

SCORGTM – Tutorial for Thermodynamic module using integrated GT-SUITE solver

SCORG is a tool for the design and analysis of rotary positive displacement machines including twin screw machines. It includes modules for grid generation; importing and editing rotor profiles; and multi-domain thermodynamic chamber module. For more information on the product please visit the website: <u>www.pdmanalysis.co.uk</u> or refer to documentation help.

GT-SUITE supplies a comprehensive set of component libraries which simulate the physics of fluid flow, thermal, mechanical, electrical, magnetic, chemistry, and controls. From those libraries, one can build accurate models of almost any engineering system, including vehicles, engines, drivelines, transmissions, general powertrains and mechanical systems, hydraulics, lubrication and friction, thermal management, cooling, chemistry, after treatment and much more.

Integration of the above softwares brings a new set of possibilities, allowing for multyphisics simulations.

This tutorial lists the steps for setting up and performing Thermodynamic calculation which could be used for performance prediction of oil free and oil injected screw compressors and expanders with SCORG and GT-SUITE. The user is expected to be familiar with screw machines. It is highly recommended that a user who attempts this tutorial study the books on the performance prediction methods for screw compressors¹². This Tutorial should be studied alongside the SCORGTM User Manual. Users are also expected to be familiar with GT-SUITE.

The steps explained in this tutorial are demonstrated for Windows 10, x64 bit OS. Refer to SCORGTM Installation Guide V5.9 for the system and hardware requirements.

² A. Kovacevic. N. Stosic, I.K. Smith, Screw Compressor Three Dimensional Computational Fluid Dynamics and Fluid Solid Interaction, Springer, 2006, ISBN 3-540-36302-5



¹ N. Stosic, I.K. Smith, A. Kovacevic Screw Compressor Mathematical Modelling and Performance Calculation, Springer, UK 2005, ISBN-10 3-540-24275-9



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1 Introduction

Screw Compressors are rotary positive displacement machines. They can be oil-free or oil injected. Oil-free compressors require rotors to be synchronised by additional timing gears on the rotor shaft in order to maintain the contact-free operation. In the oil injected compressor one rotor drives the other through direct contact, Figure 1.1



Figure 1.1 Oil injected twin screw compressor cross section

The screw compressor rotors are helically lobed gears with special rotor profile. Together with the casing, they form a closed interlobe space called the working chamber which changes the size and shape during the operation of the machine. The working chamber itself is periodically connected to the suction and discharge chambers through flow areas which vary with time both in shape and size. The schematic view of a screw machine (compressor, pump or a motor) is shown in Figure **1.2**.



Figure 1.2 Configuration of a screw compressor





This Tutorial will provide a step by step guide to set up and execute a thermodynamic simulation of a typical twin screw compressor using the integrated GT-SUITE solver. An example of a dry air compressor with 3/5 lobe combination, L/D ratio of 1.6 and wrap angle 285° is used in the tutorial. The effect of oil injection will also be demonstrated.

2 Setup the project

2.1 Start SCORGTM Project

- ► Launch SCORGTM on the Desktop.
- ▶ Select File \rightarrow New

1	SCORG V5	.7]														8 <u>-</u> 2		×
File	Edit	Run	View	Units	Help													
	New	Ctrl+	N	$C \times$	Ê P	GT	4	6 m	III	9 O	-	5100	G	T.	F. 🖏	0	\bowtie	
	Open	Ctrl+	0															
	Close																	
	Save	Ctrl+	-S															
	Save As																	
	Import		•															
	Export		Þ															
	Most Re	cent	•															
0	Exit	Ctrl+	Q															

▶ Select N35_Template.spt \rightarrow Open





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This PC	Name	Date modified	Туре	Size
3D Objects	A46_Template.spt	11/04/2019 09:14	SPT File	24 KB
Desktop	Circ46_Template.spt	05/03/2019 11:08	SPT File	24 KB
	Int34_Template.spt	05/03/2019 11:08	SPT File	24 KB
Downloads	Inv22_Template.spt	05/03/2019 11:08	SPT File	24 KB
Downloads	Inv33_Template.spt	05/03/2019 11:08	SPT File	24 KB
n Music	N35_Template.spt	11/04/2019 09:16	SPT File	24 KB
Pictures	N45_Template.spt	05/03/2019 11:08	SPT File	24 KB
Videos	N46_Template.spt	05/03/2019 11:08	SPT File	24 KB
Windows 10 (C:)	N56_Template.spt	05/03/2019 11:08	SPT File	24 KB
JetDrive (D:)	N57_Template.spt	05/03/2019 11:08	SPT File	24 KB
Storelet (G:)	N67_Template.spt	05/03/2019 11:08	SPT File	24 KB
	N68_Template.spt	05/03/2019 11:08	SPT File	24 KB
JetDrive (D:)	Vane8_Template.spt	05/03/2019 11:08	SPT File	24 KB
Network				
~				
F 31	NI25 Townships and			Score template (cot) (* cot)

- ► Save the project in a new folder named SCORG_Thermodynamics→ SCORG_Thermodynamics_Tutorial.spf
- ► The GUI of SCORGTM in the figure below shows the main items of the front panel.







- ▶ Go to Help \rightarrow Tutorials \rightarrow Folder opens
- ▶ Copy the compressor rotor profile files \rightarrow [35MaleProfile_P1.dat and 35FemaleProfile P2.dat]
- ▶ Paste these files in the working directory \rightarrow SCORG_Thermodynamics

▶ Set Length Units to meters.

Inputs Units	Properties		
Variable	Units		^
Pressure	bar	~	
Temperature	к	~	
Length	m	~	
Density	kg/m³	~	
SpecificHeat	J/(kg.K)	~	
Speed	m/e	~	

In Profile Setup, adjust Axis Distance to 93 mm.

Profile Choice	User Sp	~
Axis Distance	0.093	m
Z1	3	
Z2	5	
GAPI	0.00018	m
GAPR	0.00018	m
GAPA	5E-05	m

► Go to User Profile → Browse and Select the Male Rotor Profile from the working directory.

35MaleProfile_P1.dat





User Profile				
Imported Profiles				
Import Male	Import Female		Reset 1 Importe	ſo ed
– Default Profiles –				
Write To [Default		Reset 1 Defau	Го t
Profile Transforma	ations			
Apply to both	Male		Fema	le
Rotate (Deg)	0.00	•	0.00	-
Scale	1.000	-	1.000	-
Flip Coordinates				
Mirror About X				
Mirror About Y				
ACCI	EPT Transfo	matio	ons	
Profile Trimming				
Show Trimmin	ig Lines			
Trim Main Rot	or	Trim	Gate rotor	

Click 'Yes' to overwrite P1.dat.

Overwrite	\times
P1.dat already exist would you like to overwrite it!	
Yes No	

▶ Similarly, Select the Female Rotor Profile.

35FemaleProfile_P2.dat

► Click Write To Default.





User Profile			
Imported Profiles			
Import Male	Import Female	Rese	t To ted
– Default Profiles –		-	
Write To	Default	Rese Defa	t To ault
Profile Transform	ations		
Apply to both	Male	Fem	nale
Rotate (Deg)	0.00	0.00	-
Scale	1.000	\$ 1.000	÷
Flip Coordinates			
Mirror About X			
Mirror About Y			
ACC	EPT Transform	mations	
Profile Trimming			
Show Trimmin	ng Lines		
Trim Main Ro	tor	Trim Gate rol	or

• Click the Right button and select Refresh to view new profiles.



Inspect the Rotor Profile in the GUI for gaps in the tips, starting points of the profile indicated by the small yellow circles. For more information, please see Section 6.4 in the SCORGTM User manual.





2.2 Set Geometrical Clearances

Profile Choice	User Spe N	1
Axis Distance	0.093	m
Z1	3	
Z2	5	
GAPI	0.00018	m
GAPR	0.00018	m
GAPA	0.00010	m

► Set the following Profile Parameters to get desired clearance size:

▶ Run Geometry calculation through the shortcut highlighted in the figure below

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▶ Run Rack generation procedure by clicking on the Numerical rack shortcut button.

This is required to inspect the profile and make any required corrections of the imported rotor profiles. You will receive the following message:

Default p	rofiles!	\times
	P1.dat and P2.dat files have been replaced. Do you want to use them as default profiles?	
	Yes No Cancel	

- Click on Yes to accept the correction of the profiles.
- Now you can inspect the Interlobe clearances which the imported profile will have with the given axis distance. To do that, click with the right mouse button on file Case->Thermodynamics->Output->GapI_dist.txt, select Graphical view and select columns 2 and 3 for X and Y axis respectively. The normal clearance distribution along the sealing line represented in the relative position from the beginning to the end of the profile is shown. In the diagram below, it is visible that the normal clearance varies from 0.06 mm to 0.1 mm in the given profile.







If you want to use this clearance for calculation of thermodynamic performance then set the GAPI value to 0.

If you want to set Interlobe Clearance in thermodynamic through the Input value GAPI, then set up the GAPI to desired clearance value.

If you want to completely remove the clearance from the imported profile, then delete the file Case->Thermodynamics->Input->GapI.dat. Then recalculate Geometry and refresh the diagram. You should see the diagram below.



Save the Project.





3 Set and calculate Geometry

In order to perform thermodynamic calculation and to obtain expected results, it is important to set up all geometry and operational inputs correctly. This will be adjusted through the Inputs window for Geometry.

Inputs Units Properties	
✓ SCORG_Thermodynamics_Tutorial	
> · Profile	
✓ Geometry	
Rotor Configuration	
Machine Configuration	
Restraints	
> · Domains	
> • Thermodynamics	
> · Grids	

▶ Set values for Rotor Configuration and Machine Configuration as indicated below.

Rotor Configuration				
Relative Length	1.6			
Rotor Length	0.203718		m	
Wrap Angle	285		Deg	
Pitch Low Pressure Port	0	m		
Pitch High Pressure Port	0	m		
Rotor Pitch	Uniform	Uniform 🗸		
Rotor Profile	Constant	~		
Main Rotor Centre X	0		m	
Main Rotor Centre Y	0		m	
Main Rotor Centre Z	0		m	
Main Rotor Start Angle	0		Deg	
Rotor Stage Number	0			
Gate Rotor Angular Position	0		Deg	
Main Rotor Helix	Right	~		
Gate Rotor Position	Right	~		
Machine Configuration	on		1	
Machine Type	Screw Co	~		
N Gate	1			
Compression Start	0		Deg	
Compression End	161.792	Deg		
Volume Index	1.8			
Angle of Radial Discharge	0		Deg	
E Rotor	211		GPa	
aL Rotor	1E-05	m/m/K		
E Casing	211		GPa	
αL Casing	1E-05		m/m/K	
Wall Roughness	0		m	





The next geometry setup is related to set the size of flow domains and passages shown in Figure 1.2.



The volumes of these domains and flow areas between them are set through the menu shown in the figure above.

The domains in the Inputs are also shown in Figure 1.2 with the following numbers:

- ► Low pressure Pipe Domain 1
- ► Low Pressure Reservoir Domain 2
- High Pressure Reservoirs Domain 4
- High Pressure PipeDomain 5

All these volumes are set by the equivalent diameter and length of each of these domains.

Flow areas between these domains in reference to Figure 1.2 are defined in the following way:

- The area 6 between the Low pressure pipe (1) and Low pressure Reservoir (2) is defined by the Diameter of the Low Pressure Pipe
- The area 9 between the High Pressure Reservoir (4) and High Pressure Pipe (5) is defined by the Diameter of the High Pressure Pipe
- The area between the Low Pressure Reservoir (2) and the Working Chamber (3) is called Low pressure Port. It is calculated by the Geom program as described in the User Manual while in the Inputs it is only selected if the port is Axial, Radial or both. The size of the port is defined by the Compression Start Angle in Machine Configuration.
- The area between the Working Chamber (3) and the High Pressure Reservoir (4) is called High Pressure Port. It is calculated by the Geom program as described in the User Manual. In Inputs, it is only selected as the Axial, Radial port or both. The size of the port is defined by the Compression End Angle in Machine Configuration which directly depends on the Volume Index.





▶ Set values of the flow domains as shown below.

Low Pressure Pipe	1							
Diameter	0.1		m					
Length	0.2		m					
Low Pressure Res	ervoir							
Diameter	0.1		m					
Length 0.1 m								
Low Pressure Port Lich Pressure Port								
High Pressure Res	ervoir							
Diameter	0.075		m					
Length	0.075		m					
High Pressure Pipe	B							
Diameter	0.05		m					
Length	0.2		m					
Low Pressure Port								
Port Type	Axial	~						
Port Type Depth Radial	Axial 0.008	~	m					
Port Type Depth Radial Circular Divisions	Axial 0.008 100	~	m					
Port Type Depth Radial Circular Divisions Radial Divisions	Axial 0.008 100 8	~	m					
Port Type Depth Radial Circular Divisions Radial Divisions Depth Axial	Axial 0.008 100 8 0.009	~	m					
Port Type Depth Radial Circular Divisions Radial Divisions Depth Axial Angle Radial End Face	Axial 0.008 100 8 0.009 45	~	m m Deg					
Port Type Depth Radial Circular Divisions Radial Divisions Depth Axial Angle Radial End Face Length Radial	Axial 0.008 100 8 0.009 45 0.021	~	m m Deg m					
Port Type Depth Radial Circular Divisions Radial Divisions Depth Axial Angle Radial End Face Length Radial Axial Clearance	Axial 0.008 100 8 0.009 45 0.021 0.0002	~	m m Deg m m					
Port Type Depth Radial Circular Divisions Radial Divisions Depth Axial Angle Radial End Face Length Radial Axial Clearance Orthogonalisation Factor	Axial 0.008 100 8 0.009 45 0.021 0.0002 1	~	m m Deg m m					
Port Type Depth Radial Circular Divisions Radial Divisions Depth Axial Angle Radial End Face Length Radial Axial Clearance Orthogonalisation Factor	Axial 0.008 100 8 0.009 45 0.021 0.0002 1	~	m Deg m m					
Port Type Depth Radial Circular Divisions Radial Divisions Depth Axial Angle Radial End Face Length Radial Axial Clearance Orthogonalisation Factor	Axial 0.008 100 8 0.009 45 0.021 0.0002 1	~	m m Deg m m					
Port Type Depth Radial Circular Divisions Radial Divisions Depth Axial Angle Radial End Face Length Radial Axial Clearance Orthogonalisation Factor High Pressure Port Port Type	Axial 0.008 100 8 0.009 45 0.021 0.0002 1 Axial	~	m Deg m m					
Port Type Depth Radial Circular Divisions Radial Divisions Depth Axial Angle Radial End Face Length Radial Axial Clearance Orthogonalisation Factor High Pressure Port Port Type Inner Circle Diameter	Axial 0.008 100 8 0.009 45 0.021 0.0002 1 Axial Axial 1	~	m Deg m m					
Port Type Depth Radial Circular Divisions Radial Divisions Depth Axial Angle Radial End Face Length Radial Axial Clearance Orthogonalisation Factor High Pressure Port Port Type Inner Circle Diameter Circular Divisions	Axial 0.008 100 8 0.009 45 0.021 0.0002 1 Axial 1 20	~	m Deg m m					
Port Type Depth Radial Circular Divisions Radial Divisions Depth Axial Angle Radial End Face Length Radial Axial Clearance Orthogonalisation Factor High Pressure Port Port Type Inner Circle Diameter Circular Divisions Radial Divisions	Axial 0.008 100 8 0.009 45 0.021 0.0002 1 Axial 1 20 20	~	m Deg m m					
Port Type Depth Radial Circular Divisions Radial Divisions Depth Axial Angle Radial End Face Length Radial Axial Clearance Orthogonalisation Factor Inthe Gircular Pressure Port Port Type Inner Circle Diameter Circular Divisions Radial Divisions Z Divisions	Axial 0.008 100 8 0.009 45 0.021 0.002 1 Axial 1 20 20 5	×	m Deg m m					
Port Type Depth Radial Circular Divisions Radial Divisions Depth Axial Angle Radial End Face Length Radial Axial Clearance Orthogonalisation Factor High Pressure Port Port Type Inner Circle Diameter Circular Divisions Radial Divisions Z Divisions Length	Axial 0.008 100 8 0.009 45 0.021 0.0002 1 Axial 1 20 20 5 0.016	×	m Deg m m					
Port Type Depth Radial Circular Divisions Radial Divisions Depth Axial Angle Radial End Face Length Radial Axial Clearance Orthogonalisation Factor High Pressure Port Port Type Inner Circle Diameter Circular Divisions Radial Divisions Z Divisions Length Axial Clearance	Axial 0.008 100 8 0.009 45 0.021 0.0002 1 Axial 1 20 20 5 0.016 0.00013	×	m Deg m m m					

• Calculate Geometry by clicking on the shortcut button for geometry calculation.



► Inspect geometry diagrams.









Leakage Areas







Sealing Line XY



Port Areas – The diagram shows the area of the Suction and Discharge Ports as a function of the rotation angle as well as any other ports if they exist, such as oil injection port or economiser port. The diagram also shows the Volume curve and two vertical lines demonstrate the start and end of the compression process.

Leakage Areas – The diagram shows the flow area through leakage paths as a function of the main shaft angle. These include leakage areas of the inflow and outflow leakages.

The inflow leakage paths are those through which fluid leaks in the working chamber.

• Leading blowhole area, leading male and female tip leakage area (radial leakage) and leading axial gap area

The outflow leakage paths through which fluid leaks from the working domain are:

• Trailing blowhole area, trailing male and female tip leakage area (radial leakage), interlobe gap area and trailing axial gap area.

Sealing line – The diagram shows the sealing line in three coordinate planes, XY, YZ and ZX.

The influence of the change in clearances on the performance of the machine will be evaluated in the next Section.





▶ Inspect geometry report.

File Edit Run View Units Help	
🗋 🚔 🛃 < 🧟 Graphical Results	• 🕼 🕺 🚳 🛍 🗓 🚳 🔿
Cad imported profiles	 User Berfler Commission for the
Reports	Geometry
 SCORG_Thermody Show Output in Tab 	Thermodynamic
✓ Geometry	Forces
Rotor Conf	Grid
Machine C Inputs	
i i i i i i i i i i i i i i i i i i i	
User Profile × Geometry Inputs × Geom	etry × Geometry.txt ×
######### Screw compressor	geometry data ##########
Date: 18-Jun-2019	Time: 14:45:40
Date. 18-501-2019	Time. 14.43.40
Datas contra distance.	03 000
Rotor centre distance:	93.000 mm
Number of lobes:	3 5
Pitch circle diameters:	69.750 116.250 mm
Inner rotor diameters:	65.535 58.473 mm
Diameters difference :	30.895 30.895 mm
Wrap angle:	285.000 171.000 deg
Rotor lead:	257.328 428.880 mm
Helix angle:	40.416 deg
Lead angle:	49.584 deg
Rotor length:	203./18 mm
Rotor lobe area:	1739. 1161. mm2
Cross section area:	8700. mm2
Max. chamber volume:	570426. mm3
Displacement:	1711277. mm3/rev
	1./11 I/rev
Ports	
Axial LP port area:	2900. mm2
Axial HP port area:	2742. mm2
Radial HP port area:	0. mm2
Leakage gans	
Interlobe SL length:	203.462 mm
Interlobe SL area:	36.589 mm2
Blow-hole area:	4.375 mm2
Axial gap area:	6.179 6.179 mm2
===============================	

The values shown in two columns relate to Male (left) and Female rotor (right).

▶ View the axial discharge port.

The shape and the size of the discharge port are defined by the Compression End angle which is in turn defined by the Volume Index Vi. In order to inspect the shape and size of the discharge port please calculate grid for the discharge port using highlighted shortcut button below and then display the port mesh using the shortcut button shown in the rectangle.





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The shape and size of the port are displayed below. It will later be shown how it changes with the change in Vi.







4 Set and calculate Thermodynamics with GT-SUITE

Once the geometry of the compressor is correctly defined, it is possible to perform the thermodynamic calculation. The objective of this calculation is to determine the flow rate and power of the specified compressor operating at certain operating conditions and with a certain working fluid.

Predefined model templates are used to perform thermodynamic calculations. Selection of the template is done automatically and is based on the configuration of the specific machine. Template files are saved in SCORG installation folder > GT > GTtemplates (Usually: C:\SCORG\GT\GTtemplates). Sample model project is shown below.



There are two tabs present in the GT-SUITE model called **Main** and **ScrewMachineChambers.** Their contents can be viewed by switching between the Main and





ScrewMachineChambers tabs at the top left of the images shown. Alternatively, it is possible to double-click on the image of the rotors to see the contents of the ScrewMachineChambers subassembly. The contents of this main model can be modified such as including the piping at the inlet, outlet and optionally, the injection and economizer ports.

There is also an additional block (External Subassembly) in the Main tab called "BearingAssembly". This points to one of three external subassemblies (.gtsub file extension) that have been included with the installation – RollerBearingsAssy.gtsub (contains roller bearings on the shaft), JournalBearingsAssy.gtsub (contains journal bearings on the shaft), and NoBearingsAssy.gtsub (no bearings modeled on the shaft). Depending on the "Bearing Type" setting under Inputs -> Bearings and Seals in SCORG, one of either RollerBearingsAssy or JournalBearingsAssy will be chosen. If no bearings are desired, all of the 4 input parameters below "Bearing Type" can be set to 0. This will automatically select the NoBearingsAssy within the main GT model.

The SCORG Thermodynamic Calculation must be run first after which the Force calculation must be run to generate two additional text files containing the profiles for the radial and axial X and Y forces vs shaft angle for the male and gate rotors. Following this, the GT-SUITE Thermodynamics Calculations can be run.

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The generated force profiles can be viewed by clicking on the Force diagrams button.









Calculation of performance takes place in the SCORG installation folder > GT folder by default. However, the location of the model can be modified under Inputs -> Thermodynamic Controls -> GT Case Folder as shown below.

Thermodynamic Controls							
Speed loop	1						
Psuc loop	1						
Pdis loop	1						
Convergence loop	20						
∆Wtip	5	m/s					
∆Psuc	0	Pa					
∆Pdis	1	Pa					
∆Tevp	5	K					
∆Tcon	5	K					
Clearance adjustment	No 🗸						
Short report settings	Settings						
Thermodynamic solver	GT_SU 🗸						
GT Case Folder	C:\SCORG						

Input files (discussed below) and the template files (ScrewMachine-#chambers.gtm and one of the three bearing subassembly files) are copied from their original folders to this folder. The output of the simulation is saved in the selected folder and later copied to the SCORG installation folder > GT.

Input files are first generated in the GT Case Folder and copied to the SCORG installation folder > GT. These include:

GeomGT.txt – contains geometry values for volume, port areas, leakage flow areas

GTParameters.txt – contains parameters required for setting up and running the case in GT-SUITE.





Forces_R1_GT.txt – contains the radial and axial forces vs shaft angle for the male rotor which are referenced by the GT-SUITE model to consider bearing/seal/drag frictional power losses.

Forces_R2_GT.txt – contains the radial and axial forces vs shaft angle for the gate rotor which are referenced by the GT-SUITE model to consider bearing/seal/drag frictional power losses.

GT.bat – batch file created for each case individually to select an appropriate template and run the case.

The output files are as follows:

thermGT.trn – contains result data in a tabular form. Each column represents different value as specified in the first row. This file is later transformed into Therm.dat and copied to the Case folder > Thermodynamics > Outputs to be used for constructing diagrams in SCORG.

Thermo_Normal_GT.trn – contains integral results that characterize operation of the machine.. The results are available in the form of a short Thermodynamic report in the Case folder > Thermodynamics > Reports

*.glx – name differs depending on a template used. GT-POST file with all the results. Section 4.8 describes how to use it.

4.1 GT template selection

The template file is selected automatically using the batch file generated in the SCORG geometry calculation process.. Templates are available for the most common configurations of machines. In case of unusual combination of lobes in the male and female rotors, some modifications may required.

When running a calculation with GT-SUITE a file with an appropriate number of working chambers will be selected and called. The number of chambers is calculated as a multiplier of a number of male lobes and a number of full rotations required to complete a cycle, i.e. for a compressor with 4 lobes male rotor, completing the cycle within 3 interlobe rotations, 12 chamber model will be used. While there are several templates available, the user may pay close attention to the models where different configurations will produce the same number of the working chambers, i.e. the machine with 3 male lobes and 4 interlobe rotations will also use the 12 chamber model. In this case, some modification to interlobe leakage links may be required. The number of interlobe rotations required to complete a cycle depend on wrap angle of the machine. For standard screw compressors/expanders, the number of required interlobe rotations is usually 3.

A general rule of linking chambers with the interlobe flow is to connect every N chamber to chamber $N + #_male_lobes$. If any change is needed it can be done by removing the existing leakage links and creating new ones with the **Link** tool.





File	Home	View	Data T	ools							
New	Dpen	E Save	👈 Undo 🗬 Redo	ᢞ Cut 🖿 Copy naste	Template Library	Find ه Template ه Find Value	∲ Select	Link	Edit Parts in Spreadsheet	Flow Scale View	
	File	G.	Undo	Clipboard _{Fa}		Templates and Search		-	Map Mode	5	l

When connecting chambers specific ports must be used. For chamber N, **Outlet 5** is selected and for chamber $N + #_male_lobes$ **Inlet 5** is supposed to be chosen.

	Link Creation										
Link I	D for part [Chamber:Chamber2]				Link	D for part [Chamber:Chamber5]					
Flow	Connections				Flow Connections						
ID	Link ID Name	Required?	Used		ID	Link ID Name	Required?	Used			
16	Outlet 3		 Image: A second s	~	15	Intel 3 Outlet 3			_		
17	Inlet 4		 Image: A second s		17	Inlet 4					
18	Outlet 4		 Image: A second s		18	Outlet 4					
19	Inlet 5		 Image: A second s		19	Inlet 5					
20	Outlet 5				20	Outlet 5		1			
21	Inlet 6		 Image: A second s		21	Inlet 6					
22	Outlet 6		 Image: A second s		22	Outlet 6					
23	Inlet 7			*		00000		•	· ·		
Su	Suppress Automatic Link Dialogs To/From this Template										
Shu	Shuffle Existing Links										
			OK			Cancel					

Once interlobe leakage links are correctly modified save the template and continue with setting up the simulation. It is advised to keep the copy of the original template file.

NOTE: For standard screw machines, none of modifications are required and the performance can be directly calculated from SCORG and results can be also presented in SCORG GUI.





4.2 Thermodynamics Inputs

The setup for Thermodynamic calculations is performed through the Input controls shown in the control window below.

•

Inputs	Units Properties	
V SCC	DRG_Thermodynamics_Tutorial	٦
> .	Profile	
> .	Geometry	
~	Thermodynamics	
	Working Conditions	
	Working Fluid	
	Fluid Injection	
	Bearings and seals	
	Additional Injection Port	
	Thermodynamic Controls	
> .	Grids	

The controls are divided into 6 categories:

- Working conditions
- Working Fluid
 - Fluid injection
- Bearing and seals
- Additional Injection Port
- Thermodynamic controls

	TC1 1	•	. 1
•	Thermody	vnamic	controls
		,	

 Working Condition Working Huid Huid Injection Bearings and seal Additional Injection Thermodynamic C 	ls on Port controls	
Speed loop	1	
Psuc loop	1	
Pdis loop	1	
Convergence loop	20	
∆Wtip	5	m/s
∆Psuc	0	Pa
∆Pdis	1	Pa
∆Tevp	5	К
∆Tcon	5	К
Short report settings	Settings	
Thermodynamic solver	GT_SUITE	~

Select Thermodynamic Solver to GT-SUITE. Other controls are used only for calculations with SCORG solver and can be omitted.

After selecting GT_SUITE recalculation of geometry is needed. During this process additional following files are created in the Case folder > Thermodynamics > Output folder:

GeomGT.txt – equivalent to Geom.dat, used in GT-SUITE to set the geometry of the machine. This file is extended to provide data for a complete number of full

interlobe rotations required to complete the cycle of the machine..

GTparameters.txt – file containing all the required parameters to set the case in GT-SUITE. This is discused later in this tutorial.

GT.bat – batch file stored in SCORG Installation folder> GT, it is used to call the GT-SUITE with the appropriate template file.





Working Fluid

Fluid	Ideal Gas	~				
Gamma	1.4					
RGas	s 287					
Z	1					
Working Hu	id Real Cas					
Working Flui Fluid	id Real Gas	~				
 Working Flui Fluid Gamma 	id Real Gas 1.4	~				
Working Hui Fluid Gamma RGas	id Real Gas 1.4 287	J/(kg.K)				
Working Hu Fluid Gamma RGas Z	id Real Gas 1.4 287 1	J/(kg.K				

The working fluid can be an ideal or real gas. In this example, the ideal gas will be used. The values in the window on the left are values for air.

When working with real fluid **Real Gas** must be selected and **From NIST** button should be pressed to open the mixture options window.

•	0.460000	•
•	0.020000	*
•	0.520000	* *
*	0.000000	A T
*	0.000000	*
•	Load	
	· · · · Sum	 0.460000 0.020000 0.520000 0.000000 0.000000 Sum:

mixture as *R134a* then press Save button.

All the available fluids to be chosen in GT-SUITE are listed in the GT-SUITE Template Library under **Flow/References/Fluid...**

File	Home	View	Data	Tools	\frown		
New	Open	Save	🕈 Undo & Redo	o∱ Cut ■ Copy ■ Paste	Template Library		Find Template & Find Value
	File	r.	Undo	Clipboard 🕫	$ \frown $	Templates and Searc	ch



The appropriate mixture should be specified. Mixture name is a crucial element in this step. This is the parameter passed to the GT-SUITE model when running the simulation. It should be expressed exactly as it appears in the GT-SUITE Template Library and it is case sensitive.

At least two components of the mixture must be selected for this feature to work properly. Amount of each component is not a major property as only the name of the mixture is used in this case.

Also, some of the pure fluids are named differently in GT-SUITE and SCORG. For example, in SCORG R134a appears as **R134A** and in GT-SUITE as **R134a**. In SCORG mixture window select *R134A* fluid, add another component which amount can be set to 0 and name the



Working Conditions

Wtip	80		m/s
Rotor Speed	12000	12000	
PO	1		bar
Pr	3		bar
то	293		к
Tr	350		к
Tevp	268		К
Tcond	313		к
T Ambient	293		к
Include heat transfer	No	~	
х	1		

The rotational speed can be defined by the tip speed or by the Rotor speed. Whichever value is set, the other will automatically adjust according to the size of the rotor.

The values required to be set for this calculation are

P0 – Suction pressure (absolute)

- T0 Suction Temperature
- Pr Discharge Pressure.
- Tr-discharge Pressure

Liquid injection

Fluid Injection	Off	~	
Р	3		bar
т	310	310	
Injection Angle	63.025	63.025 C	
Axial Position	0.1 n		m
Port Diameter	0.005		m
Doil	1E-05		m
CpOil	2000		J/(kg.K)
ρ	845		kg/m³
Viscosity of Oil	5E-05		m²/s

For oil-free screw compressor, the Fluid Injection control button should be off. In such a case, it is irrelevant what the other values are in this input window as these are not used in the calculation.

Additional Injection Port

Additional Port	No	~	
P	3		bar
т	310		К
Fluid Quality	Liquid	~	
njection Angle	63.025	Deg	
Axial Position	0.1		m
Port Diameter	0.02		m

Similarly, for the Additional Port, it should be off.





Bearings and seals

Bearing Type	Rolling El 🗸	/
N Shaft	4	
Seal Ploss	300	W/1000R
Diameter Factor	0.02285	
Speed Factor	0.000835	

Depending on the "Bearing Type" setting, one of either the RollerBearingsAssy or JournalBearingsAssy subassemblies will be chosen for use in the GT main model. If no bearings are desired, all of the 4 input parameters below "Bearing Type" can be set to 0. This will automatically select the NoBearingsAssy within the main GT model. For this exercise, set the 4 inputs to 0 and run SCORG Thermodynamics prior Force to calculations to the generate Forces_R1_GT.txt and Forces R2 GT.txt files.





4.3 Oil-free compressor calculation

▶ Calculate Thermodynamics by selecting Thermodynamics Calculations shortcut.

▶ Inspect the thermodynamic diagrams.









The above two diagrams show Pressure change with the angle of rotation and the temperature change with the angle of rotation respectively. The green line marked with CW represents the main working chamber.

The blue (CW1) and green (CW2) lines are low pressure pipe and reservoir respectively.

The red (CW4) and orange (CW5) lines are high pressure reservoir and pipe respectively.

The pulsations in the main chamber and in the pipes and reservoirs are visible on the above charts. The Mass-Alpha diagram is currently not available for this calculation. However, further results can be obtained using GT-POST application. This will be discussed later.

Results presented on the screen after the calculations are finished show calculated integral parameters and Case Setup. Some values like temperature and pressure of the oil are printed even when fluid is not injected.

CASE # 1 Tinl Theoretical Mas C kg/h 19.627826 1466.0172	Pin] N bar I 0.99160801	Moil Tou kg/s C 0.0000000 17	nt Po ba 71.80996 3	ut Toi r C .0757345 36	1	Poil bar 3.0000000	Volume Index Vi No Unit 1.8000000	Speed RPM 12000.040
Tip Speed m/s 80.000130	Vol. Flow Rat m^3/min 16.414800	e Vol. Flow Rate m^3/h 984.91571	Mass Flow Rate kg/h 1162.7250	Vol. Efficiency % 80.042254	Fluid Power kW 50.043029	Fluid Power HP 67.108794		

▶ View Thermodynamic Report

While using GT-SUITE solver, the same results as above can be viewed as a short report.

File Edit Run	View Units Help		-	
🗋 💕 🛃 🔷 🦄	Graphical Results	۲	🔗 👌 🏦 🕥 🕄 🎞 🚳	🔘 署 💼 📔 🕂
Inputs Units Pr	Cad imported profiles	►	ser Profile X GTparameters by	t 🗙 Therm dat 🗙 Gri
the Thermodynamics	Reports	•	Geometry	
> Profile	Show Output in Tab		Thermodynamic +	Short
> · Geometry	Full Screen		Forces	Normal
✓ Thermodynami Working C	Inputs	•	Grid 🕨	Complete

Tinl Pinl Moil Tout Pout Toil Poil Volu IC bar kg/s C bar C bar No U 19.627826 0.99160801 0.0000000 171.80996 3.0757345 36.850000 3.0000000 1.8	Volume Index Vi Speed No Unit RPM 1.8000000 12000.	040
---	--	-----





Tip Speed Vol. Flow Rate Vol. Flow Rate m/s m^3/min m^3/h 80.000130 16.414800 984.91571	Mass Flow Rate kg/h 1162.7250	Vol. Efficiency F % 80.042254	Fluid Power kW 50.043029	Fluid Power HP 67.108794
---	-------------------------------------	----------------------------------	--------------------------------	--------------------------------

4.4 Changing compressor geometry and operating parameters

The thermodynamic module allows variation of parameters and evaluation of their influence on the performance of the compressor. As an example, the following changes will be introduced:

- Radial clearance will be changed to 50 micrometres,
- Volume Index will be increased to 2.2
- Discharge pressure will be reduced to 2.5 bar
- Size of the discharge pipe (flange) will be changed to 70 mm

To introduce these changes please alter windows below:

Profile

Profile Choice	User Spe V	
Axis Distance	0.093	m
Z1	3	
Z2	5	
GAPI	0.00018	
GAPR	0.00005	m
GAPA	0.0001	m

Geometry

Machine Type	Screw C	~	
N Gate	1		
Compression Start	0		Deg
Compression End	189.49		Deg
Volume Index	2.2		
Angle of Radial Discharge	0		Deg
E Rotor	211		GPa
aL Rotor 1E-05		m/m/K	
E Casing	211		GPa
αL Casing	1E-05		m/m/K
Wall Roughness	0		m





Thermodynamics

Wtip	80		m/s
Rotor Speed	12000		RPM
P0	1		bar
Pr	2.5		bar
то	293		к
Tr	350		К
Теvp	268		к
Tcond	313		К
T Ambient	293		к
Include heat transfer	No	~	
X	1		

Domains

High Pressure Pipe		
Diameter	0.07	m
Length	0.2	m





- ▶ Run Geometry calculation; Run Port Generation and Run Thermodynamics.
- ▶ Inspect the results and compare with the results obtained previously.
- a) Geometry Diagrams Note the difference in the size of the discharge port, Compression angle and the size of radial gaps.



Leakage Areas



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b) Note the difference in the size and shape of the discharge port.



c) Note the difference in the thermodynamic performance. The compressor now over compresses but the larger flow area behind the compressor introduces lower losses in the discharge reservoir and pipes and therefore lower pressure.







d) Inspect Thermodynamic report.

CASE # 1 Tin1 C 19.541446	Pinl bar 0.99019483	моіl kg/s 0.0000000	Tout C 133.45414	Pout bar 2.5122368	тоіl С 36.850000	Poil bar 3.0000000	Volume Index V No Unit 2.2000000	i Speed RPM 12000.040
Tip Spee m/s 80.0001	2d Vol.Fl m^3/mir L30 17.842	ow Rate Vol. F n m^3/h 2553 1070.9	low Rate Mass F kg/h 5833 1262.0	low Rate Vol. % 0453 86.9	Efficiency Fluid kW 75206 40.9	1 Power Fluid HP 089092 54.96	Power Theoret kg/h 7268 1466.0	ical Mas 172

Once the results are calculated, these can be viewed in the report as presented before or exported to excel where these could be used for preparing diagrams etc. To export in excel select the Thermo_Short.txt report from the Case tree, click on the right mouse button and select 'Export to excel' as shown in the figure



The results will be in the form shown below.

Tinl Pinl Moil Tout Pout Toil Poil Volume Index Vi Speed Tip Speed Vol. Flow Rate Vol. Flow Rate Vol. Efficiency Fluid Power Fluid Power Theoretical Mas C bar kg/s C bar C bar No Unit RPM m/s m^3/min m^3/h kg/h % kW HP kg/h 19.541446 0.99019483 0.0000000 133.45414 2.5122368 36.850000 3.0000000 2.2000000 12000.040 80.000130 17.842553 1070.5833 1262.0453 86.975206 40.989092 54.967268 1466.017	CASE #	1																			
C bar kg/s C bar C bar No Unit RPM m/s m^3/min m^3/h kg/h % kW HP kg/h 19.541446 0.99019483 0.0000000 133.45414 2.5122368 36.850000 3.0000000 2.2000000 12000.040 80.000130 17.842553 1070.5833 1262.0453 86.975206 40.989092 54.967268 1466.017	Tinl	Pin	l Moil	Tout	Pout	То	il Poil	Volume	Index Vi Spe	ed	Tip Speed	Vol. Flow F	Rate Vol. Flor	w Rate Mass	Flow Rate	Vol. Ef	ficiency Fluid	Power Flui	id Power T	heoretical Mas	
19.541446 0.99019483 0.000000 133.45414 2.5122368 36.850000 3.0000000 2.2000000 12000.040 80.000130 17.842553 1070.5833 1262.0453 86.975206 40.989092 54.967268 1466.017	C	bar	kg/s	С	bar	С	bar	No Unit	RPM	m/s	m^3/min	m^3/h	kg/h	%	kW	HP	kg/h				
	19.5414	46	0.99019483	0.0000000	133.45	5414	2.5122368	36.850000	3.000000	0 2	2.2000000 1	2000.040	80.000130	17.842553	1070.58	33	1262.0453	86.975206	40.989092	2 54.967268	1466.0172

4.5 Calculating Oil injected case

Majority of screw compressors today are oil injected. Oil is injected to seal, cool and lubricate the rotors. Rotors are in direct contact. Oil injected compressors achieve higher pressure ratios and lower discharge temperatures, rotate at lower speeds than oil-free compressors and allow clearances to be much lower than in oil-free machines.

The same compressor will be used for oil injection calculation.

The profile will be set with a nominal clearance of 50 micrometres, Volume Index will be set to 5, tip speed to 40 m/s, discharge pressure to 8 bar. Oil injection will be switched on, Oil





injection pressure set to 7 bar through oil injection port positioned at 60 degrees of the rotation of the male rotor from the closing of the suction port and oil will be injected at 310 K.

Please set the values as indicated in the figure below.

Profile

Profile Choice	User Spe V	
Axis Distance	0.093	m
Z1	3	
Z2	5	
GAPI	0.00018	m
GAPR	5E-05	m
GAPA	5E-05	m

Geometry

Machine Configuration	n		
Machine Type	Screw C	~	
N Gate	1		
Compression Start	0		Deg
Compression End	259.899		Deg
Volume Index	5		
Angle of Radial Discharge	0		Deg
E Rotor	211		GPa
aL Rotor	1E-05		m/m/K
E Casing	211		GPa
αL Casing	1E-05		m/m/K
Wall Roughness	0		m

Thermodynamics

Wtip	40		m/s
Rotor Speed	6000		RPM
PO	1		bar
Pr	8		bar
TO	293		к
Tr	350		к
Теvp	268		к
Tcond	313		к
T Ambient	293		к
Include heat transfer	No	~	
x	1		





Fluid Injection		
Fluid Injection	Oil abso 🗸	^
Р	7	bar
Т	310	K
Injection Angle	60	Deg
Axial Position	0.1	m
Port Diameter	0.005	m
Doil	1E-05	m
CpOil	2000	J/(kg.K)
ρ	845	kg/m³
Viscosity of Oil	5E-05	m²/s
Multiple injection holes	Setup	~

- ► Calculate Thermodynamics.
- ► View diagrams.











Notice the red line which represents the oil in the working chamber. As currently, heat transfer is assumed to be instantaneous, the temperature of the gas and oil are the same line. Oil is injected at 60 deg and is used to cool the air. Despite the discharge pressure reaching almost 9 bar, the discharge temperature is around 80 deg C.

The results displayed in the results window:

CASE # 1 Tinl C 19.778183	Pinl Mo bar kg 0.99759055 0.	рі] Тоц g/s С . 50603630 72	ut Po ba 2.845085 8	ut Toil r C .1570039 40.	PG ba 003733 6	oil V ar N 6.4254491	olume Index Vi Sp o Unit RPI 5.0000000 60	eed M 000.0200
Tip Speed	Vol. Flow Rate	Vol. Flow Rate	Mass Flow Rate	vol. Efficiency	Fluid Power	Fluid Power	Theoretical	Mas
m/s	m^3/min	m^3/h	kg/h	%	kw	HP	kg/h	
40.000060	8.7796663	526.79479	625.38711	85.505744	42.554207	57.066121	733.00861	

The Report

CASE # 1 Tin] C 19.778183	Pinl bar 0.99759055	Moil T kg/s C 0.50603630	out 72.845085	Pout bar 8.1570039	Toil C 40.003733	Poil bar 6.4254491	Volume Index Vi No Unit 5.0000000	Speed RPM 6000.0200
Tip Speed	Vol. Flow Rate	Vol. Flow Rate	Mass Flow Rate	Vol. Efficien	cy Fluid Power	Fluid Power	Theoretical M	as
m/s	m^3/min	m^3/h	kg/h	%	kw	HP	kg/h	
40.000060	8.7796663	526.79479	625.38711	85.505744	42.554207	57.066121	733.00861	

An increase in the mass in the working chamber can be observed.

Additional port





Often, oil injected screw compressors have an additional injection port, which in refrigeration is referred to as the economizer port. In SCORG, the additional injection port is enabled through Thermodynamics->Additional Injection Port tab:

 Working Conditions Working Fluid Liquid Injection Bearings and seals Additional Injection Port 								
Additional Port	Yes 🔻							
Р	4.5	bar						
Т	70	°C						
Fluid Quality	Vapour 👻							
Injection Angle	100	Deg						
Axial Position	100	mm						
Port Diameter	15	mm						
Thermodynamic Cor	trols							

It is necessary to specify the position and size of the additional port as well as the pressure and temperature in the port. Before thermodynamics can be calculated, it is important to calculate geometry. The additional injection port is shown as an economiser in the figure below



Once thermodynamics is calculated, it is possible to observe results through the thermodynamic diagrams below.

Notice the change in the pressure diagram where a sudden increase in the pressure can be observed from the angle of 100 deg.







The additional injection port can be also used for the injection of additional liquid in the working domain. However, calculations using GT-SUITE are currently limited to be the same as the working fluid, in this case the refrigerant.

In oil-injected compressors, the liquid injected is oil. To enable additional oil injection, it can be set up in Fluid Injection, under Multiple injection holes.





✓ Thermodyna Working	mics Condition	s		Setup		X			
Fluid Inje Bearings	ection and seals	Dert		Number	Number of injection holes 2				
> · Grids	lynamic Co	ontrols		No.	Injection Angle [deg]	Diameter [m]			
·			_	1	60.000 ‡	0.005000 🔹			
Working Condi Working Ruid Ruid Injection	tions			2	100.000	0.005000			
P	7	bar	^	3	0.000	0.000000			
Т	313.15	К		4	0.000	0.000000			
Injection Angle	60	Deg		4	0.000	0.000000			
Axial Position	0.1	m		5	0.000	0.000000			
Port Diameter	0.005	m							
Doil	1E-05	m							
CpOil	2000	J/(k							
ρ	845	kg/m ³							
Viscosity of Oil	5E-05	m²/s							
Multiple injection hol	Setup				Cancel	Save			
	-		¥						

The same liquid selected in the Fluid Injection input will be injected through both injection holes. In this case, it is oil.

The results of thermodynamics calculation without the additional oil injection are shown below (Economizer port is off).

CASE # 1 Tin] C 19.778183	Pinl bar 0. 99759055	Moil kg/s 0.50603630	Tout C 72.845085	Pout bar 8.1570039	Toil C 40.003733	Poil bar 6.4254491	Volume Index Vi No Unit 5.0000000	Speed RPM 6000.0200
Тір Speed m/s 40.000060	Vol. Flow Rate m^3/min 8.7796663	vol. Flow Rate m^3/h 526.79479	Mass Flow Rate kg/h 625.38711	Vol. Efficiency % 85.505744	Fluid Power kW 42.554207	Fluid Power HP 57.066121	Theoretical Mas kg/h 733.00861	

Once the additional oil injection is enabled, the overall mass flow rate and the performance will change dramatically:

CASE # 1 Tin] C 19.768854	Pinl M bar 4 0.99750321 (моіі т kg/s с 0.96739468	out 58.837629	Pout bar 8.2564102	Toil C 40.017508	Poil bar 5.5061107	Volume Index Vi No Unit 5.0000000	Speed RPM 6000.0200
Tip speed	Vol. Flow Rate	e vol. Flow Rate	Mass Flow Rate	vol. Efficienc	y Fluid Power	Fluid Power	Theoretical Mas	
m/s	m∧3/min	m^3/h	kg/h	%	kw	HP	kg/h	
40.000060	8.9551117	537.32181	637.82665	87.261066	43.532245	58.377691	733.00861	





Almost double the amount of oil is injected which results in increased drag losses due to oil in the chamber leading to an overall slightly higher power.

The discharge temperature also changed as shown in the figure below.



⁻ CW1 T - CW2 T - Gas in CW - Oil in CW - CW4 T - CW5 T





4.6 Expander calculation

GT-SUITE allows also for the simulation of an expander. Used Inputs are set to the original values as presented in section 1 and 2. With the difference in Machine configuration. Machine Type is now set to be Screw Expander.

Machine Type	Screw Expa ~	
N Gate	1	
Compression Start	0	Deg
Compression End	161.792	Deg
Volume Index	1.8	
Angle of Radial Discharge	0	Deg
E Rotor	211	GPa
αL Rotor	1E-05	m/m/K
E Casing	211	GPa
αL Casing	1E-05	m/m/K
Wall Roughness	0	m

Thermodynamics inputs are set to previous values from section 4.3 with fluid injection switched off.

Fluid Injection	Off	~	
P	3		bar
Т	310		К
Injection Angle	63.025		Deg
Axial Position	0.1		m
Port Diameter	0.005		m
Doil	1E-05		m
CpOil	2000		J/(kg.K)
ρ	845		kg/m ³
Viscosity of Oil	5E-05		m²/s

- Calculate Geometry and Thermodynamics
 Calculate Geometry and Thermodynamics
- Inspect thermodynamics diagrams. Note that results for the expander are written and shown in reverse. This means the cycle starts on the right-hand side and ends at the lefthand side of the diagram.











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►	View the report
---	-----------------

CASE # 1 Tinl C -25.409566	Pinl bar 1.0523734 -	Moil To kg/s C 3.54849853E-14 7	out 76.739786	Pout bar 7.8727925	тоіl с 36.850000	Poil bar 7.0000000	Volume Inde No Unit 1.8000000	x Vi Speed RPM 6000.0200
Tip Speed	Vol. Flow Rate	e Vol. Flow Rato	e Mass Flow F	Rate Vol. Ef	ficiency Fluid	Power Flui	d Power т	heoretical Mas
m/s	m^3/min	m^3/h	kg/h	%	kw	HP	k	g/h
40.000060	-35.737080	-2144.2851	-3050.0682	323.40	5447 -84.48	35464 -113	.29685	733.00861

More detailed results can be seen within the GT-POST application, which is discussed in section 4.8.





4.7 GT-SUITE model overview

As discussed before, to carry out the calculations with the integrated GT-SUITE solver, the GT template model (.gtm), the bearings subassembly model (.gtsub) and four additional files are used (GeomGT.txt, GTparameters.txt, Forces_R1_GT.txt and Forces_R2_GT.txt).

Setup of the model is based on the geometry and parameters obtained through the calculations within SCORG. It is possible to further adjust the parameters to meet the user's requirements. For example, simulating oil injected refrigeration screw compressor may currently have some limitations which can be solved through user's modifications. This is further explained in the SCORG User Manual Section 8.10.3.

ScrewMachineChambers part needs to be considered in case of any changes. It differs between the templates depending on the number of chambers.



Links between the chambers and inlet and outlet volumes represent flows. The area of the flow depends on the current angular position of the shaft. This is based on the geometry obtained in SCORG and driven by the **ScrewShaft** part. Double-clicking it will open the following window in which all of the chamber geometry profiles are referenced.





Home Data Adva	inced														8
This tem (speed so models of Help	plate is the main driver ource) for detailed of rotating machinery	Connectivi Informatio	ity Sho on Exan	ow ples	Attrib	A ute Abilities	Object (Part Co	Comm mmer	nent:					Add Long Comment	
Template I	Documentation		Help							Commen	ts				
bject Family	🗸 Main 🗸 Chamber Ge	ometry 🗸 F	low & Eff	iciencie	es 🖾 Plo	ts									
ScrewShaft	Attri	bute			Unit	Object Va	lue								
	Chamber Volume Object	Chamber Volume Object				ChamberVo	ume								
	Chamber Surface Area	Object				ChamberCasi	ng								
	Effective Chamber Press	ure Force Ar	ea Profile	mm	^2 ~		ign								
	Effective Chamber Press	Effective Chamber Pressure Force Angle Profile deg 💛 ign													
	Attribute		Unit			Object Value			Attr	bute		Unit		Object Value	
	Inlet Area Profiles										Outle	et Area I	Profi	iles	
	Chamber Inlet 1 Port A	rea Object			Suction	nAreaAxia	xial Chamber Outlet 1 Port Area Object				DischargeArea	Axial			
	Chamber Inlet 2 Port A	rea Object				Suction	AreaRadia	I	Chamber Outlet 2	Port Area C)bject			DischargeAreaR	adial
	Chamber Inlet 3 Port A	rea Object		Econ			omizerPor	t	Chamber Outlet 3	Port Area C)bject			Injection	nPort
	Chamber Inlet 4 Port A	rea Object				BlowholeLe	adingAre	a	Chamber Outlet 4	Port Area C	Object			BlowholeTrailing	JArea
	Chamber Inlet 5 Port A	rea Object				InterlobeLe	adingAre	a	Chamber Outlet 5	Port Area C	Object			InterlobeTrailing	Area
	Chamber Inlet 6 Port A	rea Object				MaleTipLe	adingAre	a	Chamber Outlet 6	Port Area C	bject			MaleTipTrailing	Area
	Chamber Inlet 7 Port A	rea Object				FemaleTipLe	adingAre	a	Chamber Outlet 7	Port Area C	bject			FemaleTipTrailing	Area
	Chamber Inlet 8 Port A	rea Object		_	LPE	ndFaceMaleLe	eakLeadin	9	Chamber Outlet 8	Port Area C	bject			LPEndFaceMaleLeakTra	ailing
	Chamber Inlet 9 Port A	rea Object			LPEnc	FaceFemaleLe	eakLeadin	9	Chamber Outlet 9	Port Area C)bject			LPEndFaceFemaleLeakTra	ailing
	Chamber Inlet 10 Port /	Area Object			HPt	ndFaceMaleLe	eakLeadin		Chamber Outlet 1	Dert Area	Object			HPEndFaceMaleLeakTra	alling
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All the area profile objects are imported from the GeomGT.txt file. Modification of this **ScrewShaft** part is not advised.

Parameters setting the conditions under which simulation is run are imported directly from the GTparameters.txt. file and can be seen under **Case Setup**.

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The red * indicates that the value is linked to the corresponding parameter in the file. It may be required to change some of the values to the user's intended values. For example, FLUID in oil injected refrigeration screw compressor must be customized by the user. Case Setup can also be used to set up cases with different working conditions. The Append Case or Insert Case buttons can be used to add additional cases.

For additional user control over the amplitude and frequency of the pressure pulsations within the chambers of the screw machine, the two parameters – [diffcoef-gas] and [diffcoef-liquid] – can be varied to study the effect of damping the diffusion coefficient term in the momentum equation solved by GT-SUITE. By default, their values are 0.01 and 1 respectively but the gas diffusion coefficient multiplier can be varied anywhere from 1 to 10 depending on the size of the compressor. Please contact GT Support (<u>support@gtisoft.com</u>) for further information regarding these parameters.

For the ease of multiple calculations with different setups, a batch file may be run, altering values in the GT parameters.txt file.







4.8 Further results

More detailed results of the simulations can be accessed through GT-SUITE application. After the calculation was successfully carried out, clicking the **View Results** button while the model template is open or opening *.gdx file (C:\SCORG\GT\) will run GT-POST application.



This allows seeing results at specific parts of the machine. Especially data under **FluidMachineShaft:ScrewShaft** may be of the main interest.

Clicking on one of the FluidMachineChamber parts (Chamber 1) will show the different instantaneously varying quantities such as pressure, temperature, etc. within the screw machine chamber. Shown below is the instantaneous pressure within the chamber.



The plot is drawn for 1080 degrees which is the nearest multiple of 360 rounded up from the actual duration of one cycle. That is why around 943 degrees in the plot above, the chamber is closed and the fluid within the chamber is shown to be at a constant pressure. While comparing the GT model results to test data, it is important not to consider the portions of the 1080 deg duration plotted here which are not part of the actual cycle.

If a bearing model was chosen, the relevant results to look at within GT-POST is within the OutputRLTs part. The breakdown between Fluid (Indicated) Power and Friction Power can be seen here.





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Data can be exported by right-clicking specific plot title.

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5 Summary

This document describes the steps to set up and calculate of thermodynamic performance predictions using integrated GT-SUITE solver. More detailed information on using SCORG can be found in the user guide (SCORG, 2019). Thermodynamic calculations are used as the preliminary performance predictions which could be utilised for the design of screw machines, initial conditions for CFD and FEM.

6 Bibliography

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End of Document

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