B2	45.00	101.76	192.87	141.53	233.27	0.00	0.00	0.00	98.50	120.27	113.36	77.01
1LCT1034974CL_L3_B1	40.00	99.05	81.18	119.97	97.15	0.00	743.92	617.43	97.10	107.22	93.08	82.01
1LCT110221CL_L3_B1	40.00	105.88	81.44	128.11	98.00	0.00	732.07	539.29	97.00	115.45	102.62	82.01
1LCT110332CL_L3_B1	40.00	99.28	81.19	120.35	97.17	0.00	744.26	617.45	97.35	107.50	93.26	82.01
1LCT110465CL_L3_B1	45.00	36.61	48.82	48.12	59.46	0.00	453.09	397.22	29.25	40.04	38.41	77.01
Kr001_IP00_L4B1_L4_B1	45.01	67.09	63.07	90.31	75.77	0.00	868.57	775.19	60.14	73.34	73.85	63.03
Kr002_IP00_L4B1_L4_B1	20.00	81.59	77.84	104.91	93.01	0.00	967.21	774.77	63.29	86.62	89.43	77.14
Kr003_IP00_L2B2_L2_B2	20.00	81.02	48.70	91.98	58.49	0.00	700.96	446.05	78.82	82.46	-293.15	-293.15
Kr005_IP00_L3B3_L3_B3	20.00	53.25	78.79	61.60	89.04	0.00	848.20	1015.14	45.19	56.72	54.53	102.01
Kr007_IP00_L2B2_L2_B2	40.00	88.90	85.13	100.10	101.57	0.00	478.34	602.37	91.19	86.98	-313.15	-313.15
Kr008_IP00_L3B2_L3_B2	45.00	101.76	192.87	141.53	233.27	0.00	0.00	0.00	98.50	120.27	113.36	77.01
Kr009_IP00_L4B1_L4_B1	20.00	42.47	62.00	50.14	72.30	0.00	546.12	742.77	38.64	45.58	45.65	39.82
Kr010_IP00_L4B3_L4_B3	20.00	67.56	80.07	89.68	94.52	0.00	1007.56	1001.39	64.73	74.48	72.49	59.49
Kr013_IP00_L4B1_L4_B1	20.00	88.77	81.28	115.98	97.31	0.00	1034.57	802.61	68.83	94.16	97.30	84.03
Sh003_IP00_L3B1_L3_B1	27.00	13.83	47.40	15.78	53.88	0.00	328.47	458.14	13.72	14.84	13.17	95.01

ANSYS Simulation controlled by Excel Shell



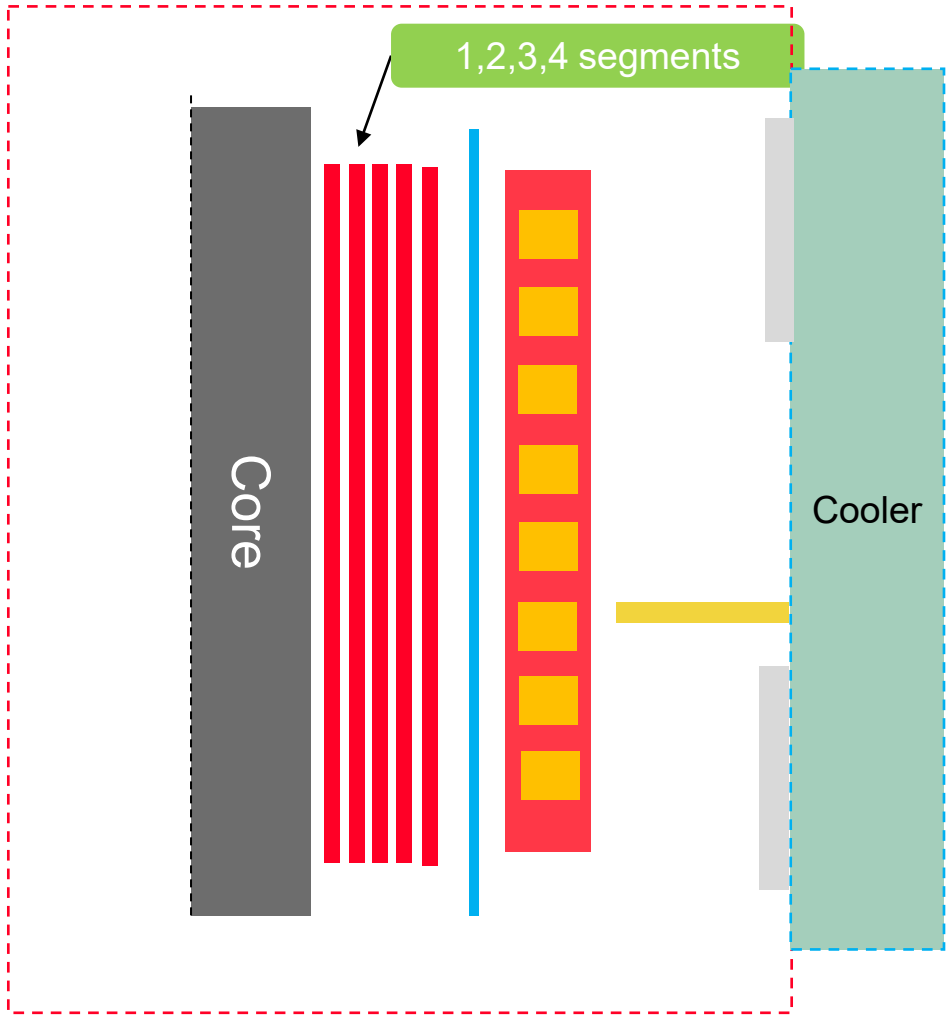
Batch mode simulation

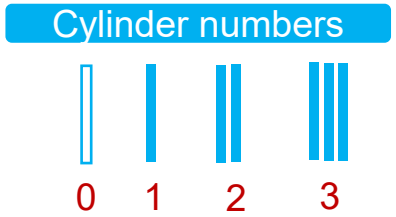




- The calculation process will be shown and can be checked to know the status;
- Wait roughly 2~3 h until prompt “Case xx finished!”

Variants

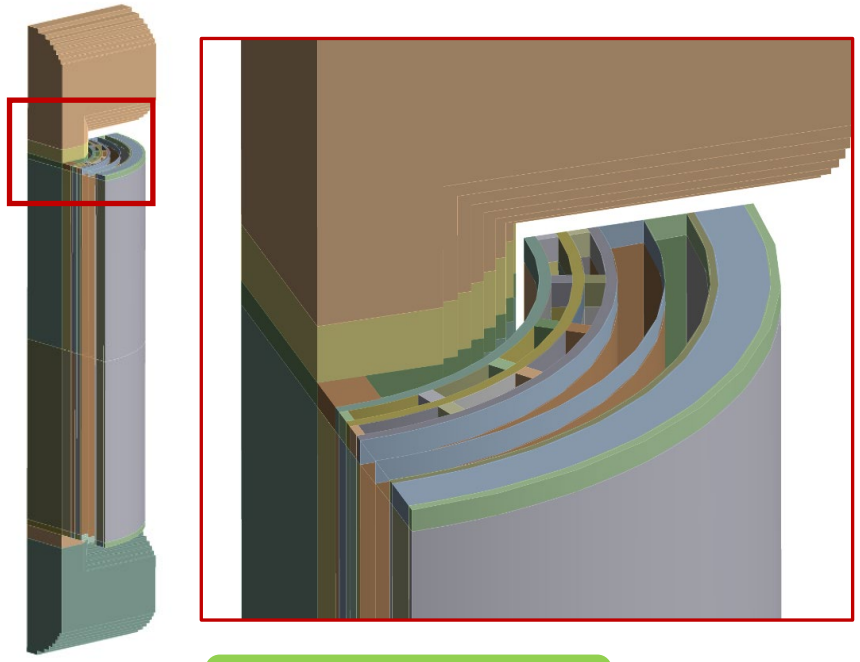




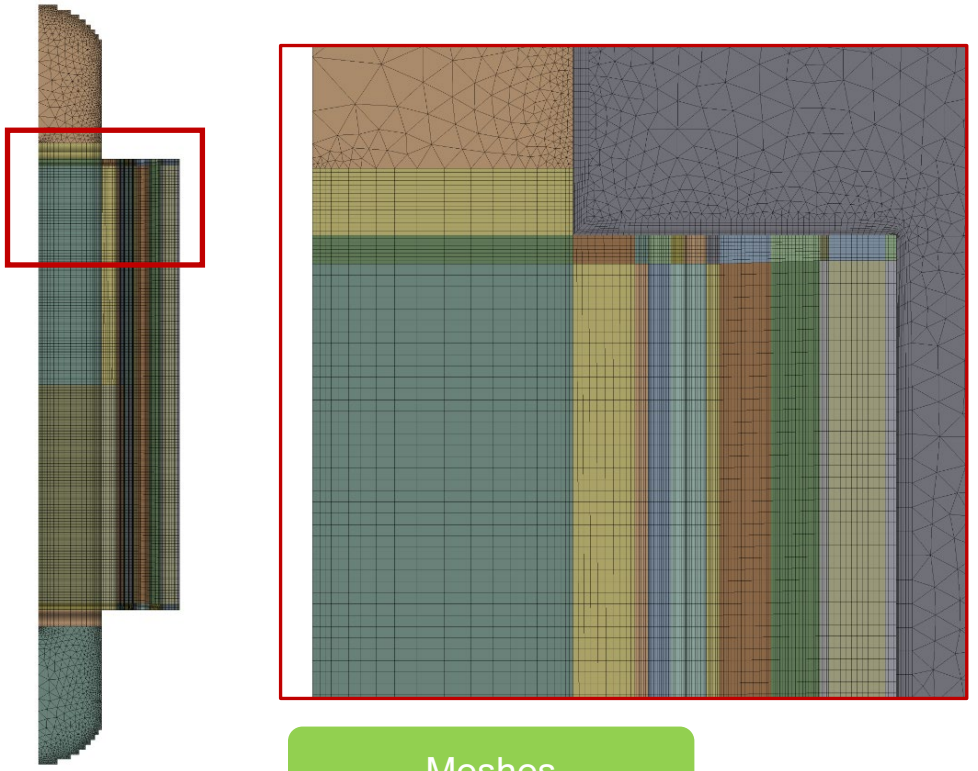
The CFD tool could be run on

- **Different layouts**
- **Different cooling conditions (AN, AF, AFWF)**

Geometry & meshing



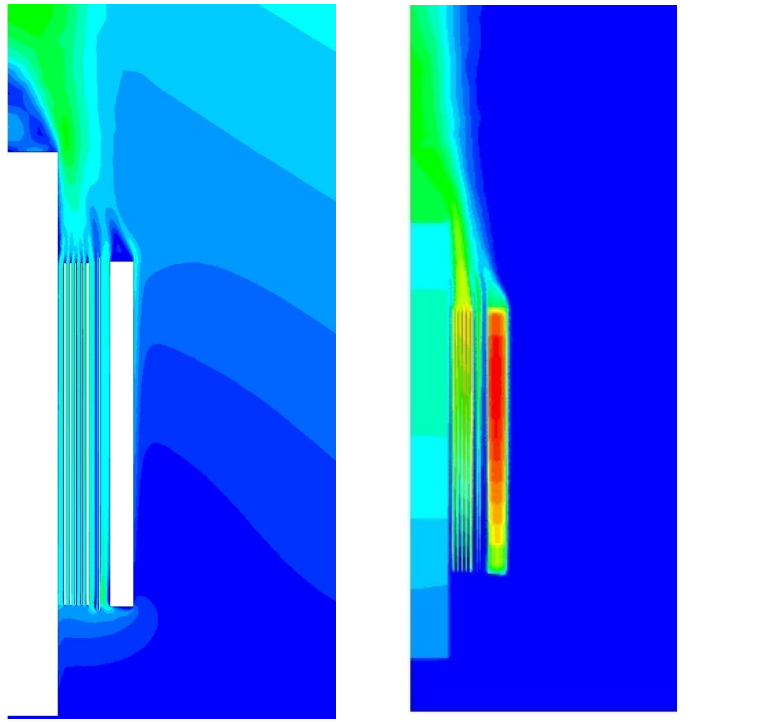
Geometry



Meshes

Ideal setup for CFD simulation

- **Turbulence:** kw-SST model
- **Gas density property:** (Ideal-gas model highly recommended)
- **Radiation model**: (S2S instead of DO for 2D, DO is selected for 3D)
- **Pressure and velocity solution:** Coupled
- **Spatial discretization for pressure:** Body Force Weighted or PRESTO! (preferred)



Velocity | Temperature rise

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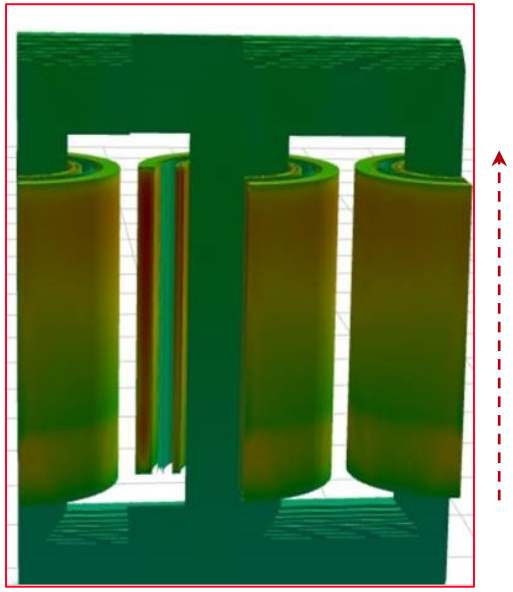
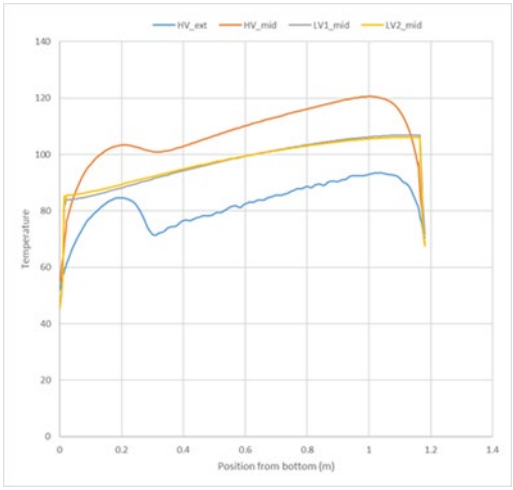
Case under AF condition

Prototype

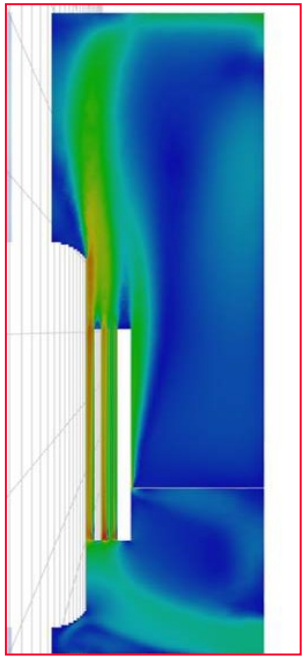
Temperature distribution



Temperature-rise along height

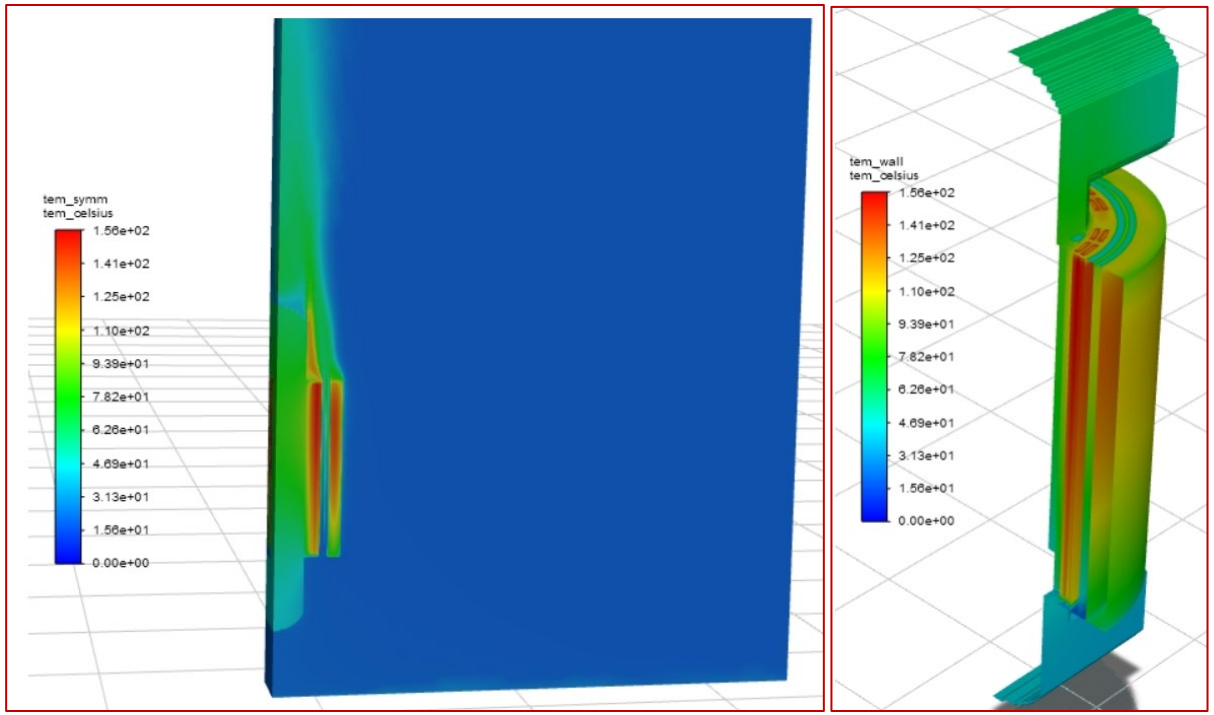


Velocity distribution

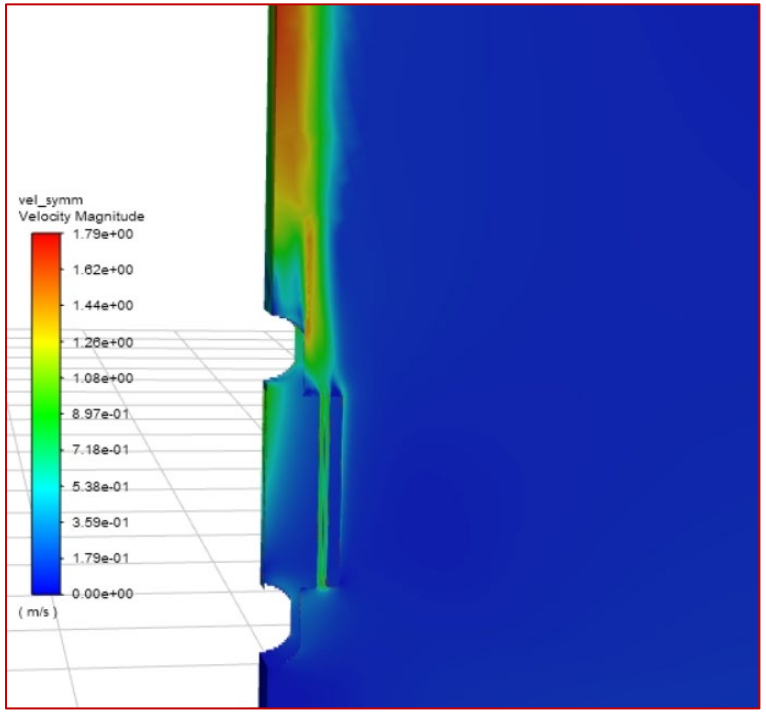


Auto-Thermo3D

Case under AN condition



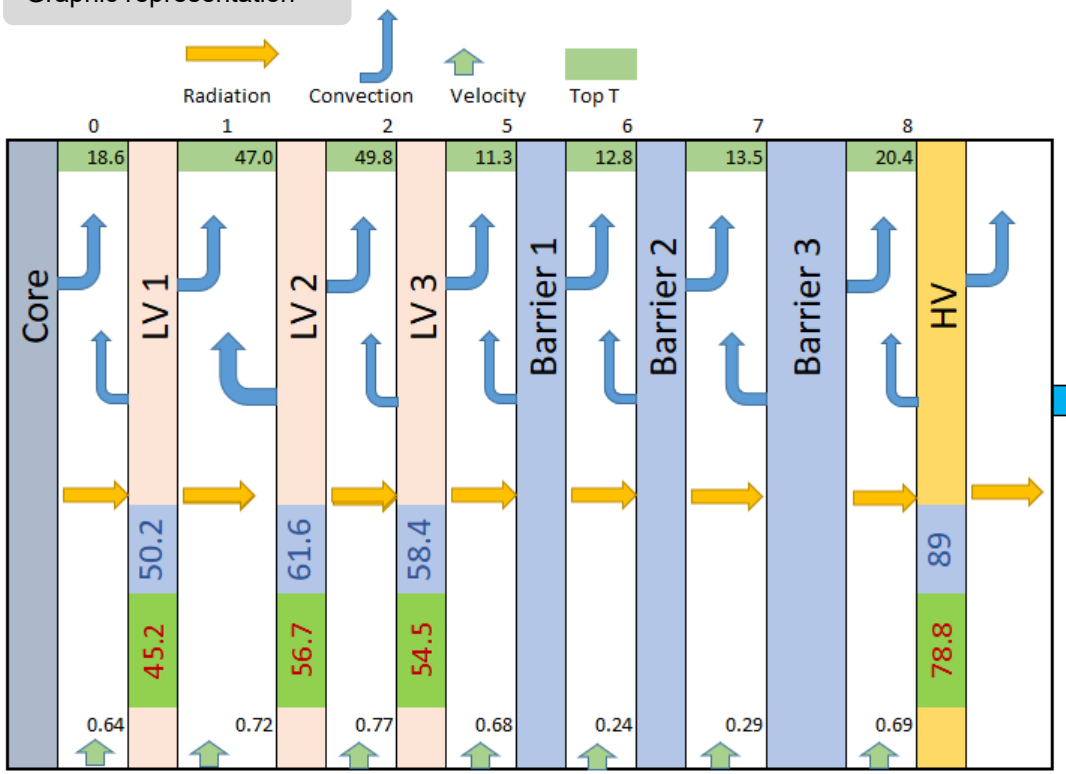
Temperature rise distribution



Velocity distribution

Post-processing

Graphic representation



Temperature rise (K)		
	LV	HV
Avg	53.3	78.8
Max	61.6	89.0

WB_Ambient_T	293.15	K
	20	°C

Results compilation sheet

Update data | Append data | Clear Data | Importing results from CDF calculation files

Case	Amb. Temp	Average		Maximum		Heat Source	Average					
ID	Avg	LV	HV	LV	HV	core	LV	HV	LV1	LV2	LV3	LV4
	40.00	98.43	96.32	111.59	113.94	0.00	409.40	427.83	91.57	104.98	98.09	82.01
	45.00	101.76	192.87	141.53	233.27	0.00	0.00	0.00	98.50	120.27	113.36	77.01
	40.00	99.05	81.18	119.97	97.15	0.00	743.92	617.43	97.10	107.22	93.08	82.01
	40.00	105.88	81.44	128.11	98.00	0.00	732.07	539.29	97.00	115.45	102.62	82.01
	40.00	99.28	81.19	120.35	97.17	0.00	744.26	617.45	97.35	107.50	93.26	82.01
	45.00	36.61	48.82	48.12	59.46	0.00	453.09	397.22	29.25	40.04	38.41	77.01
	45.01	67.09	63.07	90.31	75.77	0.00	868.57	775.19	60.14	73.34	73.85	63.03
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	27.00	13.83	47.40	15.78	53.88	0.00	328.47	458.14	13.72	14.84	13.17	95.01

DRY CFD Shell Development

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Summary

- A completely automatic SHELL is developed with ANSYS WORKBENCH environment.
- Relatively higher accuracy comparing to traditional methods.
- Detailed temperature distribution is presented with hot-spot and average temperature rise
- Detailed velocity distribution is presented along all ducts
- Calculation time is acceptable, further ROM model (optiSLang) could be created based on this tool to obtain accurate results in seconds.

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