

SCORGTM Setup for Analysis of Twin Screw Machines with Design Exploration

SCORG[™] is the unique design platform for rotary twin screw machines. The tool includes additional modules for designing and editing rotor profiles, executing a basic thermodynamic calculation based on quasi 1D chamber models and generating the deforming working chamber grids for selected commercial CFD solvers.

For more information on the product please visit the website: <u>www.pdmanalysis.co.uk</u> or refer to documentation help.

This guide lists the steps for setting to use Design Exploration Framework with SCORG[™]. The user is expected to be familiar with screw machines, CFD and SCORG Thermodynamic model in order to be able to use these procedures. It is highly recommended that books on that topic are studied¹²

Table of Contents

1	Introduction	1
2	Design Scenario 1: Evaluate sensitivity of clearance gaps	4
	Design Scenario 2: Evaluate compressor performance for variation of built-in volume x, rotor length and rotor wrap angle	0
	Design Scenario 3: Compressor performance map for variation of built-in volume index r length and rotor wrap angle	
5	Bibliography2	7

1 Introduction

During the design of twin screw compressors and expanders, it is required to vary several geometrical and operational variables to achieve best performance for a given operating condition. SCORG has been used for this purpose by setting the initial configuration of the rotors, clearance sizes and then calculating the performance. When design variable is changed, a new project is setup and performance recalculated. All the data collected by this means can

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



be processed either internally or externally in programs such as MS-Excel which helps to further evaluate machine designs.

SCORG Design Exploration Framework provides an automation approach in the compressor or expander design activity. This is achieved by setting a single project and exploring the effect of design variable changes in the Design Exploration. Entire machine definition from profile parameters, leakage gaps and rotor geometry can be explored. Selected design data can then be further processed for CFD grid generation and CAD export functionality.

This Tutorial will provide a step-by-step guide for the procedure to use SCORG Design Exploration Framework for analysis of a typical twin-screw compressor, expander, pump or motor simulation. An example of a dry air compressor with 3/5 lobe combination, L/D ratio of 1.7 and wrap angle 285 deg has been considered and three common design scenarios have been setup.

Design Scenario	Description
1	Evaluate sensitivity of clearance gaps
2	Evaluate compressor performance for variation of built-in volume index, rotor length and rotor wrap angle
3	Compressor performance map for variation of built-in volume index, rotor length and rotor wrap angle

The Design Exploration in SCORG can be initiated in three ways.

- Go to View \rightarrow Inputs \rightarrow Design Exploration
- Shortcut Icon in main menu
- Define a Parameter in GUI inputs

Each of these will open the Design Exploration tab in the GUI.





\star D:\DelWIP\N35D	P - [SCORG v2022-Beta]				•	
File Edit Run	View Units Help			Г	ר 2	
🗋 💕 🛃 🐔 🖞	Graphical Results	- F 🖗	👌 🛕 🔘 👀 🕽	🖾 🕼 🔘 🖛 🔤	🖬 🕒 🗶 🗐 🗜 🛚	
Inputs Units	Cad imported profiles	🖿		xploration × Geome		
▼ · N35DP	Reports		ne of All Paramete			
> Profile	Show Output in Tab	, i i i i i i i i i i i i i i i i i i i		Parameter Name	Value	
✓ Geometry	Full Screen			GAPI	0.18	r
Rotor Co		•	Geometry		0.18	r
Restraint	ts	I P:	Thermodynamic	cs	0.05	r
> Domains > Thermodyna		P4	Restraints	ength.	1.7	
> Grids	mics	P!	Design Explorat	ion gth	213.042	r
		P6		Wrap Angle	306.647012	1
 Rotor Configur 	3 ation					
Relative Length	1.7 P					
Rotor Length	213.042 P nm					
Wrap Angle	306.647012 P Deg					
Pitch Low Pressure	0 mm					
Pitch High Pressur	0 mm					
Datar Ditab	Uniform S2					

The main steps of design exploration are:

- a. Project Parameterisation
- b. Design Point definition
- c. Design Point Calculation Selection
- d. Performance Evaluation

These steps will be described in the considered Design Scenarios in this tutorial. Refer to SCORG Help Manual for more details.





2 Design Scenario 1: Evaluate sensitivity of clearance gaps

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

	sc	ORG																- (x
Γ	File	Edit	Run	Vie	w	Units	Help)											
		New	Ctrl+	N		0 🔅	🗙 💼		STOP	\$	۶ 📢	1	G	Ţ	و ھ				
	2	Open	Ctrl+	0	- 1														
	2	Close			_														
		Save	Ctrl	۰S															
		Save As																	
		Import			•														
		Export																	
		Most Re	cent		•														
	0	Exit	Ctrl+	Q	- 1														

► Select N35_Template.spt \rightarrow Open

) 🗸 🗸 🕹 🖉 🖉	ment SCORG(C) SGUI Scorg	 bin > Templates 	Search Templates
Organize 🔻 🛛 New fold	ler		8= - 🗌 🔞
☆ Favorites	Name	Date modified	
🧮 Desktop	A46_Template.spt	27/08/2014 11:46	
📙 Downloads	Zirc46_Template.spt	27/08/2014 11:46	
Recent Places	Inv22_Template.spt	27/08/2014 11:46	
퉬 SkyDrive	Inv33_Template.spt	27/08/2014 11:46	
E	N35_Template.spt	27/08/2014 11:46	
词 Libraries	N45_Template.spt	27/08/2014 11:46	
Documents	N46_Template.spt	27/08/2014 11:46	No preview available.
J Music	N56_Template.spt	27/08/2014 11:46	
Pictures	N57_Template.spt	27/08/2014 11:46	
Subversion	N67_Template.spt	27/08/2014 11:46	
Videos 🗧			
🖳 Computer			
🏭 Local Disk (C:)			
👝 D (D:) 👻	•	•	
File r	name: N35_Template.spt		▼ Scorg template (spt) (*.spt) ▼
			Open Cancel

► Save the project in a new folder





★ Save As	×
\leftarrow \rightarrow \checkmark \uparrow \blacksquare \rightarrow This PC \rightarrow Work (D:) \rightarrow DelWIP \rightarrow	✓ ♂ Search DelWIP
Organise 🔻 New folder	■ - ?
 This PC 3D Objects Desktop Documents Downloads Music Pictures Videos Local Disk (C:) Work (D:) CHT_SysCoup_P compressor-tect Compressor Cor 	
File name: Design_Scenerio1	~
Save as type: Scorg Project file (spf) (*.spf)	~
∧ Hide Folders	Save Cancel

▶ Set Project Units to SI

D:\TwinScrewPumplinxSetup\SCORG_Grid_Tutorial								
File Edit Run View	Un	iits Help						
🗋 🖆 🛃 🎒 🐟 🔦 🛛	~	SI (mm,kg,m/s,c)						
Selections Properties SCORG_Grid_Tutorial Profile Setup		SI (m,kg,m/s,k) Imperial (psi,°F,inch,Btu/(lb.°F))						
		More						
Profile Elements	_							

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

GAPI = 0.06mm

GAPR = 0.06mm

GAPA = 0.05mm

Profile Setup			
Profile Choice	User Sp 🗸		
Axis Distance	93	mm	
Z1	3		
Z2	5		
GAPI	0.06	mm	
GAPR	0.06	mm	
GAPA	0.05	mm	
NL	5		

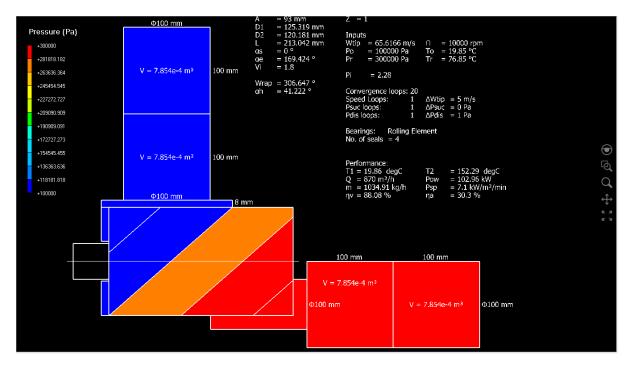
• Go to Thermodynamics \rightarrow Set the following parameters:





Wtip	66.6665	m/s
Rotor Speed	10000	RPM
PO	100000	Pa
Pr	300000	Pa
то	293	К
Tr	350	К
Tevp	268	К
Tcond	313	К
T Ambient	293	К
Ts	0	К
х	1	

- ► Save the Project.
- ▶ Run Geometry and Thermodynamics
- ► Inspect the performance data







T1 = 19.86 degC P1 = 1 bar Moil = 0 kg/s	T2 = 152.29 degC P2 = 3 bar Toil = 36.86 degC Poil = 3 bar
Volume Index Vi Pressure Ratio Pi Speed Tip speed	= 1.8 = 2.28 = 10000 rpm = 65.62 m/s
Volume flow rate Mass flow rate Volumetric efficiency	= 14.5 m3/min = 870 m3/h = 1034.91 kg/h = 88.08 %
Power (excl. gearbox) Specific power Adiabatic efficiency	= 102.96 kW = 138.07 HP = 7.1 kW/m3/min = 30.3 %
Theoretical mass flow Discharge mass flow	= 1174.96 kg/h = 1034.91 kg/h

▶ Design Exploration: Set GAPI, GAPR and GAPA as parameters

Profile Setup					
Profile Choice	User Sp	\sim			
Axis Distance	93			mm	
Z1	3				
Z2	5	-			
GAPI	0.06		Ρ	mm	
GAPR	0.06		Ρ	mm	
GAPA	0.05		Ρ	mm	
NL	5	4			
NR	0				

Update Design Point data as below

Table of Des	Table of Design Points								
	Name	P1-GAPI	P2 - GAPR	P3 - GAPA					
	Units	mm	mm	mm					
F DP0 (Current)		0.06	0.06	0.06					
4	DP1	0.12	0.06	0.06					
🗲 DP2		0.18	0.06	0.06					
4	DP3	0.06	0.12	0.06					
4	DP4	0.06	0.18	0.06					
4	DP5	0.06	0.06	0.12					
4	DP6	0.06	0.06	0.18					
₩									

Each gap size has been increased by 2x and 3x times for a constant value of the other gaps.





ID	Calculation	Options	On/Off
1	Generate Profile	User Specified Profile	
2	Geometry	Screw Compressor	
3	Thermodynamics		
4	Force		
5	Grid - Rack	Off	~
6	Grid - Boundary	Casing to Rotor Nonconforma	/
7	Grid - Rotor2D		
8	Grid - Ports	Axial	
9	Grid - CFDPreprocessor	Off	
	Vertex Files Start Number	1	
	Vertex Files End Number	40	
10	Export CAD	STEP Format	

Select Calculations of Geometry and Thermodynamics

▶ Right-Click DP table and Update All Design Points

Table of De	esign Points				
	Name		P1 - GAPI	P2 - GAPR	P3 - GAPA
	Units		mm	mm	mm
4	DP0 (Curre	ent)	0.06	0.06	0.06
4	DP1		0.12	0.06	0.06
4	DP2		0.18	0.06	0.06
- /	DP3	C.	et as Current Desigr	0.06	
4	DP4		0.06		
4	DP5	Update Design Point 0.12	0.12		
4	DP6		ive Design Point As	0.18	
**			elete Design Point As		
		U	odate All Design Po		
		CI	ear Output of All D		
		De	elete All Design Poi		

On completion of the calculations, the status icons will indicate an up-to-date result.





Table of Desi	ign Points			
	Name	P1 - GAPI	P2 - GAPR	P3 - GAPA
	Units	mm	mm	mm
 Image: A set of the set of the	DP0 (Current)	0.06	0.06	0.06
 Image: A set of the set of the	DP1	0.12	0.06	0.06
 Image: A set of the set of the	DP2	0.18	0.06	0.06
 Image: A set of the set of the	DP3	0.06	0.12	0.06
 Image: A set of the set of the	DP4	0.06	0.18	0.06
 Image: A set of the set of the	DP5	0.06	0.06	0.12
 Image: A second s	DP6	0.06	0.06	0.18
▶*				

► Review the performance data

N[rpm]	Psuc[bar]	Pdis[bar]						
10000	✓ 1	✓ 3	\sim					
	DP	WTP	N	Q	Qn	М	ηv	Powe
۱.	Units	m/s	RPM	m3/m	nm3/m	kg/min	_	Kw
~	DP0	65.62	10000	14.48	14.488	17.22	0.8793	103.0
~	DP1	65.62	10000	13.304	13.31	15.82	0.8079	102.4
~	DP2	65.62	10000	12.1	12.107	14.39	0.7348	101.8
~	DP3	65.62	10000	13.858	13.865	16.479	0.8415	105.5
 Image: A second s	DP4	65.62	10000	13.138	13.145	15.624	0.7978	107.8
~	DP5	65.62	10000	14.334	14.341	17.046	0.8704	103.5
 Image: A second s	DP6	65.62	10000	14.184	14.191	16.867	0.8613	103.9
								

• It can be seen from the volumetric efficiency data that the sensitivity of GAPI is highest and GAPA is the least for this compressor design at the given operating condition.





3 Design Scenario 2: Evaluate compressor performance for variation of built-in volume index, rotor length and rotor wrap angle

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

😫 s	CORG													x
Fil	e Edit	Run	View	Units	Help									
	New	Ctrl+	N	ي 📀	🗙 💼	🖻 🎸	۶ () M	G	T	ء 💿			
12	Open	Ctrl+	0											
	Close													
	Save	Ctrl	-S											
	Save As.													
	Import		•											
	Export		Þ											
	Most Re	cent	•											
0	Exit	Ctrl+	Q											
														- 23

► Select N35_Template.spt \rightarrow Open

🖉 🖉 🖉 🖉 🖉	nent ► SCORG(C) ► SGUI ► Scorg	bin Femplates	 ✓ ✓
Organize 🔻 New folde	r		i= • 🗖 🔞
🔆 Favorites 📩	Name	Date modified	
📃 Desktop	A46_Template.spt	27/08/2014 11:46	
〕 Downloads	🔊 Circ46_Template.spt	27/08/2014 11:46	
🕮 Recent Places	🔊 Inv22_Template.spt	27/08/2014 11:46	
퉬 SkyDrive	🔊 Inv33_Template.spt	27/08/2014 11:46	
E	N35_Template.spt	27/08/2014 11:46	
🥽 Libraries	N45_Template.spt	27/08/2014 11:46	
Documents	N46_Template.spt	27/08/2014 11:46	No preview available.
J Music	🔊 N56_Template.spt	27/08/2014 11:46	·
E Pictures	N57_Template.spt	27/08/2014 11:46	
Subversion	🔊 N67_Template.spt	27/08/2014 11:46	
Videos			
🖳 Computer			
🏭 Local Disk (C:)			
👝 D (D:) 🛛 👻	•	•	
File na	ame: N35_Template.spt		✓ Scorg template (spt) (*.spt)
			Open Cancel

Save the project in a new folder





★ Save As	×
← → × ↑ 📴 > This PC > Work (D:) > DelWIP >	✓ Ö Search DelWIP
Organise 🔻 New folder	■ • ?
 This PC 3D Objects Desktop Documents Downloads Music Pictures Videos Local Disk (C:) Work (D:) CHT_SysCoup_P compressor tect Compressor Cor 	vane
File name: Design_Scenerio2spf	~
Save as type: Scorg Project file (spf) (*.spf)	~
∧ Hide Folders	Save Cancel

► Set Project Units to SI

🛃 D:\TwinScrewPumplinxSetu	p\SC	ORG_Grid_Tutorial
File Edit Run View	Un	its Help
🗄 🗋 🚰 🛃 🕐 🤏 (4	SI (mm,kg,m/s,c)
Selections Properties		SI (m,kg,m/s,k) Imperial (psi,°F,inch,Btu/(Ib.°F))
SCORG_Grid_Tutorial Profile Setup		More
Profile Elements	-	

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

GAPI = 0.06mm

GAPR = 0.06mm

GAPA = 0.05mm

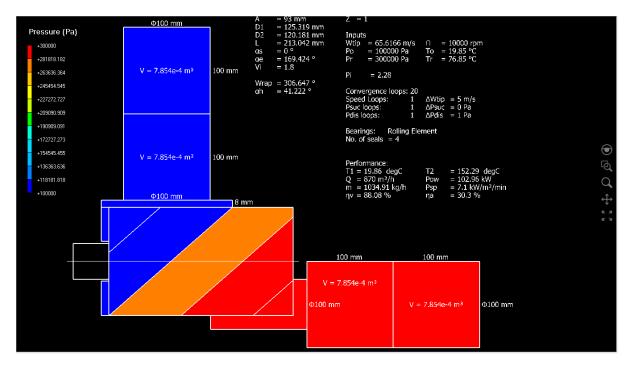
• Go to Thermodynamics \rightarrow Set the following parameters:





Wtip	66.6665	m/s
Rotor Speed	10000	RPM
PO	100000	Pa
Pr	300000	Pa
то	293	К
Tr	350	К
Теvp	268	К
Tcond	313	К
T Ambient	293	К
Ts	0	К
х	1	

- ► Save the Project.
- ▶ Run Geometry and Thermodynamics
- ► Inspect the performance data







T1 = 19.86 degC P1 = 1 bar Moil = 0 kg/s	T2 = 152.29 degC P2 = 3 bar Toil = 36.86 degC Poil = 3 bar
Volume Index Vi Pressure Ratio Pi Speed Tip speed	= 1.8 = 2.28 = 10000 rpm = 65.62 m/s
Volume flow rate Mass flow rate Volumetric efficiency	= 14.5 m3/min = 870 m3/h = 1034.91 kg/h = 88.08 %
Power (excl. gearbox) Specific power Adiabatic efficiency	= 102.96 kW = 138.07 HP = 7.1 kW/m3/min = 30.3 %
Theoretical mass flow Discharge mass flow	= 1174.96 kg/h = 1034.91 kg/h

Design Exploration: Set built-in volume index, rotor length and rotor wrap angle as parameters

Machine Config	guration		
N Gate	1		
Compression Start	0		Deg
Compression End	169.424	Ρ	Deg
Volume Index	1.8	Ρ	
Angle of Radial Dis	0		Deg
E Rotor	211		GPa
αL Rotor	1E-05		m/m/℃
E Casing	211		GPa
			· · · -

Rotor Configuration								
Relative Length	1.7		Ρ					
Rotor Length	213.042		Ρ	mm				
Wrap Angle	306.647012		Ρ	Deg				
Pitch Low Pressure	0			mm				
Pitch High Pressur	0			mm				
Rotor Pitch	Uniform	\sim						
Rotor Profile	Constant	\sim						
Main Datas Cantas V	0							

Note that setting Volume Index as a parameter will also set Compression End angle as parameter as these are related.

Similarly, setting Rotor Length as a parameter will also set Relative Length as parameter as these are related.

Five parameters P1 to P5 will be listed in the Current Design Point (DP0)

Table of Design Points										
	Name	P1 - Volume Index	P2 - Compression End	P3 - Rotor Length	P4 - Relative Length	P5 - Wrap Angle				
Þ	Units		Deg	mm		Deg				
4	DP0 (Current)	1.8	169.424	213.042	1.7	306.647012				
*										





Update Design Point data as below

Table of D	esign Points					
	Name	P1 - Volume Index	P2 - Compression End	P3 - Rotor Length	P4 - Relative Length	P5 - Wrap Angle
	Units		Deg	mm		Deg
4	DP0 (Current)	1.2	87.738	213.042	1.7	306.647012
4	DP1	1.5	136.82	213.042	1.7	306.647012
4	DP2	1.8	87.738	213.042	1.7	306.647012
4	DP3	2.2	199.081	213.042	1.7	306.647012
4	DP4	1.2	87.738	180	1.43633975	306.647012
4	DP5	1.2	87.738	250	1.99491631	306.647012
4	DP6	1.2	87.738	213.042	1.7	250
4	DP7	1.2	87.738	213.042	1.7	275
4	DP8	1.2	87.738	213.042	1.7	325
F ₩						

Volume Index has been increased from 1.2 to 2.2.

Rotor Length has been varied from 180 mm to 250 mm.

Wrap Angle has been varied from 250 deg to 325 deg.

▶ Select Calculations of Geometry and Thermodynamics

ID	Calculation	Options	On/Off	
1	Generate Profile	User Specified Profile	-	
2	Geometry	Screw Compressor		\checkmark
3	Thermodynamics			\checkmark
4	Force			
5	Grid - Rack	Off	\sim	
6	Grid - Boundary	Casing to Rotor Nonconform	al	
7	Grid - Rotor2D			
8	Grid - Ports	Axial		
9	Grid - CFDPreprocessor	Off		
	Vertex Files Start Number	1		
	Vertex Files End Number	40		
10	Export CAD	STEP Format		

▶ Right-Click DP table and Update All Design Points





	Name	P1 - Volume Index	P2 - Compression End	P3 - Rotor Length	P4 - Relative Length	P5 - Wrap Angle
	Units		Deg	mm		Deg
4	DP0 (Current)	1.2	87.738	213.042	1.7	306.647012
4	DP1	1.5	136.82	213.042	1.7	306.647012
4	DP2	1.8	87.738	213.042	1.7	306.647012
1	DP3	Set as Current De	Set as Current Design Point Update Design Point Clear Output of Design Point		1.7	306.647012
4	DP4	Update Design Po			1.43633975	306.647012
4	DP5	Clear Output of D			1.99491631	306.647012
4	DP6	Save Design Poin	2	13.042	1.7	250
4	DP7	Delete Design Poi	int	13.042	1.7	275
4	DP8	Undata All Davies			1.7	325
		Update All Design Clear Output of A Delete All Design	All Design Points			

On completion of the calculations, the status icons will indicate an up-to-date result.

Table of D	esign Points					
	Name	P1 - Volume Index	P2 - Compression End	P3 - Rotor Length	P4 - Relative Length	P5 - Wrap Angle
	Units		Deg	mm		Deg
 Image: A second s	DP0 (Current)	1.2	87.738	213.042	1.7	306.647012
 Image: A second s	DP1	1.5	136.82	213.042	1.7	306.647012
 Image: A second s	DP2	1.8	87.738	213.042	1.7	306.647012
\checkmark	DP3	2.2	199.081	213.042	1.7	306.647012
× .	DP4	1.2	87.738	180	1.43633975	306.647012
 Image: A second s	DP5	1.2	87.738	250	1.99491631	306.647012
 Image: A second s	DP6	1.2	87.738	213.042	1.7	250
 Image: A second s	DP7	1.2	87.738	213.042	1.7	275
 Image: A second s	DP8	1.2	87.738	213.042	1.7	325
Þ#						

• Review the performance data





V[rpm]	Psuc[bar]	Pdis[bar]					
0000	~ 1	~ 3	\sim				
	DP	Qn	М	ηv	Power	Psp	ηad
•	Units	nm3/m	kg/min	_	Kw	kW/m3/min	-
 Image: A second s	DP0	14.064	16.716	0.8536	124.864	8.883	0.2421
~	DP1	14.446	17.17	0.8768	107.248	7.428	0.2896
 Image: A second s	DP2	14.064	16.716	0.8536	124.864	8.883	0.2421
 Image: A second s	DP3	14.506	17.242	0.8805	103.635	7.148	0.3009
 Image: A second s	DP4	11.664	13.864	0.8379	106.77	9.158	0.2349
 Image: A second s	DP5	16.712	19.863	0.8644	145.582	8.716	0.2468
 Image: A second s	DP6	14.757	17.54	0.867	122.664	8.316	0.2586
~	DP7	14.385	17.098	0.855	128.019	8.904	0.2416
~	DP8	14.064	16.716	0.8536	124.864	8.883	0.2421

It can be seen from the volumetric efficiency data that the sensitivity of GAPI is highest and GAPA is the least for this compressor design at the given operating condition.

Click on the Specific Power column title to arrange data in ascending order.

N[rpm]	Psuc[bar]	Pdis[bar]					
10000	✓ 1	~ 3	\sim				
					_	-	
	DP	Qn	М	ηv	Power	Psp	Δ ŋad
•	Units	nm3/m	kg/min	_	Kw	kW/m3/min	_
 Image: A second s	DP3	14.506	17.242	0.8805	103.635	7.148	0.3009
 Image: A second s	DP1	14.446	17.17	0.8768	107.248	7.428	0.2896
 Image: A second s	DP6	14.757	17.54	0.867	122.664	8.316	0.2586
× .	DP5	16.712	19.863	0.8644	145.582	8.716	0.2468
 Image: A second s	DP2	14.064	16.716	0.8536	124.864	8.883	0.2421
 Image: A second s	DP0	14.064	16.716	0.8536	124.864	8.883	0.2421
 Image: A second s	DP8	14.064	16.716	0.8536	124.864	8.883	0.2421
 Image: A second s	DP7	14.385	17.098	0.855	128.019	8.904	0.2416
 Image: A second s	DP4	11.664	13.864	0.8379	106.77	9.158	0.2349

Lest Specific Power is obtained for DP3 with Volume Index = 2.2 as the compressor discharge pressure is set at 3.0 bar.

For short rotors of DP4 = 180 mm with low Volume Index = 1.2, the Specific Power is the highest.

Click on the Volumetric Efficiency column title to arrange data in descending order.





N[npm]	Psuc[bar]	Pdis[bar]					
10000	✓ 1	~ 3	\sim				
					-		
	DP	Qn	м	ηv	V Power	Psp	ηad
Þ	Units	nm3/m	kg/min	_	Kw	kW/m3/min	_
 Image: A second s	DP3	14.506	17.242	0.8805	103.635	7.148	0.3009
 Image: A second s	DP1	14.446	17.17	0.8768	107.248	7.428	0.2896
 Image: A second s	DP6	14.757	17.54	0.867	122.664	8.316	0.2586
 Image: A second s	DP5	16.712	19.863	0.8644	145.582	8.716	0.2468
 Image: A second s	DP7	14.385	17.098	0.855	128.019	8.904	0.2416
 Image: A second s	DP8	14.064	16.716	0.8536	124.864	8.883	0.2421
 Image: A second s	DP0	14.064	16.716	0.8536	124.864	8.883	0.2421
 Image: A second s	DP2	14.064	16.716	0.8536	124.864	8.883	0.2421
~	DP4	11.664	13.864	0.8379	106.77	9.158	0.2349

Highest Volumetric Efficiency is obtained again for DP3.





4 Design Scenario 3: Compressor performance map for variation of built-in volume index, rotor length and rotor wrap angle

- ► Launch SCORGTM on the Desktop.
- ▶ Select File \rightarrow Open the project saved in Design Scenario 2

→ ~ ↑	is PC \rightarrow Work (D:) \rightarrow DelWIP \rightarrow Des	ign_Scenerio2 >	`	✓ ^O	h Design_Scenerio2
rganise 🔻 New fold	er				
This PC	Name	Date modified	Туре	Size	
3D Objects	Design	10/01/2022 21:15	File folder		
Desktop	Grid	10/01/2022 21:18	File folder		
Documents	Profile	10/01/2022 21:18	File folder		
Downloads		10/01/2022 21:18	File folder		
Music	Design_Scenerio2.spf	10/01/2022 21:20	SPF File	24 KB	
-					
Pictures					
Videos					
🏰 Local Disk (C:)					
🚔 Work (D:)					
CHT_SysCoup_P					
🛫 compressor-tecł					
🛖 Compressor Cor					
🛖 Desktop (\\PFSN					
	ame: Design_Scenerio2.spf			Scora Proje	ct file (spf) (*.spf)

 Open Design Exploration: Set for built-in volume index, rotor length and rotor wrap angle as parameters

User Profile 🕻	Design Exploration ×			
Outline of All	Parameters			Tab
ID	Parameter Name	Value	Unit	
P1	Volume Index	1.2		
P2	Compression End	87.72	Deg	•
P3	Rotor Length	213.042	mm	
P4	Relative Length	1.7		
P5	Wrap Angle	306.647012	Deg	

An up-to-date status will be seen for the data.





	Name	P1 - Volume Index	P2 - Compression End	P3 - Rotor Length	P4 - Relative Length	P5 - Wrap Angle
	Units		Deg	mm		Deg
 Image: A second s	DP0 (Current)	1.2	87.738	213.042	1.7	306.647012
×	DP1	1.5	136.82	213.042	1.7	306.647012
 Image: A second s	DP2	1.8	87.738	213.042	1.7	306.647012
\sim	DP3	2.2	199.081	213.042	1.7	306.647012
×	DP4	1.2	87.738	180	1.43633975	306.647012
 Image: A second s	DP5	1.2	87.738	250	1.99491631	306.647012
 Image: A second s	DP6	1.2	87.738	213.042	1.7	250
 Image: A second s	DP7	1.2	87.738	213.042	1.7	275
~	DP8	1.2	87.738	213.042	1.7	325
*						

Design Poi	int Performance Da	ata (Click variat	ble name to sort p	performance data)				
N[rpm]	Psuc[bar]	Pdis[bar]						
10000	× 1	 ✓ 3 	\sim					
	DP	WTP	Ν	Q	Qn	М	ηv	Pov
۱.	Units	m/s	RPM	m3/m	nm3/m	kg/min	_	Kw
 Image: A second s	DP0	65.62	10000	14.057	14.064	16.716	0.8536	124
~	DP1	65.62	10000	14.438	14.446	17.17	0.8768	107
~	DP2	65.62	10000	14.057	14.064	16.716	0.8536	124
 Image: A set of the set of the	DP3	65.62	10000	14.499	14.506	17.242	0.8805	103
~	DP4	65.62	10000	11.658	11.664	13.864	0.8379	106
 Image: A second s	DP5	65.62	10000	16.703	16.712	19.863	0.8644	145
~	DP6	65.62	10000	14.75	14.757	17.54	0.867	122
~	DP7	65.62	10000	14.378	14.385	17.098	0.855	128
~	DP8	65.62	10000	14.057	14.064	16.716	0.8536	124

- ▶ Design Exploration: Set Rotor Speed and Discharge Pressure for performance map.
- ▶ In Thermodynamics → Working Conditions, set Rotor Speed and Discharge Pressure

Working Conditions	5	
Wtip	52.4933	m/s
Rotor Speed	8000	RPM
P0	100000	Pa
Pr	150000	Pa
то	19.85	°C
Tr	76.85	°C
Теvp	-5.15	°C
Tcond	39.85	°C
T Ambient	19.85	°C

► In Thermodynamics → Thermodynamic Controls, set Speed loop, Discharge Pressure loop, Tip speed increment and Discharge Pressure increment values.





Thermodynamic Co	ntrols	
Speed loop	5	
Psuc loop	1	
Pdis loop	4	
Convergence loop	20	
Convergence criteria	0.5	°C
∆Wtip	5	m/s
∆Psuc	0	Pa
∆Pdis	50000	Pa
∆Tevp	5	°C
ATcon	5	°C.

These updated settings will clear the existing performance data and DP status icons will change.

	Name	P1 - Volume Index	P2 - Compression End	P3 - Rotor Length	P4 - Relative Length	P5 - Wrap Angle
•	Units		Deg	mm		Deg
4	DP0 (Current)	1.2	87.72	213.042	1.7	306.647012
4	DP1	1.5	136.822	213.042	1.7	306.647012
•	DP2	1.2	87.72	213.042	1.7	306.647012
4	DP3	2.2	199.103	213.042	1.7	306.647012
4	DP4	1.2	87.72	180	1.43633975	306.647012
4	DP5	1.2	87.72	250	1.99491631	306.647012
4	DP6	1.2	87.72	213.042	1.7	249.999993
4	DP7	1.2	87.72	213.042	1.7	274.999975
4	DP8	1.2	87.72	213.042	1.7	306.647012
*						

Select Calculations of Geometry and Thermodynamics





ID	Calculation	Options	On/Off
1	Generate Profile	User Specified Profile	
2	Geometry	Screw Compressor	
3	Thermodynamics		
4	Force		
5	Grid - Rack	Off ~	
6	Grid - Boundary	Casing to Rotor Nonconformal	
7	Grid - Rotor2D		
8	Grid - Ports	Axial	
9	Grid - CFDPreprocessor	Off	
	Vertex Files Start Number	1	
	Vertex Files End Number	40	
10	Export CAD	STEP Format	

Right-Click DP table and Update All Design Points

	Name	P1 - Volume Index	P2 - Compression End	P3 - Rotor Length	P4 - Relative Length	P5 - Wrap Angle
	Units		Deg	mm		Deg
4	DP0 (Current)	1.2	87.738	213.042	1.7	306.647012
4	DP1	1.5	136.82	213.042	1.7	306.647012
4	DP2	1.8	87.738	213.042	1.7	306.647012
4	DP3	Set as Current Design Point		13.042	1.7	306.647012
4	DP4	Update Design F	Point	30	1.43633975	306.647012
4	DP5	Clear Output of	Design Point	50	1.99491631	306.647012
4	DP6	Save Design Poi	-	13.042	1.7	250
۶	DP7	Delete Design P		13.042	1.7	275
4	DP8			13.042	1.7	325
		Update All Desig Clear Output of Delete All Desig	All Design Points			

On completion of the calculations, the status icons will indicate an up-to-date result.





	Name	P1 - Volume Index	P2 - Compression End	P3 - Rotor Length	P4 - Relative Length	P5 - Wrap Angle
	Units		Deg	mm		Deg
×	DP0 (Current)	1.2	87.738	213.042	1.7	306.647012
 Image: A second s	DP1	1.5	136.82	213.042	1.7	306.647012
 Image: A second s	DP2	1.8	87.738	213.042	1.7	306.647012
\sim	DP3	2.2	199.081	213.042	1.7	306.647012
×	DP4	1.2	87.738	180	1.43633975	306.647012
×	DP5	1.2	87.738	250	1.99491631	306.647012
 Image: A second s	DP6	1.2	87.738	213.042	1.7	250
 Image: A second s	DP7	1.2	87.738	213.042	1.7	275
 Image: A second s	DP8	1.2	87.738	213.042	1.7	325
*						

Review the performance data

N[mpm]	Psuc[bar]	Pdis[bar]						
3000	× 1	× 1.5	\sim					
	DP	WTP	Ν	Q	Qn	М	ηv	F
Þ	Units	m/s	RPM	m3/m	nm3/m	kg/min	_	K
 Image: A second s	DP0	52.49	8000	12.021	12.027	14.295	0.9125	32
 Image: A second s	DP1	52.49	8000	12.01	12.016	14.282	0.9117	3
 Image: A second s	DP2	52.49	8000	12.021	12.027	14.295	0.9125	3
 Image: A second s	DP3	52.49	8000	11.756	11.762	13.98	0.8924	4
 Image: A second s	DP4	52.49	8000	10.07	10.076	11.976	0.9047	2
 Image: A second s	DP5	52.49	8000	14.187	14.194	16.871	0.9177	3
 Image: A second s	DP6	52.49	8000	12.489	12.495	14.852	0.9176	3
 Image: A second s	DP7	52.49	8000	12.284	12.29	14.608	0.9132	3
 Image: A second s	DP8	52.49	8000	12.021	12.027	14.295	0.9125	3

In the performance data table there is a set of pull-down menu which indicates the rotor speed N [rpm], suction pressure Psuc [bar] and discharge pressure Pdis [bar] for which the data in the table is listed.

In Design Scenario 2, it was found that DP3 has the best Specific Power at 3.0 bar discharge pressure.

Select 11048.1 rpm speed and 3.0 bar discharge pressure and the design data is reconfirmed.





V[mpm]	Psuc[bar]	Pdis[bar]						
1048.1	∨ 1	× 3	~					
	DP	Qn	М	ηv	Power	Psp	Δ	ηad
Þ	Units	nm3/m	kg/min	_	Kw	kW/m3/min		_
 Image: A second s	DP3	16.181	19.232	0.8889	120.797	7.469		0.288
 Image: A second s	DP1	16.124	19.164	0.8858	124.787	7.743		0.2778
 Image: A second s	DP6	16.492	19.602	0.877	142.971	8.673		0.248
 Image: A second s	DP5	18.668	22.188	0.874	170.737	9.151		0.2351
 Image: A second s	DP2	15.749	18.719	0.8652	146.048	9.278		0.2318
 Image: A second s	DP0	15.749	18.719	0.8652	146.048	9.278		0.2318
 Image: A second s	DP8	15.749	18.719	0.8652	146.048	9.278		0.2318
 Image: A second s	DP7	16.095	19.13	0.866	150.013	9.325		0.2307
~	DP4	13.101	15.572	0.8519	124.567	9.513		0.2261

▶ Now select 11048.1 rpm speed and 1.5 bar discharge pressure and the arrange the Specific Power in ascending order. It is seen that for lower delivery pressure DP6 has better Specific Power due to lower volume index = 1.2 and a lower Wrap Angle = 250 deg.

pm] 48.1	Psuc[bar] V 1	Pdis[bar] ✓ 1.5	~				
	DP	Qn	М	ηv	Power	Psp	Δ nad
•	Units	nm3/m	kg/min	_	Kw	kW/m3/min	_
 Image: A second s	DP6	17.514	20.817	0.9313	52.095	2.976	0.2408
 Image: A second s	DP1	16.88	20.063	0.9273	52.624	3.119	0.2297
 Image: A second s	DP5	19.846	23.589	0.9291	62.399	3.146	0.2278
 Image: A second s	DP8	16.892	20.078	0.928	53.499	3.169	0.2261
 Image: A second s	DP0	16.892	20.078	0.928	53.499	3.169	0.2261
 Image: A second s	DP2	16.892	20.078	0.928	53.499	3.169	0.2261
 Image: A second s	DP7	17.247	20.5	0.9279	55.933	3.245	0.2208
 Image: A second s	DP4	14.211	16.89	0.924	46.111	3.247	0.2207
~	DP3	16.615	19.748	0.9128	74.209	4.469	0.1603

• Click on the Performance Map icon in main menu.









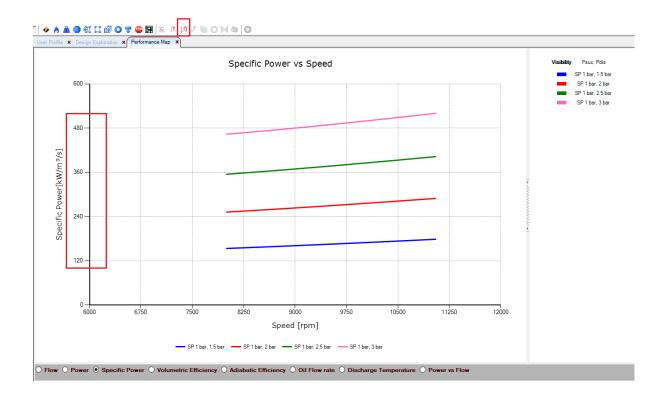
- ▶ This will plot the performance map for Current Design Point which is DP0.
- Go back to Design Exploration tab, Right-click Design Point table on DP6 and Set as Current Design Point.

	Name	P1 - Volume Index	P2 - Compression End	P3 - Rotor Length	P4 - Relative Length	P5 - Wrap Angle
	Units		Deg	mm		Deg
×	DP0 (Current)	1.2	87.72	213.042	1.7	306.647012
×	DP1	1.5	136.822	213.042	1.7	306.647012
×	DP2	1.2	87.72	213.042	1.7	306.647012
×	DP3	2.2	199.103	213.042	1.7	306.647012
×	DP4	1.2	87.72	180	1.43633975	306.647012
 Image: A second s	DP5	1.2	87.72	250	1.99491631	306.647012
\checkmark	DP6	10	07 70	213.042	1.7	249.999993
 Image: A second s	DP7	et as Current Desi	2	213.042	1.7	274.999975
 Image: A second s	DP8	Jpdate Design Poir Clear Output of De		213.042	1.7	306.647012
	S	ave Design Point A Delete Design Point	As			
		Jpdate All Design F	Points			

- Click again on the Performance Map icon in main menu.
- ▶ This will plot the performance map for new Current Design Point which is DP6







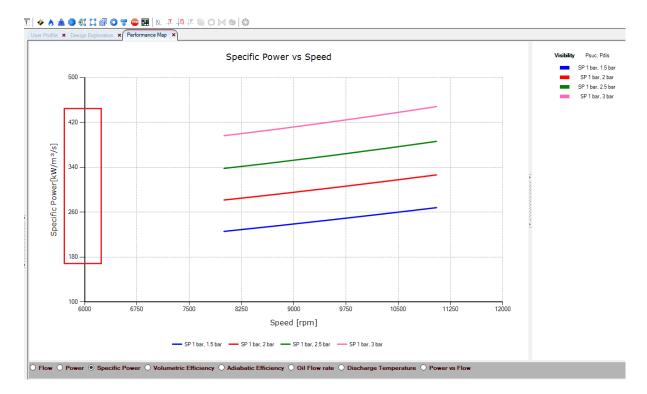
- ► A lower Specific Power with DP6 can be seen over the whole speed range at all discharge pressures as compared to DP0 plots.
- Go back to Design Exploration tab, Right-click Design Point table on DP3 and Set as Current Design Point.

	Name	P1 - Volume Index	P2 - Compression End	P3 - Rotor Length	P4 - Relative Length	P5 - Wrap Angle
	Units		Deg	mm		Deg
~	DP0	1.2	87.72	213.042	1.7	306.647012
~	DP1	1.5	136.822	213.042	1.7	306.647012
~	DP2	1.2	87.72	213.042	1.7	306.647012
\sim	DP3 (Current)	2.2	199.103	213.042	1.7	306.647012
~	DP4	1.2	87.72	180	1.43633975	306.647012
~	DP5	1.2	87.72	250	1.99491631	306.647012
~	DP6	1.2	87.72	213.042	1.7	249.999993
~	DP7	1.2	87.72	213.042	1.7	274.999975
~	DP8	1.2	87.72	213.042	1.7	306.647012





- Click again on the Performance Map icon in main menu.
- ▶ This will plot the performance map for new Current Design Point which is DP3.



A lower Specific Power with DP3 can be seen over the whole speed range at the high discharge pressures of 3.0 bar as compared to DP0 and DP6 plots. But at lower discharge pressures of 1.5 and 2.0 bar, the Specific Power of DP3 is higher than that of DP0 and DP6.

Thus, for the desired operating condition of the compressor the design can be analysed, and a better configuration can be obtained using the SCORG Design Exploration Framework.





5 Bibliography

ANSYS CFX, 2021. User Guide, 2022-R1: ANSYS Inc..

DISCO, 2007. DISCO, User Help Manual, London: City University.

Kovačević, A. & Rane, S., 2017. Algebraic generation of single domain computational grid for twin screw machines Part II – Validation. *Advances in Engineering Software*, Volume 107.

Kovacevic, A., Stosic, N. & Smith, I. K., 2007. *Screw compressors - Three dimensional computational fluid dynamics and solid fluid interaction, ISBN 3-540-36302-5.* 1 ed. New York: Springer-Verlag Berlin Heidelberg.

Rane, S., 2015. *Grid Generation and CFD analysis of Variable Geometry Screw Machines,* London: City University London.

Rane, S. & Kovačević, A., 2017. Algebraic generation of single domain computational grid for twin screw machines. Part I. Implementation. *Advances in Engineering Software*, Volume 107, pp. 38-50.

Rane, S., Kovačević, A. & Stošić, N., 2016. *CFD Analysis of Oil Flooded Twin Screw Compressors. Paper 2392.*. Purdue, Int. Compressor Eng. Conference.

SCORG, 2022. SCORG, User Help Manual, London: City University.

Stosic, N., Smith, I. K. & Kovacevic, A., 2005. *Screw compressors: Mathematical modeling and performance calculation, ISBN 3540242759.* 1 ed. London: Springer.

End of Document

PDM Analysis Ltd Bourne House, 475 GodstoneRoad, Whyteleafe, Surrey, CR3 0BL, United Kingdom +44 20 7040 8780; +44 78 2781 8689 <u>SCORG@PDMAnalysis.co.uk http://www.pdmanalysis.co.uk</u>

