SYRTHES 5 Tutorial

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Chapter 1

Getting started with anisotropic conduction

3disks3d

1.1 What is the problem?

We would like to compute the temperature field inside 3 disks heated in their center. According the disk considered, conductivity is isotropic, orthotropic or anisotropic.

1.1.1 Geometrical description

The solid domain constists in three separated disks with a hole in the center.

Radius of internal holes is 0.05 m and the radius of each disk is 0.4 m.

Geometrical characteristics are shown on figure 5.1

1.1.2 Physical description

Density and specific heat are considered identical for the three disks and set to : $\rho = 7700 \ kg/m^3$ and $C_p = 460 \ J/kg^{\circ}C$ (that could correspond to steel).

Each disk is affected by a different conductivity :

- For the disk 1, conductivity is isotropic : $25 W/m/^{\circ}C$
- For the disk 2, conductivity is orthotropic : 25 $W/m/^{\circ}C$ along the direction x, 5 $W/m/^{\circ}C$ along direction y, and 25 $W/m/^{\circ}C$ along direction z
- For the disk 3, conductivy is anisotropic : (25, 5, 25) $W/m/^{\circ}C$ along the axis of a local system of coordinates being at a 45° with respect to the reference system of coordinates.

1.1.3 Initial conditions and boundary conditions

The initial temperature is $20^{\circ}C$. Boundary conditions are :

- center of the disks : T = 50°C, h = 1000 $W/m^2/°C$
- other surfaces : adiabatic

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FIGURE 1.1 - Sketch of the problem

1.2 How to do that?

1.2.1 To organize the study

We propose in this section an organization for the different files of your study. This is only advice, but advanced users can do as they wish...

- create a new directory for your study : mkdir cas_3disks3d
- go inside : cd cas_3disks3d
- \bullet create a new directory for the creation of the mesh : $\mathtt{mkdir \ salome}$

1.2.2 Creating mesh

If the geometry stays very simple and do not create any trouble, attention must however be paid to the references allowing to identify materials and boundary conditions. We used SALOME to define the geometry and create the mesh.

In the directory mkdir cas_3disks3d/salome, run SALOME:/.../runAppli (the command is depending on your local installation of SALOME. Your are ready to create your mesh. Save your SALOME-study and export your mesh to MED format in this directory.

In order to define the different boundary conditions and material properties, groups of faces and edges have been created.

For that specific case, conduction mesh counts 23667 nodes and 120722 elements (4-nodes tetrahedra).

You can create your own mesh, but below, are described the characteristics of the mesh provided in the SYRTHES distribution :

/..../syrthes5.x/arch/your_arch/share/syrthes/tests/1-cas_3disks3d.

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FIGURE 1.2 – Group names for volumes



FIGURE 1.3 – Group names for surfaces

1.2.3 Create your SYRTHES-study

Go back to the initial directory : cas_3disks3d If not already done : source the SYRTHES environment (Linux only) : source /.../syrthes5.0.1/arch/myarch/bin/syrthes.profile Run the SYRTHES-gui : syrthes.gui

 $Create \ a \ new \ case: {\tt synthes}$

Now, all your calculation will be managed by the SYRTHES Graphic User Interface.

1.2.4 Main view

Give a title to your study. The dimension of the problem is 3D. Save your data file :

1.2.5 File Names

- Click on the next item in the menu on the left : File Names
- Select your conduction mesh : cas_3disks3d/salome/3disks.med

A conversion of the file format is done automatically and you should get the message :

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FIGURE 1.4 – SYRTHES Managing your cases

SYRTHES V.5.0 - syrthes / 3disks3	d.syd	×
	Run SYRTHES 🕟 Stop SYRTHES 🔇 Calculation Progress	Μ
Home File Names Conduction User C functions Control Output Running options	Case title : 3disks3d User description of the case	

FIGURE 1.5 - Syrthes Main View

Open Ctrl+0		Run SYRTHES 🕞 Stop SYRTHES 🔯 Calculation Progress
Save Ctrl+S Save as	Case title :	3disks3d
Quit Ctrl+R		User description of the case
Physical properties Volumetric conditions Periodicity User C functions		V4.1
Control Output Running options	Dimension of	the problem : 3D
	Additional p	otysical modelling radiation / Heat and moisture transfer
	🗌 Conjuga	te Heat Transfer

FIGURE 1.6 - SYRTHES Save your data file



FIGURE 1.7 – SYRTHES File format conversion OK

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Finally, give a name for your results files (a name without extension; SYRTHES will create different files with the same radical but different extensions depending on the type of files).

The file Names looks as shown below :

File Loois Preferences Help		Run SYRTHES 🕞	Stop SYRTHES 🔕	Calculation Progress 📈
Home File Names Conduction Initial conditions Boundary conditions Physical properties Volumetric conditions Periodicity	Conduction input file name ar Conduction mesh: Radiation mesh: Restart File : Weather data (optional) :	nd location		
Control Output Running options	Conduction output files name Results names prefix : resul	s prefix and location ——		
Screenshot	1			

FIGURE 1.8 – SYRTHES File Names window

1.2.6 Input data for conduction computation

1.2.6.1 Group names and references numbers

While SALOME is using group names to distinguish different parts in the mesh, SYRTHES is using reference numbers. Group names and reference numbers are included in the mesh file 3disks.med. The links between both are given in an additional file (.syr_descr) created while converting the MED file to the SYRTHES file. You can open this ASCII in the SYRTHES GUI : menu "Tools" and "Open Desc".

WARNING : depending on SALOME version, pairs (group-name, number) could change. So make sure you have a look on the description file and adapt numbers before proceeding.

Here is 3disks.syr_desc provided file :

group_of_faces	10	disk1_centre
group_of_faces	11	disk1_border
group_of_faces	12	disk1_up
group_of_faces	13	disk3_down
group_of_faces	14	disk3_centre
group_of_faces	15	disk3_border
group_of_faces	16	disk3_up
group_of_faces	17	disk2_down
group_of_faces	18	disk2_centre
group_of_faces	19	disk2_border
group_of_faces	20	disk2_up
group_of_volumes	6	vol_disk1
group_of_volumes	7	vol_disk3
group_of_volumes	8	vol_disk2
group_of_faces	9	disk1_down

1.2.6.2 Initial conditions

Unroll the conduction menu by clicking on the arrow, and select the first item : Initial conditions

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Set the initial temperature $(20^{\circ}C)$, and the list of volumes considered (6 7 8). If all the volumes are affected by the same initial condition, you can put "-1" instead of an explicit list. You can add a comment in the last column (optional).

Home File Names Conduction Initial conditions Boundary conditions Physical properties Volumetric conditions Periodicity User C functions Control Output Running options Initial temperature (Deg C) Initial te				Run SYRTHE	S 🕞 Stop SYRTHES 🔕 Calculation Pro	gress
Conduction Type Temperature References User comments 1 Boundary conditions Physical properties 20 -1 20 degrees for all the disks 1 Physical properties Image: Constant ↓ 20 -1 20 degrees for all the disks 1 User C functions Image: Constant ↓	Home File Names	Initial temperature (I	Deg C)			
Boundary conditions Physical properties Volumetric conditions Periodicity User C functions Control Output Running options	✓ Conduction	Type	Temperature	References	User comments	12
Physical properties Image: Constant \$ Image: Const	Boundary conditions	🔽 Constant 🗘	20	-1	20 degrees for all the disks	
Periodicity Image: Constant (c)	Physical properties Volumetric conditions	🗹 Constant 🗘				
Control Output Running options	Periodicity User C functions	🗹 Constant 💲				
Output Running options	Control	Constant 🗘				
Running options	Output					

Figure 1.9 - syrthes - Initial conditions

1.2.6.3 Boundary conditions

We now want to set an heat exchange coefficient at the center of the 3 disks. The values of the boundary condition are the same for the 3 disks, therefore you can define it with only 1 line.

- External temperature = $50^{\circ}C$
- Heat exchange coefficient = $1000 W/m^2/^{\circ}C$
- References of the faces concerned : 10 18 14 (disk1_centre,disk2_centre,disk3_centr,)

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] 🔄 🕭 🚺 🔤				Run S	YRTHES 🕑	Stop SYRTHES 🚫 Calculation F	Progress
Home File Names ▼ Conduction Initial conditions	Heat exch	ange Flux hange coel	condition fficient (W/m	Dirichlet 2/Deg C)	condition Co	ntact resistance Infinite radiatio	on
Physical properties		Туре	External T	Coef h	References	User comments	
Volumetric conditions		onstant 💲	50	1000	101814	centers of the disks	3
User C functions	✓ C	onstant 韋					
Control Output		onstant 韋					
Running options	⊮ c	onstant 🗘					
	I C	onstant 💲					_
	1						

FIGURE 1.10 – SYRTHES - Boundary conditions

1.2.6.4 Physical properties

The disks have different material properties.

For the first disk, conductivity is isotropic : click the Isotropic tab and set the material properties. The elements reference is 6 (group vol_disk1) for the disk 1.

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Home			-,		_			
File Names	Isotropio	Orthotropi	c Ani	sotropi	с			
✓ Conduction								
Initial conditions	o (ka/r	n³) Cn (I/ka/F		k · Isot	ronic c	onductivity (W	(m/Deg C)	
Boundary conditions	p (reg/	n n op omgre	eg en		i opici c	onductivity (11)	in, bog of	
Physical properties		Туре	ρ	Ср	k	References	User comments	
Volumetric conditions		Constant C	7700	460	25	6	disk 1	Ξ
Periodicity						-		
User C functions	V	Constant 🗘						
Control		. · ·			1	1	1	_
Output	<							>
Running options								

FIGURE 1.11 – SYRTHES - Isotropic conductivity

For the second disk, conductivity is orthotropic : click the Orthotropic tab and set the material properties. The elements reference is 7 (group vol_disk2) for the disk 2.

For the last disk, conductivity is anisotropic : click the Anisotropic tab and set the material properties. The elements reference is 8 (group vol_disk3) for the disk 3.

In this case we have to define the values of the conductivity in a local system of coordinates.

Now all physical parameters are defined, for this simple case you can jump directly to the Control Window.

1.2.7 Control

We have to set the time step since we are dealing with a thermal transient (the converged solution has no interest, indead all disks will reach a uniform temperature). The time step has to stay reasonnable, if a fair precision is required during the transient, indeed the time error is more or less proportionnal to the time step retained. In the present case, and considering the mesh, a time step from 10s to 100s seems

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Home			_							
File Names	Isotropi	c Orthotrop	ic Ani	sotropi	с					
✓ Conduction			_							
Initial conditions	o (ka/	mª). Cp (I/ka/I	Dea C).	kx ky k	z : Ortho	otropic o	onducti	vity (W/m/Deg	c)	
Boundary conditions	P trigs								-,	
		Туре	ρ	Ср	kx	ky	kz	References	User comments	
Volumetric conditions	V	Constant 🗘	7700	460	25	5	25	8	disk 2	=
Periodicity						-				
User C functions		Constant C	J							
Control										5
Output										
Running options										

FIGURE 1.12 – SYRTHES - Orthotropic conductivity

le Tools Preferences Help														Run SYI	THES (Sto	p syrthes 🔀	Calculation Pro	gres
Home File Names ♥ Conduction Initial conditions	Isotrop p (ki	pic Orthotrop g/m³), Cp (J/kg/	ic An Deg C)	isotropi , kx ky k	ic Iz : Aniso	otropic c	onduct	ivity (W/	n/Deg C	:)									
Boundary conditions		Type	-	Cp	kx	kv	kz	ux	uv	uz	VX	w	VZ	WX	WV	WZ	References	User comment	s
Volumetric conditions	V	Constant \$	7700	460	25	5	25	1	1	0	-1	1	0	0	0	1	7	disk 3	=
User C functions		Constant 🗘																	
Control	<u> </u>																		\rightarrow
Output																			
Bunning options																			

FIGURE 1.13 – SYRTHES - Anisotropic conductivity

reasonnable.

For your first run, you can compute 100 time steps. An average time step for this case is around 50 seconds.

🗀 🔄 🔄 💽	Run SYRTHES 🕟 Stop SYRTHES 🔯 Calculation Progress 💒
Home File Names © Conduction Boundary conditions Deviation of the second Physical properties Volumetric conditions Pariodacity User C functions Control Output Running options	Time management Restart Management Restart calculation Setting a new restart time(in second) 1.e-6 Time step management Global number of time steps : 100 Time step : constant (\$ Time step (in seconds) : 50

FIGURE 1.14 – SYRTHES - Control window

Generally, there is no need to change the default values provided for the solver.

1.2.8 Output

In this section, we are going to define the type of results to be generated by SYRTHES.

Whatever the options you will have a result file with the temperature on all nodes of the mesh.

But, sometimes, it is also advisable to define some thermal probes : during the run, you will be able to follow the temperature evolution at some strategic points of your domain.

Set the coordinates of points in your domain. Here we have selected just 1 point per disk.

Then, define the frequency you want to save the values of the probes on file : here, 1 means " every time step".

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i 🖆 🖄 📭 🗐			R	un SYRTH	IES 🕟 St	op SYRTHES 🔕 Calculation Pro	gress
Home		_					
File Names	Prob	es	Result fiel	ds Surfa	ce balance	Volume balance	
Initial conditions	Ero	au 0 r	ov of outr	t. []		stops 1	
Boundary conditions	ne	quei	icy of outp	ur li	Every IT time	steps v	
Physical properties	Def	initio	on by coor	dinates			
Volumetric conditions						Licer commonte	
Periodicity			×	У	2	Oser commencs	_
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Control	2	\mathbf{V}	1.1	0	0.1		
Output	2		0.6	1	0.1		-
Running options	3	N.	0.6	1	0.1		- 11
	4	\checkmark					~
	<						

Figure 1.15 - syrthes - Defining thermal probes

Click on the next tab in the same window (Control) to select "result fields".

At the end of the calculation, you will get of course the temperature field corresponding to the last time step. But, you can also get intermediate results with a choosen frequency. Click "Fields" and set the frequency to 25 : you will get the temperature every 25 time steps.

These temperature fields will be recorded in the ".rdt" file and will be post-processed like the final result (".res" file).

<u>File</u> Tools Preferences <u>H</u> elp	
📑 🖆 🏝 📘	Run SYRTHES 🅟 Stop SYRTHES 🔕 Calculation Progress 🗾
Home File Names Conduction Initial conditions Boundary conditions Physical properties Volumetric conditions Periodicity User C functions Control Output Running options	Probes Result fields Surface balance Volume balance Frequency at which the result fields are written in the intermediate result file (extension ".rdt"): Image: Treguency at which the result fields are written in the intermediate result file (extension ".rdt"): Image: Treguency at which the result fields are written in the intermediate result file (extension ".rdt"): Image: Treguency at which the result fields are written in the intermediate result file (extension ".rdt"): Image: Treguency at written steps Image: Treguency at written steps Image: Treguency at written steps Image: Treguency at written steps Image: Treguency at written steps Image: Treguency at written steps Image: Treguency at written steps Image: Treguency at written steps Image: Treguency at written steps Image: Treguency at written steps Image: Treguency at written steps Image: Treguency at written steps Image: Treguency at written steps Image: Treguency at written steps Image: Treguency at written steps Image: Treguency at written steps Image: Treguency at written steps Image: Treguency at written steps Image: Treguency at written steps Image: Treguency at written steps Image: Treguency at written steps Image: Treguency at written steps Image: Treguency at written steps Image: Treguency at written steps Image: Treguency at written step
Screenshot	

FIGURE 1.16 – SYRTHES - Defining transient result file

1.2.9 Running options

This is the last step : give a name for the listing file. SYRTHES will give you some information about the calculation (option summary, solver convergence,...)

Furthermore, according the kind of computer at your disposal and how big is the case, you can try a parallel computation, setting the number of processors to 3 or 4 (but here, as the element number of this mesh is very low, the benefit in term of CPU time will be very low).

1.2.10 You're ready to run SYRTHES!

Click "Run SYRTHES", the "calculation progress" window appears and you can display the evolution of the temperature at the 3 points defined previously.

- The 3 tabs display :
- Listing file browser : displays the 200 last lines of the listings
- Listing file editor : whole SYRTHES listing file

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<u>File</u> Tools Preferences <u>H</u> elp	
📑 🖆 🕭 📷	Run SYRTHES 📀 Stop SYRTHES 🔕 Calculation Progress 📈
Home File Names Conduction Initial conditions Boundary conditions Physical properties Volumetric conditions Periodicity User C functions Control Output Running options	Scalar/ Parallel calculation : number of processor used for conduction : 1 Scalar/ Parallel calculation : number of processor used for radiation : 1 Listing name: listing Advanced options Domain partitioning : automatic mesh partitioning using SCOTCH Convert result for softwares : Ensight/Paraview Run SYRTHES
Screenshot	

FIGURE 1.17 - Syrthes - Running options window

• Log : system messages (usefull in case of error during user files compilation)

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FIGURE 1.18 – SYRTHES Calculation progress window

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1.2.11 Analyzing the results

When SYRTHES calculation ends, you can visualize the results using a post-processor. For this example, we are using the opensource sofware Paraview, but you can also use Ensight.

1.2.11.1 Final temperature field

Run paraview and open the file : cas_3disks3d/syrthes/POST/resu1.ensight.case It is interesting



FIGURE 1.19 – Temperature field after 5000 s

to note the behaviour difference when using different material physical properties. The isothermals of the disk 1 stay concentric, while for the others, ellipses appear before being affected by the outer boundary conditions. One may underline that in the fully anisotropic case, the ellipses axis are not aligned with the axis of the reference system of coordinates.

1.2.11.2 Transient temperature field

As we selected transient result file (see figure 1.16), we can also post-process this file. Run paraview (or ensight) and open the file:mkdir cas_3disks3d/syrthes/POST/resu1_rdt.ensight.case. Then the temperature field can be visualized at different times : 1250 s, 2500 s, 3750 s, and finally 5000 s.

1.2.11.3 Result files

At the end of the run, in the directory where the SYRTHES calculation has taken place, one should be able to find several files :

- resul.res : final result file
 - Temperature field at the end of the calculation. This file is automatically converted to a post-processor file format (Ensight/Paraview or SALOME-MED) in the POST directory.
- resul.rdt : transient result file Temperature field during the transient. This is an optional file (depending on the output options defined). If existing, it is also automatically converted to a post-processor file format (Ensight/Paraview or SALOME-MED) in the POST directory.

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• resul.his : temperature probes

This file contains the temperature at the probes locations initially defined. This is an "in columns" kind of file.

- column 1 : time
- column 2 : temperature
- columns 3-5 : coordinates (only columns 3-4 in 2D)

The values can also be extracted automatically through an option of the SYRTHES GUI. To help users, a gnuplot command file is also automatically generated.

• resu1.mnx : min-max values

The min and max values of each variable of the calculation and the place where these maximum values are reached during the transient. This is an "in columns" file. Content depends on the type of calculation. The content is described at the beginning of the file.

Each variable is corresponding to a column. This file can be post-processed with a 1D plotter. Example :

1=temps 2=T_min 3=x 4=y 5=z 6=T_max 7=x 8=y 9=z 12=y # 10=rho_min 11=x 16=y 17=z } 13=z 14=rho_max 15=x

- In this file, you will find :
- column 1 : time
- column 2 : minimum of temperature
- columns 3-5 : coordinates where is located the minimum of temperature
- columns 6 : maximum of temperature
- columns 7-9: coordinates where is located the maximum of temperature
- column 10 : minimum of density
- columns 11-13 : coordinates where is located the minimum of density
- columns 14 : maximum of density
- columns 15-16 : coordinates where is located the maximum of density
- resul.add : additionnal file This file is unused in this study. In other cases, you can calculate some specific entities and save them in this file for further graphical post-processing.

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Chapter 2

Conduction and radiation in an oven

plates3d

2.1 Description of the problem?

We want to estimate the temperature field inside an oven in which 7 disks or rings are placed. This purely theorical oven is supposed to be heated at the top while the bottom is maintained at $20^{\circ}C$. 3 different materials have been used :

- steel for the oven,
- copper for the rings,
- granite for the disks.

2.1.1 Geometrical description

The solid domain is constituted of an oven and inside, 4 granite disks and 3 copper rings. The oven is 1.3 m high for a diameter of 0.59 m.

Geometrical characteristics are shown on figure 5.1

2.1.2 Physical description

The physical characteristics of the materials are :

- steel : $\rho = 7700 \ kg/m^3$, $C_p = 460 \ J/kg/^{\circ}C$, $k = 25 \ W/m/^{\circ}C$
- copper : $\rho = 8900 \ kg/m^3$, $C_p = 385 \ J/kg^{\circ}C$, $k = 390 \ W/m/^{\circ}C$
- granite : $\rho=2500~kg/m^3,\,C_p=790~J/kg^\circ C,\,k=2.2~W/m/^\circ C$

2.1.3 Initial conditions and boundary conditions

The initial temperature is $20^{\circ}C$. Boundary conditions are :

- bottom of the oven : $T = 20^{\circ}C$
- top of the oven : $T = 800^{\circ}C$, $h = 1000 W/m^2/{^{\circ}C}$
- other extern surfaces of the oven : adiabatic
- all the surfaces inside the oven : radiation exchange

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FIGURE 2.1 -Sketch of the problem

2.2 How to proceed?

2.2.1 To organize the study

We propose in this section a possible organization for the different files of your study. This is only advice, and more expert users may do as they wish...

- create a new directory for your study : mkdir plates3d
- go inside : cd plates3d
- create a new directory for the creation of the mesh : mkdir salome

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2.2.2 Creating the conduction mesh

We used SALOME to define the geometry and create the mesh.

In the directory mkdir plates3d/salome, run SALOME: /.../runAppli (the command is depending on your local installation of SALOME. Your are ready to create your mesh. Save your SALOME-study and export your mesh to MED format in this directory.

In order to define the different boundary conditions and material properties, groups of volumes and faces have been created.

Here, the conduction mesh counts 186024 elements (4-nodes tetrahedra) and 43152 nodes. The radiation mesh counts 3440 faces (3-nodes triangles).

You can create your own mesh, but below, we describe the characteritics of the mesh provided in the SYRTHES distribution :





FIGURE 2.2 – Group names for volumes

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FIGURE 2.3 – Group names for surfaces

2.2.3 Creating the radiation mesh

The radiation mesh consists in inner surfaces of the oven and surfaces of all the disks and rings. We have created 2 groups of faces to separate the granite with an emissivity of 0.8 and steel and copper with an emissivity of 0.96.

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FIGURE 2.4 – Radiation mesh

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2.2.4 Create your SYRTHES-study

Go back to the initial directory : plates3d If not already done : source the SYRTHES environment (Linux only) : source /.../syrthes4.1/arch/myarch/bin/syrthes.profile Run the SYRTHES-gui : syrthes.gui



FIGURE 2.5 – SYRTHES Managing your cases

Create a new case : syrthes Now, all your calculation will be managed by the SYRTHES Graphic

User Interface.

2.2.5 Main view

Give a title to your study. The dimension of the problem is set to 3D. Click the "Thermal radiation" button to activate the radiation module.

SYRTHES V.5.0 - syrthes / plates3	i.syd
<u>File T</u> ools Preferences <u>H</u> elp	
📄 🗁 🏊 🌗	Run SYRTHES 🕟 Stop SYRTHES 🔇 Calculation Progress 🚽
Home File Names > Conduction User C functions Control Output Running options	Case title : even and plates in 3D User description of the case Dimension of the problem : 3D • Additional physical modelling V Thermal radiation Humidity Heat and moisture transfer Conjugate Heat Transfer Conjugate Heat Transfer SYRTHES 0D fluid flow Transparent media • SYRTHES 1D fluid flow

FIGURE 2.6 – SYRTHES Main View

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Save your data file (either using the main menu or the icon) :

FIGURE 2.7 – SYRTHES Save your data file

2.2.6**File Names**

- Click on the next item in the menu on the left : File Names
- Select your conduction mesh : plates3d/salome/plates3d.med

• Select your radiation mesh : plates3d/salome/plates3d-rad.med For both files, a conversion of a proper format (here from MED to SYRTHES) is done automatically and the you should get the message :



FIGURE 2.8 – SYRTHES File format conversion OK

Finally, provide a name for your results files (a name without extension; SYRTHES will create different files with the same radical but different extensions depending on the type of files). Now, the File Names window should look like :

) 🖆 🖄 💽 🔤 🗌		Run SYRTHES 🕞 Stop SYRTHES 🚫 Calculat	ion Progress
Home		nd location	
File Names	Conduction mesh	/salome/plates3d svr	
Conduction	conduction means	in submorphicessursy.	
Initial conditions	Radiation mesh:	/salome/plates3d-rad.syr	
Boundary conditions			
Physical properties	Restart File :		
volumetric conditions	Weather data (ontional) -		
Periodicity			
Radiation			
Spectral parameters	Conduction output files name	es prefix and location	
View Factor	Results names prefix : resul		
Material radiation properti	[
Boundary conditions			
Solar modelling			
Oser C functions			
Control			
Durping entires			
Running options			

FIGURE 2.9 – SYRTHES File Names window

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2.2.7 Input data for conduction computation

2.2.7.1 Group names and references numbers

While SALOME is using group names to distinguish the different parts of the mesh, SYRTHES is using reference numbers. Group names and reference numbers are included in the mesh file plates3d.med. The links between both are given in an additional file .syr_descr. This file is automatically created (next to the .med file) when the convertion from MED file to SYRTHES file takes place. You can open this ASCII file in the SYRTHES GUI : menu "Tools" and "Open Desc".

WARNING : depending on SALOME version, pairs (group-name , number) could change. So make sure to check your description file and adapt numbers accordingly before proceeding.

Here is plates3d.syr_desc provided file :

10	bord-d3
11	bord-d1
12	dessous
13	dessus
14	couronne
15	Disk1
16	Disk2-int
17	Disk2-ext
18	Disk3-int
19	Disk3-ext
20	Disk4-int
21	Disk4-ext
22	four
6	interne
7	interne_ss_couvercle
8	bords-d4
9	bord-d2
	10 11 12 13 14 15 16 17 18 19 20 21 22 6 7 8 9

Here is the plates3d-rad.syr_desc file content :

group_of_faces	4	steel-copper
group_of_faces	5	granite

2.2.7.2 Initial conditions

Unroll the conduction menu by clicking on the arrow, and select the first item : Initial conditions Set the initial temperature (here $20^{\circ}C$), and the list of volumes considered (15 16 17 18 19 20 21 22). If all the volumes are concerned by the same initial condition, you may set "-1" instead of the explicit list. You can add a comment in the last column (optional).

) 🖆 🕭 🚺 🔍			Run SYRTHE	Stop SYRTHES 🔯 Calculation	n Progress
Home File Names	Initial temperat	ure (Deg C)			
Conduction	Туре	Temperature	References	User comments	A
Boundary conditions	Constar	nt 🗘 20	-1	same temperature everywhere	1
Physical properties Volumetric conditions	Constar	nt 🗘			
Periodicity Radiation	Constar	nt 😂			
User C functions	✓ Constar	nt 🛟			-
Control Output Running options	<u>د</u>				

FIGURE 2.10 – SYRTHES Initial conditions

2.2.7.3 Boundary conditions

We want to set an heat exchange coefficient for the upper surface of the oven and an imposed temperature at the bottom.

Click on the "Heat Exchange" tab and set the external tempaerature and the heat exchange coefficient :

- External temperature = $800^{\circ}C$
- Heat exchange coefficient = 1000 $W/m^{2\circ}C$
- References of the concerned faces : 13 14 (groups : "dessus" + "couronne")

l 🔄 🛃 🚺							Run S	YRTHES 🕑	Stop SYRTHES 🚫	Calculation Progres
Home File Names ♥ Conduction Initial conditions	Heat exe Heat e	change F	lux c	ondition	Dirichlet 2/Deg C)	condition C	ontact resistance	Infinite radia	ition	
Boundary conditions Reveical properties		Type		External T	Coef h	References	. I	Jser comme	nts	×
Volumetric conditions		Constant	÷ 8	00	1000	1314	upper face (grou	p "dessus" +	group "couronne")	
Periodicity N Padiation		Constant								
User C functions		Constant	•							
Control		Constant	-							
Running options	~	Constant	÷							
5 1		Constant	¢							
		~ · ·								
	4									F

FIGURE 2.11 – SYRTHES Boundary conditions : heat exchange

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Click on the "Diriciblet condition" tab and set the imposed temperature :

- Dirichlet $T = 20^{\circ}C$
- References of the faces concerned : 12 (groups : "dessous")

] 🖆 🖄 📭 🔤	Run SYRTHES 🕟 Stop SYRTHES 🔯 Calculation Progress								
Home File Names 7 Conduction Initial conditions	Heat	exchange	Flux	condition	Dirichlet condi	tion Contact resistance	Infinite radiation		
Boundary conditions Physical properties		Тур	e	Dirichlet T	References	User comr	nents		
Volumetric conditions	V	Consta	nt 🛟	20	12	lower part of the oven	3		
▶ Radiation	V	Consta	nt 韋						
User C functions Control	V	Consta	nt 💲						
Output	V	Consta	nt 韋						
Running options		Consta	nt 🌲						
	l lie						•		
	4				4		•		

FIGURE 2.12 – SYRTHES Boundary conditions : T imposed

2.2.7.4 Physical properties

In this case, we have to consider 3 different materials, but all are assumed to be isotropic. Click "Physical properties" in the left menu and be sure to have the "Isotropic" tab selected. Set the values of the physical properties :

<u>File Tools Preferences Help</u>								
📑 🖆 🏝 📕					Run S	SYRTHES 🕑	Stop SYRTHES 🔯 Calculation	Progress 📝
Home File Names ▼ Conduction Initial conditions	Isotropic ρ (kg/m	Orthotropi ³), Cp (J/kg/D	c Ani)eg C),	sotropio k : Isot	ropic c	onductivity (W/	m/Deg C)	
Physical properties		Туре	ρ	Ср	k	References	User comments	A
Volumetric conditions		Constant 💲	7700	460	25	22	Stell for oven (group "four")	3
▶ Radiation	V	Constant 🗘	2500	790	2.2	15 16 18 20	Granite (inner disks)	
User C functions Control		Constant 韋	8900	385	390	17 19 21	Copper (rings)	
Output		Constant 🚊						-
Running options							·	
Screenshot								

FIGURE 2.13 – SYRTHES Material properties

Now all the physical parameters are defined, you can jump directly to the radiation menu.

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2.2.8 Radiation

In this part, you will define all the parameters related to the radiation solver.

2.2.8.1 Spectral parameters

By default, in this simple configuration, we consider only one spectral band. If required for further problems you will be abble to define several spectral bands here, depending on your material behaviour. Even, if only one material must be defined on two bands, all materials will have to be specified for these two bands.

🖆 🖄 🚺 🔤				Run	SYRTHES 🕑 Stop SYRTHES 🔞 Calculation Progress	
Home File Names	SYR	HES Radi	iation Spectra	l Band Definition (v	wave length in m)	
Conduction		Band #	lower Band	upper Band	User comments	4
Radiation	1	1	1e-10	10		1
Radiation Factors	1					
Material radiation properti	1					
Boundary conditions	1					
User C functions	1					
Control	1					
Output	1					
Running options	4					•

FIGURE 2.14 – SYRTHES Spectral bands

2.2.8.2 View factors

For a given surfacic mesh, it is impossible for SYRTHES to determine which part is inside or outside your computational domain (because many mesh generators don't orient properly the faces of a surfacic mesh). For example, if your radiation surfacic mesh is a sphere, do you want to calculate radiation inside the ball, or radiation through the space outside the ball? To give an answer to this problem, it is compulsory to give an "interior point" of the radiation problem. If we come back to the example of the ball, and if you want to calculate the radiation inside the ball, the center of the ball is a good choice for this point. Select the "View Factor" tab and set the coordinates of an inner point : (0, 0.05, 0.2). For more complex cases with shadowing, it is a good idea to locate the inner point at a non-ambiguous position.

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FIGURE 2.15 – SYRTHES Position of the inner point for view factors calculation

It is straightforward to take into account a symmetry for the conduction phenomena (by default a symmetry corresponds to an adiabatic condition for which no boundary condition is required), it is much more difficult for the radiation point of view. Fortunately for users, to handle symmetrical geometries as the present case, you just have to define the position of the symmetry plane.

Click the "symmetry/periodicity" tab and set the coefficients of symmetry plane equation (here y = 0).

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i 🖆 🖄 🚺 🔊 🔤		Ru	n SYRTHES 🜔 Stop SY	'RTHES 🔇 Calculation Progress 📈
Home File Names Conduction Radiation Spectral parameters Radiation Factors Material radiation properti Baundary conditions	Radiation factors Radiation Factors m Radiation Factors m	Symmetry/F anagment : C ethod :	Periodicity Calculation • View Factors method •	
Solar modelling	Internal points coord	linates (in m)	to define connex domains	
Control Output Running options	v 0.05 v 0.05			voinieras voinie

FIGURE 2.16 – SYRTHES View factors

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j 🖆 🏝 🦫 🔊 i						Run	SYRTH	es 🧕	Stop SYRTHES	🔕 Calculation Progress 亅
Home File Names Conduction	Ra Defi	diation fa nition of s	ctors symmet	Symm ry plane	etry/Peri s for rad	odicity iation (a	x+by+	cz+d=	0)	
Spectral parameters		Coef a	Coef b	Coef c	Coef d				User commer	nts
Radiation Factors Material radiation properti Boundary conditions Solar modelling User C functions Control Output Running options			1	0	0	plane	/=0			4
	Den	lx (in m) ly (in	m) Iz ((in m)	Vx	Vv	V7	θ (in degree)	User comments
	V		., .,				.,		- (acg. cc,	
	1									
	1									

FIGURE 2.17 - Syrthes View factors

2.2.8.3 Material radiation properties

In this case, only 1 spectral band is defined (grey material), and we consider 2 different emissivities : 0.8 for steel and copper, and 0.96 for granite.

					Run SYRIF	IES 🕑 Stop SYRI	HES 🔯 Ca	loulation Progress
Home File Names	Mat	erial rad	diation prope	erties				
Conduction		Band	Emissivity	Transmitivity	Reflectivity	Diffuse behaviour	References	User Comments
Radiation	1	1	0.8	0.	0.2	0	5	granite
Badiation Factors	1	1	0.96	0	0.04	0	4	steel an cooper
Material radiation properti	1							
Boundary conditions	1							
Solar modelling	J							
User C functions	Ĵ							
Output	÷							
Bunning options	V							
ranning options	4							•

FIGURE 2.18 – SYRTHES Emissivity definition

2.2.8.4 Boundary conditions

In this section, you have to define how conduction mesh and radiation are coupled together. You must at least define :

- the references of the faces of the radiation mesh coupled with the conduction mesh. In this case, it's quite easy, because all faces are coupled, so we have all the references to set : 4 and 5 (groups "steel-copper" and "granite" in the radiation mesh)
- the references of the boundary faces of the conduction mesh which are coupled with the radiation mesh. In the present case, it corresponds to all boundary surfaces inside the oven : 11 9 10 8 6 7

Now, all physical and geometrical parameters are defined, you can jump to the Control section.

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) 🖆 🖄 🚺 🔤 🛛	Run SYRTHES 🕟 Stop SYRTHES 🔕 Calculation Progress
Home File Names	Conduction/Radiation coupling Imposed temperature Imposed Flux Problem with aperture
Initial conditions	Solid conduction faces references coupled with radiation
Physical properties Volumetric conditions Periodicity	
✓ Radiation	
Spectral parameters	
View Factor	
Material radiation properti	
Boundary conditions	Rediction faces references counted with conduction
Solar modelling	
User C functions	4 5 User comments
Control	
Output	
Running options	

FIGURE 2.19 - Syrthes Coupling conduction and radiation

2.2.9 Control

We want to reach a steady state. This one will be reached after a transient calculation, but since we are not interested by the transient, we can set a fairly large time step. For your first run, you can compute 230 time steps. An average time step for this case is around 300 seconds.

File Tools Preferences Help	
📄 🗁 🏝 📑	Run SYRTHES 📀 Stop SYRTHES 🔇 Calculation Progress 🗾
Home File Names Conduction Initial conditions Boundary conditions Physical properties Volumetric conditions Periodicity Radiation Spectral parameters View Factor Material radiation properti Boundary conditions Solar modelling User C functions Control Output Running options	Time management Solver information Restart Management Restart calculation Setting a new restart time(in second) 1.e-6 Time step management Global number of time steps : 230 Time step : Constant Time step (in seconds) : 300
1 b	
Screenshot	

FIGURE 2.20 – SYRTHES Control window

Generally, there is no need to change the default values for the solver.

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2.2.10 Output

In this section, we are going to define the type of results generated by SYRTHES.

Whatever the options you will have a result file with the temperature on all the nodes of the conduction mesh.

But, sometimes, it is also advisable to define some thermal probes : during the run, you will be able to follow during the calculation the temperature evolution at some strategic points of your domain.

Set the coordinates of points in your domain. Here we have selected 1 point per disk and ring. Then, define the frequency at which you want to record the temperature values of the probes on file : here, 1, which means "every time step".

File Tools Preferences Help					Ru	n SYRTHES (>) Sto	op SYRTHES 🔯	Calculation Progress 📈
Home File Names Conduction Initial conditions Boundary conditions Physical properties	Prob Fre	es quer	Result fie	lds Surf	face balance Every n tim	e Volume balance		
Volumetric conditions	De		x	y	z	User comments		A
▼ Radiation	1	~	0	0.1	0.7	Disk 4		3
Spectral parameters	-		0	0.25	0.7	Ding 4		-
View Factor	2		0	0.35	0.7	Ring 4		
Material radiation properti	3	~	0	0.1	0.56	Disk 3		
Boundary conditions	4	~	0	0.3	0.56	Ring 3		
Solar modelling	5	~	0	0.1	0.44	Disk 2		
User C functions	-		0	0.2	0.44	Ding 2		
Control	0		0	0.5	0.44	Ning 2		
Bupping options	7	-	0	0.075	0.275	Disk 1		-
Ranning options	4							Þ
Screenshot								

FIGURE 2.21 – SYRTHES Defining probes

Click on the next tab in the same window (Control) to select "result fields".

At the end of the calculation, you will get of course the temperature field corresponding to the last time step (unless you have specified otherwise). But, you can also get intermediate results with a chosen frequency. Click "Fields" and set the frequency to 50 : you will get the temperature every 50 time steps. These temperature fields will be recorded in the ".rdt" file and can be post-processed like the final result (".res" file).

] 🗁 🕭 🚺 🔍	Run SYRTHES 🕟 Stop SYRTHES 🔯 Calculation Progress
Home File Names Conduction Initial conditions Boundary conditions Physical properties Volumetric conditions Periodicity Radiation Spectral parameters View Factor Material radiation properti Boundary conditions Solar modelling User C functions Control Output Punning options	Probes Result fields Surface balance Volume balance Frequency at which the result fields are written in the intermediate result file (extension ".rdt") : Image: Trequency at which the result fields are written in the intermediate result file (extension ".rdt") : Image: Trequency at which the result fields are written in the intermediate result file (extension ".rdt") : Image: Trequency at which the result fields are written in the intermediate result file (extension ".rdt") : Image: Trequency at which the result fields are written in the intermediate result file (extension ".rdt") : Image: Trequency at written in the intermediate result file (extension ".rdt") : Image: Trequency at written in the intermediate result file (extension ".rdt") : Image: Trequency at written in the intermediate result file (extension ".rdt") : Image: Trequency at written in the intermediate result file (extension ".rdt") : Image: Trequency at written in the intermediate result file (extension ".rdt") : Image: Trequency at written in the intermediate result file (extension ".rdt") : Image: Trequency at written in the intermediate result file (extension ".rdt") : Image: Trequency at written in the intermediate result file (extension ".rdt") : Image: Trequency at written in the intermediate result file (extension ".rdt") : Image: Trequency at written in the intermediate result file (extension ".rdt") : Image: Trequency at written in the intermediate result file (extension ".rdt") : Image: Trequency at written in the intermediate result file (ex

FIGURE 2.22 – SYRTHES Defining transient result file

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2.2.11 Running options

This is the last step : give a name for the listing file. In that file, SYRTHES will give you some information about the calculation (option summary, solver convergence,...)

Furthermore, you may try a parallel computation, setting the number of processor to 3 or 4 (but, as the number of elements of this mesh is quite small, the benefit in term of CPU time will be low).

T 🖆 🏝 📭 🔍	Run SYRTHES 📀 Stop SYRTHES 🔯 Calculation Progress
Home File Names Conduction Initial conditions Boundary conditions Physical properties Volumetric conditions	Scalar/ Parallel calculation : number of processor used for conduction : 1 Scalar/ Parallel calculation : number of processor used for radiation : 1
Periodicity User C functions Control Output	Listing name: listing
Running options	Advanced options Domain partitioning : automatic mesh partitioning using SCOTCH Convert result for softwares : Ensight/Paraview
	Run SYRTHES 📀

FIGURE 2.23 – SYRTHES Running options window

2.2.12 You're ready to run SYRTHES!

Click "Run SYRTHES", the "calculation progress" window appears and you can display the evolution of the temperature at the points previously defined.

Code Syrthes calculation progress						_ = ×
Progress of Syrthes run 100% Reset Scale Graph 1 Graph 2 Graph 3 Graph 4 History • Temp •	757 665 573 481 296 204 112					
Line Style :	20 300	14040 emp Disk 4 🔳 Te	27780 Tim emp Ring 4	41520 e (s) Temp Disk 3 =	55260 Temp Ring 3	69000
Listing file browser Listing file editor Log Conversion or results Time step 50 (15000.000000 seconds > Reading variable TEMPERATURE Time step 100 (30000.0000000 second > Reading variable TEMPERATURE Time step 150 (45000.0000000 second > Reading variable TEMPERATURE Time step 200 (60000.000000 second > Reading variable TEMPERATURE * SYRTHES4ENSIGHT : FIN NOP) (on nodes) (s) (on nodes) (s) (on nodes) (on nodes) ************************************	****				
			41414			

FIGURE 2.24 – SYRTHES Calculation progress window

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The 3 tabs display :

- Listing file browser : displays the 100 last lines of the listings
- Listing file editor : whole SYRTHES listing file
- Log : system messages (usefull in case of error during user files compilation)

2.2.13 Analyzing the results

When SYRTHES calculation is finished, you can visualize the results using a post-processor. For this example, we are using the open source postprocessor Paraview (but you can also use Ensight or even your own post-processor provided that you have written a conversion tool between the SYRTHES format and your own).

2.2.13.1 Final temperature field

Run Paraview and open the file:mkdir plates3d/syrthes/POST/resu1.ensight.case and visualize the temperature field after 19.17 hours



FIGURE 2.25 – Temperature field after 69000 s

2.2.13.2 Transient temperature field

As we selected the transient result file option (see figure 2.22), we can also post-process this file. Run Paraview and open the file : mkdir plates3d/syrthes/POST/resu1_rdt.ensight.case. Then the temperature field can be visualized at different times : 15000 s, 30000 s, 45000 s, and finally 60000 s.

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FIGURE 2.26 – Temperature field after 15000 s

2.2.13.3 Result files

At the end of the run, in the directory where the calculation has taken place, one should be able to find several files :

- resul.res : final result file Temperature field at the end of the calculation. This file is automatically converted to a postprocessor file format (Ensight/Paraview or SALOME-MED) in the POST directory.
- resul.rdt : transient result file Temperature field during the transient. This is an optional file (depending on the output options defined). If existing, it is automatically convert to a post-processor file format (Ensight/Paraview or SALOME-MED) in the POST directory.
- resu1.his : temperature probes

This file contains the temerature at the probes initially defined. This is an "in columns" file.

- column 1 : time
- column 2 : temperature
- columns 3-5 : coordinates (only columns 3-4 in 2D)
- resul.mnx : min-max values

The min and max values of each variable of the calculation and the place where there are reached. This is an "in columns" file. Content depends on the type of calculation and is described at the beginning of the file.

Each variable is corresponding to a column. This file can be post-process with a 1D plotter. To help users, a gnuplot command file can be also be automatically written thanks to an icon of the calculation progress window. Example :

1=temps 2=T_min 3=x 4=y 5=z 6=T_max 7=x 8=y 9=z
10=rho_min 11=x 12=y 13=z 14=rho_max 15=x 16=y 17=z }
In this file, you will find :

- column 1 : time
- column 2 : minimum of temperature
- columns 3-5 : coordinates where is located the minimum of temperature
- columns 6 : maximum of temperature
- columns 7-9 : coordinates where is located the maximum of temperature
- column 10 : minimum of density

- columns 11-13 : coordinates where is located the minimum of density
- columns 14 : maximum of density
- columns 15-16 : coordinates where is located the maximum of density
- resul.add : additionnal file This file is unused in this study. In other cases, you can calculate some specific entities and save them in this file for further graphical post-processing.

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Chapter 3

Getting started with 1D model SYRTHES fluid model

pipes2_fluid1d

3.1 What is the problem?

We would like to compute the temperature inside a concrete block in which 2 water pipes are going through. Adiabatic conditions are put around the block. Inlet fluid temperature is $10^{\circ}C$ for the first pipe and $40^{\circ}C$ for the second one.

3.1.1 Geometrical description

The solid domain consists in a block whose dimensions are 0.5m x 0.3 m x 0.2 m. Diameter of the pipes is 0.1 m.

Distance between the pipes is 0.15 m.

Geometrical characteristics are shown on figure 5.1



FIGURE 3.1 - Sketch of the problem

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3.1.2 Physical description

Physical properties are :

- Density : $\rho = 2500 \ kg/m^3$
- Heat capacity : $C_p = 1000 \ J/kg^{\circ}C$
- Conductivy $\lambda = 2 W/m/^{\circ}C$

3.1.3 Initial conditions and boundary conditions for the concrete block

The initial temperature is $20^{\circ}C$. Boundary conditions on the external side of the block are adiabatic.

3.1.4 Description of the 1D fluif flow

- Fluid is water :
 - Density : $\rho = 1000 \ kg/m^3$
 - Heat capacity : $C_p = 4185 \ J/kg^{\circ}C$
 - Dynamic vicosity : $\mu = 0.1 Pa.s$
 - Conductivy $\lambda = 0.6 W/m/^{\circ}C$
- Flow rates at the inlet are set to 1 kg/s for both pipes.
- Initial and inlet temperatures are :
 - pipe $\#1:10^{\circ}C$
 - pipe $#2:40^{\circ}C$

3.2 How to do that?

3.2.1 To organize the study

We propose in this section a possible organisation for the different files of your study. This is only a piece of advice, but expert users can do as they wish...

- create a new directory for your study : mkdir mycase_pipes2
- go inside : cd mycase_pipes2
- $\bullet\,$ create a new directory for the creation of the mesh : ${\tt mkdir\,\,mesh}$

3.2.2 Creating meshes

Here, even if the geometry stays very simple and do not create any trouble, attention must however be paid to the references allowing to identify materials and boundary conditions.

We used SALOME to define the geometry and create the mesh. Two meshes have to be built : a 3D mesh

with tetrahedra for the structure (concrete block), and one a 1D one (containing only edges) for the fluid flow. Meshes are independent and have to be saved in separated files.

In the directory mkdir mycase_pipes2/mesh, run SALOME, create your geometry and mesh. Save your SALOME-study and export your mesh to MED format in this directory.

You can create your own mesh, but below, we describe the characteritics of the mesh provided in the SYRTHES distribution :

/..../syrthes5.x/arch/your_arch/share/syrthes/tests/3-cas_pipes2_fluid1d.

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FIGURE 3.2 – 3D mesh and volumic/surfacic groups



FIGURE 3.3 - 1D mesh and groups

3.2.3 Create your SYRTHES-study

Go back to the initial directory : mycase_pipes2 If not already done : source the SYRTHES environment (Linux only) : source /home/.../syrthes5.x/arch/myarch/bin/syrthes.profile Run the SYRTHES-gui : syrthes.gui

Create a new case : synthes

Now, all your calculation will be managed by the SYRTHES Graphic User Interface.

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FIGURE 3.4 – SYRTHES Managing your cases

3.2.4 Main view

Give a title to your study. The dimension of the problem is 3D.

Check the dimension of the problem : 3D

Select an additional physical modelling : "SYRTHES 1D fluid flow"



FIGURE 3.5 – SYRTHES Main View

Save your data file ("file", "save as") as pipes2.syd.

3.2.5 File Names

- Click on the next item in the menu on the left : File Names
- Select your conduction mesh : mycase_pipes2/mesh/Structure.med
- Select your 1D fluid mesh : mycase_pipes2/mesh/Fluid.med

A conversion of the file format is done automatically and you should get the following message for both files :

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FIGURE 3.6 - Syrthes File format conversion OK

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EDF R&D	Tutorial	version 1

Finally, give a name for your results files (a name without extension; SYRTHES will automatically create different files with the same radical but different extensions depending on the type of files).

The file Names should look as shown below :

Image: Conduction input file name and location Home File Names Conduction input file name and location Oudput Viser C functions Output Running options Conduction output files names prefix and location Conduction mesh: Weather data (optional): Conduction output files names prefix and location	SYRTHES V 5.0 - syrthes / untitled File Tools Preferences Help	d.syd			- • ×
Home Conduction input file name and location Field Startes Conduction input file name and location SyRTHES 1D fluid flow Conduction mesh: User C functions Conduction mesh: SyRTHES 1D fluid mesh: /mesh/Structure.syr SyRTHES 1D fluid mesh: /mesh/Fluid.syr Running options Pastart File : Conduction output files names prefix and location Pesuits names prefix : resul	📑 🗁 🏝 🌗 🗃		Run SYRTHES	Stop SYRTHES	🔯 Calculation Progress 🛛 📈
	Home File Homeso Symptes D Briad Row User C functions Control Output Running options	Conduction input file name a Conduction mesh: Radiation mesh: SVRTHES 1D fluid mesh: Restart File : Weather data (optional) : Conduction output files name Results names prefix : result	nd location /mesh/Structur /mesh/Fluid.syr	e.syr	

FIGURE 3.7 – SYRTHES File Names window

3.2.6 Input data for conduction computation

On the left, unroll the conduction menu by clicking on the arrow.

3.2.6.1 Group names and references numbers

While SALOME is using group names to distinguish the different parts of the mesh, SYRTHES is using reference numbers. Group names and reference numbers are included in the mesh file Structure.med. The links between both files are given in an additional file (.syr_descr) created while you have converted the MED file to the SYRTHES file. You can open it in the SYRTHES GUI : menu "Tools" and "Open Desc".

WARNING : depending on SALOME version, pairs (group-name , number) may change. So check the description file and adapt numbers accordingly before proceeding.

Here is Structure.syr_desc provided file :

10	dessus-dessous
6	solid
7	int-cyl1
8	int-cyl2
9	bordure
	10 6 7 8 9

3.2.6.2 Initial conditions

Select the first item of the Conduction Menu : Initial conditions

Set the initial temperature $(20^{\circ}C)$, and the volume considered, here it is 6. Note that if all the volumes are affected by the same initial condition, you can put "-1" instead of the explicit list. You can add a comment in the last column (optional).

📼 🖭 💽 🔤			Ru	n SYRTHES	Stop SYRTHES Calculation Progress
Home File Names	Initia	al temperature	(Deg C)		
Conduction		Туре	Temperature	References	User comments
Boundary conditions	1	Constant 👻	20	-1	
Physical properties	1	Constant 👻			
Volumetric conditions Periodicity	V	Constant 👻	1		
SYRTHES 1D fluid flow	V	Constant 👻	1		
Jser C functions		Constant *			
Dutput		Constant *	1		
lunning options	÷	Constant			
	4	TT Anstant 🔻			
Jutput Nunning options	4	Constant +			

Figure 3.8 - syrthes - Initial conditions

3.2.6.3 Boundary conditions

No boundary conditions are set on the boundaries of the concrete block.

3.2.6.4 Physical properties

Put the values of density, heat capacity and conductivity.

🗋 🔛 💽 📷		Run SYR	THES	🕑 s	top SYF	THES 🔕 C	alculation Progres	5
Home File Names • Conduction Initial conditions	lso ρ (kg	tropic Ortho g/m³), Cp (J/kg/	otropic Deg C).	Anis , k : Isot	otropic ropic cc	nductivity (W/	m/Deg C)	
Boundary conditions		Туре	ρ	Ср	k	References	User comments	A
Physical properties	V	Constant 👻	7700	460	25	-1	steel	
Periodicity	1	Constant 👻						11
SYRTHES 1D fluid flow User C functions	1	Constant 👻						
Control	1	Constant -						1 -
Output Bupping options	1	Constant -						
Running options		Constant -						
	L.	Constant						
	V	Constant 👻						
	4	Constant -						Þ

FIGURE 3.9 – SYRTHES - material properties

All is done regarding the 3D thermal problem. Now, the 1D fluid flow model has to be defined.

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3.2.7 Input data for 1D fluid flow model

On the left side of the window, unroll the SYRTHES 1D fluid flow menu by clicking on the arrow.

3.2.7.1 1D fluid Geometry

Definition of the geometry of the pipes : for each part of the pipes, depending on the reference number of the 1D elements of the mesh, you have to give the hydraulic diameter in meter, the section in square meter, and possibly the roughness (0 for a smooth wall).

In the present case, we have only 2 references, one for each pipe.

SYRTHES V 5.0 - syrthes / untitled	.syd					_ = X
		Run SYRTH	ES 🕑 St	op SYRTHES	🔕 Calculation Pro	gress 📈
Home File Names	Hydraulic diameter	(m) Section (m²)	Roughness (-)		
 Conduction 	Hydraulic di	ameter Section	Roughness	References	User comments	A
Initial conditions	✔ 0.1	0.00785	0	6	tube 1	
Physical properties	✔ 0.1	0.00785	0	7	tube 2	
Volumetric conditions	1					
Periodicity	V					
 SYRIHES ID fluid flow ID fluid Geometry 	v					
1D fluid Initial conditions	1					
1D fluid Boundary conditic	V					
1D fluid Physical propertie	v					
1D fluid Volumetric conditi	J					-
User C functions	•					-
Control						
Output						
Running options						

FIGURE 3.10 – SYRTHES - 1D fluid Geometry

3.2.7.2 1D fluid Initial conditions

For each pipe, we define the initial conditions of the fluid flow : temperature and velocity.

SYRTHES V.5.0 – syrthes / pipes.sy File Tools Preferences Help	d	3a					_	
Home File Names Conduction	Initia	l temperature Type	Ru (Deg C) Norm i Temperature	n SYRTH nitial veloc	ES () Stop : city (m/s) References	SYRTHES 🔕 User	Calculation Progress	
Initial conditions Boundary conditions Physical properties Volumetric conditions Periodicity SYRTHES 10 fluid flow 10 fluid geometry 10 fluid potial conditions 10 fluid soundary conditic 10 fluid Physical propertie 10 fluid Volumetric conditi 10 fluid Volumetric conditions Control Output Running options	V V V V V	Constant + Constant + Constant + Constant + Constant + Constant + Constant +	10 40	0.1	6 7		1	

FIGURE 3.11 – SYRTHES - 1D fluid Geometry

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3.2.7.3 1D fluid Boundary conditions

Click first on the "Conduction/1D fluid coupling" tab.

Here we define how fluid flow and thermal calculations are coupled.

In the table, we consider the 1D fluid mesh and we have to define the heat exchange coefficient between fluid and solid. In that case, we choose an automatic computation of the heat exchange computation using a Colburn correlation (based on the velocity, hydraulic diameter, and fluid properties). So, we only have to define the part of the pipes where this law has to be applied : all along the 2 pipes (ie : references 6 and 7).

The second step is to define which solid wall is coupled with the fluid flows.

We have to give the references on the structure mesh wich are the wall of the fluid flow : here faces references are 7 and 8.

] 🗁 🏝 💽 🔤 🗍			Run S	RTHES	🕑 Stop	SYRTHES 🔕 Ca	lculation Progress
Home File Names Conduction Initial conditions Powndary conditions	Cond Solid d	duction/1D conduction	luid coupling faces referenc	Inlet es coupl	Closed loo ed with 1D f	op 🛛 Delta Pressur luid	e Thermal clos 4
Physical Properties Volumetal properties Volumetal properties Periodicity 9 KPR-IES 10 fluid flow 10 fluid Geometry 10 fluid Insial conditions 10 fluid Boundary conditions 10 fluid Physical propertie 10 fluid Volumetric condit 10 fluid Volumetric condit 10 fluid Time step User C functions Control	Type Coef h References User comments I Colburn 6 7 6 7 I Constant - 6 7 I Constant * - - I Constant * - -				ments *		
Output Running options	1D flui Refe Use	id reference rences r comment	7 8	conduc	tion		

FIGURE 3.12 – SYRTHES - Conduction/1D fluid coupling

Now, we define how the fluid goes through the pipes : definition of the inlet.

In the same window, click on the "Inlet" tab.

Define the location of the inlet for each pipe : give a point close to the inlet of each tube. Points are not necessarily included in the mesh. Then, give the flow rate of each pipe (kg/s) and the inlet temperature (°C)

📄 🖆 🏝 🥼 🗃				Rur	SYR	THES	•	Stop SYP	RTHES 🔕 Calcula	tion Progress
Home File Names Conduction Initial conditions Boundary conditions Physical properties	Con Inlet P(x.) Q : F	nduction/1D t (,z) (m) : Po low rate (kg	flu int /s),	id coupl close to T : Inlet	ing the i	Inlet nlet peratur	Clos	ed loop	Delta Pressure	Thermal clc
Volumetric conditions	Ė	Type		×	У	z	Q	Т	User comr	nents
Periodicity ✓ SYRTHES 1D fluid flow		Constant	*	-0.125	0	0.1	1	10		
1D fluid Geometry	V	Constant	-	0.125	0	0.1	1	10		
1D fluid Initial conditions 1D fluid Boundary conditio	V	Constant	+			-				
1D fluid Physical propertie	5	Constant	-							
1D fluid Volumetric conditi 1D fluid Time step	E.	Constant	-			-				
User C functions		Constant	-							
Control	1	Constant	*							
Running options	1	Constant	*							
	1	Constant	*							
	4	i					-			Þ

Figure 3.13 - syrthes - Inlet

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3.2.7.4 1D fluid Physical properties

Definition of the physical properties of the fluid, here water. We have the same fluid in both pipes.

] 🗁 逸 🃭 🔤 🗌				Rur	SYRTH	IES	🕑 St	op SYRTHES	Calculation Progress	
Home File Names Conduction	Flu p (kç	id properties J/m³), Cp (J/kg	d J/De	Gravity g C), λ	(W/m/D	eg C),	μ (Pa.s)		
Boundary conditions		Туре		ρ	Ср	λ	μ	References	User comments	٦
Physical properties	1	Constant	*	1000	4185	0.6	0.1	67	water	٦
Periodicity	-	Constant	*							1
SYRTHES 1D fluid flow	V	Constant	-							-
1D fluid Initial conditions	~	Constant	*							-
1D fluid Boundary conditio	-	Constant	-							-
1D fluid Volumetric conditi	-	Constant	-							-
User C functions	~	Constant	-							-
Control	E.	Constant	-							
Bunning options	•									Þ

FIGURE 3.14 – SYRTHES - Physical properties

3.2.7.5 1D fluid Time step

As we are interested by a steady state, we choose to not have the same time step in fluid and solid to speed up the convergence : fluid time step is set to 60s.

lie Tools Preferences Help		
i 🗁 ⊵ 🃭 🔊	Run SYRTHES 🕟 Stop SYRTHES 🔕 Calculation Progress	М
Home File Names Conduction Initial conditions Boundary conditions Physical properties Volumetric conditions Periodicity D fluid Geometry D fluid Initial conditions ID fluid Physical propertie ID fluid Physical propertie ID fluid Untertic conditi ID fluid Time step User C functions Control Output Running options	1D fluid flow time step Use solid time time step 1D fluid flow time step (in seconds) : 10	

FIGURE 3.15 – SYRTHES - Time step

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3.2.8 Control

To reach a steady state, we can use a quite large time step on the solid : 600 s and perform 500 time steps.

📑 🚍 🏝 🃭 🔤	Run SYRTHES 🕟 Stop SYRTHES 🔞 Calculation Progress 📝
Home File Names Conduction Initial conditions Physical properties Volumetric conditions Periodicity SWTHES 1D fluid flow 1D fluid Geometry 1D fluid Secondary conditions 1D fluid Boundary conditions 1D fluid Secondary Conditions	Time management Bestart management Solver information Time step management Global number of time steps: 500 Time step: Constant Constant time step Time step (in seconds) : 600

FIGURE 3.16 - SYRTHES - Control window

Generally, there is no need to change the default values provided for the solver.

3.2.9 Output

In this section, we are going to define the type of results to be generated by SYRTHES.

Whatever the options you will have a result file with the temperature on all the nodes of the mesh.

But, it is also advisable to define some thermal probes : during the run, it will allow to follow the temperature evolution at some strategic points of the domain.

Set the coordinates of points in the domain. Then, define the frequency at which you want to save the temperature values of the probes on file : here, 1, which means every time step.

🗁 🖭 💽 🛋					Run SYF	THES	 Stop SYRTHES 	Calculation Progress				
Home File Names	P	rohe	C Roci	It fielde	Surface bals		olume balance					
Conduction	From the suit neids			nut	Even n time	etone v						
Boundary conditions Physical properties	De	Definition by coordinates										
Volumetric conditions			×	У	z		User com	ments				
SVETUES 1D fluid flow	1	۷	-0.23	0.15	0.1							
1D fluid Geometry	2	1	0	0.15	0.1							
1D fluid Initial conditions	3	1	0.23	0.15	0.1							
1D fluid Boundary conditic	4	1										
1D fluid Volumetric conditi	5	۷										
1D fluid Time step	6	1										
User C functions	7	1										
Control	8	1										
Running options	9	1										
	4							•				

FIGURE 3.17 - Syrthes - Defining thermal probes

Click on the next tab in the same window (Control) to select "result fields".

At the end of the calculation, you will get of course the temperature field corresponding to the last time step (unless you have specifically chosen not to obtain such a field). But, you can also get intermediate results with a choosen frequency. Click "Fields" and set the frequency to 100 : you will get the temperature every 100 time steps.

These temperature fields will be recorded in the ".rdt" file and will be post-processed in a way identical to the final result (".res" file).

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FIGURE 3.18 – SYRTHES - Defining transient results file

3.2.10 Running options

This is the last step : give a name for the listing file. SYRTHES will provide you with some information about the calculation (option summary, solver convergence,...)

For bigger cases, you could try a parallel computation, setting the number of processor to 3 or 4 or much more (but here, as the number of elements of this mesh is very small, the benefit in term of CPU time is likely to be very low).

Control of the second sec	Run SYRTHES Stop SYRTHES Calculation Progress Scalar/ Parallel calculation : number of processor used for conduction : 1 Scalar/ Parallel calculation : number of processor used for radiation : 1 Listing name: 1 Herapical calculation : number of processor used for radiation : 1 Listing name: 1 Preprocessing : automatic preprocessing for 0D/LD fluid mesh • Domain partitioning : automatic mesh partitioning using SCOTCH • Convert result for softwares : Ensight/Paraview • Run SYRTHES

FIGURE 3.19 – SYRTHES - Running options window

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3.2.11 You're ready to run SYRTHES!

Click "Run SYRTHES", the "calculation progress" window should appear and you can display the evolution of the temperature at the 3 locations defined previously.



FIGURE 3.20 – SYRTHES Calculation progress window

The 3 tabs display :

- Listing file browser : displays the 200 last lines of the listing
- Listing file editor : whole SYRTHES listing file
- Log : system messages (usefull in case of error during user files compilation)

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3.2.12 Analyzing the results

When SYRTHES calculation ends, you can visualize the results using a post-processor. For this example, we are using Ensight, but you can also use the open source post-processor Paraview.

3.2.12.1 Final temperature field

Run paraview and open the file : mycase_pipes2/syrthes/POST/resu1.ensight.case



FIGURE 3.21 – Temperature field at steady state

3.2.12.2 Intermediate results

As we selected transient result file (see figure 4.20), we can also post-process this file. Run the post-processor and open the file : mkdir mycase_pipes2/syrthes/POST/resu1_rdt.ensight.case. Then the temperature field can be visualized at different time steps : 100, 200, 300, 400. As time steps for fluid and structure computationare not the same, the intermediate time steps can't be considered as realistic fields, they are just intermediate states before reaching a steady state.



FIGURE 3.22 – Temperature fields after 100 and 200 time steps

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3.2.12.3 Fluid flow results

Run the post-processor Paraview and open the file: mycase_pipes2/syrthes/POST/resu1_f1d.ensight.case



FIGURE 3.23 – Temperature field at the steady state and a zoom on the cold pipe

3.2.12.4 Result files

At the end of the run, in the directory where the SYRTHES calculation has taken place, one should be able to find several files :

- resul.res : final result file Temperature field at the end of the calculation. This file is automatically converted to a postprocessor file format (Ensight/Paraview or SALOME-MED) in the POST directory.
- resul.rdt : transient result file Temperature field during the transient. This is an optional file (depending on the output options defined). If existing, it is automatically convert to a post-processor file format (Ensight/Paraview or SALOME-MED) in the POST directory.
- resu1.his : temperature probes
 - This file contains the temperature at the probes initially defined. This is an "in columns" file.
 - column 1 : time
 - column 2 : temperature
 - columns 3-5 : coordinates (only columns 3-4 in 2D)

To help users, it is also possible to save a gnuplot command file (in the calculation progress window).

• resul.mnx : min-max values

The min and max values of each variable of the calculation and the place where there are reached. This is an "in columns" file. Content depends on the type of calculation and is described at the beginning of the file.

Each variable is corresponding to a column. This file can be post-processed with a 1D plotter. Example :

1=temps 2=T_min 3=x 4=y 5=z 6=T_max 7=x 8=y 9=z
10=rho_min 11=x 12=y 13=z 14=rho_max 15=x 16=y 17=z }

- In this file, you will find :
- column 1 : time
- column 2 : minimum of temperature
- columns 3-5 : coordinates where is located the minimum of temperature
- columns 6 : maximum of temperature
- columns 7-9 : coordinates where is located the maximum of temperature

- column 10 : minimum of density
- columns 11-13 : coordinates where is located the minimum of density
- columns 14 : maximum of density
- columns 15-16 : coordinates where is located the maximum of density
- resul_fld.res and resul_fld.rdt : 1D fluid flow result with temperature, velocity and heat exchange coefficient. Results are provided at the end of the calculation and for intermediate time steps.
- resu1_cplf1d.res and resu1_cplf1d.rdt : results at the fluid/solid interface (on the structure mesh) : boundary fluid temperature and fluid heat exchange coefficient projected on the solid coupled wall



FIGURE 3.24 – Fluid boundary temerature on the solid mesh

• resul.add : additionnal file This file is unused in this study. In other more complex cases, some specific entities can be calculated by users and saved them in this file for further graphical post-processing.

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Chapter 4

Getting started with 0D fluid model

spheres_fluid0d

4.1 What is the problem?

We consider 2 concentric spheres with an annular space filled with air. The external side of half of the sphere is heated. We study conduction transfer inside the outer sphere, radiation exchanges between the spheres, conduction transfer in the inside sphere, and the temperature of the air between the spheres.

4.1.1 Geometrical description

The solid domain consists in 2 concentric spheres with a radius of 0.1 m and 0.2 m. The thickness of the hollow outer sphere is 0.05m.



FIGURE 4.1 -Sketch of the problem

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4.1.2 Physical description

Material is steel for both spheres and physical properties are :

- Density : $\rho = 7700 \ kg/m^3$
- Heat capacity : $C_p = 460 \ J/kg^{\circ}C$
- Conductivy $\lambda = 25 W/m/^{\circ}C$

4.1.3 Initial conditions and boundary conditions for the concrete block

The initial temperature is $20^{\circ}C$.

Boundary conditions : temperature and heat exchange coefficient on the half top of the outer sphere : T = 50°C, h = 1000 $W/m^2/^{\circ}C$

4.1.4 Air in the cavity between the two spheres

- Fluid is air :
 - Density : $\rho = 1 \ kg/m^3$
 - Heat capacity : $C_p = 1017 \ J/kg^{\circ}C$

4.2 How to do that?

4.2.1 To organize the study

We propose in this section a possible organization of the different files of your study. This is only a piece of advice, but advanced users can do as they wish...

- create a new directory for your study : mkdir mycase_sphere
- go inside : cd mycase_sphere
- $\bullet\,$ create a new directory for the creation of the mesh : ${\tt mkdir\,\,mesh}$

4.2.2 Creating meshes

If the geometry stays very simple and do not create any trouble, attention must however be paid to the references allowing to identify the different materials and boundary conditions. SALOME is used to define the geometry and create the mesh.

Two meshes have to be built : a 3D mesh with tetrahedra for the structure (the two spheres), and one surfacic 2D mesh with triangles for the radiative solver. This surfacic mesh corresponds to the 2 spherical surfaces facing each other.

Meshes are independent and have to be saved in two separate files.

In the directory mkdir mycase_sphere/mesh, run SALOME, create your geometry and mesh. Save your SALOME-study and export your mesh to MED format in this directory.

You can create your own mesh, but below, we describe the characteritics of the mesh provided in the SYRTHES distribution :

 $/ \dots / \texttt{syrthes5.x/arch} / your_arch/\texttt{share/syrthes/tests/4-cas_spheres_fluid0d}.$

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FIGURE 4.2 – 3D mesh and volumic/surfacic groups for conduction



FIGURE 4.3 – 2D mesh and volumic groups for radiation

4.2.3 Create your SYRTHES-study

Go back to the initial directory : mycase_sphere If not already done : source the SYRTHES environment (Linux only) : source /home/.../syrthes5.x/arch/myarch/bin/syrthes.profile Run the SYRTHES-gui : syrthes.gui

Create a new case : synthes

Now, all your calculation will be managed by the SYRTHES Graphic User Interface.

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FIGURE 4.4 – SYRTHES Managing your cases

4.2.4 Main view

Give a title to your study. The dimension of the problem is 3D.

Check the dimension of the problem : 3D

Select an additional physical modelling : "SYRTHES 1D fluid flow"



FIGURE 4.5 - Syrthes Main View

Save your data file ("file", "save as") as sphere.syd.

4.2.5 File Names

- Click on the next item in the menu on the left : File Names
- Select your conduction mesh : mycase_sphere/mesh/solid.med
- Select your radiation mesh : mycase_sphere/mesh/ray.med

A conversion of the file format is done automatically and then you should get the following message for both files :

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FIGURE 4.6 - Syrthes File format conversion OK

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Finally, give a name for your results files (a name without extension; SYRTHES will create different files with the same radical but different extensions depending on the type of files).

The file Names window looks as shown below :

SYRTHES V.5.0 - syrthes / sphere	_ray.syd	_ • ×
		Run SYRTHES 🕑 Stop SYRTHES 🔞 Calculation Progress 📈
Home File Names Conduction Radiation User C functions Control Output Punning options	Conduction input file name a Conduction mesh: Radiation mesh: SYRTHES 1D fluid mesh: Restart File : Weather data (optional) :	nd location mesh/solid syr mesh/rajksyr
	Conduction output files nam Results names prefix : [resul	es prefix and location

FIGURE 4.7 – SYRTHES File Names window

4.2.6 Input data for conduction computation

On the left part of the window, unroll the conduction menu by clicking on the arrow.

4.2.6.1 Group names and references numbers

While SALOME is using group names to distinguish the different parts of the mesh, SYRTHES is using reference numbers. Group names and reference numbers are included in the mesh files solid.med and ray.med. The links between both are given in the additional files (.syr_descr) created while you have converted the MED file to the SYRTHES file. You can open this file thanks to the SYRTHES GUI : menu "Tools" and "Open Desc".

You can create your own mesh, but below, we describe the characteristics of the mesh provided in the SYRTHES distribution : /..../syrthes5.x/arch/your_arch/share/syrthes/tests/4-cas_spheres_fluid0d.

Here is solid.syr_desc provided file :

group_of_faces	10	anneau_int_bas
group_of_faces	11	anneau_int_haut
group_of_faces	12	sphere_int_bas
group_of_faces	13	<pre>sphere_int_haut</pre>
group_of_volumes	6	sphere_int
group_of_volumes	7	sphere_ext
group_of_faces	8	anneau_ext_bas
group_of_faces	9	anneau_ext_haut

Here is ray.syr_desc provided file :

group_of_faces	6	peau_ext_haut
group_of_faces	7	peau_ext_bas
group_of_faces	8	peau_int_haut
group_of_faces	9	peau_int_bas

4.2.6.2 Initial conditions

Select the first item of the Conduction Menu : Initial conditions

Set the initial temperature $(20^{\circ}C)$. As the initial temperature is uniform (same values for all volumes), we can put "-1" instead of the explicit list of references. You can add a comment in the last column (optional but often usefull).

] 🔄 🔝 💽 🔍			Ru	n SYRTHES	 Stop SYRTHES 	Calculation Progress	
Home File Names	Initia	l temperature	(Deg C)				
Conduction		Туре	Temperature	References	User	comments	1
Boundary conditions	V	Constant 👻	20	-1			
Physical properties	1	Constant 👻					1
Periodicity	1	Constant 👻					1
Radiation	1	Constant 👻					1
User C functions	1	Constant 👻					1
Control	V	Constant 👻					1
Running options	1	Constant 👻	1				•
	4						

Figure 4.8 – syrthes - Initial conditions

4.2.6.3 Boundary conditions

A heat exchange boundary condition is set on the top half of the outer sphere :

i 🖆 🔛 🚺 🔤				Run SY	RTHES 🕑	Stop SYRTHES	🛛 Calcu	lation Progress
Home File Names • Conduction	He Heat	at exchange : exchange co	Flux condit	ion D	irichlet condit)	ion Contact res	istance	Infinite radial
Boundary conditions		Type	External T	Coef h	References	User comments	3	
Physical properties	1	Constant +	50	1000	9			
Periodicity	V	Constant 👻	1					
Radiation Sportral parameters	1	Constant 👻	1				1	
Radiation Factors	1	Constant 👻	1					_
Material radiation properti Boundary conditions	1	Constant 👻	1					
Solar modelling	1	Constant 👻	1					
0D fluid Geometry	5	Constant 👻	1					
0D fluid Boundary conditio	5	C					-	
D fluid Volumetric conditi OD fluid Volumetric conditi OD fluid Rediation properti User C flunctions Control Output Running options								

Figure 4.9 - syrthes - Initial conditions

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4.2.6.4 Physical properties

Put the values of density, heat capacity and conductivity (here steel has been retained) :

] 🗁 📐 🚺 🔤					Ri	ın SYR	THES 🌔 S	top SYRTHES 🛛 Calculation Progres	s
Home File Names	Isc	tropic O	rthe	otropic	Anis	otropic			
Conduction	p (k	g/m³), Cp ()	kg/	Deg C)	, k : Isot	ropic co	nductivity (W/r	m/Deg C)	
Boundary conditions		Туре		ρ	Ср	k	References	User comments	
Physical properties	1	Constant	Ŧ	7700	460	25	-1		
Periodicity	V	Constant	*	1					
Radiation	V	Constant	*	1					
Radiation Factors		Constant	*						
Material radiation properti Boundary conditions		Constant	*						-
Solar modelling		Constant	-	-		-			-
SYRTHES OD fluid flow	L.	Constant	-	-		-			-
0D fluid Boundary conditic		Constant	*						_
0D fluid Physical propertie	4								Þ
OD fluid Radiation properti									
User C functions									
Output									
Running options									

FIGURE 4.10 – SYRTHES - material properties

That's all for the 3D conduction problem. Now, we have to define the radiation model.

4.2.7 Input data for the radiation model

On the left part of the window, unroll the SYRTHES radiation menu by clicking on the arrow.

4.2.7.1 Spectral parameters

By default, in this simple configuration, we consider only one spectral band (grey material physical property). If required for more complex problems you will be able to define several spectral bands here, depending on your material behaviour (even if it turns out to be quite difficult to have access to such properties).

] 🖆 🖄 🚺 🔊				Run SYRTHES	🕑 Stop SYRTHES 🧯	Calculation Progres	5
Home File Names	SYR	HES Radi	ation Spectra	Band Definition (wa	ave length in m)		
Conduction		Band #	lower Band	upper Band	User comn	hents	-
Roundany conditions	1	1	le-10	10			
Physical properties	1						
Volumetric conditions	1						
Periodicity	1						
Radiation	1						
Rediction Factors	1						-11
Material radiation properti	÷						-11
Boundary conditions	÷						
Solar módelling	4						Þ
SYRTHES OD fluid flow							
User C functions							
Output							
Bunning options							
- ann ag apriorite							

FIGURE 4.11 – SYRTHES Spectral bands

4.2.7.2 View factors

For a given surfacic mesh, SYRTHES can't determine what is inside or outside your computational domain (because mesh generators generally don't orient properly the surfacic faces of the mesh). In our case, SYRTHES needs to know if you want to calculate radiation inside or outside the balls. To give an

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answer to this problem, it is compulsory to give an "interior point" for the radiation problem. It will be a point located inside the radiation cavity, and for our case, a point in the air cavity located between the 2 spheres. Select the "View Factor" tab and set the coordinates of an inner point : (0.12, 0., 0.)

710					
116					
Names	Radiati	on factors	Symme	ry/Periodicity	
iduction					
nitial conditions	Radiatio	- Factors ma	nagment	· Calculation -	
Boundary conditions	- adiation	in accors me	aginen	- curculation	
Volumetric conditions	Radiation	n Factors me	thod :	View Factors method 👻	
Periodicity					
liation	Internal	points coord	inates (in	m) to define connex domains	
Spectral parameters	cod	ord x coord	coord z	User comments	
Radiation Factors	✓ 0.1	2 0	0	In the air cavity	
Material radiation properti	1		-		
Boundary conditions					_
Solar modelling	~				-
THES OD fluid flow	1				
r C functions	1				
trol	1				
put	1				_
ning options					
put ning options	4				

FIGURE 4.12 – SYRTHES Position of the inner point for view factors calculation

4.2.7.3 Material radiation properties

In this case, only 1 spectral band is defined (grey material), and we condider an emissivity of 0.9 for the steel.

SYRTHES V.5.0 - syrthes / sphere File Tools Preferences Help	_ray.s	/d ¹	<u>}</u>			· · · ·	-	- 8 ×
📄 🗁 🏝 🌗 🔊				Run S	RTHES 🕒	Stop SYRTHES 🛛	Calculation Pr	ogress 📈
Home File Names	Mate	erial rad	diation prope	erties				
 Conduction 		Band	Emissivity	Transmitivity	Reflectivity	Specular behaviour	References	User C 🔺
Initial conditions	1	1	0.9	0.1	0	0	-1	
Boundary conditions	7	-			-	-	_	
Volumetric conditions								
Periodicity								
▼ Radiation								
Spectral parameters	~							
Radiation Factors	1							
Material radiation properti	v							_
Boundary conditions	4							• • •
Solar modelling								
User C functions								
Control								
Output								
Running options								

FIGURE 4.13 – SYRTHES Emissivity definition

4.2.7.4 Boundary conditions

In this section, you have to define how conduction mesh and radiation are coupled. You must at least define :

- the references of the **boundary faces of the conduction mesh** which are coupled with the radiation mesh. In the present case, it corresponds to surface of the inner sphere and the inner surface of the outer sphere 10 11 12 13
- the references of the faces of the **radiation mesh** which are coupled with the conduction mesh. In this case, it's easy, since all faces are to be coupled, so all references have to be set : 6 7 8 9

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File Tools Preferences Help Image: Step SYRTHES Image: Step SyRTHE	SYRTHES V.5.0 - syrthes / sphere.	_ray.syd
Image: Conduction/Radiation coupling Imposed temperature Imposed Flux Problem with aps Imposed flux Imposed flux Imposed flux	<u>File T</u> ools Preferences <u>H</u> elp	
Home File Names Conduction/Radiation coupling Imposed temperature Imposed Flux Problem with aps Conduction Boundary conditions Physical properties Volumetric conditions Periodicity Solid conduction faces references coupled with radiation 10 11 12 13 Value of the second se	📄 🚰 🏝 📭 🖘	Run SYRTHES 🕟 Stop SYRTHES 🔕 Calculation Progress 🧾
	Home File Names Conduction Initial conditions Boundary conditions Physical properties Volumetric conditions Periodicity Radiation Factors Material radiation properti Boundary conditions Control Output Running options 4 P	Conduction/Radiation coupling Imposed temperature Imposed Flux Problem with aps Solid conduction faces references coupled with radiation User comments Radiation faces references coupled with conduction Fadiation faces references coupled with conduction Fadiati

FIGURE 4.14 – SYRTHES Coupling conduction and radiation

4.2.8 Input data for the 0D fluid model

Let's define the last model : the 0D fluid model to take into account the air located between the 2 spheres. On the left of the main view, unroll the SYRTHES 0D fluid flow menu by clicking on the arrow.

4.2.8.1 0D fluid Geometry

First, define the characteristics of the fluid cavity. Give a number to your cavity (indeed a complex case may contain several cavities), its volume, and the surfaces surrounding each cavity (on the conduction mesh).

		P	un SYDTHES			
Contuction Initial conditions Boundary conditions Physical properties Volumetric conditions Physical properties Volumetric conditions Periodicity Radiation Spectral parameters Radiation Factors Material radiation properti Boundary conditions Solar modelling SYRTHES Do fluid flow Of fluid Boundary conditic OD fluid Physical propertie OD fluid Volumetric conditi Control Boundary conditic OD fluid Physical propertie User C functions Control Running options	Number of the cav Cavity # V V V V V V V V	R ity, Volume (r 9.9484e-3	un SYRTHES	Stop SYRTHES	Calculation Progress	

FIGURE 4.15 – SYRTHES - 0D fluid Geometry

4.2.8.2 0D fluid Boundary conditions

We define how fluid and solid thermal calculations are coupled by defining an heat exchange coefficient : in our case, a value of 9 $W/m^{2\circ}C$ for all the surfaces.

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				Run SYRTHE	Stop SYRTHE	S 🙆 Calculation Program	cc 🚺
Conduction Initial conditions Device of the Names Conduction Initial conditions Device of the Names Conduction Device of the Name Conduction Device of the Name Conduction Spectral assessment Solar modeling Strictless of huid Rew Conductions Conductions	Heat exchang Type Z Constan Z Constan Z Constan Z Constan Z Constan Z Constan Z Constan Z Constan	e coe t + t + t + t + t + t +	Coef h 9.	Run SYRTHE	S Stop SYRTHE:	comments	

FIGURE 4.16 – Syrthes - Conduction/0D fluid coupling

4.2.8.3 0D fluid Physical properties

For the present cavity, give the fluid physical properties and the initial temperature.

- <u>-</u> .			R	un SYI	THES	🕞 s	top SYRTHES	Calculation Progress
Home File Names Conduction Boundary conditions Physical properties Volumetric conditions Periodicity Radiation Factors Radiation Factors Material radiation properti Boundary conditions Solar modelling SystRHES Do Hiud Row OD Filid Geometry OD Filid Addiation properti User C functions Control Output Running options	ρ (kg	g/m³), Cp (J/k Type Constant Constant Constant Constant Constant Constant	к eg C), Initial Cavity #	emper P 1 ·	ature (D	eeg C) Ti 20	air 20 degreesC	comments

FIGURE 4.17 - syrthes - 0D Physical properties

Now, all physical and geometrical parameters are defined, you can jump to the Control section.

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4.2.9 Control

We are going to compute the temperature during a transient lasting 1 hour.

📑 🔚 🏝 🥼 🗃		Run SYRTHES	 Stop SYRTHES 	Calculation Progress	
Home File Names Conduction Initial conditions Boundary conditions Physical properties Periodicity Radiation Spectral parameters Radiation Factors Material radiation propert Solar modelling solar modelling Solar Modeometry OD Ruid Geometry OD Ruid Geometry OD Ruid Bernary condition DD Ruid Physical propertion DD Ruid Physical propertion Control Output Running options	Time management - Time step managen Global number of tim Time step : Consta - Constant time st Time step (in se	Restart management nert esteps: 60 nt • esp • conds): 60	Solver information		

FIGURE 4.18 – SYRTHES - Control window

Generally, there is no need to change the default values provided for the solver.

4.2.10 Output

In this section, we are going to define the type of results to be generated by SYRTHES.

Whatever the options you will have a result file with the temperature on all the nodes of the mesh. But, it is also advisable to define some thermal probes : during the run, you will be able to follow the temperature evolution at some strategic locations of the domain.

Set the coordinates of points in your domain. Then, define the frequency at which you want to record the values of the probes on file : here, 1, which means every time step.

🔄 💽 💽 🔤					Run	SYRTHE	s 🕑 Stop SYRTHES 🛯	Calculation Progress
Home File Names	P	robe	S Recu	lt fielde	Surface	halance	Volume balance	
Conduction		1006	nesu	it fields	Sunace		volume balance	
Initial conditions	⊦re	que	ncy of out	put	Every n t	ime steps	- I	
Physical properties	De	finiti	on by coo	rdinates				
Volumetric conditions			×	У		z	User comments	
Periodicity	1	1	0.	0.175	0	out	ter sphere - middle thickness	5
Radiation Spectral parameters	2	1	0	0.09	0	inn	er sphere - close to the wall	
Badiation Factors	3	1	0	0	0	inn	er sphere - centre	
Material radiation properti	4	1						
Boundary conditions	5	1						
Solar modelling	6	1						
0D fluid Geometry	7	1						
0D fluid Boundary conditic	8	1						
0D fluid Physical propertie	9	1						
0D fluid Volumetric conditi	4	-						•
User C functions								
Control								
Output								
Running options								

FIGURE 4.19 – SYRTHES - Defining thermal probes

Click on the next tab in the same window (Control) to select "result fields".

At the end of the calculation, you will get of course the temperature field corresponding to the last time step. But, you can also get intermediate results with a choosen frequency. Click "Fields" and set the frequency to 15 : you will get the temperature every 15 time steps.

These temperature fields will be recorded in the ".rdt" file and will be post-processed like the final result (".res" file).



FIGURE 4.20 – SYRTHES - Defining transient results file

4.2.11 Running options

This is the last step : give a name for the listing file. SYRTHES will rpovide you with some information about the calculation (option summary, solver convergence,...)

For bigger cases, you could try a parallel computation, setting the number of processor to 3 or 4 or much more (but here, as the element number of this mesh is very low, there is little gain to be gained).

	Run SYRTHES 🕑 Stop SYRTHES 🔯 Calculation Progress
Home File Names Conduction Soundary conditions Physical properties Volumetric conditions Periodicity Ferridicity Furthes 10 fuild flow 10 fluid Geometry 10 fluid Boundary condition 10 fluid Boundary condition 10 fluid Boundary condition 10 fluid Hoysical propertie 10 fluid Hoysical propertie 10 fluid Wolumetric conditi 10 fluid Time step User C functions Control Output Running options	Scalar/ Parallel calculation : number of processor used for conduction : Scalar/ Parallel calculation : number of processor used for radiation : Listing name: listing Advanced options Preprocessing : automatic preprocessing for 0D/LD fluid mesh Preprocessing : automatic mesh partitioning using SCOTCH Convert result for softwares : Ensight/Paraview Run SYRTHEE

FIGURE 4.21 – SYRTHES - Running options window

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······································	Accessibilité : EDF R&D SA	Page 68/76	©EDF 2018

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4.2.12 You're ready to run SYRTHES!

Click "Run SYRTHES", the "calculation progress" window appears and you can display the evolution of the temperature at the 3 locations defined previously.

Code Synthes calculation progress	_ = ×
Progress of Syrthes run 100% Reset Scale Graph 1 Graph 2 Graph 3 Graph 4 History Line Style : 3 * o yleft o hide o yright Temp external spher • Temp inside sphere	3600
Listing file browser Listing file editor Log 1 2.10255e-18 1.18449e-18 OD FLUID MODEL > Time= 3.600000000e+03 Cavity 1 Tf= 38.597801 TEMPERATURE SOLVER GRCONJ: Iteration Relative Precision Absolute Precision 20 1.42386e-08 6.03546e-07 > Time= 3.600000000e+03 Tmin= 24.48347 Tmax= 49.85834 > Writing transient file (.rdt) >>>> Solving CPU time : 0.01 s [cond: 0.01] [rad: 0.00] <<<<	

FIGURE 4.22 – SYRTHES Calculation progress window

The 3 tabs display :

- Listing file browser : displays the 200 last lines of the listings
- Listing file editor : whole SYRTHES listing file
- Log : system messages (usefull in case of error during user files compilation)

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4.2.13 Analyzing the results

When SYRTHES calculation ends, you can visualize the results using a post-processor. For this example, we are using Ensight, but you can also use the open source post-processor Paraview.

4.2.13.1 Final temperature field

Run the post-processor Paraview and open the file : mycase_sphere/syrthes/POST/resu1.ensight.case



FIGURE 4.23 – Temperature after 1 hour (using 2 different scales)

4.2.13.2 Intermediate results

As we selected transient result file (see figure 4.20), we can also post-process this file. Run the post-processor and open the file : mkdir mycase_sphere/syrthes/POST/resu1_rdt.ensight.case. Then the temperature field can be visualized at different time step : 25,50,75,100, 200, 300, 400. As time steps for the fluid and the solid structure computation are not identical, the intermediate time steps can't be considered as realistic fields, they are just intermediate states before reaching the steady state.



FIGURE 4.24 – Temperature fields after 100 and 200 time steps

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4.2.13.3 Fluid results

Fluid results are saved into the file resul_fod.res (last value only) and resul_fod.rdt (values during the transient). You can plot the values with a 1D plotter like *gnuplot*, *excel*,...).

Run Paraview and open the file : mycase_sphere/syrthes/POST/resu1_f1d.ensight.case



FIGURE 4.25 – Evolution of the fluid temperature

4.2.13.4 Result files

At the end of the run, in the directory where the calculation has taken place, one should be able to find several files :

- resul.res : final result file Temperature field at the end of the calculation. This file is automatically converted to a postprocessor file format (Ensight/Paraview or SALOME-MED) in the POST directory.
- resul.rdt : transient result file Temperature field during the transient. This is an optional file (depending on the output options defined). If existing, it is automatically converted to a post-processor file format (Ensight/Paraview or SALOME-MED) in the POST directory.
- resu1.his : temperature probes

This file contains the temperature at the probes initially defined. This is an "in columns" ASCII file.

- column 1 : time
- column 2 : temperature
- columns 3-5 : coordinates (only columns 3-4 in 2D)
- resul.mnx : min-max values

The min and max values of each variable of the calculation and the place where there are reached. This is an "in columns" file. Content depends on the type of calculation and is described at the beginning of the file.

Each variable is corresponding to a column. This file can be post-process with a 1D plotter. Example :

1=temps 2=T_min 3=x 4=y 5=z 6=T_max 7=x 8=y 9=z
10=rho_min 11=x 12=y 13=z 14=rho_max 15=x 16=y 17=z }

- In this file, you will find :
- column 1 : time
- column 2 : minimum of temperature
- columns 3-5 : coordinates where is located the minimum of temperature
- columns 6 : maximum of temperature
- columns 7-9: coordinates where is located the maximum of temperature
- column 10 : minimum of density
- columns 11-13 : coordinates where is located the minimum of density
- columns 14 : maximum of density
- columns 15-16 : coordinates where is located the maximum of density
- resu1_f0d.res and resu1_f0d.rdt : temperature of the 0D fluid flow model. Results are provided at the end of the calculation and for intermediate time steps.
- resul.add : additionnal file This file is unused in this simple study. In other more complex cases, user may calculate some specific entities and save them in this file for further graphical post-processing.

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Chapter 5

Working by yourself

Lost flux

5.1 What is the problem?

We consider 3 underground pipes. Hot water at a temperature of $90^{\circ}C$ flows through the pipes. We want to compute the flux transmitted by conduction through the ground and the energy lost at the surface.

5.1.1 Geometrical description

The solid domain (in 2D) consists of a rectangular portion of ground with the section of 3 pipes represented here by three holes.

Internal radius of each hole is 0.05 m and centers of each pipe are 0.2 m apart.

Geometrical characteristics are shown on figure 5.1



FIGURE 5.1 – Sketch of the problem

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5.1.2 Physical description

Physical properties of the ground are :

- $\rho = 1250 \ kg/m^3$,
- $C_p = 600 \ J/kg^{\circ}C$
- $k = 1 W/m/^{\circ}C$

5.1.3 Initial conditions

The initial temperature is $20^{\circ}C$.

5.1.4 Boundary conditions

Boundary conditions are :

- pipes boundaries : $T_p = 90^{\circ}C, \ h_p = 10000 \ W/m^2/^{\circ}C$
- surface : $T_{ext} = 20^{\circ} \dot{C}, h_{ext} = 5 \dot{W}/m^2/^{\circ}C$
- other surfaces : adiabatic



FIGURE 5.2 – Group names for volumes and boundary conditions

5.2 Mesh provided

Mesh can be found in the SYRTHES distribution :

/..../syrthes5.x/arch/your_arch/share/syrthes/tests/5-cas_flux. The 2D mesh counts 6822 triangles. Groups have been created for material and boundary conditions.

WARNING : depending on SALOME version, pairs (group-name, number) could defered. So have a look on your description file and adapt numbers when going on.

Here is flux.syr_desc provided file :

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group_of_edges	4	Gauche
group_of_edges	5	Disque_1
group_of_edges	6	Bas
group_of_edges	7	Disque_2
group_of_edges	8	Haut
group_of_edges	9	Disque_3
group_of_edges	10	Droite
group_of_faces	11	Ensemble

5.3 Approached theorical solution

For a row of pipes of lenght L and radius r, spaced by e and at a depth H, an approximation of the flux between surfaces T_p and T_{ext} is given by :

$$\phi = \frac{T_p - T_{ext}}{\frac{e}{2\pi\lambda} \ln\left(\frac{e}{\pi r} sh\left(\frac{2\pi H}{e}\right)\right) + \frac{1}{h_{ext}}}$$

Warning : this formula supposes that conductivity and temperatures at the surface are constants (and generally, it's not the case !).

5.4 Results

Figures 5.3 and 5.4 shows the temperature in the ground at convergence.



FIGURE 5.3 – Ground temperature

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FIGURE 5.4 – Ground temperature - zoom around the surface

Using the approached theorical formula : $\phi_T = 245.12 \ W/m^2$. Then, the surface temperature can be evaluated :

$$T_{surface} = \frac{\phi}{h_{ext}} + T_{ext} = \frac{245.12}{5} + 20 = 69.02$$

SYRTHES simulation gives : $\phi_S = 155.922/0.6 = 259.87W/m^2$ The computed value is likely to be more precise because, as shown in figure 5.5 the temperature isn't constant along the upper surface (as it was approximated in the formula).



FIGURE 5.5 – Surface temperature

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