EDF R&D



FLUID DYNAMICS, POWER GENERATION AND ENVIRONMENT DEPARTMENT SINGLE PHASE THERMAL-HYDRAULICS GROUP

6, quai Watier F-78401 Chatou Cedex

MAY 2013

documentation

version 3.0 tutorial - Three 2D disks

contact: saturne-support@edf.fr



EDF R&D	Code_Saturne version 3.0.0-rc1 tutorial - Three 2D disks	documentation Page 1/31
---------	---	----------------------------

TABLE OF CONTENTS

	I Three 2D disks	3
1	General description	4
1.1	Objective	4
1.2	Remarks	4
1.3	Description of the configuration	4
1.4	Characteristics	5
1.5	Mesh characteristics	6
2	CASE 6: 3 2D disks	7
2.1	PARAMETERS	7
2.2	Output management	7
2.3	COUPLING COMPUTATION	8
2.4	Results	8

	II Step by step solution	10
1	Solution for case6	11
1.1	LAUNCHING THE SYRTHES COMPUTATION ALONE	12
1.2	LAUNCHING THE Code_Saturne COMPUTATION ALONE	21
1.3	LAUNCHING THE Code_Saturne-SYRTHES COUPLING COMPUTATION	28

Part I

Three 2D disks

1 General description

1.1 Objective

The aim of this case is to train the *Code_Saturne* coupling with a thermal conduction and radiation code SYRTHES on a simplified 2D problem. It corresponds to a natural convection inside a sheath with different electric wires.

We can see with this test-case the conjugate heat transfer phenomenon between the solid and fluid domains.

1.2 Remarks

• Remark - 1: create the 3disks2D study directory, two subdirectories fluid and solid as below:

\$ code_saturne create -s 3disks2D -c fluid --syrthes solid

• Remark - 2: The fluid mesh must be copied in the directory MESH. The solid mesh must be copied in the subdirectory solid.

• Remark - 3: launch the SYRTHES Graphical User Interface (Gui) (\$ syrthes.gui &) inside the subdirectory solid for the first solid computation alone.

• **Remark - 4**: launch the *Code_Saturne* Graphic User Interface (GUI) inside the subdirectory fluid for the fluid computation alone.

• **Remark - 5**: launch the *Code_Saturne*-SYRTHES coupling computation with the **runcase_coupling** script.

1.3 Description of the configuration

The 2D configuration represents a simplification of the real 3D geometry of the wires inside an electric sheath. As we can see, we have 3 different wires represented as 3 different disks inside a bigger disk for the sheath. We assume that the 3 disks are in contact with an air flow inside the electric sheath.

The geometry is shown on figure I.1.

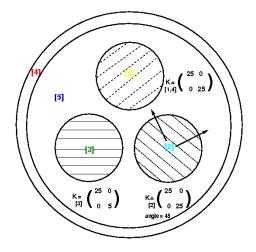


Figure I.1: Geometry of the test-case with [1,2,3,4] the solid domain and [5] the fluid domain. The 4 disk physical properties are specified for the solid domain.

For the fluid domain, there are two symmetry conditions and walls conditions imposed to the faces

coupling with the solid domain. We have no velocity imposed to create movement inside the fluid area and gravity force is taken into account.

Nevertheless, we define a density which is variable in function of the temperature for the air flow. The 3 disks, which are warmer than the air flow, generate a temperature difference creating a fluid movement. The warmer air flow is moving to the top and the colder air flow to the bottom of the fluid domain.

With this test-case, we can easily observe the effect of the solid disks on the air flow contained in the electric sheath.

1.4 Characteristics

• <u>Solid domain</u>:

The initial and boundary conditions to choose without conjugate heat transfer for the solid domain are defined hereafter:

Initial conditionsTemperature condition $T_{ini,s} = 20^{\circ} \mathrm{C}$

Boundary conditions	value	surface reference
Heat exchange conditions $(q_{w,ext})$	$T_{ext} = 90^{\circ}$ C.; $h_{ext} = 1000 (W/m^2.K)$	color 2 or 5 or 8

Characteristics of the solid domain with the 4 different disks (1 to 3 for the electric wires and 4 for the disk for the electric sheath):

	Conductivity type	values	$(W/m/^{\circ}C)$		volume reference
disk 1	isotropic	$k_{11} = 25$			color 1
disk 2	orthotropic	$k_{11} = 25$; $k_{22} = 5$		color 2
disk 3	orthotropic	$k_{11} = 25$; $k_{22} = 5$	$\alpha = 45^o$	color 3
disk 4	anisotropic	$k_{11} = 25$			color 4

Physical properties	values	
Density $[\rho]$	7700	(kg/m^2)
Specific heat $[C_p]$	460	$(J/kg/m^3)$

• Fluid domain:

The characteristics of the air flow inside the fluid domain are defined as following:

Thermophysical models	choosen type
Time step	constant in time and uniform in space
Turbulence model	ε −k
Scalar	Temperature (°C)

The initial and boundary conditions to choose without conjugate heat transfer for the solid domain are defined below:

Initial conditions	
Temperature condition	$T_{ini,f} = 20^{\circ} \mathrm{C}.$

Boundary conditions	values	surface reference
Walls (Heat exchange $q_{w,ext}$)	$T_{ext} = 30^{\circ}\text{C}$; $h_{ext} = 10(W/m^2.K)$	color 1
Symmetry		color 2 or 3

In this case, the fluid density is function of the temperature, the following ideal gas law is specified in the Graphical User Interface (GUI):

$$\rho = \frac{p_0}{R_g \ (T+273.15)} \tag{I.1}$$

where ρ is the density, T is the temperature (°C), ideal gas constant $R_g = 287 \ (m^2 \cdot s^{-2} \cdot K^{-1}), p_0 = 101325 \ (Pa)$ the reference pressure choosen as $p \approx p_{atmos}$.

1.5 Mesh characteristics

• Description of the solid mesh:

The solid mesh used in the conduction problem contains 11688 nodes (P_1 discretization) and 5688 elements. We have to take care of the references allowing to identify materials properties and boundary conditions which are specified in this solid mesh by reference colors.

Type: unstructured mesh Mesh generator used: SIMAIL Color definition: see figure I.3.

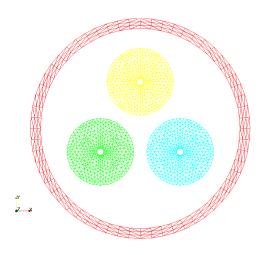


Figure I.2: Colors of the boundary faces

• Description of the fluid mesh:

The fluid mesh contains 3866 nodes. We have to apply the **check mesh** available in the *Code_Saturne* Graphical User Interface to check the quality criteria and identify the reference colors associated to the boundary conditions.

Type: unstructured mesh Mesh generator used: SIMAIL Color definition: see figure I.3.

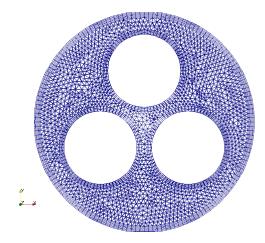


Figure I.3: Colors of the boundary faces

2 CASE 6: 3 2D disks

The post-processing containing the "temperature" field will be post-processed on a sub-mesh with ParaView. A 2D clip plane will also be extracted along the symmetry plane of the fluid domain and temperature will be written on it.

2.1 Parameters

All the parameters necessary to this study can be defined through the *Code_Saturne* (GUI) and SYRTHES (Gui) respectively, as below:

Numerical parameters	s of solid computation
Reference time step	0.1 (s)
Number of iterations	100
Numerical parameters of fluid computation	
Reference time step	0.1 (s)
Number of iterations	100

These numerical time steps and iterations number have been defined to run the fluid and solid computations independently one from each other. Thus, we can test the setting data for the fluid computation with *Code_Saturne* and the solid conduction computation with SYRTHES. After that we will be able to run the coupling computation with the computation option **conjugate heat transfer** activated on both data setting.

2.2 Output management

The standard options for output management will be used. Only one monitoring point will be created for the solid conduction computation at the following coordinates:

Probe	x (m)	y(m)
1	0.003	-1.2

For this probing we choose to save the temperature value every 10 time steps and the temperature field every 25 time steps.

2.3 Coupling computation

The numerical parameters used for the coupling computation must be modified to be sure to see the conjugate heat transfer phenomenon between the solid and fluid domains. For this reason, we increase the iterations number and the time step for the fluid and solid data setting.

By default, the smaller iterations number will be used to drive the coupling computation. If we choose an iterations number of 10000 for the fluid domain and 5000 for the solid domain, the coupling computation will be stopped after 5000 instead of 10000.

Numerical parameters	s of solid computation
Reference time step	0.5 (s)
Number of iterations	50000
Numerical parameters	s of fluid computation
Numerical parameters Reference time step	s of fluid computation 0.5 (s)

2.4 Results

Figure I.6 shows the evolution of the temperature in the solid domain without **conjugate heat transfer** with the fluid domain. We have represented below the evolution of the temperature in the fluid domain without coupling with SYRTHES.

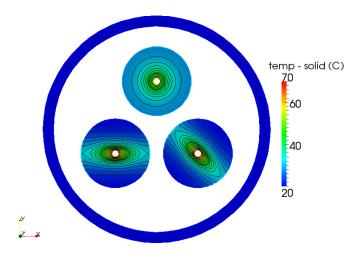


Figure I.4: The temperature evolution in the solid domain without coupling method

Figure I.6 shows the evolution of the temperature in the solid and fluid area with the **conjugate heat transfer activated**. The natural convection in the fluid domain due to the temperature difference imposed by the solid disks is clearly visible with the velocity field and vector.

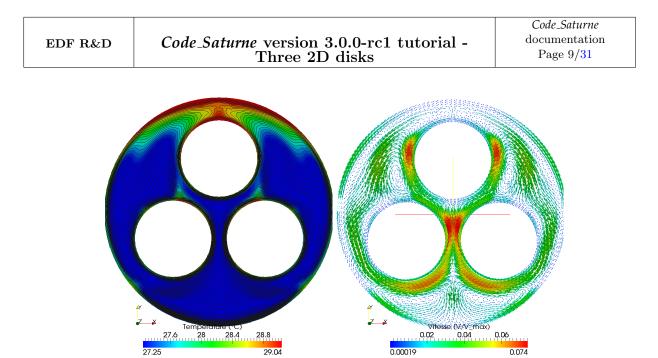


Figure I.5: The temperature evolution in the **fluid domain without coupling method**

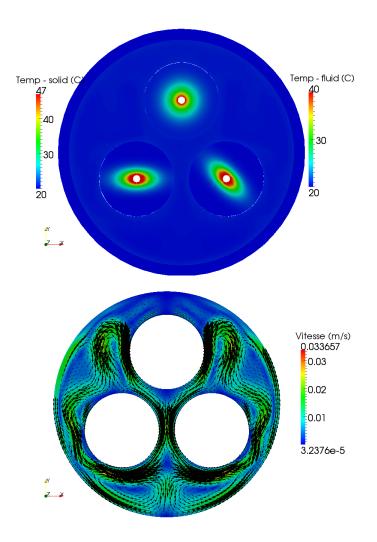


Figure I.6: Evolution of temperature

Part II

Step by step solution

1 Solution for case6

• Step 1: check the post-install required for coupling *Code_Saturne* with SYRTHES.

The first step is to check the post-install required for coupling with SYRTHES and verify if the SYRTHES PATH is correctly known in the system environment. We just need to edit the batch file¹ name code_saturne.cfg as below:

```
$ vim <install-prefix>/etc/code_saturne.cfg
>### Set the location to the SYRTHES installation directory.
> syrthes = <install-prefix-syrthes>
```

• Step 2: source the syrthes.profile file in your user environment.

Before using SYRTHES alone, you have to copy and source this file to define SYRTHES environment variables (like **\$SYRTHES4_HOME**) in your terminal, as follows:

```
$ cp <install-prefix-syrthes>/bin/syrthes.profile .
$ source syrthes.profile
```

\$ echo \$SYRTHES4_HOME (to check the SYRTHES PATH in your environment)

After having defined correctly your environment, to be able to launch a coupling computation *Code_Saturne*-SYRTHES or a SYRTHES computation alone, you just have to create the coupling study directory.

• Step 3: create the 3disks2D study directory, two subdirectories fluid and solid.

This is done using the standard command:

• **Remark**: The fluid mesh must be copied in the directory MESH. The solid mesh must be copied in the subdirectory solid.

¹see the installation guide, name install.pdf, in <install-prefix>/share/doc/code_saturne/ directory.

1.1 Launching the SYRTHES computation alone

The preparation of the computation for **case5** is defined below:

- Step 1: launch the SYRTHES Graphical USer Interface (syrthes.gui),
- Step 2: open a New Data File,
- Step 3: check the name of the mesh and convert this one in .syr format,
- Step 4: define the initial and boundary conditions for the conduction problem,
- Step 5: define the physical properties of each disk {1, 2, 3 and 4},
- Step 6: running the SYRTHES computation alone.

• Step 1: launch the SYRTHES Graphical User Interface (Gui).

The SYRTHES Graphical User Interface is launched by the following command lines in the solid subdirectory:

```
$ cd 3disks2D/solid/
$ syrthes.gui &
```

• Step 2: choose a New Data File inside the (Gui).



Figure II.1: Running the SYRTHES's IHM with synthes.gui

.	SYRTHES V 4.0.0 - untitled.syd	
File Tools Preferences	-	
📑 🗁 🏝 🧾	Run SYRTHES 📀 Stop SYRTHES 😵	Calculation Progress 📈
Home File Names > Conduction User C functions Control Output Running options	Case title : 3disks2D - thermal conduction - solid alone User description of the case Dimension of the problem : 2D_cart 2D_axi_OX Additional physical model Dimension of the problem : 2D_cart 2D_axi_OX Dimension of the problem : 2D_cart 2D_axi_OX	V 4.0.0

Figure II.2: Define the dimension and physical modelling of the problem treated

' 🗁 🏝 🃭 📾 🗌		Dun	SYRTHES 🗩	Ston		Calcu	lation Prog	roc
		Kui	I STRIILS 🥑	Stop	SINILS		nation Prog	ies
Home	⊂Conductio	on input file name	and location					_
File Names	Conductio	n mesh:	3rond2d.syr][
Conduction	Radiation		Select	File			\boxtimes	١
User C functions	Restart Fi							
Control		📝 🔇 ITECH-C	S-nov-2012	3disks	2D solid		>	
Output	🗆 Weathe		3][
Running options		<u>R</u> accourcis	Nom	~	Taille	Modifié		
	Conducti Results na	Q Rechercher	🖿 usr_examp	oles		15:42		
	Results na	🕙 Récemmen	□ 3rond2d.d		167,2 Kio			JĿ
		🖻 B16457	🗈 Makefile		645 octets	15:42	-	
		🗟 Bureau	syrthes.py		54,3 Kio	15:42		
		Système d	syrthes da	ata	9.5 Kio	15:42		
			ar <u>-</u>					
		Ajouter Enlever			All Fil	es 🗧		
						_	_	

Figure II.3: Choose the 2D solid mesh file with the format .des.

		4.0.0 - untitled.s	yd	
File Tools Preference	s <u>H</u> elp			
📑 🔚 🏝 🦫 🔊		Run SYRTHES 🕑	Stop SYRTHES 🔇	Calculation Progress 📈
Home File Names ▷ Conduction User C functions Control Output Running options	Conduction input file r Conduction mesh: Radia Resta Wea Cond Result	name and location [3rond2d.syr Message onversion from "des	" to "syr"	

Figure II.4: The SYRTHES (Gui) directly converts the .des to the .syr format.

• Remark: Inside the SYRTHES Graphical USer Interface (Gui), we can load the SIMAIL format *.des for the solid mesh. This one will be automatically transformed to the *.syr format.

It can also be done with the following command line:

```
$ convert2syrthes4 -m 3rond2d.des
```

• Remark: You can convert the ***.syr** format into a ***.med** format. Like that, you can load the ***.med** file inside SALOME, after having used this command line below:

\$ syrthes4med30 -m 3rond2d.syr -o 3rond2d.med

ግ 🗁 🖎 🃭 🔊 📄	Run SYRTHES 📀 Stop SYRTHES 🔕 Calculation Pr	oaress
Home File Names © Conduction User C functions Control Output Running options	Conduction input file name and location Conduction mesh: 3rond2d.syr Radiation mesh: Restart File : Weather data (optional) : Conduction output files names prefix and location Results names prefix : resul	

Figure II.5: Choose a name for the results files .res, .his and .rdt

T 🖆 🖄 📭 🔊 📄				Run SYR	THES 🕑 Sto	op SYRTHES 🔕 🛛 Calculatio	on Progress 🗦
Home File Names	Initia	al temperat	ure	e (Deg C)			
✓ Conduction		Туре		Temperature	References	User comment	s 🔒
Initial conditions	V	Constant	\$	20	-1	20 °C everywhere	=
Boundary condit Physical properti	V	Constant	٥)			
Volumetric cond	V	Constant	0				
Periodicity	4	C	1.	Í.			
User C functions	<		_				
Control							
Output							
Running options							

Figure II.6: Define the initial temperature conditions inside the different disks.

] 들 📐 📴 🔍 Home				Run Si	KIRES	Stop St	RTHES 🔕 🛛 Calculati	on Progress
File Names	Heat	exchange	Flu	x condition	Dirichlet	t condition	Contact resistance	Infinite ra
Conduction Initial conditions	Heat	t exchange	со	efficient (W/	m²/Deg (C)		
Boundary condit		Туре		External T	Coef h	References	User comm	ents 🗎
Physical properti	V	Constant	0	90	1000	258	extern faces of di	sks
Volumetric cond Periodicity		Constant	0)				
User C functions		Constant	\$					
Control	V	Constant	\$]				
Output Running options		Constant	0)				
Running options	<							>

Figure II.7: Define the temperature boundary conditions for the extern face of the three disks.

8		SYRTHES	V 4.0	.0 - u	ntitle	d.syd	
File Tools Preferences	<u>H</u> elp						
📑 🗁 🎦 📷			Ru	n SYR	THES	🕑 S	top SYRTHES 🔕 Calculation Progress 🖉
Home File Names	Isotro	opic Orthotropi	c Anis	otropi	c		
 Conduction Initial conditions 	ρ (k	g/m²), Cp (J/kg/	m³), k :	lsotro	pic co	onduct	tivity (W/m/Deg C)
Boundary condit		Туре	ρ	Ср	k	eren	User comments
Physical properti	V	Constant	7700	460	25	14	isotropic cond. for disk 1 and pipe
Volumetric cond Periodicity	V	Constant)				
User C functions		Constant 🛛 🛇]				
Control	<	r .	×				
Output							
Running options							
< >							

Figure II.8: Define the physical properties for the disk 1 and 4 with isotropic conductivity.

	SYRTHES	V 4.0	.0 - ui	ntitle	d.syd	d		
<u>H</u> elp								
		Ru	ı SYR	THES	د 🔸	Stop SYRTHES	🛿 🕲 Calculation Progre	ess 📈
lsotro	pic Orthotropic	Aniso	otropio	:				
ρ (kg	g/m²), Cp (J/kg/n	n³), kx	ky : 0	rthoti	ropic o	conductivity (W/m/Deg C)	
	Туре	ρ	Ср	kx	ky	References	User comments	
V	Constant 🔹	7700	460	25	5	2	orthotropic disk 2	H II
	Constant 😒)						
V	Constant 🔷)						
	iž , š		1	1		i		
	sotro ρ(kg	Help Isotropic Orthotropic ρ (kg/m ²), Cp (J/kg/r Τype Ο Constant ο Constant ο	Help Run Isotropic Orthotropic Anise ρ (kg/m²), Cp (J/kg/m³), kx Τype ρ Ο Constant 0 7700 Constant 0	Help Run SYR Isotropic Orthotropic Anisotropic ρ (kg/m ²), Cp (J/kg/m ³), kx ky : O Γυρφ ρ Cp Ο Constant ο 7700 460 Ο Constant ο	Help Run SYRTHES Isotropic Orthotropic Anisotropic ρ (kg/m²), Cp (J/kg/m³), kx ky : Orthotr τype ρ Cp kx Constant ο 7700 460 25 Constant ο 100 460 25	Help Run SYRTHES ≥ S Isotropic Orthotropic Anisotropic ρ (kg/m²), Cp (J/kg/m³), kx ky : Orthotropic of ∇ype ρ Cp kx ky Ø Constant 0 7700 460 25 5 Ø Constant 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Run SYRTHES ● Stop SYRTHES Isotropic Orthotropic Anisotropic ρ (kg/m²), Cp (J/kg/m³), kx ky : Orthotropic conductivity (Type ρ Cp Ø Constant 7700 460 25 5 Ø Constant 0 0 0 0 Ø Constant 0 0 0 0 Ø Constant 0 0 0 0 Ø Constant 0 0 0 0	Help Run SYRTHES Stop SYRTHES Calculation Progra Isotropic Orthotropic Anisotropic ρ (kg/m²), Cp (J/kg/m³), kx ky : Orthotropic conductivity (W/m/Deg C) V Type Ø Constant Ø Constant

Figure II.9: Define the physical properties for the disk 2 with isotropic conductivity.

• **Remark**: To correctly identify the volume references associated to a specific physical property, we can check the mesh regions directly inside ParaView after having used following command line:

B /		SYRTI	IES V	4.0.	0 - u	ntitl	ed.syd		
File Tools Preferences	<u>H</u> el	p							
📑 🖆 🏝 🌆				Run	SYR	THE	S 📀 Stop SYR	THES 🔕 🛛 C	alculation Progress
Home File Names	Iso	tropic Orthoti	opic	Aniso	tropi	с			
 Conduction Initial conditions 	ρ	(kg/m²), Cp (J/	kg/m³), kx	ky : A	nisot	ropic conducti	vity (W/m/D	Deg C)
Boundary condit		Туре	ρ	Ср	kx	ky	Angle (in Deg)	References	User comments 🔒
Physical properti	F	Constant ≎	7700	460	25	5	45	3	Anisotr. disk 3
Volumetric cond Periodicity		☑ Constant ≎							
User C functions	E	Constant≎							
Control	<								
Output									
Running options									

Figure II.10: Define the Physical properties for the disk 3 with anisotropic conductivity.

	SYRTHES V 4.0.0 - solidalone.syd
File Tools Preferences	Help
📑 🖆 🏝 🌗 🔊	Run SYRTHES 📀 Stop SYRTHES 🔇 Calculation Progress 📈
Home File Names ~ Conduction	Time management Solver information
Initial conditions Boundary condit	Restart Management Restart calculation Setting a new restart time(in second) 1.e-6
Physical properti Volumetric cond	Time step management Global number of time steps : 100
Periodicity User C functions	Time step : Constant 🔹
Control Output	Time step (in secc 10
Running options	

Figure II.11: Define the global number of time steps and the time step for the 2D solid conduction computation.

• 🖅 🗛 📖 🛌 l							
] 🗁 🖄 🚺 🔍				Ri	IN SYRTHES 🕑	Stop SYRTHES 🔯	Calculation Progress 🧏
Home File Names	Prol	oes	Result fie	elds Surfa	ace balance Vol	ume balance	
 Conduction Initial conditions 	Fre	eque	ency of ou	Itput	Every n time st	eps 💠 10	
Boundary condit	De	finit	ion by co	ordinates			
Physical properti x			у		User Commer	its 🔒	
Volumetric cond Periodicity	1		0.003	-1.2	disk1		
User C functions	2						
Control	3	V					
Output	4	V					~
Running options	<				III		\supset

Figure II.12: Define the probe coordinates for output management.

e <u>T</u> ools Preferences	Help	
🖆 📐 📴 🔤	Run SYRTHES 📀 Stop SYRTHES 🔕 Calculation Progres	s
Home File Names Conduction	Probes Result fields Surface balance Volume balance	
Initial conditions	Frequency at which the result fields are written in the intermediate result file (ex	ct
Boundary condit	☑ Fields Every n time steps ♀ 25	
Physical properti		
Volumetric cond		
Periodicity		
User C functions		
Control		
Output		
Running options		

Figure II.13: Define the frequency at which the results fields are written

B ,	SYRTHES V 4.0.0 - untitled.syd
File Tools Preferences	s <u>H</u> elp
📑 🗁 🏝 🖬	Run SYRTHES 📀 🛛 Stop SYRTHES 🔕 🛛 Calculation Progress 📈
Home	
File Names	
 Conduction 	Scalar/ Parallel calculation : number of processor used for conduction :
Initial conditions	Scalar/ Parallel calculation : number of processor used for radiation :
Boundary condit	
Physical properti	
Volumetric cond	Listing name: listing
Periodicity	
User C functions	
Control	Advanced options
Output	Domain partitioning : automatic mesh partitio 🗧
Running options	Convert result for softwares Ensight/Paraview 🗧
	Run SYRTHES 🕑

Figure II.14: Define the file name of the SYRTHES listing and the number of processors used.

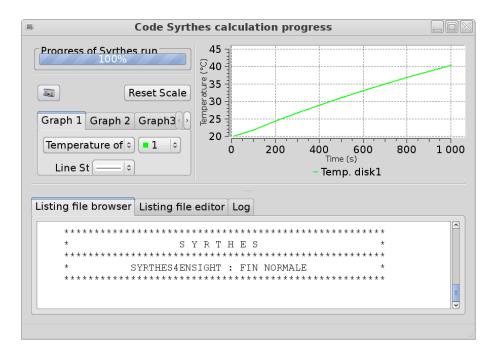


Figure II.15: Screenshot of the computation progress window.

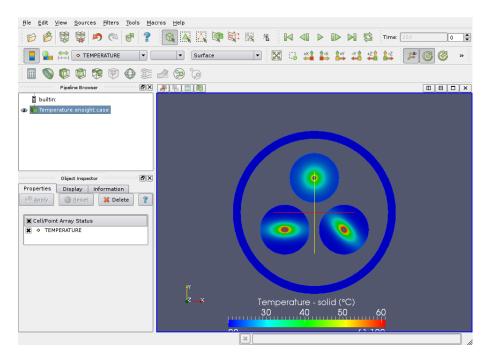


Figure II.16: Screenshot of the 2D solid temperature Field.

• **Remark**: We can visualize the temperature results fields by applying the following command line to the results file resul.res or resul.rdt (for the results saved at the last time step or the results saved at each time step):

```
$ syrthes4ensight -m 3rond2d.syr -r resu1.res -o Results_Temp
$ syrthes4ensight -m 3rond2d.syr -r resu1.rdt -o Chrono_Temp
```

1.2 Launching the *Code_Saturne* **computation alone**

- The preparation of the fluid computation alone for case5 is defined below:
- Step 1: launch the Code_Saturne Graphical User Interface (./SaturneGUI),
- Step 2: open a New case,
- Step 3: check the quality of the fluid mesh with the check_mesh,
- Step 4: define the initial and boundary conditions for the air flow problem,
- Step 5: define the physical properties of the disk for the air flow,
- Step 6: running the *Code_Saturne* computation alone.

	3disks2D-fluid-alon	e.xml -	Code_Saturne	GUI	
<u>F</u> ile <u>E</u> dit	<u>T</u> ools <u>W</u> indow <u>H</u> elp				
	🏝 🙆 📴 🥱 🥐 🗷				
					0 X
Study:	3disks2D				
Case:	fluid				
XML file:	local00/home/B16457/Formation-ITECH-CS-20	D12/ITECH	-CS-nov-2012/3di	sks2D/fluid/DATA/3di	sks2D-fluid-alone.xml
	8 B				A
🕞 Ider	ntity and paths	Meshes	Periodic Bounda	ries	
	culation environment	Mesh i			
	leshes selection	⊚ Imp	oort meshes 🛛 U	se existing mesh inpu	it
	lesh quality criteria rmophysical models	Loca	mesh directory (ontional)	
	sical properties	/ME			
🕨 🔛 Volu	ume conditions	· ·			
	ndary conditions	List c	of meshes		
	nerical parameters		File name	Format	Reorient
	culation management	Зro	nd2d_fluide.des	Simail/NOPO	
	-				
		Face jo	ining (optional)		
		-	ion Plane Verb		Selection criteria
				+ -	
		□ Subc	livide warped fa	2005	
		🗆 Mest	n smoothing		~
Click righ	t for context menu				

Figure II.17: Choose the fluid mesh with Code_Saturne (GUI)

B 3disks2D-fluid-a File Edit Tools Window Help	lone.xml - Code_Saturne GUI	
I 🗋 🖆 🙆 🚺 🥱 🕐 I 🗷		
		12
Study: 3disks2D		
Case: fluid		
XML file: local00/home/B16457/Formation-ITECH-C	S-2012/ITECH-CS-nov-2012/3disks2D/fluid/DATA/3disks2D-	fluid-alone.xml
	Steady/Unsteady flow algorithm	
Identity and paths Calculation environment	unsteady flow	0
Calculation environment Meshes selection		
Mesh guality criteria	Eulerian-Lagrangian multi-phase treatment	
Thermophysical models	off	0
Calculation features		
🕒 Deformable mesh	Atmospheric flows	
Turbulence models	off	0
🕒 Thermal model	Gas combustion	
Radiative transfers		
🗈 Conjugate heat transfer	off	0
Species transport	Pulverized fuel combustion	
B Physical properties B Volume conditions	off	0
Boundary conditions		
 Boundary conditions Numerical parameters 	Electrical models	
Calculation control	off	0
> Calculation management	(
	Compressible model	
	off	0
Click right for context menu		

Figure II.18: Define the physical modelling associated to the air flow inside the fluid domain.

5	3disks2D-fluid-a	lon	e.xml - Code_S	aturne GUI	
<u>File</u> <u>E</u> dit	t <u>T</u> ools <u>W</u> indow <u>H</u> elp				
I 📑 📹	🕭 🔕 🎼 😙 🥐 💷				
					2 8
Study:	3disks2D				
Case:	fluid				
XML file	e: local00/home/B16457/Formation-ITECH-CS	5-20	12/ITECH-CS-nov-	2012/3disks2D/fluid/DATA/3disks2	D-fluid-alone.xml
		3 (8)	Thermal scalar		
	entity and paths			Temperature (Celsius)	
	Iculation environment			Temperature (census))
	Meshes selection				
	Mesh quality criteria				
	ermophysical models Calculation features				
	Calculation reatures Deformable mesh				
	Turbulence models Thermal model				
	Radiative transfers				
	Conjugate heat transfer				
	Species transport				
	ysical properties				
	lume conditions				
	undary conditions				
	merical parameters				
	Iculation control				
	Iculation management				
4	н				

Figure II.19: Choose the Temperature scalar.

	3disks2D-fluid-alone.xml - Code_Saturne GUI						
1 🗋 🖌	2 0 De 1 3 C 1	a.					
					8 (
Study:	3disks2D						
Case:	fluid						
XML file:	local00/home/B16457/F	ormation-ITECH-CS-20	12/ITECH-CS-nov-2012/3disk	s2D/fluid/DATA/3disks2I	0-fluid-alone.xml		
	(
		8	Density				
	ntity and paths		user law		•		
	ulation environment						
	leshes selection lesh quality criteria		Reference value	ρ 1.17862	kg/m ³		
	rmophysical models		Viscosity				
	alculation features		constant		0		
	eformable mesh						
	urbulence models		Reference value	μ 1.83e-05	Pa.s		
	hermal model		Conselfin hand				
	adiative transfers		Specific heat				
	onjugate heat transfer		constant				
	pecies transport sical properties		Reference value	Cp 1017.24	J/kg/K		
	eference values						
	luid properties		Thermal conductivity				
🕒 G	ravity		constant		0		
	ime conditions		Reference value	λ 0.02495	W/m/K		
	ndary conditions	Mathematica	l expression editor	a			
	nerical parameters						
	culation control culation management	User expression Pre	edefined symbols Examples				
	ulation management	rho = p0 / (287*	(TempC + 273.0));				
0			Annuler OK				

Figure II.20: Define the variable density with a ideal gas law inside the *Code_Saturne* (GUI).

5	3	disks2D-fluid-alon	e.xml - Cod	e_Satu	rne GUI		
<u>File</u> <u>E</u> dit	Tools Window Help						
1	🕭 🔕 🗈 😒 🥐 🗈	a					
							28
Study:	3disks2D						
Case:	fluid						
XML file:	local00/home/B16457/F	ormation-ITECH-CS-20	12/ITECH-CS-I	10V-2012	?/3disks2D/flui	d/DATA/3disks2D-fluid-	alone.xml
		88					
- Idor	ntity and paths		Gravity				
	culation environment			g×	0.0	m/s ²	
	leshes selection			a,	-9.81	m/s ²	
	lesh quality criteria						
	rmophysical models			gz	0.0	m/s ²	
	alculation features						
	eformable mesh						
	urbulence models						
	hermal model						
	adiative transfers						
	onjugate heat transfer						
	pecies transport sical properties						
	eference values						
	luid properties						
	ravity						
	ume conditions						
	indary conditions						
	nerical parameters						
	culation control						
Calc	culation management						
	-						
<	11	D					

Figure II.21: Define the gravity

		luid-alone.xml - Code_Saturne GUI
File Fait	<u>T</u> ools <u>W</u> indow <u>H</u> elp	
I 🗋 🚰	🕭 🙆 📴 😒 🥐 🗷	
		8
Study:	3disks2D	
Case:	fluid	
XML file:	local00/home/B16457/Formation-IT	ECH-CS-2012/ITECH-CS-nov-2012/3disks2D/fluid/DATA/3disks2D-fluid-alone.xn
		8 8 Initialization
🖪 Ider	ntity and paths	
	culation environment	Volume zone all_cells 🗧
B M	leshes selection	Velocity 😵
🖻 M	lesh quality criteria	
	rmophysical models	Thermal 🕑
	alculation features	Turbulence Initialization by reference value(s)
	eformable mesh	
	urbulence models	
	hermal model	
	adiative transfers	Mathematical expression e
	onjugate heat transfer	· Hachematical expression e
	pecies transport	User expression Predefined symbol
	sical properties	
	eference values	TempC = 20;
	luid properties	
	ravity	
	ume conditions	
	olume regions definition	
	nitialization	
	oriolis Source Terms	
	Indary conditions	
	nerical parameters culation control	Annuler OK
	culation management	
<		2

Figure II.22: Initalization of the velocity components and temperature variables.

.⊪ <u>F</u> ile <u>E</u> dit	Tools Window Help	3disks2D-flu	id-alone.x	ml - Code_9	Saturne G	UI	
i 📑 🗁 i	خ 🔄 🍕 🔕 🕭	a.					
							0
Study:	3disks2D						
Case:	fluid						
XML file:	lc≡ Se	elect a Code_	Saturne F	reprocesso	or listing		idisks2D-fluid-alone.xml
	ITECH-	CS-nov-2012	3disks2D	fluid RESU	check_m	nesh	>
🕒 Ider		Nom			 Taille 	Modifié	tion criteria
V 🖿 Calc		🛯 🖻 postproce	essing			18:37	
P M		Check me	esh.log		15,2 Kio	18:37	
👻 🗎 The	rn 5816457] performa			1,5 Kio	18:37	
Ci Ci	ale Bureau	setup.log			796 octe	ts 18:37	
B D	er	~					
D TI					Preproce	ssor log	
🗈 Ra					Treproce	Joor log	•
C C					Annule	r <u>Q</u> uvrir	•] [
🗎 Sp	pe sical properties						processor listing 🔚
	eference values						
	uid properties						
G	ravity						
	ume conditions						
	olume regions definiti	on					
	nitialization						
	oriolis Source Terms						
	ndary conditions		_				
	efinition of boundary oundary conditions	regions					
	nerical parameters						
	culation control						
C							

Figure II.23: Load the check_mesh.log file inside the *Code_Saturne* (GUI).

16,	3disks2D-flui	-alon	e.xml - C	ode_	Saturne (GUI 🛛 🗋 🗖 🖉	
<u>File</u> <u>E</u> dit	Tools Window Help						
I 📑 🖆 I	🖭 🙆 📭 😒 🕐 🖪						
						0	
Study:	3disks2D						
	fluid						
XML file:	local00/home/B16457/Formation-ITECI	-CS-20	12/ITECH-	CS-no	/-2012/3disk	s2D/fluid/DATA/3disks2D-fluid-alone.xml	
		ßB					
		00	Definitio	on of I	boundary r	eaions	
	tity and paths	-		Zone		Selection criteria	
	ulation environment eshes selection		BC 1		Wall	1	
	esh quality criteria		BC 2		Symmetry	-	
	rmophysical models		DC_2	2	Symmetry	2 01 3	
	alculation features						
	eformable mesh						
Βπ	urbulence models						
E TI	hermal model				_		
	adiative transfers					Add Delete	
	onjugate heat transfer		Add fr	om Pr	eprocesso	r listing	
	pecies transport		Imp	ort gro	ups and refe	erences from Preprocessor listing 🔚	
	sical properties			-			
	eference values						
	uid properties ravity						
	me conditions						
	olume regions definition						
	itialization						
B C	oriolis Source Terms						
🕶 🗎 Bou	ndary conditions						
	efinition of boundary regions						
	Boundary conditions						
	E Numerical parameters						
🕩 🖺 Calc	ulation control	~					
<	ill i						

Figure II.24: Loading the check_mesh.log file automatically defines the boundary regions.

16.	3disks2D-flui	d-alone	e.xml - Co	de_Satu	rne GUI			
<u>File E</u> dit	Tools Window Help							
📑 🚰	🕭 🙆 📴 😒 🥐 🛛 🗷							
								20
Study:	3disks2D							
Case:	fluid							
XML file:	local00/home/B16457/Formation-ITEC	H-CS-201	12/ITECH-CS	-nov-2012	/3disks2D/flu	id/DATA	\/3disks2D-fluid	-alone.xml
		8 X	Boundary	conditio	16			
	ntity and paths		Label	Zone	Nature	Feler	tion criteria	
	culation environment		BC 1	Zone		Jelec	tion criteria	_
	1eshes selection		BC ^T	1	Wall	1		
	1esh quality criteria							
	ermophysical models							
	Calculation features							
	Deformable mesh							
	urbulence models							
	hermal model							
	ladiative transfers		Smooth	or rough	wall			
🖹 C	Conjugate heat transfer			۲	smooth wal	l o rou	gh wall	
🖻 S	pecies transport							
🗢 🗎 Phy	/sical properties	-						
🖹 R	leference values		🗆 Slidii	ng wall				
🖹 F	luid properties							
🗎 G	Fravity		Therma	d I				
👻 🗎 Voli	ume conditions			Ta	e Exchange	coeffic	ient o	
🖻 V	olume regions definition			1.61	Exchange	, coeme	°	
🖹 İr	nitialization		Temp	C 🗢 Val	ue		30.0	
BC	Coriolis Source Terms			-			10.0	
🕶 🛅 Bou	undary conditions			EX	change coeff	icient	10.0	
D	Definition of boundary regions							
	oundary conditions							
	merical parameters							
Cale	culation control							
(

Figure II.25: Define a thermal transfer condition as wall boundary condition with a extern wall temperature $T_{ext} = 30^{\circ}C$ and a exchange coefficient $q_{ext} = 10 \ (W/m^2.K)$.

$Code_Saturne \text{ version } 3.0.0\text{-rc1 tutorial -} \\ Three 2D disks$

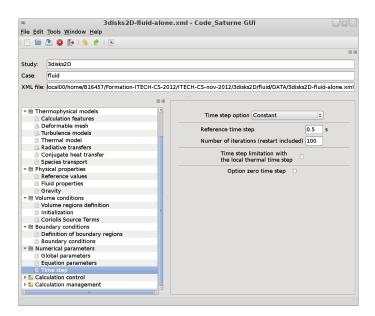


Figure II.26: Define the iterations number and time step.

	3disks2D-fluid-alone.xml - Code Saturne GUI					
<u>File</u> <u>E</u> dit	Tools Window Help					
I 📑 📹	🖭 🙆 🎼 😒 🥐 🛛 🗷					
						20
Study:	3disks2D					
Case:	fluid					
XML file:	local00/home/B16457/Formation-ITECH-C	S-2012/IT	FECH-CS-nov-	2012/3disks	2D/fluid/DATA/3disks	2D-fluid-alone.xml
		38	and Control	10/mitan 84		
	adiative transfers		tput Control	writer Me	esh Monitoring Point	5
	onjugate heat transfer		Name	Id	Format	Directory
	pecies transport		results		EnSight	postprocessing
	sical properties		results	-	Linoight	postprocessing
	eference values					
	luid properties					
	ravity ume conditions	_				
	olume regions definition					
	oriolis Source Terms				+ -	
	ndary conditions					
	efinition of boundary regions	E FI	requency			
	oundary conditions		Output eve	ery 'n' time	steps 0 25	
	nerical parameters		✓ Output a	-		
	lobal parameters		M Output a	t end of cal	culation	
	quation parameters	Ті	me-depende	ency		
	ime step		ine depende	Fixed	mesh	
	culation control			lived	v v	
	ime averages	0	ptions			
	utput control			format	binary (native)	
	olume solution control					
B SI	urface solution control			polygons	display	;
B P	rofiles			polyhedra	display	5
🕨 🔛 Calo	culation management			poryfieura	anabia3	J
<						
Click righ	t for context menu					

Figure II.27: Define the writer and frequency output inside the Code_Saturne (GUI).

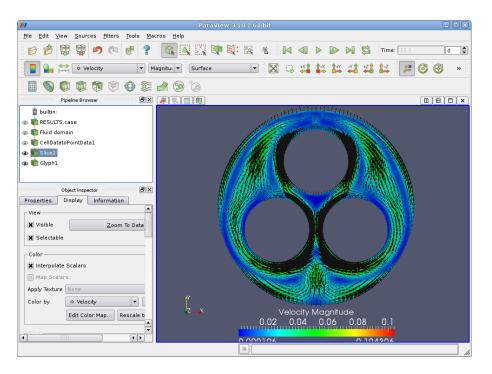


Figure II.28: Visualization of the 2D fluid velocity field

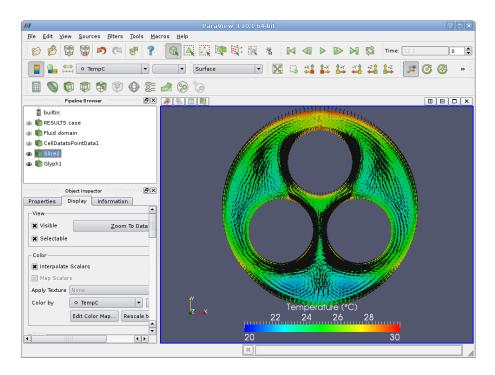


Figure II.29: Visualization of the 2D fluid temperature field

1.3 Launching the Code_Saturne-SYRTHES coupling computation

The last modification to prepare the coupling computation are given below:

- Step 1: activate the conjugate heat transfer in the SYRTHES (Gui),
- Step 2: activate the conjugate heat transfer in the *Code_Saturne* (GUI),
- Step 3: give identical iterations number and time step for both codes,
- Step 4: check the runcase_coupling script and launch it.

	SYRTHES V 4.0.0 - untitled.syd	
<u>File</u> Tools Preferences	s <u>H</u> elp	
📑 🖆 🏝 🚺	Run SYRTHES 📀 Stop SYRTHES 🚳 Ca	alculation Progress 📈
Home File Names Conduction Initial conditions Boundary conditio Physical properties Volumetric conditi Periodicity Conjugate heat trans User C functions Control Output Running options	Case title : 3disks2D - thermal conduction - solid alone User description of the case Dimension of the problem : 2D_cart Additional physical modelling Thermal radiation Humic Heat and moisture transfer Conjugate Heat Transfer	

Figure II.30: Activate the conjugate heat transfer for the solid domain.

		SYRTHES	/ 4.0.0 - untitl	ed.syd)DX
File Tools Preferences	s <u>H</u> elp)					
📑 🖆 🏝 📭 🔊		Ru	n SYRTHES 🕑	Stop S	YRTHES 🔕 🛛 C	alculation Progr	ess 📈
Home File Names	Surf	ace coupling	Volumetric cou	pling			
 Conduction 	Definition of the conjugate heat transfer coupling with CFD codes.						
Initial conditions		Name of t	he CFD code ins	tance	References	Jser commen	t:
Boundary condit Physical properti	V	Code_SaturneCFD			1	coupling zone	
Volumetric cond	V						
Periodicity	V						
Conjugate heat tra							
User C functions Control							
Output							
Running options							

Figure II.31: Specify the reference zone for the coupling surfaces with Code_Saturne.

	SYRTHES V 4.0.0 - untitled.syd				
<u>F</u> ile <u>T</u> ools Preferences <u>H</u> elp					
📑 🔚 📐 🃭 🔊	Run SYRTHES 📀 Stop SYRTHES 🔕 Calculation Progress 📈				
Home File Names Conduction Initial conditions Boundary condit Physical properti Volumetric cond Periodicity Conjugate heat tra User C functions Control	Time management Solver information Restart Management Restart calculatior Restart calculatior Setting a new restart time(in second) Time step management Global number of time steps : 50000 Time step : Constant Time step (in secc 0.5) Setting a new restart time(in second)				
Output Running options					
(III)					

Figure II.32: Change the iterations number and time step for the solid domain.

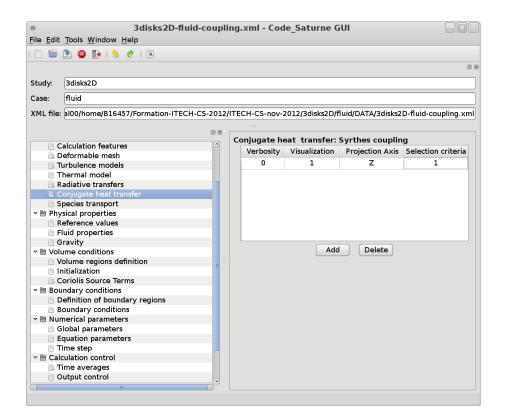


Figure II.33: Activate the conjugate heat transfer for the fluid domain.

Sile Edit	3disks2D-fluid-coupling.xml - Code_Saturne GUI le Edit Tools Window Help							
	🕭 🙆 📴 🏂 👌 🖉 🗷							
							2 (
Study:	3disks2D							
Case:	fluid							
XML file:	al00/home/B16457/Formation-ITECH	-CS-2012/I	TECH-CS-n	ov-2012/3	disks2D/fluid/	/DATA/3disks2D-fluid-	coupling.xml	
	(
	Boundary conditions							
	alculation features	^	Label	Zone	Nature	Selection criteria		
	eformable mesh		BC 1	1	wall	1		
	urbulence models		PC_T	-	Wall	1		
	hermal model							
	adiative transfers							
	onjugate heat transfer							
	pecies transport							
	sical properties eference values							
			Current		h			
	Fluid properties		Smooti	n or roug		I ○ rough wall		
 Gravity Volume conditions 					smooth wai	ii O rough wall		
	olume regions definition							
Initialization		= "	🗆 Slidi	ng wall				
	oriolis Source Terms							
	ndary conditions		Therma					
	efinition of boundary regions		mermit		pe Exchange	ffisiont		
	oundary conditions			(י	pe Exchange	coefficient		
	nerical parameters		Temp	C 🔍 Va	lue	0.0		
🗎 G	lobal parameters			-				
E E	Equation parameters			E	change coeff	icient 0.0		
🖻 Time step								
	culation control							
🔜 Time averages								
0 🖻	utput control	~						
	10							

Figure II.34: Change the boundary conditions for the wall temperature.

	88
Study: 3disks2D	
Case: fluid	
XML file: al00/home/B16457/Formation-ITECH-CS-2012/ITECH-CS-nov-2012/3disks2D/fluid/DATA/3disks2D-fluid-co	oupling.xml
19 10 I	
Calculation reatures	
Deformable mesh	
Thermal model Reference time step 0.5 s	
Radiative transfers Number of iterations (restart included) 50000	
Conjugate heat transfer	
Time step limitation with	
Species transport The scep initiation with a scep initiat	
Fluid properties Option zero time step	
Gravity	
Control of the second secon	
Volume regions definition	
nitialization	
Coriolis Source Terms	
Boundary conditions	
Definition of boundary regions	
Boundary conditions	
v 🖹 Numerical parameters	
🖹 Global parameters	
Equation parameters	
E Time step	
v 🛅 Calculation control	
🖳 Time averages	
Output control	

Figure II.35: Change the iterations number and time step for the fluid computation.

• **Remark**: After having modified the data setting for the fluid and solid domains to activate the conjugate heat transfer on both sides, we just have to increase the iterations number and check the runcase_coupling script.

We just need to edit the runcase_coupling script and give the name of your SYRTHES script saved in the SYRTHES (Gui) as below:

```
$ vim runcase_coupling
> domains = [
>
> 'solver': 'Code_Saturne',
> 'domain': 'fluid',
> 'script': 'runcase',
> 'n_procs_weight': None,
> 'n_procs_min': 4,
> 'n_procs_max': 4
>
> 'solver': 'SYRTHES',
> 'domain': 'solid',
> 'script': 'solid-coupling.syd',
> 'n_procs_weight': None,
> 'n_procs_min': 2,
> 'n_procs_max': 2,
> 'opt' : '-v ens'
>
> ]
```

You just have to launch the runcase_coupling present in the study directory (named in our case 3disks2d) and run the coupling computation, as follows:

```
$ runcase_coupling
```

• **Remarks**: in the **runcase_coupling**, you can specify the processors number for each code (as this example with 4 processors for *Code_Saturne* and 2 processors for SYRTHES) in parallel or just one processor for each code in sequential.

You can specify the ouput results format for SYRTHES with an option (opt) which takes the value -v ens for a 3D fields output with a EnSight format or -v med for a 3D fields output with a SALOME format).