# HOW TO SET UP MULTI-ZONE PROBLEMS IN SU2

# 11.06.2020, i.e. v7.0.5

BOSCH

### 1. MESH HANDLING





### 2. CONFIG FILES

## 3. POST PROCESSING





### Disclaimer(s) Please don't sue me

- This is by no means my work and there are a lot of people to give credit to ... therefore I just thank the SU2 community <sup>(i)</sup>
- SU2 is mostly NOT a streamlined developed software => concepts might be inconsistent and bugs occur
- ► I did my best to get all infos right, but ...
  - there can be errors on the slides and audio track
  - not everything can be mentioned
  - edge cases are not covered

- ▶ Who is this for? Everyone ...
  - ... who wants to set up a multizone computation
    - ... and has already some SU2 background
- This presentation is certified 100% equationfree!



### 1. Mesh Handling What is a Zone?



- ► What defines a 'zone'?
  - Used physics (fluid flow, heat conduction, structural mechanics)
  - Moving mesh (fluid-fluid)
  - Not necessarily geometric connectivity (see image)
- Connection between zones via interface boundaries (optional)
- MULTIZONE single physics and MULTIPHYSICS possible for fluidfluid cases



© Robert Bosch GmbH 2020. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights

### 1. Mesh Handling What is a Zone?



- ► What defines a 'zone'?
  - Used physics (fluid flow, heat conduction, structural mechanics)
  - Moving mesh (fluid-fluid)
  - Not necessarily geometric connectivity (see image)
- Connection between zones via interface boundaries (optional)
- MULTIZONE single physics and MULTIPHYSICS possible for fluidfluid cases



2020-06-07 T. Kattmann, Robert Bosch GmbH © Robert Bosch GmbH 2020. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.

### 1. Mesh Handling How should I create the mesh?





- ► Each zone is discretized independently
- Interface Boundary markers have to be 'geometrical' pairs
  - KIND\_INTERPOLATION= ... specifies how values are communicated over the boundary
- Sidenote: internal structures are separate for each zone (config, solver, etc.)
- MPI: each rank gets a chunk of each zone
  - Important for e.g. Multigrid methods.



#### T. Kattmann, Robert Bosch GmbH

© Robert Bosch GmbH 2020. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.

### 1. Mesh Handling How to create a multizone Mesh

- ► MULTIZONE\_MESH= NO
  - Create meshes for each zone just as for single zone cases
  - Mesh has to be specified in each zonal config

- MULTIZONE\_MESH= YES (default)
  - Easy creation from single zone meshes as shown below
  - Order of the meshes is kept for config files in CONFIG\_LIST= (...)

BOSCH



#### 2020-06-07

T. Kattmann, Robert Bosch GmbH

© Robert Bosch GmbH 2020. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.

8



Config files





#### Q 2020-06-07

T. Kattmann, Robert Bosch GmbH

© Robert Bosch GmbH 2020. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.





- All config options set in the master are also used in the zonal config (i.e. they are internally copied), except...
- ... config options that are set in the zonal config as well.
- If an option is set in neither of the config files, the default value is taken

Suggestion:

- 1. Try single zones independently
- 2. Create master and add zonal configs
- 3. Transfer common options to master



© Robert Bosch GmbH 2020. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights



- ► Options to set into the master config:
  - ► SOLVER= MULTIPHYSICS
  - ► MULTIZONE\_MESH= YES/NO
  - ► CONFIG\_LIST= ( zoneA.cfg, ... )
  - MARKER\_ZONE\_INTERFACE= (wallA, wallB, ...)
  - ► TIME/OUTER\_ITER= 100
- ► Zonal:
  - Do not set interface boundary markers again
- Use 'SU2\_CFD <master.cfg>' to start the simulation

BOSCH

11 2020-06-07

#### T. Kattmann, Robert Bosch GmbH

© Robert Bosch GmbH 2020. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.









14

SOLVER= INC_NAVIER_STOKES	SOLVER= MULTIPHYSICS MULTIZONE_MESH= YES MESH_FILENAME= multizone.su2 CONFIG_LIST= (zoneA.cfg \ zoneB.cfg)	SOLVER= HEAT_EQUATION
MARKER_whatever= (interfaceA)		MARKER_whatever= (interfaceB)
ITER= 100		ITER= 100
HISTORY_OUTPUT= (ITER, \ AERO_COEFF)		AVG_TEMPERATURE) HISTORY_OUTPUT= (ITER, HEAT)
OUTPUT_FILES= (RESTART,\ PARAVIEW_MULTIBLOCK)		PARAVIEW_MULTIBLOCK)
zoneA.cfg	master.cfg	zoneB.cfg



SOLVER= INC_NAVIER_STOKES	SOLVER= MULTIPHYSICS MULTIZONE_MESH= YES MESH_FILENAME= multizone.su2 CONFIG_LIST= (zoneA.cfg \	SOLVER= HEAT_EQUATION
MARKER_whatever= (interfaceA)	<pre>zoneB.cfg) MARKER_ZONE_INTERFACE= (\     interfaceA, interfaceB) MARKER_CHT_INTERFACE= (\     interfaceA, interfaceB)</pre>	MARKER_whatever= (interfaceB)
ITER= 100		ITER= 100
SCREEN_OUTPUT= (ITER, DRAG)		SCREEN_OUTPUT= (ITER, \
HISTORY_OUTPUT= (ITER, \ AERO_COEFF)		HISTORY_OUTPUT= (ITER, HEAT)
OUTPUT_FILES= (RESTART,\ PARAVIEW_MULTIBLOCK)		OUTPUT_FILES= (RESTART,\ PARAVIEW_MULTIBLOCK)
zoneA.cfg	master.cfg	zoneB.cfg



Singlezone steady only uses ITER



16





- Singlezone steady only uses ITER
- Singlezone unsteady uses TIMER\_ITER and INNER\_ITER







- Singlezone steady only uses ITER
- Singlezone unsteady uses TIMER\_ITER and INNER\_ITER
- ► In Multizone computations:
  - TIME\_ITER -> OUTER\_ITER -> INNER\_ITER independent of steady-unsteady
  - Exchange of interface data (Coupling) happens with each OUTER\_ITER
  - Update in pseudo time with each INNER\_ITER



2020-06-07 T. Kattmann, Robert Bosch GmbH © Robert Bosch GmbH 2020. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights

SOLVER= INC_NAVIER_STOKES	SOLVER= MULTIPHYSICS MULTIZONE_MESH= YES MESH_FILENAME= multizone.su2 CONFIG_LIST= (zoneA.cfg \ zoneB.cfg) MARKER_ZONE_INTERFACE= (\ interfaceA, interfaceB) MARKER_CHT_INTERFACE= (\ interfaceA, interfaceB)	SOLVER= HEAT_EQUATION
INNER_ITER= 1	OUTER_ITER= 100	INNER_ITER= 1
SCREEN_OUTPUT= (ITER, DRAG)		SCREEN_OUTPUT= (ITER, \
HISTORY_OUTPUT= (ITER, \ AERO_COEFF)		HISTORY_OUTPUT= (ITER, HEAT)
OUTPUT_FILES= (RESTART,\ PARAVIEW_MULTIBLOCK)		OUTPUT_FILES= (RESTART,\ PARAVIEW_MULTIBLOCK)
zoneA.cfg	master.cfg	zoneB.cfg



### 3. Post- / Midprocessing Screen and History output (SU2\_CFD -d <config>.cfg)

SOLVER= INC_NAVIER_STOKES	SOLVER= MULTIPHYSICS MULTIZONE_MESH= YES MESH_FILENAME= multizone.su2 CONFIG_LIST= (zoneA.cfg \ zoneB.cfg)	SOLVER= HEAT_EQUATION
	MARKER_ZONE_INTERFACE= (\ interfaceA, interfaceB) MARKER_CHT_INTERFACE= (\ interfaceA, interfaceB)	
INNER_ITER= 1	OUTER_ITER= 100	INNER_ITER= 1
<pre>SCREEN_OUTPUT= (ITER, DRAG) HISTORY_OUTPUT= (ITER, \    AERO_COEFF)</pre>	<pre>SCREEN_OUTPUT= (OUTER_ITER, \     DRAG[0], AVG_TEMPERATURE[1]) HISTORY_OUTPUT= (ITER, \     AERO_COEFF[0], HEAT[1])</pre>	<pre>SCREEN_OUTPUT= (ITER, \   AVG_TEMPERATURE) HISTORY_OUTPUT= (ITER, HEAT)</pre>
	OUTPUT_FILES= (RESTART,\ PARAVIEW_MULTIBLOCK)	
zoneA.cfg	master.cfg	zoneB.cfg



### 3. Postprocessing Output Files



- Option A: Write zonal output independently and load consecutively into your preferred tool (Paraview, Tecplot, etc.) ...
- Option B: ... or use OUTPUT\_FILES= ( PARAVIEW\_MULTIBLOCK). Load that into Paraview via the .vtm file
- Sidenote: Default name for vtm-folder and history is the master-config filename





### 3. Postprocessing Paraview Multiblock (.vtm)



2020-06-07

#### T. Kattmann, Robert Bosch GmbH

🕒 BOSCH

© Robert Bosch GmbH 2020. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.

### 3. Postprocessing Paraview Multiblock (.vtm) animation

File Edit View Search Terminal Tabs Help



2020-06-07



### Discrete Adjoint Gradients

- Gradients via discrete adjoint method are available just like in single zone simulations
- Explicitly set OBJECTIVE\_FUNCTION and OBJECTIVE\_WEIGHT in each zonal config, even for no zonal contribution to the objective function
- Python scripts, e.g. shape\_optimization.py, do not work with in multizone in the moment



- Image: Heatflux sensitivities of the inner pin
- https://su2code.github.io/tutorials/Inc\_Heated \_\_Cylinders/

BOSC

### Finishing Remarks "I slept the last 30 minutes... what did I miss?" – Random Listener

We covered (in a basic manner):

- Mesh creation
- Basic structure of the multizone config files
- Output considerations



### Finishing Remarks "I slept the last 30 minutes... what did I miss?" – Random Listener

We covered (in a basic manner):

- Mesh creation
- Basic structure of the multizone config files
- Output considerations
- ... so now everything should be easy, right?



### Finishing Remarks "I slept the last 30 minutes... what did I miss?" – Random Listener

We covered (in a basic manner):

- Mesh creation
- Basic structure of the multizone config files
- Output considerations
- ... so now everything should be easy, right?

If there are problems:

- See website <u>https://su2code.github.io</u> for more information ...
- ... if that does not help take a look into 'TestCases' folder (e.g. 'grep -r MULTIPHYSICS')...
- In or ask a question <a href="https://www.cfd-online.com/Forums/su2/">https://www.cfd-online.com/Forums/su2/</a> and bug reports <a href="https://github.com/su2code/su2/issues">https://github.com/su2code/su2/issues</a> include me via @TobiKattmann

Thank you for tuning in and I hope you enjoy working with SU2 ©