Gerotor Design Studio

Installation & User Guide

Gerotor Design Studio V2021.1
User Guide Version 2021.1
May 2021

Contents

Partnership Programs

We are pleased to be involved in the following Partner Programs with industry leading CAD/CAM and Simulation providers

GT

CERTIFIED Solution Partner

SOLIDWORKS

AUTODESK
Authorized Developer

Solution Partner
PLM
SIEMENS

for

SOLID EDGE

Installation, Limitations and Registration

Gerotor Design Studio (GDS) is available for installation in three different formats:

- A Node Locked version
    - Single license, locked to one PC
- A USB version
    - License can be moved from PC to PC by moving the USB dongle
- Network solution
    - License is installed on a server and can serve many different client PCs
    - Also supports multiple licenses from one server

A trial version is available from the Gerotor Design Studio website and is free to use for 30 days. After this, the software becomes inactive unless a license is purchased.

The download link for the trial version can be obtained from our website: www.GerotorDesignStudio.com

The trial version has full functionality in all respects EXCEPT for generation of high quality inner rotor solid models. Models can be produced from the trial version to showcase this functionality but the quality of the inner rotor is not sufficient to use for manufacturing. High quality CAD models are produced by the fully licensed product.

The software is licensed on an annual basis. Current pricing structures can be found on our website: www.GerotorDesignStudio.com

To obtain a license for the full product or to enquire further about the software, please contact Gerotor Design Studio directly: sales@gerotordesignstudio.com

Installation of the Trial Version

The installation file for the trial version can be downloaded from our website www.gerotordesignstudio.com. Run the file from your desktop to install the software. A specific Program Folder – “Gerotor Design Studio V2021 – Trial” – will be created.

The trial version expires after 30 days use. Uninstalling and/or re-installing the software will not reset the trial license period.

This help file can be accessed at any time from within the program, by pressing the F1 key.

Any problems with installation should be reported to support@gerotordesignstudio.com

Installation, Limitations and Registration

Installation of the Full Version

On purchase of a license, a download link for the full version will be forwarded. This can be installed by running from the desktop.
A different program folder will be created – "Gerotor Design Studio V2021".

USB and Network versions

If a USB license is purchased, a USB dongle containing the license, the installation and all support files will be mailed to the purchaser via secure, recorded delivery. On receipt of the dongle the program should be installed using the installation file contained. The USB license will only work with installations made from the USB.

If a Network license is purchased, specific instructions will be sent to the purchaser regarding set up files for the license server and installation files for the client machines. These instructions will include links to the Network version of the program.

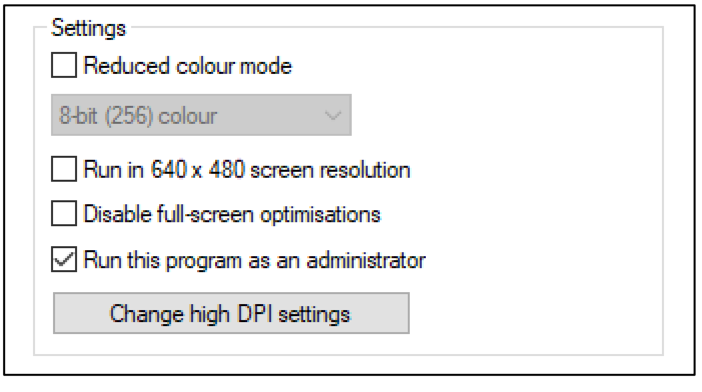
Running GDS with GT-SUITE

In order for GDS to successfully connect to GT-SUITE, it must be run with administrator privileges. If an error is reported during build of GT-SUITE models and GT-SUITE is installed with the license running correctly, then GDS needs to be manually set to run in administrator mode.

Navigate to the Gerotor Design Studio V2021 installation directory. Find the main executable file for your version of the program:

- V2021.exe for node locked
- V2021_USB.exe for the USB version
- V2021_NETWORK.exe for the network version
- V2021_TRIAL.exe for the trial version

Right click on this file and select Properties, then the Compatibility tab.
Check the box 'Run this program as an administrator' and click OK. GDS should now correctly connect to GT-SUITE to create GT models.



Installation, Limitations and Registration

In addition to developing and providing engineering software, Gerotor Design Studio manufacture prototype and volume gerotors (and housings) in-house using high quality CNC equipment, tooling and measurement facilities, to ISO 9001:2015 standards. We can help you with your projects, either through the development stages or for series production. Please contact us for more information at sales@gerotordesignstudio.com

Main Program Features

The Gerotor Design Studio software can be used to design gerotor profiles either from existing data or as a 'clean sheet' design process.

In addition to creating the profile geometry the software will assist in the design of the porting, including shadow porting and metering grooves if required.

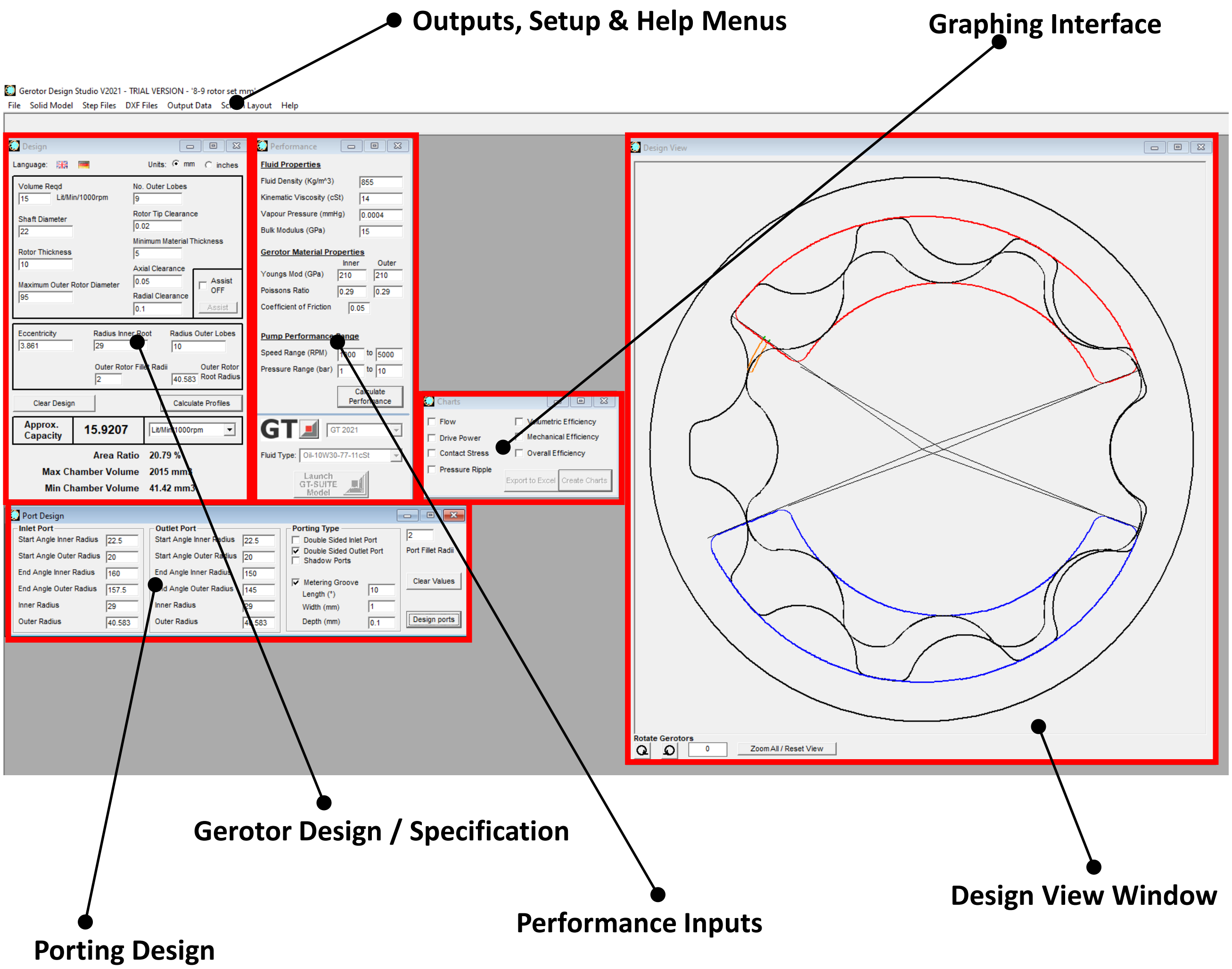
Performance predictions using in-program calculations can help fine tune your gerotor design prior to creating CAD models. The results of these calculations can be viewed graphically within the GDS software, exported as text files or exported directly to Excel (with graphs).

Alternatively, high fidelity performance simulations can be carried out by utilising our partnership with Gamma Technologies and their World leading 1D simulation tool GT-SUITE. This functionality offers the user a 'single button click' method to build a full GT-SUITE model directly from the GDS interface. All parameters used in the specification of the gerotor pump in GDS are carried into GT-SUITE, allowing for simulation cases to be run within seconds.
To use this functionality the engineer must have a current license for GT-SUITE (v2020 and v2021 are supported). More information about GT-SUITE and licensing options can be found on the Gamma Technologies web site: www.gtisoft.com

When the design of the gerotor (and porting) is complete, outputs can be obtained directly from the GDS interface allowing integration into a larger product assembly or for use in manufacture of parts. These outputs are:

- Solid Models – single click creation of Inner Rotor, Outer Rotor, Rotor Assembly and Porting can be generated for the following formats:
    - SOLIDWORKS
    - Solid Edge
    - AutoCAD
    - AutoDesk Inventor
    - Catia v5
    - STEP files
- DXF files of the Inner Rotor, Outer Rotor and porting profiles (2D format)
- Co-ordinate information for rotor and port manufacture
    - Absolute profile co-ordinates
    - Toolpath offset co-ordinates
    - Pocket milling routines (for porting)
    - G-Code outputs (for Outer Rotors)
    - X/C code outputs (for lathes)

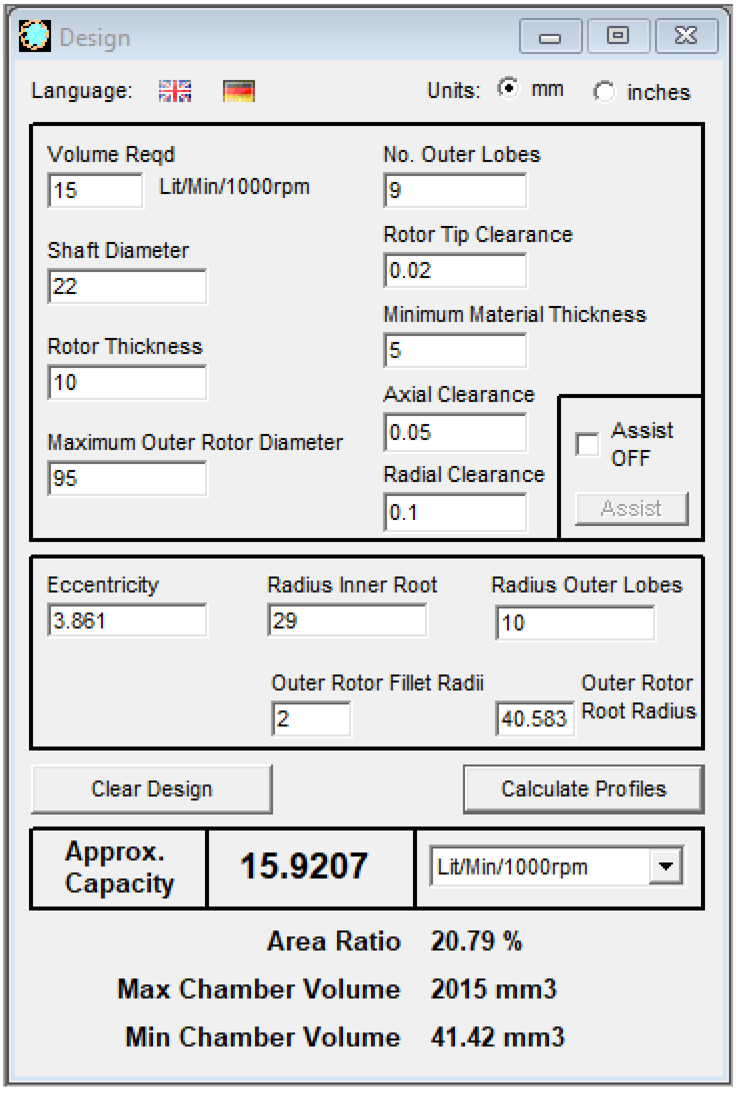
Desktop Layout



The layout of the GDS interface can be organised by the user to suit their PC desktop size and preferences. The individual forms can be moved and resized (click and drag the title bars of the forms to move, or click and drag the corners to resize). When the Design View Window is resized, the pictorial representation of the gerotor will resize accordingly when the ‘Zoom All’ button is clicked.

The layout of the forms can be saved for future use by clicking ‘Screen layout’ on the menu bar, then ‘Save Current Layout’. Clicking ‘Restore Default Layout’ returns the forms to their original size and position.

Gerotor Design / Specification



This is the main form in the software and controls the geometric parameters used to define the gerotor profile.

The language used within the program can be selected by clicking on the UK flag (for English language) or the German flag (for German language). Please note the language throughout the program is affected by this selection, but can be changed at any time.

The units for the design can be selected – mm or inches. Please note that this selection also affects the outputs of the program (models, co-ordinate values and graphical units).

Gerotor Design / Specification

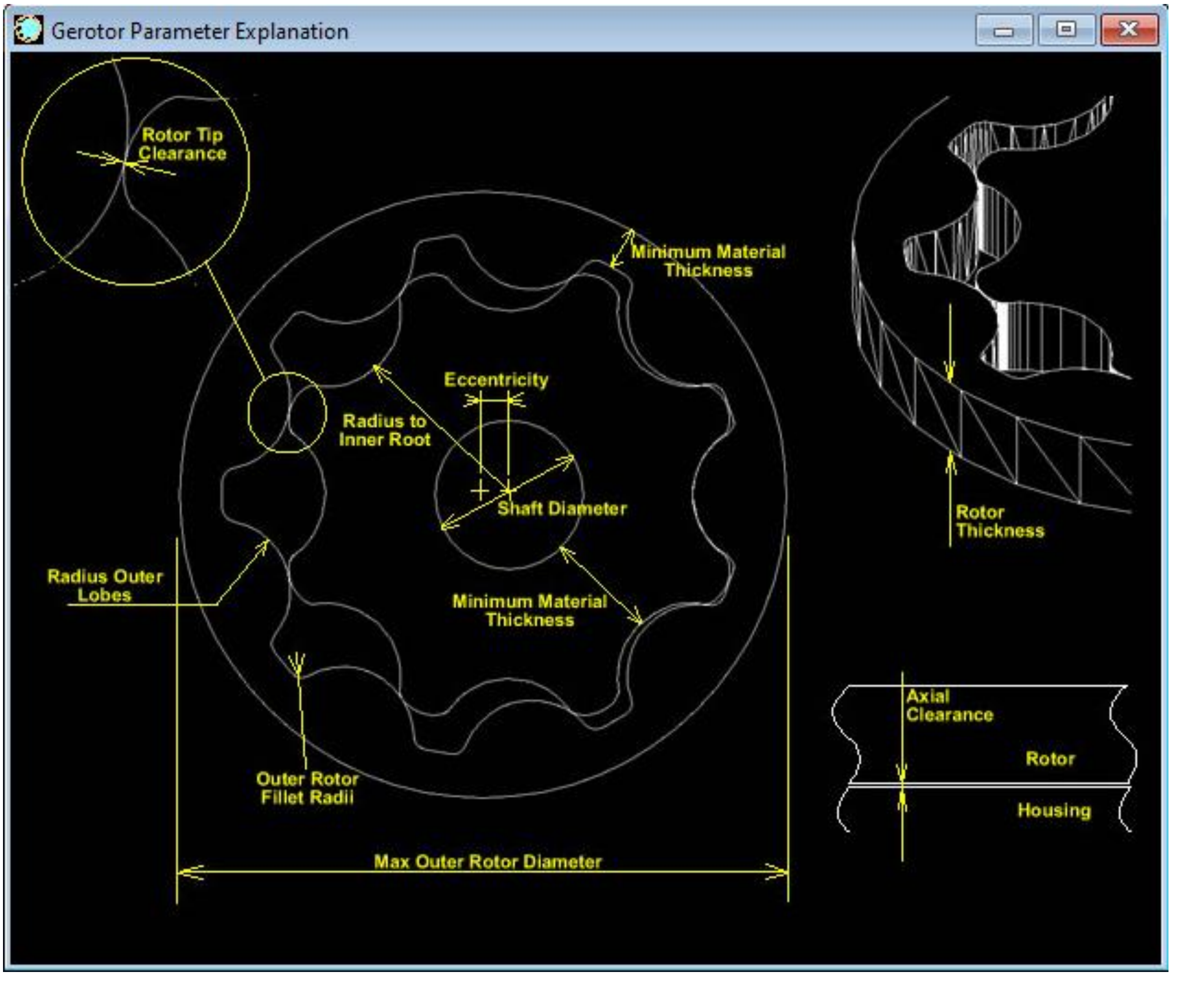
The design parameters for the gerotor profile can be entered 'fully' by the user, or some assistance can be offered by the program if required. These scenarios are discussed at the following links:

- Reverse engineer an existing profile
- Design a profile using the design assistance

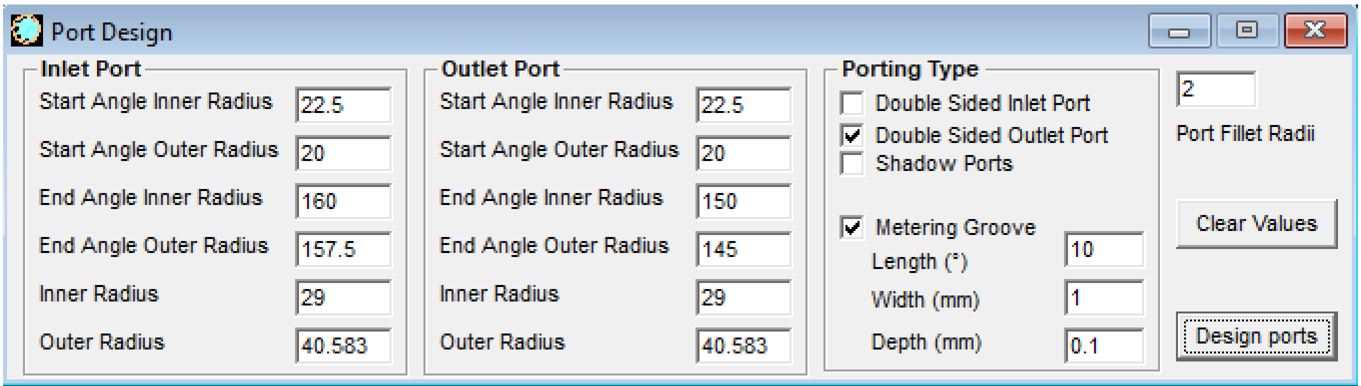
The units of Approx. Capacity can be changed by the user. This does not affect any other aspect of the software.

The 'Calculate Profiles' button is the most important function on this form. Even if the design assistance has been used, the calculation and generation of the gerotor profiles will not occur until this button is pressed.

An explanation of the terms used on this form can be found by clicking 'Help' on the menu followed by 'Gerotor Explanation'. The same graphic is shown below:



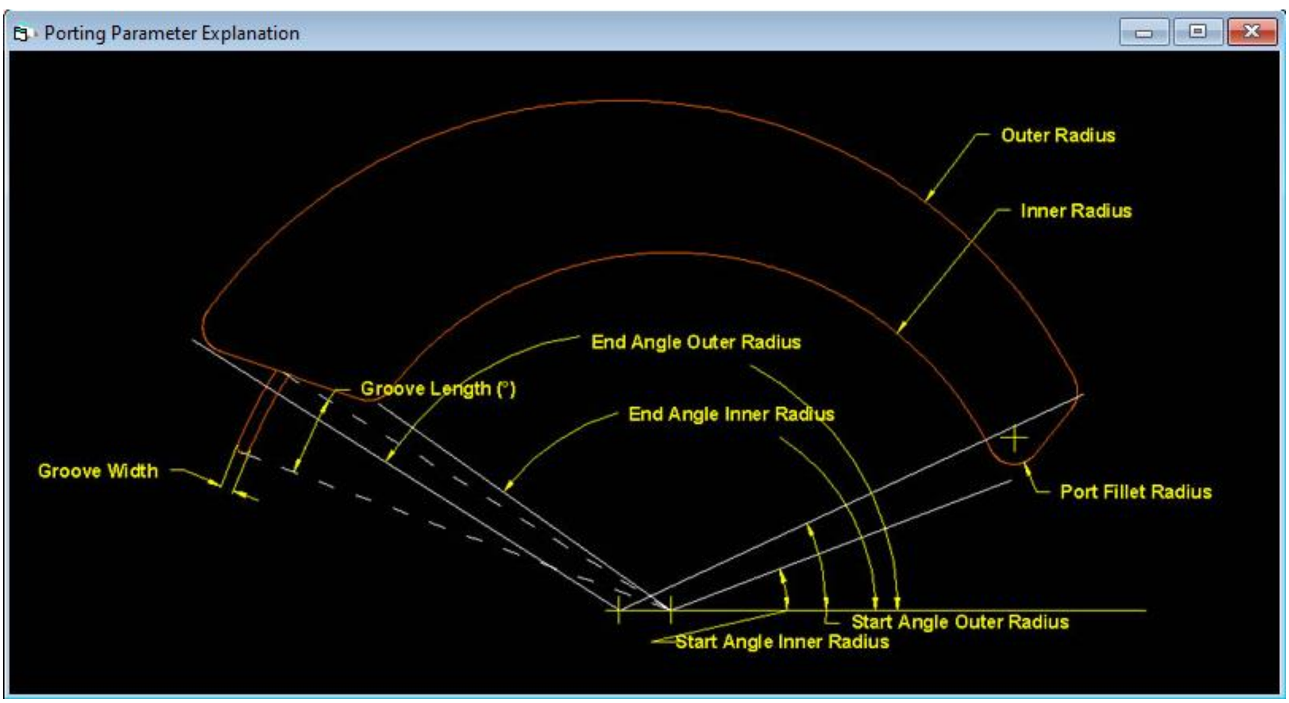
Porting Design / Specification



Similar to the Gerotor Design / Specification, this form contains all the necessary parameters to allow the creation of the porting geometry. In addition, the type of porting can be specified (double sided for inlet and/or outlet and also shadow porting).

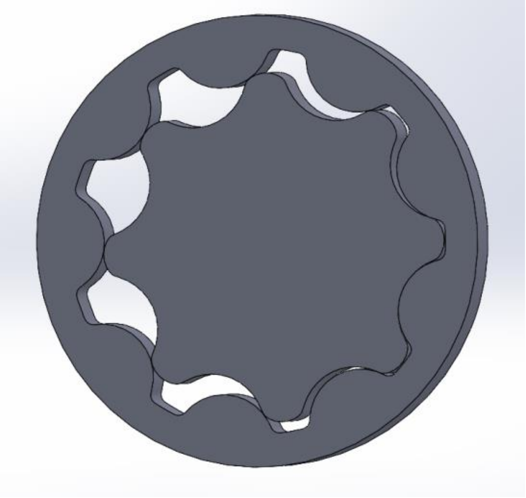
A metering groove on the outlet port can also be defined on this form, as can the radii in the corners of the porting.

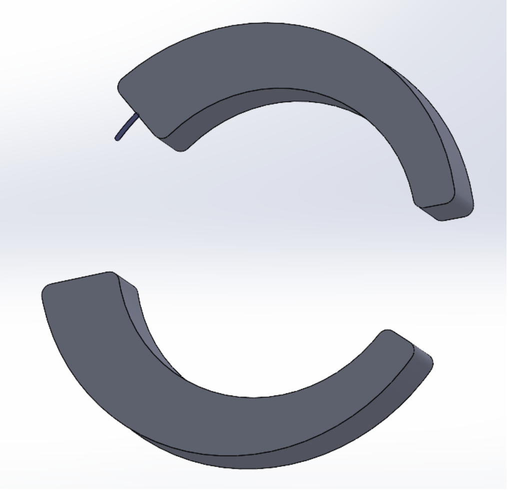
An explanation of the terms used on this form can be found by clicking 'Help' on the menu followed by 'Porting Explanation'. The same graphic is shown below:



The 'zero' line for the angular dimensions is the horizontal line, to the right of the centreline of the inner rotor (i.e. the 3 o'clock direction on a clock face). Positive angles are measured anti-clockwise from this line.

Solid Model / DXF Generation





Once the gerotor (and porting if required) geometry is defined, solid CAD models can be output in various formats directly from the software interface.

To use a supported CAD package for model generation in their native formats, choose the modelling package installed on the users PC by clicking ‘Solid Model’ on the menu and ‘Choose Solid Modelling Package’.

Once the correct modelling package has been selected, the individual components can be output by clicking ‘Solid Model’ again and then the desired component.

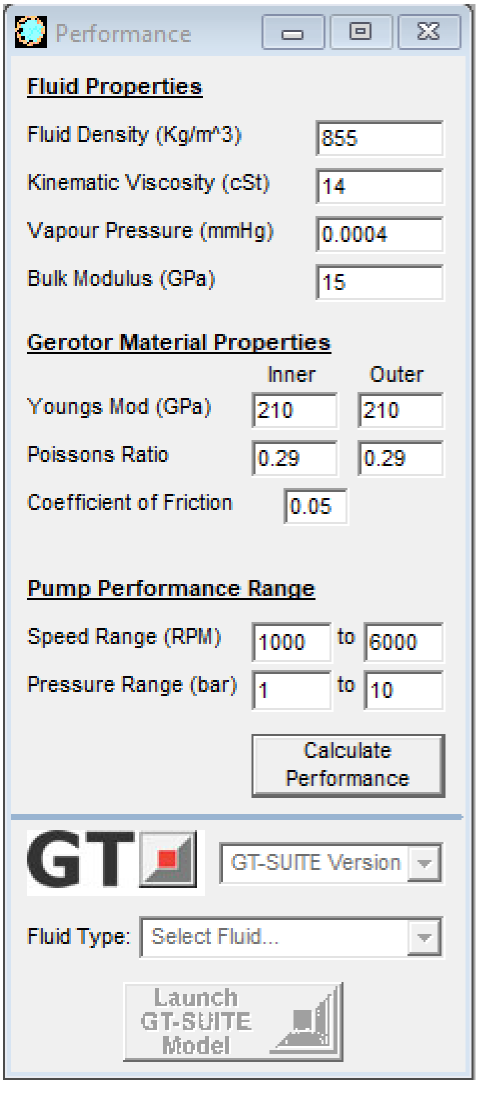
NOTE:

- Trochoidal curve outputs a sketch of the trochoid generated to form the inner rotor. It is for info only
- The inner rotor is not modelled with a shaft bore – this is because many gerotor drive forms do not have a simple round bore. This is left for the designer to include accordingly.

In addition to the supported CAD packages, models can be output in STEP format which can be opened in any other CAD package. These can be generated by clicking ‘Step Files’ on the menu and then selecting the required component. The user will be prompted for a save location and filename.

2D DXF plots can also be output, by clicking ‘DXF files’ on the menu and then the required component. Again the user will be prompted for a save location and file name.

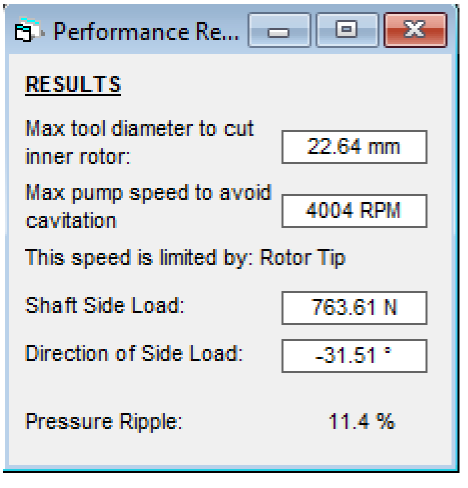
Performance Calculations (in-program)



Performance calculations for a pump assembly can be obtained within the GDS program to allow for examining the effect of changing parameters on pump flow, efficiency, rotor contact stress and pump power requirements.

In order to make these calculations, information is required regarding the fluid to be pumped, the material of the gerotor elements and the pump operating envelope (speed and pressure rise). Please note viscosity of fluids vary with temperature and should be set according to the conditions of interest.

Clicking the 'Calculate Performance' button will show an initial results window (below) with some useful information and will also enable the 'Charts' form for further outputs.



The 'Charts' form can be used to show graphs of various outputs directly in the GDS program (select the required data and click 'Create Charts'). These graphs can be moved and sized in the same way as the main parameter forms, and their position and size are also saved with the 'Save Current Layout' function.

The position of the graph legends can also be moved by clicking and dragging the legend title.

Performance Calculations (in-program)

Pressure ripple is calculated as the fluctuating pressure seen in the outlet port due to the intersection of each successive gerotor chamber (pressure drop due to instantaneous volume increase, then rise back to nominal level as the chamber empties into the main port).

The contact stress is calculated between the contacting inner and outer lobes during rotation. The load is due to the torque on the inner rotor, which is as a result of the pressure and friction forces within the pump. Only the contacting lobes are calculated (due to the tip clearance not all lobes will be in contact at the same time). The graph shows contact stress as a function of outer rotor rotation (which lags the inner rotor by the ratio of lobes Inner/Outer). Please see the separate file regarding contact stress for further information.

Cavitation is reported as being due to either pump speed or port fluid velocity. This is further explained in the separate file regarding this topic.

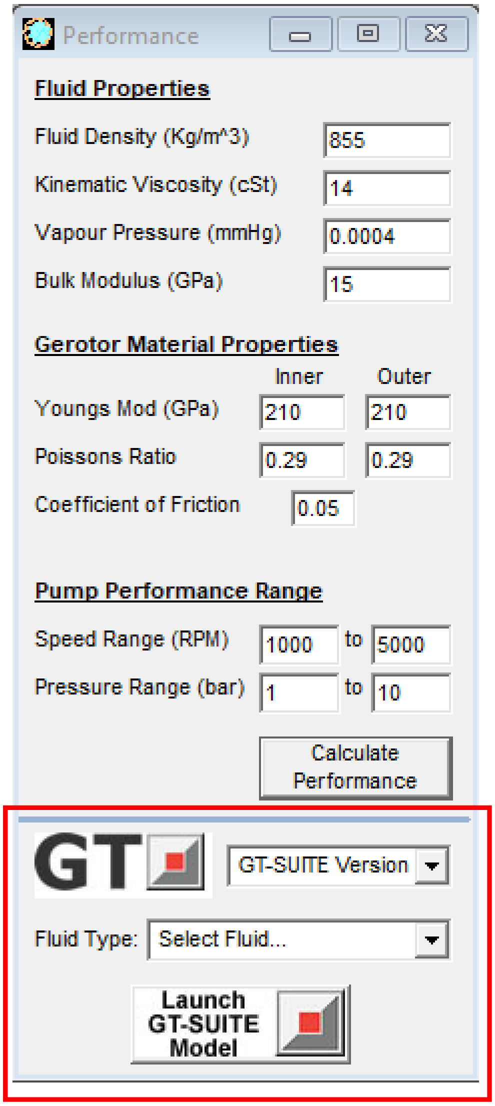
Numerical data can be obtained by clicking ‘Output Data’ on the menu options and then ‘Performance Data Files’. The user will be prompted to save four files with various data sets included.

Alternatively, all the numerical and graphical data can be exported directly to MS Excel, by selecting the data of interest in the ‘Charts’ form and clicking ‘Export to Excel’. You must have a licensed copy of MS Excel to use this function.

NOTE:
The formulae and calculation procedures used in the program are based on sound engineering principles and methods obtained from technical literature in the public domain. However they are not as accurate as using finite element methods and more sophisticated simulation tools, nor do they allow for subtle differences within the pump envelope. They do however give a good indicator of performance and are useful during the design stage to assist the engineer in defining the main pump geometries.

For a more detailed analysis of the pump it is recommended to use the GT-SUITE simulation functionality built into the program.

GT-SUITE Simulations



Once the in-program performance calculations have been completed, the GT-SUITE panel becomes active (see below). If the PC in use has an active license available for GT-SUITE then it is possible to create a GT model directly from GDS and run simulations without any further modelling input from the user.

Select the version of GT-SUITE installed (supported versions are v2020 onwards and will be updated at each release of GT-SUITE).

Select the fluid which should be used within the simulations. This pick list is direct from the GT library and includes detailed viscosity and density information versus temperature for each fluid.

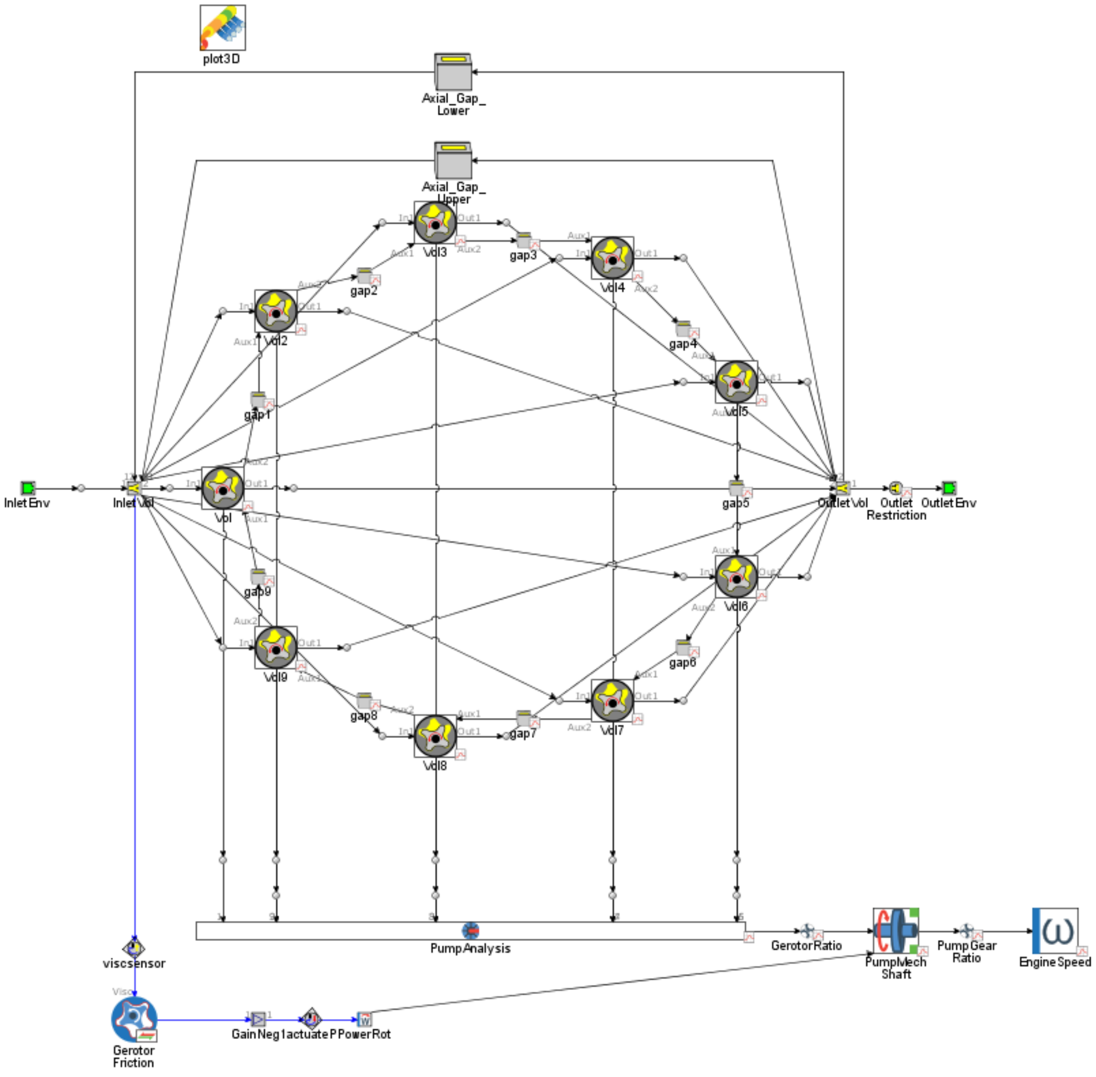
Click the 'Launch GT-SUITE' Model button and GDS will create the necessary model files from the input data, pass them to GT to create a GT Model, open GT-SUITE (if not already open) and populate the case setup table to reflect the speeds and pressures input by the user in GDS.

Without any further input or interaction from the user, the green arrow 'Run' button can be pushed in GT and the simulations will run.

Main | Design of Experiments | All

Parameter	Unit	Description	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7
Case On/Off		Check Box to Turn Case On	☑	☑	☑	☑	☑	☑	☑
Case Label		Unique Text for Plot Legends	1000 RPM : 1 bar	1000 RPM : 2.8 bar	1000 RPM : 4.6 bar	1000 RPM : 6.4 bar	1000 RPM : 8.2 bar	1000 RPM : 10 bar	1800 RPM : 1 bar
DesiredPressureDrop-bar	bar		1	2.8	4.6	6.4	8.2	10	1
ExpectedFlow-LPM	L/min		15.81961	15.81961	15.81961	15.81961	15.81961	15.81961	28.4753
OutletRestrictArea	mm^2		17.12805	10.23597	7.985993	6.770455	5.981374	5.416364	30.83049
RPM	RPM		1000	1000	1000	1000	1000	1000	1800
FLUID			Oil-5W30-62-10cSt	Oil-5W30-62-10cSt	Oil-5W30-62-10cSt	Oil-5W30-62-10cSt	Oil-5W30-62-10cSt	Oil-5W30-62-10cSt	Oil-5W30-62-10cSt
Tip_Clearance	micron		20	20	20	20	20	20	20
TEMP	K		303	303	303	303	303	303	303
WALLTEMP	K		303	303	303	303	303	303	303
Axial_Clearance_Each_Side	micron		25	25	25	25	25	25	25
fluid_density	kg/m^3		855	855	855	855	855	855	855
fluid_viscosity	cSt		14	14	14	14	14	14	14
Radial_Clearance	micron		25	25	25	25	25	25	25
Coefficient_Friction			0.05	0.05	0.05	0.05	0.05	0.05	0.05
Rotor_Diameter	mm		95	95	95	95	95	95	95
Rotor_Width	mm		10	10	10	10	10	10	10
shaft_bearing_clearance	micron		22	22	22	22	22	22	22
shaft_bearing_length	mm		11	11	11	11	11	11	11
Shadow_Port_Enable		Shadow Port ON = 1; Shadow Port O...	0	0	0	0	0	0	0

GT-SUITE Simulations



A more detailed explanation of this process and how to analyse the results can be found in [this section.]

Further enhancements to this partnership will include the ability to optimise the gerotor geometry by using the powerful Optimization Tool within GT-SUITE. This will allow multiple iterations of geometry to be run between GT and GDS in order to see the effect of multiple parameter changes on the overall design.

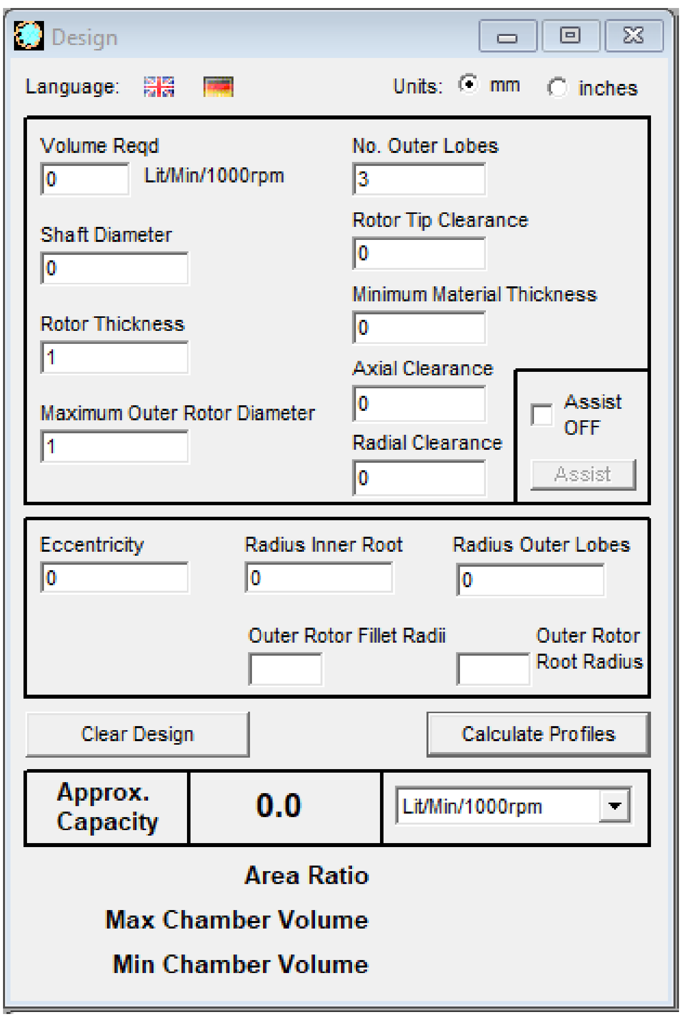
Using Gerotor Design Studio Software

Clean Sheet Design & Reverse Engineering

This section will walk through a 'clean sheet' design process which is very similar to a reverse engineering process, whereby the user already knows the key parameter dimensions before beginning.
It is also the process to use if the majority of parameters are known / fixed, namely:

- Eccentricity
- Bore size
- Outside Diameter of Outer Rotor
- Rotor Thickness
- Minimum Material Thickness

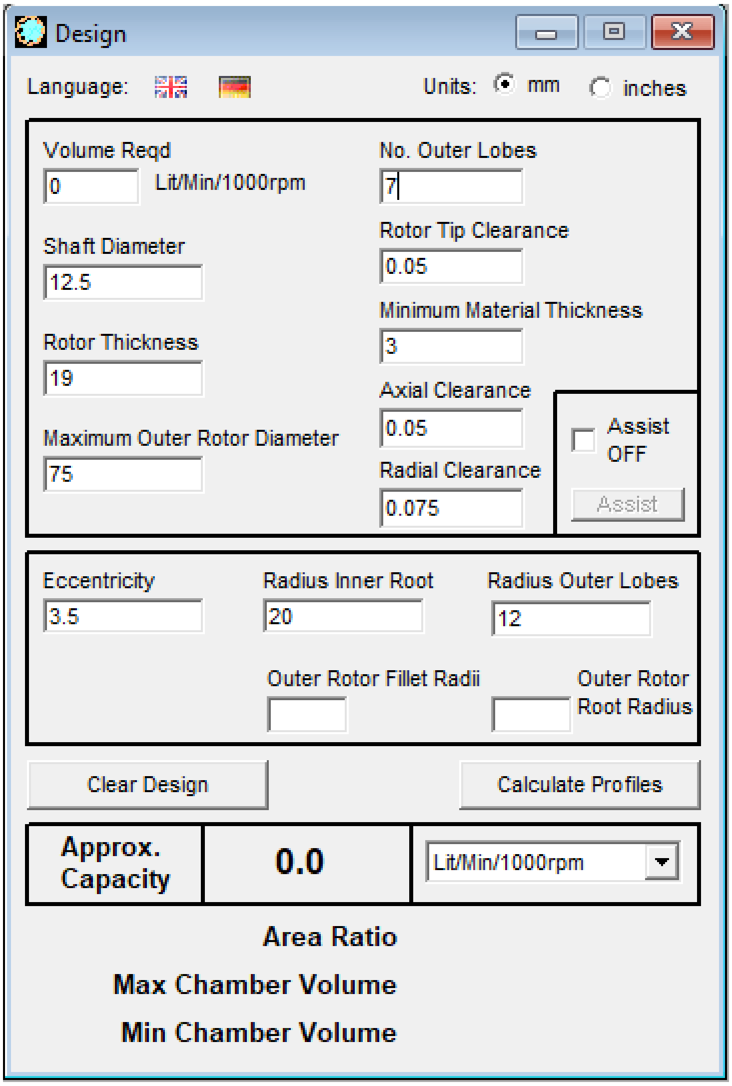
Firstly, create a New Project and give it a name: Click File on the menu items then New Project. You will be prompted to keep the existing fluid and material properties. Select Yes or No accordingly.



The default Design form shows no inputs, expect for No. of Outer Lobes = 3 (this is the minimum lobe count allowed).
Units are set to mm by default and the capacity is set to Litres/Min/ 1000rpm by default.

Select the units you wish to use (this walkthrough will use mm).
Select the capacity units you wish to use.

Populate the fields with the known parameters. Use the Gerotor Explanation (select Help>Gerotor Explanation) to understand the terminology for the parameters.



As the main parameters in this example are known, the value in Volume Required does not need to be completed and can be left blank. This value is only used by the software when the Design Assistance is in use.

Similarly the Outer Rotor Fillet Radii and Outer Rotor Root Radius can be left blank at this stage. The Root Radius is calculated by the software (but can be manually changed later).

Most of the other parameters have been measured from an existing gerotor (for reverse engineering) or are determined by the housing package space.

The parameters which may not be governed by the housing space and may still be unknown are:

- Tip, Axial & Radial clearances
- Radius Inner Root
- Radius Outer Lobes

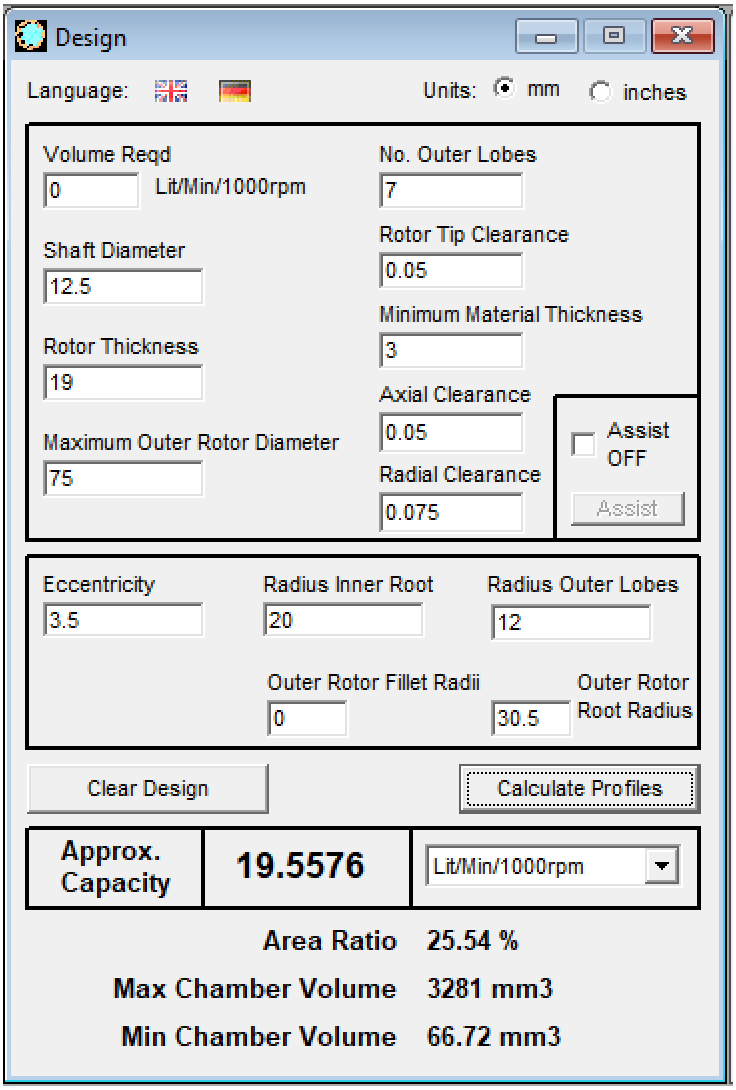
The clearances are determined based on knowledge of the application – sludge pumps require high clearances, high accuracy pumps using very low viscosity fluids and low speeds will require very small clearances. In general the range of clearances for most oil based pumps will be 0.04 – 0.200mm. Manufacturing capability also has to be taken into account, as does material selection for the housing and operating pressure (housing distortion). These factors may affect the clearances ‘required’ rather than ‘desired’ and should be part of the overall engineering process for development of the entire pump assembly. A good starting point is 0.08mm for both tip and axial clearance.

The Radius Inner Root is governed by the Shaft Diameter and Minimum Material Thickness (for its minimum value). It cannot be lower than half the shaft diameter + the minimum material thickness. The shaft diameter would likely have been determined already due to

the foreseen performance requirements of the pump (even if only for the hydraulic power required, not including friction losses). In a reverse engineering scenario this will of course be known, but the drive may not a round bore. In this case use the largest radial dimension to the drive features as the shaft diameter.
The Radius Inner Root has a direct impact on the pump capacity and the gerotor geometry and is a key dimension. Care should be taken to ensure this value is correct.

The Radius of the Outer Lobes has no effect on the capacity of the pump but it does affect the contact stress between inner and outer rotor lobes. It will also affect the feasible geometry of the gerotors for manufacture. If this value is not known, a good start value is half the value of Radius Inner Root. It can then be changed to obtain a more suitable profile for contact stress or manufacture.

Once the parameters have been entered, click ‘Calculate Profiles’



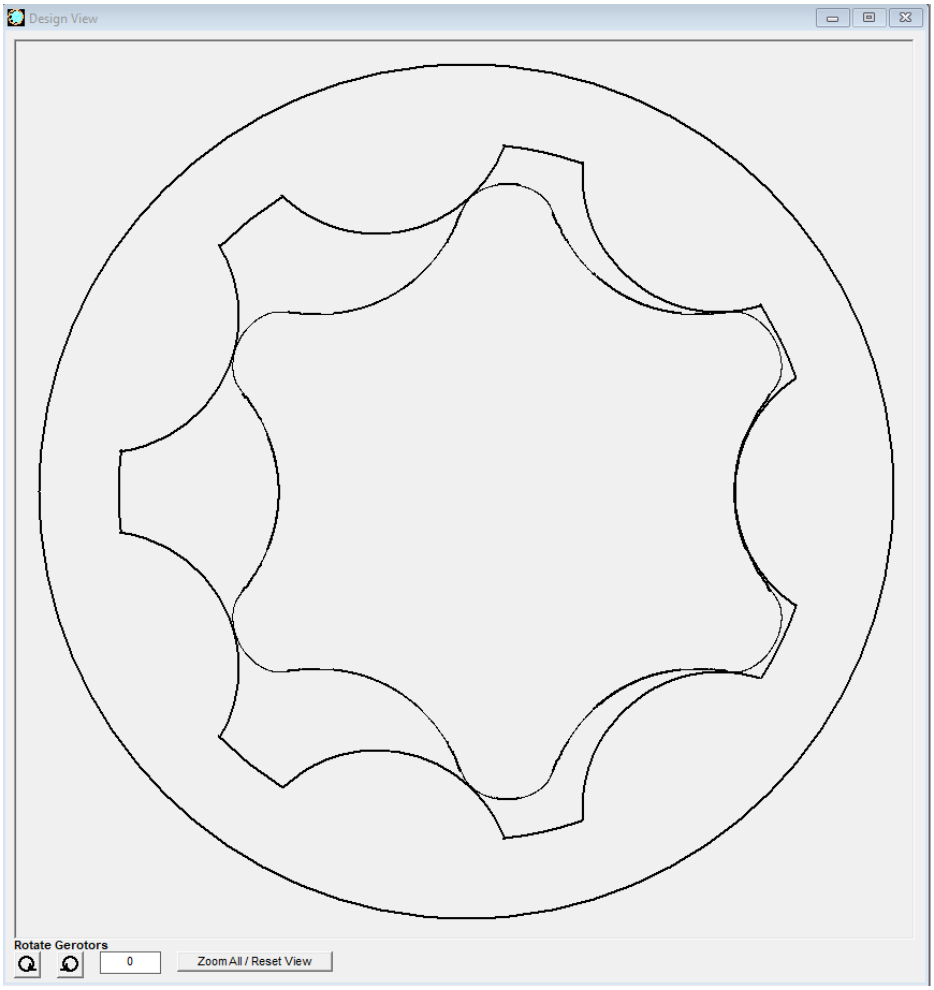
Depending upon the values entered, one or more notifications / error messages may appear.

Generally a notification will appear telling the user about the minimum value for Outer Rotor Root Radius. This is because no value was previously entered and the software has updated the parameter with this minimum value.

Messages regarding creation of an Inner Rotor with errors are due to parameter conflicts. If these parameters have been determined by physical measurement (for reverse engineering) please re-check the dimensions. Otherwise make changes based on the suggestions from the error messages – normally changes to the Radius Inner Root, number of lobes and eccentricity are the governing parameters.

Error messages regarding the volume of the pump not being able to fit the diameter specified are usually related to the Eccentricity and Radius Inner Root also. If this message keeps appearing, increase the Maximum Outer Rotor Diameter to allow a profile to be drawn then it may be possible to spot the reason for the error.

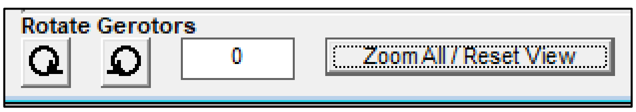
It is possible, in a reverse engineering scenario, that an acceptable profile CANNOT be created. This is always due to different profile types between some existing gerotors and the type used in Gerotor Design Studio software. The GDS software creates trochoidal profiles. However, there are a number of different profile creation algorithms in use (some of which have been developed by gerotor manufacturers and are not available in the public domain). If the rotors being reverse engineered fall into this category it may be difficult to find an acceptable profile within GDS. In this case contact us directly (support@gerotordesignstudio.com) and we can help you resolve the problem or create an acceptable alternative.



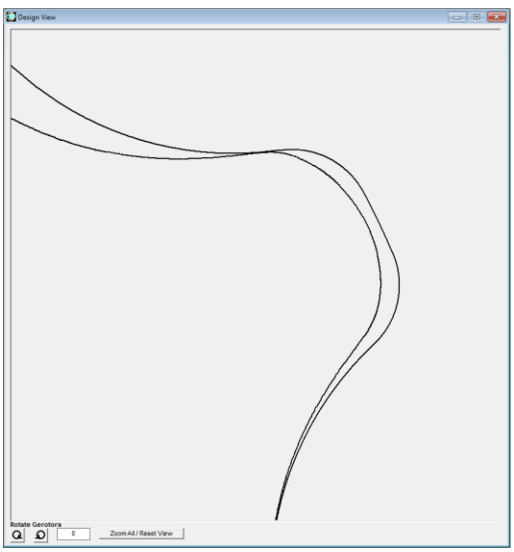
Once any error message issues are resolved a profile will appear in the Design View window, similar to that shown.

The profile is shown without any fillet radii in the outer rotors, as none has yet been specified. Enter a value in the Outer Rotor Fillet Radii parameter and click ‘Calculate Profiles’ again.
If the value entered is acceptable the new profile will be drawn.
If the value is too large and cannot fit the design space an error message will be shown and a smaller value should be entered. In this case no profile will be drawn.
If the value creates an interference between the inner and outer profiles a message will be displayed giving the interference dimensions and suggesting to choose a smaller radius. In this case a profile will be drawn and the user can zoom to see this interference if required.

The profile drawn can be rotated and zoomed.
To rotate the profiles, click on either the clockwise or anti-clockwise buttons at the base of the Design View window. Each click rotates the inner rotor 1 degree and the outer rotor by a corresponding amount. It is also possible to enter a value in the box and hit Enter and the rotors will jump to that rotation value.
Hold the directional buttons down to step the rotors in one degree increments continuously.



The profile drawn can be zoomed by clicking and dragging a box around the area of interest. It is possible to zoom ‘in’ further from this point, but not to zoom ‘out’. Whilst in zoom mode the rotors can be rotated using the directional buttons.



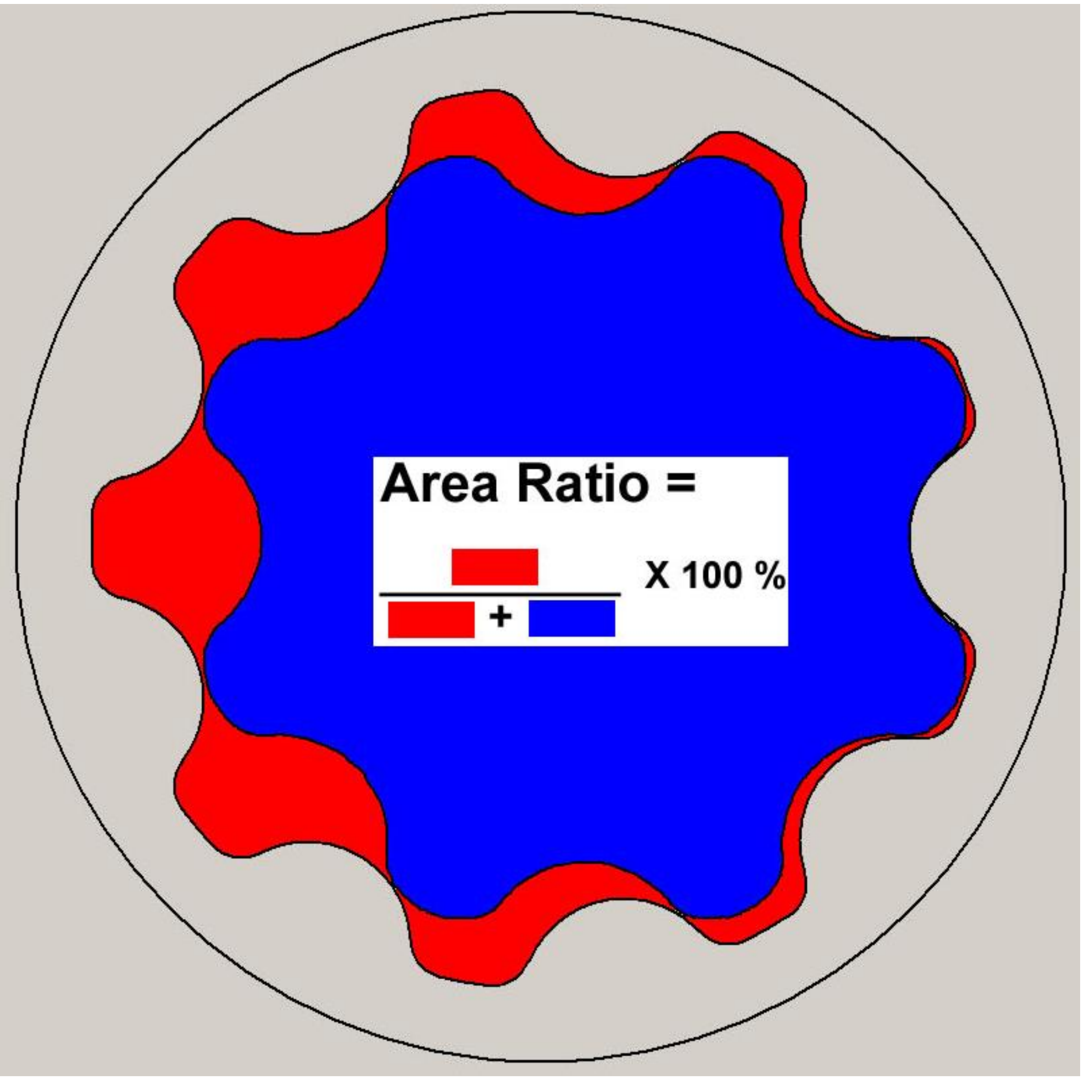
To redraw the rotors at full size and at zero degree rotation, click the ‘Zoom All / Reset View’ button.

The Outer Rotor Root Radius can be increased if desired, especially to allow for more radial movement in the working pump or debris entrapment. Enter the value and click ‘Calculate Profiles’ to see the results.
Note that the MAXIMUM value allowed here will be equal to half the Outer Rotor Diameter minus the Minimum Material Thickness.

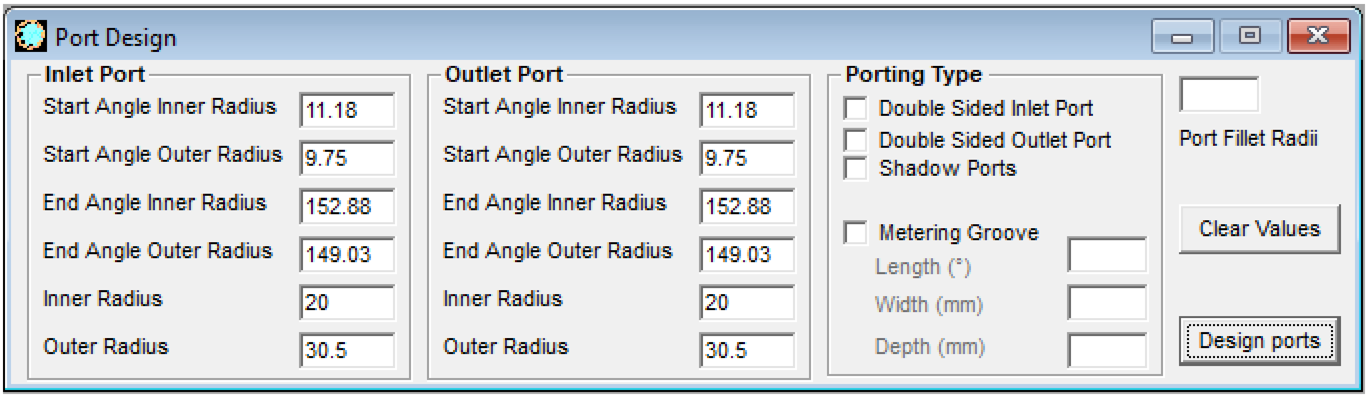
Changes can be made to the parameters of the gerotors at this point, perhaps to see their effect on the geometry or to closer align with an existing gerotor set. Once the porting and performance calculations have been completed, this step can be returned to again to refine the geometry especially regarding contact stress alleviation or efficiency improvements (usually related to clearances).

At the bottom of the Design form there are some results for:

- Maximum Chamber volume – the maximum volume of the chamber when at the 'open' point of rotation
- Minimum Chamber volume – the minimum volume of the chamber when at the 'closed' point in rotation
- Area ratio – this is the area between the rotors divided by the area bounded by the outer rotor profile
    - It is a measure on the effective use of the area encompassed by the rotor set for fluid transfer – a higher value means more of the space is used as working volume rather than structural volume. It is for info only.



Once the gerotor geometry is defined, the porting can be designed. This can be done automatically in the software by clicking ‘Design Ports’ in the Port Design form.



The ports are drawn on top of the gerotor profiles in the Design View window. The inlet port is drawn in blue, the outlet port is drawn in red. The assumed direction of rotation is clockwise (looking at the Design View).

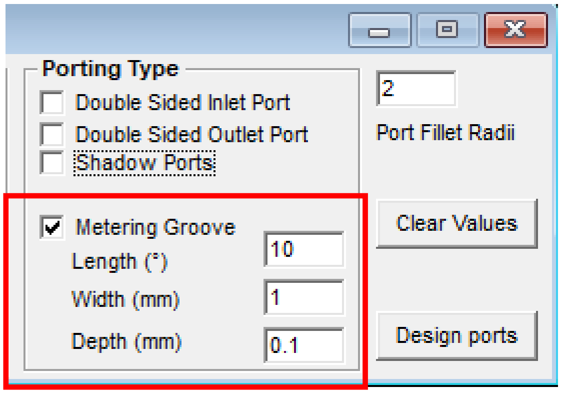
The values entered are calculated by the GDS software to place the edge of the ports on the intersection points of the inner and outer rotors, when the rotors are at minimum chamber volume (to determine the ‘start angles’) and maximum chamber volume (to determine the ‘end angles’).
The angles are referenced from the horizontal. The datum for the Inner Radius angles is the centre of the Inner Rotor; the datum for the Outer Radius angles is the centre of the Outer Rotor.
The Inner Radius and Outer Radius values coincide with the Radius Inner Root and Outer Rotor Root Radius values from the gerotor Design form.

All of these values can be changed manually if required.

The Port Fillet Radii (corner radii) can be set. If too large a value is entered an error message will be displayed.

Check boxes for Double Sided inlet and outlet ports and also Shadow ports can be selected. Double sided porting allows slower fluid velocities into / out of the gerotor chambers, as two ports are used (one each side of the gerotor set). A shadow port is a shallow port which is placed on the opposite side to the main porting, its purpose is to provide a pressurised volume of fluid which counteracts the axial thrust on the gerotor set from the high pressure outlet port. This greatly affects friction and has an impact on pump life (wear of the housing face).

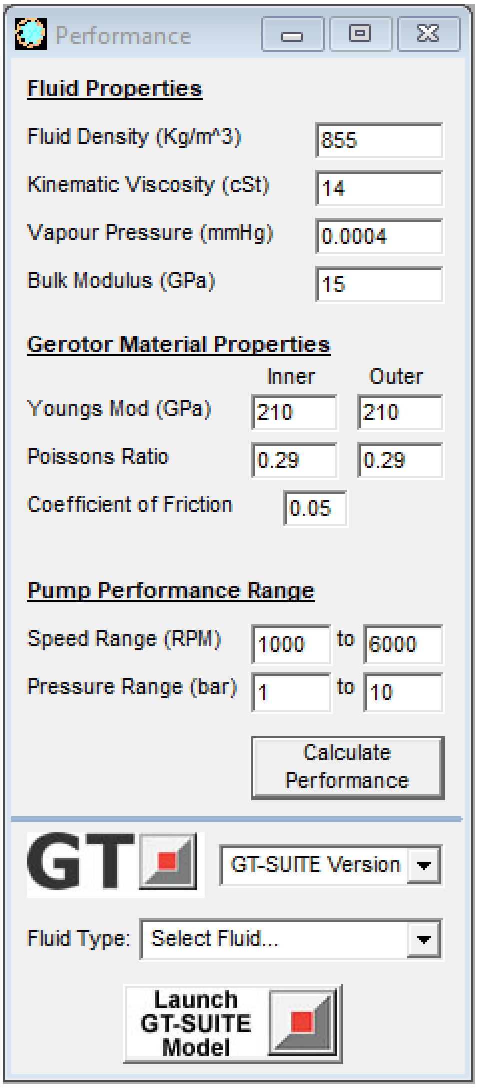
GDS sets the depth of the ports equal to the gerotor thickness (in this case 19mm). If double sided porting is selected, each port is half this depth. Shadow ports are created at 20% depth of the main ports. These can be changed in the output models easily if required.



If required a Metering Groove can be added. Select the checkbox to enable this section and enter the values as required. Note that the length of the groove is expressed in degrees.

The purpose of a metering groove is to reduce the high pressure spike associated with the full gerotor chamber (at inlet pressure) crossing into the outlet port (at high pressure). During this initial transition there is a backflow of fluid from the outlet port to the chamber and an associated pressure rise (high rate of change) in the chamber and pressure fall (low rate of change) in the port. As the gerotors continue to rotate, the pressure in the gerotor chamber builds again to the port average pressure. These pressure spikes can lead to fluid borne and structure borne noise in some applications. Detailed design of metering grooves and their detailed analysis cannot be done with the GDS software but is possible with the GT-SUITE collaboration, however the overall effect on pressure ripple can be seen within the GDS results.

Once the porting design is complete, performance calculations can be run. The Performance form can be completed with information regarding the fluid to be pumped, the material of the gerotors (for calculating contact stress values) and the operating conditions of the pump (speed and pressure ranges).



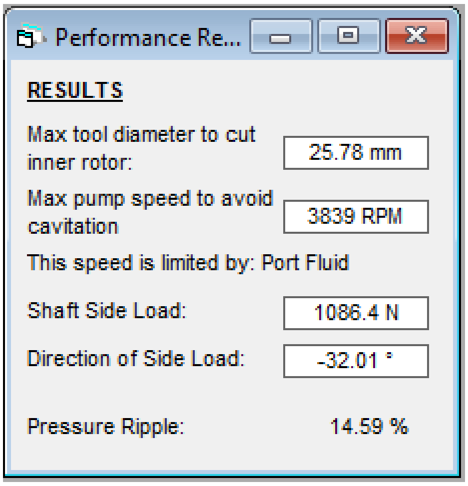
The fluid properties should be entered for values relating to the operating conditions of the pump. i.e. enter the viscosity and vapour pressure values for the known operating temperature and environment of the pump.

For lubricating oil, the vapour pressure value is extremely low and is generally not a significant concern for cavitation. Of greater concern is the 9% dissolved air in this type of fluid which can give rise to cavitation-like performance.
The Bulk Modulus for lubricating oil is generally around 15GPa and is used for pressure ripple calculations.

The material properties for the gerotors should be entered. Steels generally have a Youngs Modulus (Modulus of Elasticity) around 210GPa, with a Poissons Ratio of 0.29.
Coefficient of friction is usually 0.05-0.10 for lubricated steel on steel (with good surface finish).

Enter the minimum and maximum values for pump speed (inner rotor speed) and expected pressure rise across the pump.

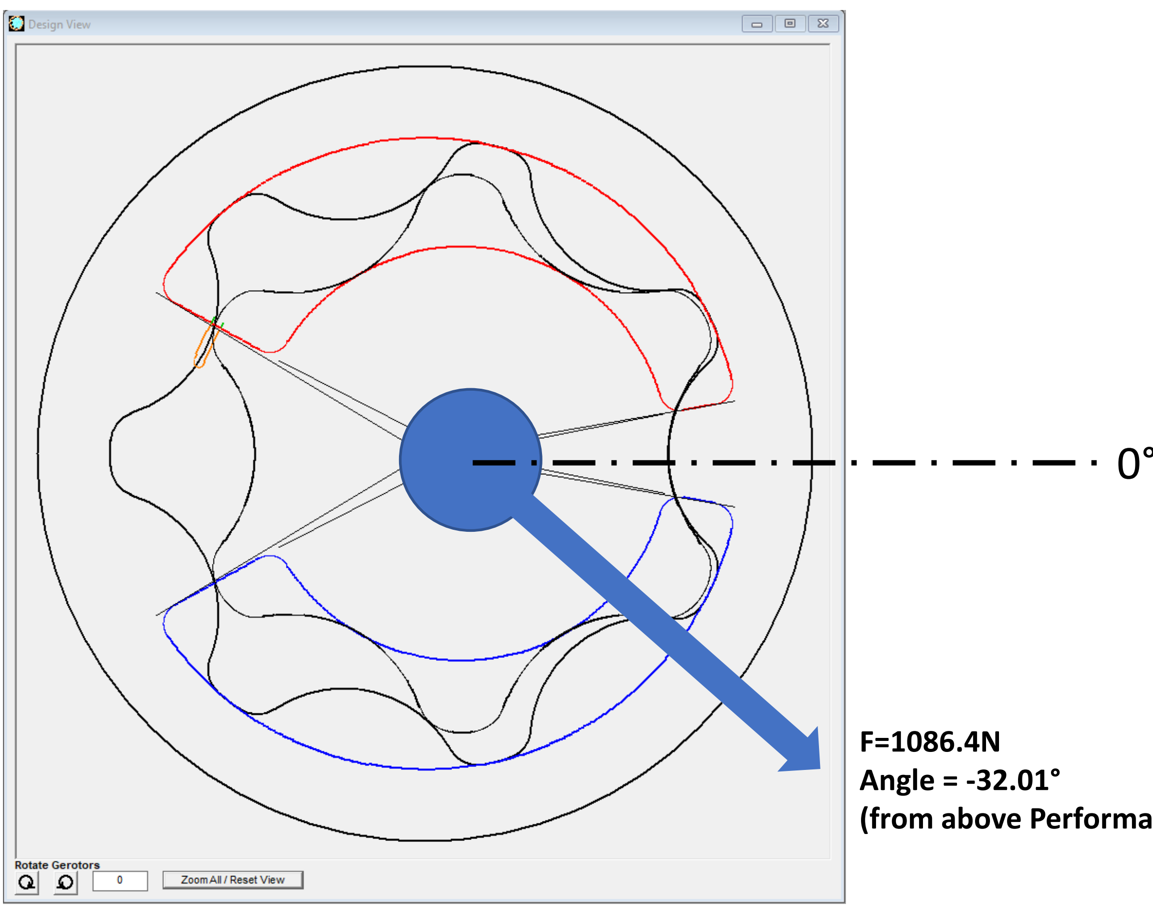
Clicking the ‘Calculate Performance’ button will display the ‘Performance Results’ window. This window shows some overview results which may be of interest prior to analysing in greater depth with the charting functions.



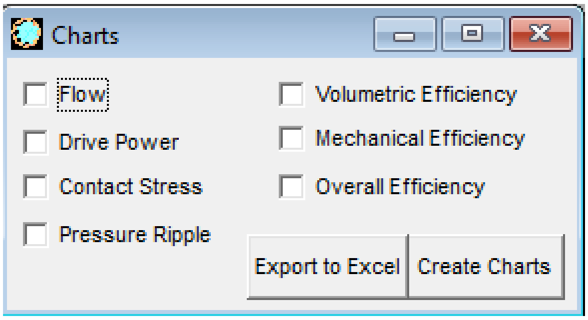
The Max Tool Diameter to Cut Inner Rotor is shown as the inner rotor profile is not made up of discrete arcs, therefore it is not obvious where the minimum radius exists.

The Max Pump Speed to avoid cavitation is calculated. This value is based either on rotor speed or fluid velocity in the port and the relevant basis is also reported. A more detailed investigation into the cavitation results can be found in a separate document.

The Shaft Side load is reported for the highest speed and pressure load in the selected range (worst case). It is the total radial load being exerted on the shaft from the gerotors and is expressed as a vector, with both magnitude and direction values. The orientation of the gerotors and porting and the direction of rotation are as displayed in the Design View window of the GDS software. A graphical representation is shown below.

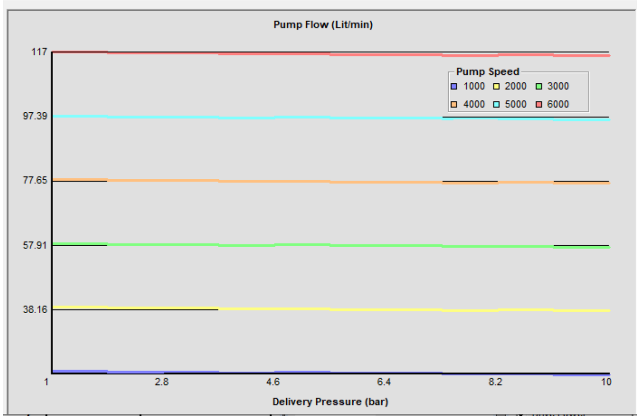


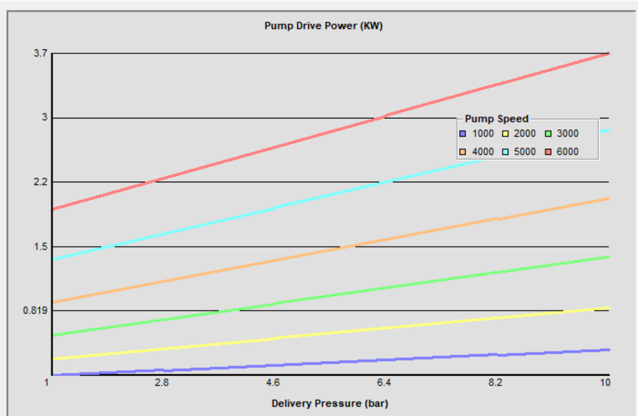
F=1086.4N
Angle = -32.01°
(from above Performance Results)

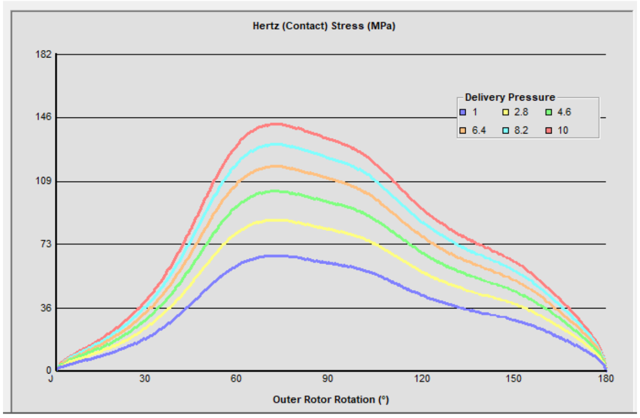


Once the performance calculations are complete, the Chart form becomes active.

Select the results of interest and click the ‘Create Charts’ button.





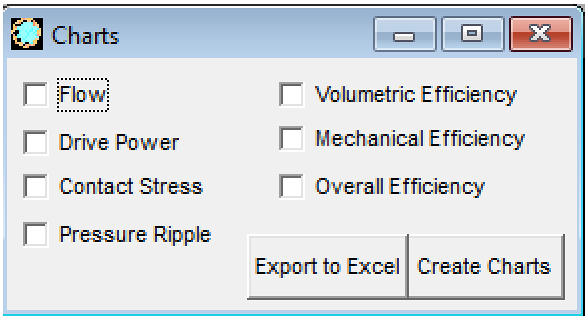


In this case three graphs have been selected, Flow, Drive Power and Contact Stress.

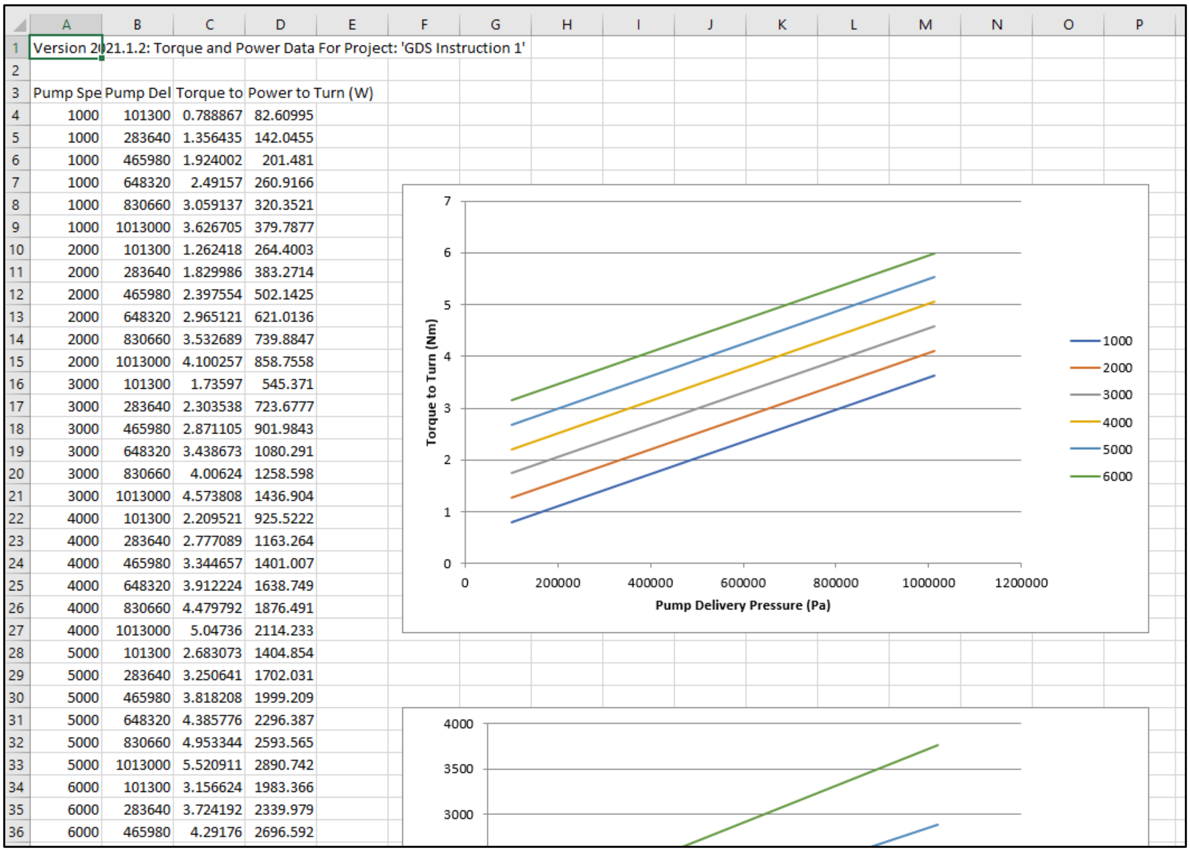
The graphs can be moved by dragging the title bar. They can be resized by clicking and dragging the bottom right corner.

The legends can be moved by clicking the legend title and dragging.

The graphs typically show series of data for six speeds, between the upper and lower bounds selected in the Performance form. On the above graphs the effect of the clearances can be seen on the Flow chart (reducing flow with increasing pressure); the effect of friction and hydraulic power can be seen in the Drive Power chart; the effect of geometry can be seen in the Contact Stress chart. A more detailed explanation of the Contact Stress results can be found in a separate document.



Clicking the ‘Export to Excel’ button will send all the numerical data to Microsoft Excel (a licensed version of Excel needs to be available on the same PC as the GDS installation). This will open automatically and will also create the associated graphs. Typically more data is available via this method (for example, drive torque is also shown as well as drive power).


Version 2021.1.2: Torque and Power Data For Project: 'GDS Instruction 1'

Pump Spe	Pump Del	Torque to	Power to Turn (W)
1000	101300	0.788867	82.60995
1000	283640	1.356435	142.0455
1000	465980	1.924002	201.481
1000	648320	2.49157	260.9166
1000	830660	3.059137	320.3521
1000	1013000	3.626705	379.7877
2000	101300	1.262418	264.4003
2000	283640	1.829986	383.2714
2000	465980	2.397554	502.1425
2000	648320	2.965121	621.0136
2000	830660	3.532689	739.8847
2000	1013000	4.100257	858.7558
3000	101300	1.73597	545.371
3000	283640	2.303538	723.6777
3000	465980	2.871105	901.9843
3000	648320	3.438673	1080.291
3000	830660	4.00624	1258.598
3000	1013000	4.573808	1436.904
4000	101300	2.209521	925.5222
4000	283640	2.777089	1163.264
4000	465980	3.344657	1401.007
4000	648320	3.912224	1638.749
4000	830660	4.479792	1876.491
4000	1013000	5.04736	2114.233
5000	101300	2.683073	1404.854
5000	283640	3.250641	1702.031
5000	465980	3.818208	1999.209
5000	648320	4.385776	2296.387
5000	830660	4.953344	2593.565
5000	1013000	5.520911	2890.742
6000	101300	3.156624	1983.366
6000	283640	3.724192	2339.979
6000	465980	4.29176	2696.592

If Excel is not installed on the same PC as the GDS installation it is still possible to obtain the detailed numerical data. This is available by clicking ‘Output Data’ on the menu items, then ‘Performance Data Files’. The user will be prompted to save four files (Flow vs Pressure; Torque & Power; Lobe Contact & Stress; Efficiency Data and Volumetric Data). The last set of data relates to the chamber volume rate of change and also the pressure ripple data.

Having stepped through the full design and analysis process it is now possible to determine if any design changes need to be made. These could be for many reasons but the most common are listed below along with the corresponding parameters which may need adjustment.

Reason for Change	Influencing Parameters
Capacity not as expected (especially at high pressure)	Thickness Eccentricity Radius Inner Root Tip clearance Axial clearance
Drive power too high	Maximum Outer Rotor Diameter Porting choice (shadow or double sided) Clearances Viscosity Thickness
Contact stress too high	Radius Outer Lobes Eccentricity Radius Inner Root Thickness Clearances Pressure Speed
Cavitation speed reported too low	Fluid viscosity Fluid density Speed NOTE: This may be an overly cautious warning – see separate document regarding cavitation
Volumetric Efficiency too low	Clearances
Mechanical Efficiency too low	Porting choice (shadow or double sided) Maximum Outer Rotor Diameter Thickness Pressure range Speed
Pressure Ripple	Number of lobes Porting design Metering groove selection and design Fluid properties

To reach a satisfactory solution it is necessary to perform iterations within the program until all the required design criteria are met.

The design file can be saved at any time (click File on the menu items followed by Save or Save As) during the process.

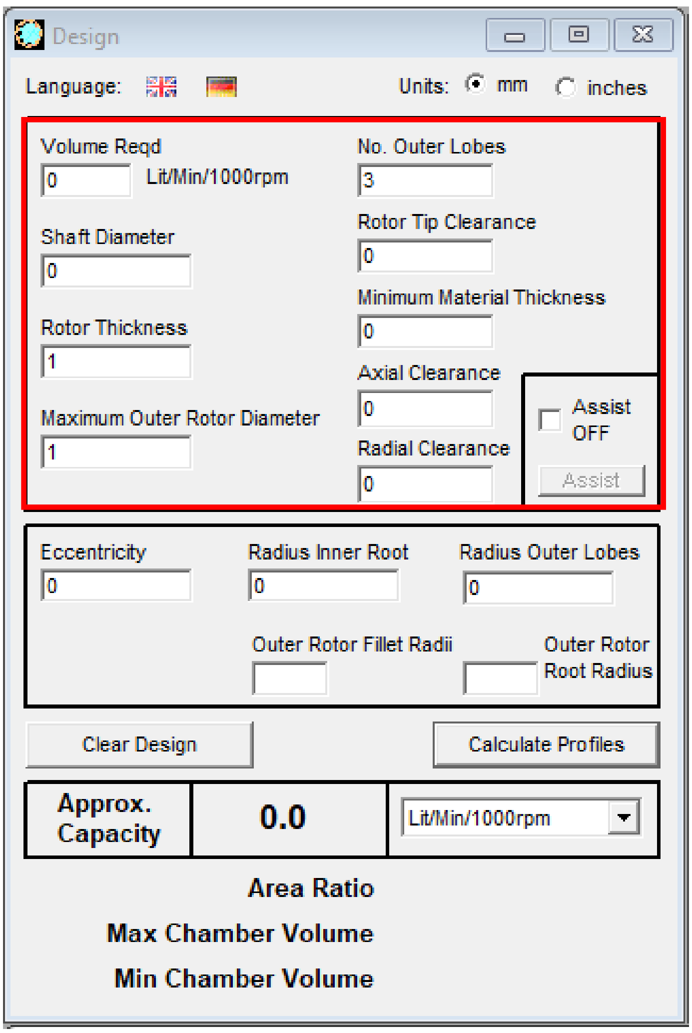
Using Gerotor Design Studio Software

Using the Design Assistant Feature

This section will show how the Design Assistant feature in the Design form can be used to help determine a baseline gerotor profile, from which further analysis and design iterations can be made.

If a gerotor system has to be designed 'from scratch' it is likely that the most complicated decision to make is that for the eccentricity. The package space for Rotor Thickness and Outer Rotor Diameter are generally known or can be estimated well due to other constraints on the pump. Likewise the shaft diameter is likely understood based on other aspects of the pump assembly or its drive mechanism.

Using the Design Assistant we can find the minimum required eccentricity to create a given gerotor capacity, from which a fully defined gerotor profile can be developed.



The Design Assistant input values are shown in the red bounded box.

The units of capacity should be set using the Approx Capacity dropdown menu at the bottom of the form.

The capacity value should be entered in the Volume Required parameter. This determines the pumping capacity of the desired gerotor set.

The other parameters which require input are:

- Shaft Diameter – this should be known from the drive mechanism design – or use a MAXIMUM value if not known exactly

- Rotor Thickness – a good approximation of this should already be known from the package constraints of the pump assembly (remember that the port depth should also be equal to the rotor thickness, so ensure enough space is left for the ports)

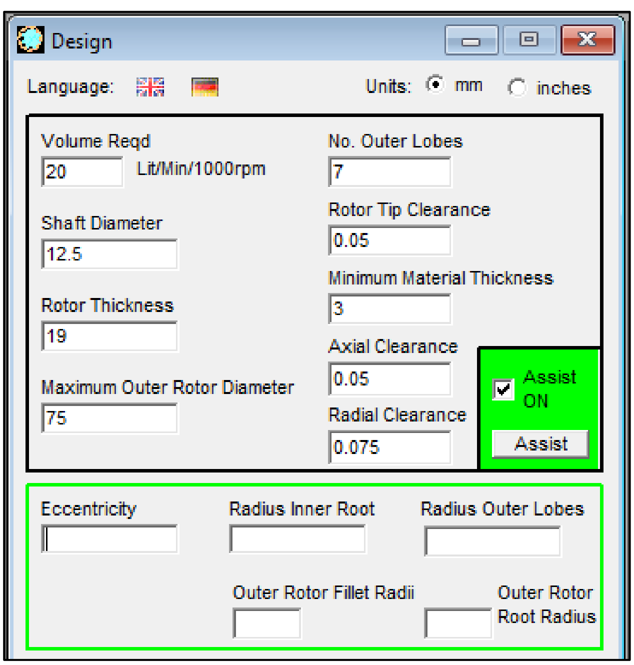
- Maximum Outer Rotor Diameter – a good approximation should be known from the packaging constraints.

- Number of Outer Lobes – this is dependant upon the use of the pump, but generally it should be noted that higher lobe counts require larger diameter rotor sets (for the same capacity) but also result in lower pressure ripple

- Tip , Axial & Radial (outer rotor to housing bore) clearances – these should be set at nominal values to get a baseline design (0.05-0.100mm)

- Minimum Material Thickness – this is dependant upon application and material choice, but for standard rotors of under 100mm diameter and pressure ranges under 10bar manufactured in steel, a value of 3mm is a good starting point

Once these parameter are entered the Design Assistant can be employed.



Click the check box next to Assist OFF. The box turns green and now says Assist ON.

The results area for the Design Assistant is also bounded in green.

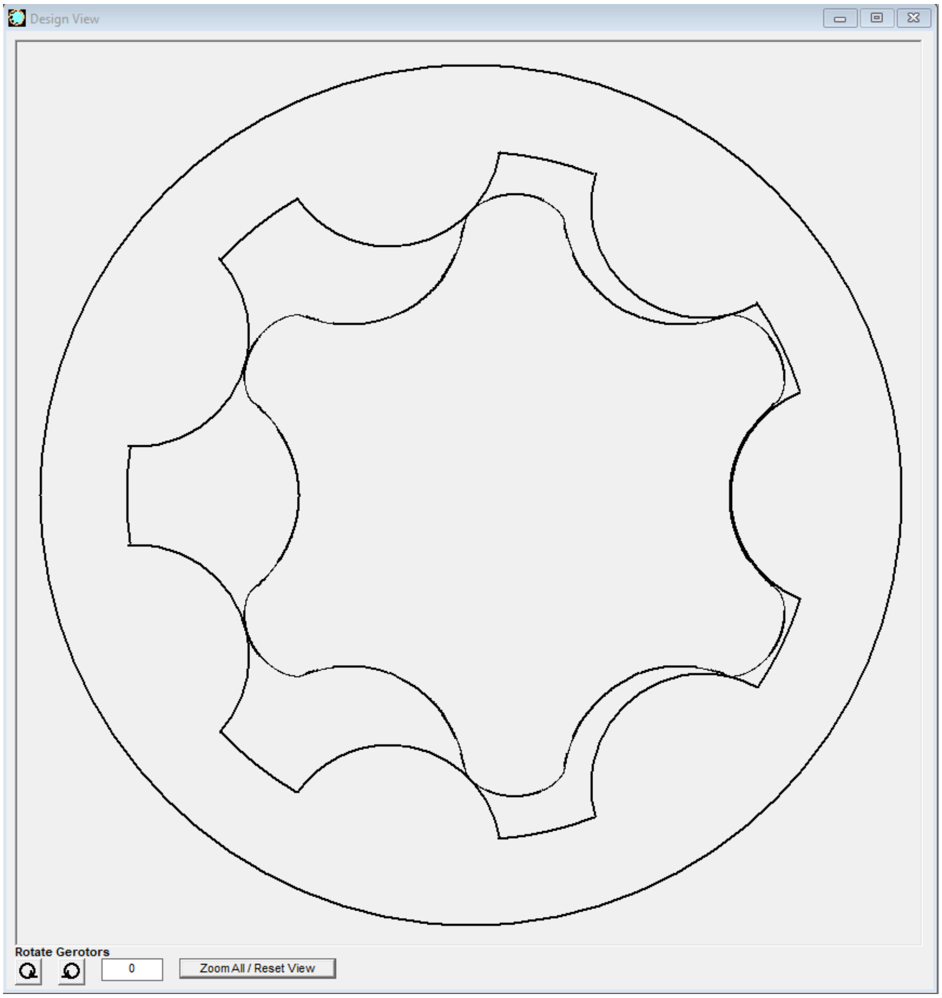
Click the 'Assist' button.

You will see a set of results in the green bounded area and may see an error message if the generated profile cannot fit the specified Outer Rotor Diameter.

If an error occurs (max diameter error) it is possible to change the parameters to get a suitable profile.
A good tip to get a starting profile is to expand the rotor diameter or thickness to ensure the required capacity can be met. Some iterations of diameter vs thickness can then be trialled to get a resulting profile which can be packaged.

Once a set of results are present with no accompanying error message, untick the 'Assist ON' checkbox and the Design Assistant will be turned off. It is now possible to click the 'Calculate Profiles' button to view your gerotor profile form.

The generated profile is approximately the minimum Eccentricity and Radius Inner Root values to generate the required capacity. Due to the interactions of the parameters on the geometry and subsequently the capacity, the reported capacity may be slightly greater than required. It is possible to modify the results to trim this capacity if required.



From this point the method to determine a suitable final gerotor profile is the same as in the section 'Clean Sheet Design & Reverse Engineering'.

Using Gerotor Design Studio Software

GT-SUITE Simulation Modelling with Gerotor Design Studio

The collaboration with Gamma Technologies and their GT-SUITE software allows users of Gerotor Design Studio to create highly sophisticated simulation models of gerotor pumps for in depth analysis of standalone gerotor / porting combinations or for inclusion in wider models such as:

- Pump housings including other flow volumes
- Integration with relief valve systems
- Simulation of suction systems and priming functions
- Integration with complete engine / powertrain or even full vehicle systems if required

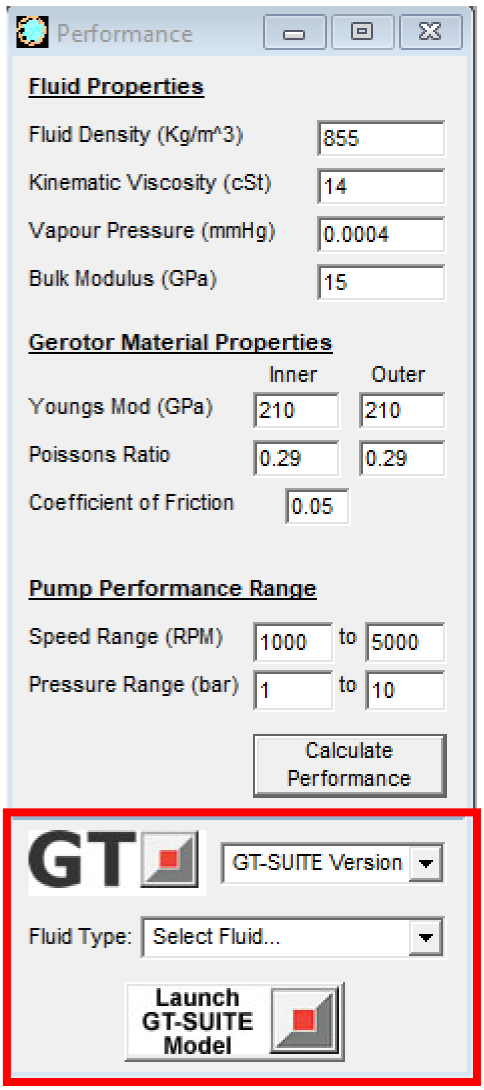
The results available from sophisticated 1D models allow detailed analysis of:

- Gerotor chamber pressure vs time or rotation angle for noise analysis
- Examination of flow leakages / losses through individual leak paths
- Temperature rise of the pumped fluid (especially in high pressure applications)
- Examination of drive torque and shaft loads in the angular domain
- Interaction with mechanical features of housings, shafts and bearings to determine displacement due to pressure forces and their subsequent effect on gerotor performance
- Detailed examination of the liquid / gas phases in the fluid during chamber expansion

In order for Gerotor Design Studio to be able to output models to GT-SUITE, a license for GT-SUITE must be available on the same PC as the GDS installation.
For more information regarding GT-SUITE, contact Gamma Technologies directly:
www.gtisoft.com

To create a model in GT-SUITE, a full gerotor / porting / performance design must first be completed using Gerotor Design Studio (see sections 'Clean Sheet Design & Reverse Engineering' and 'Using the Design Assistant Feature').

Once the 'Calculate Performance' button has been clicked at the end of that process, the GT-SUITE panel becomes enabled.



Select the version of GT-SUITE you wish to run.

- Supported versions are v2020 onwards

Select the Fluid Type you wish to perform the simulation with (this can be changed once the model is built, but it pre-populates the Case Setup page automatically):

- The fluid type dropdown box contains all the options from the GT incompressible fluids library.

Click the 'Launch GT-SUITE Model' button

Some notifications regarding progress will be shown to the user whilst the following activities occur in the background:

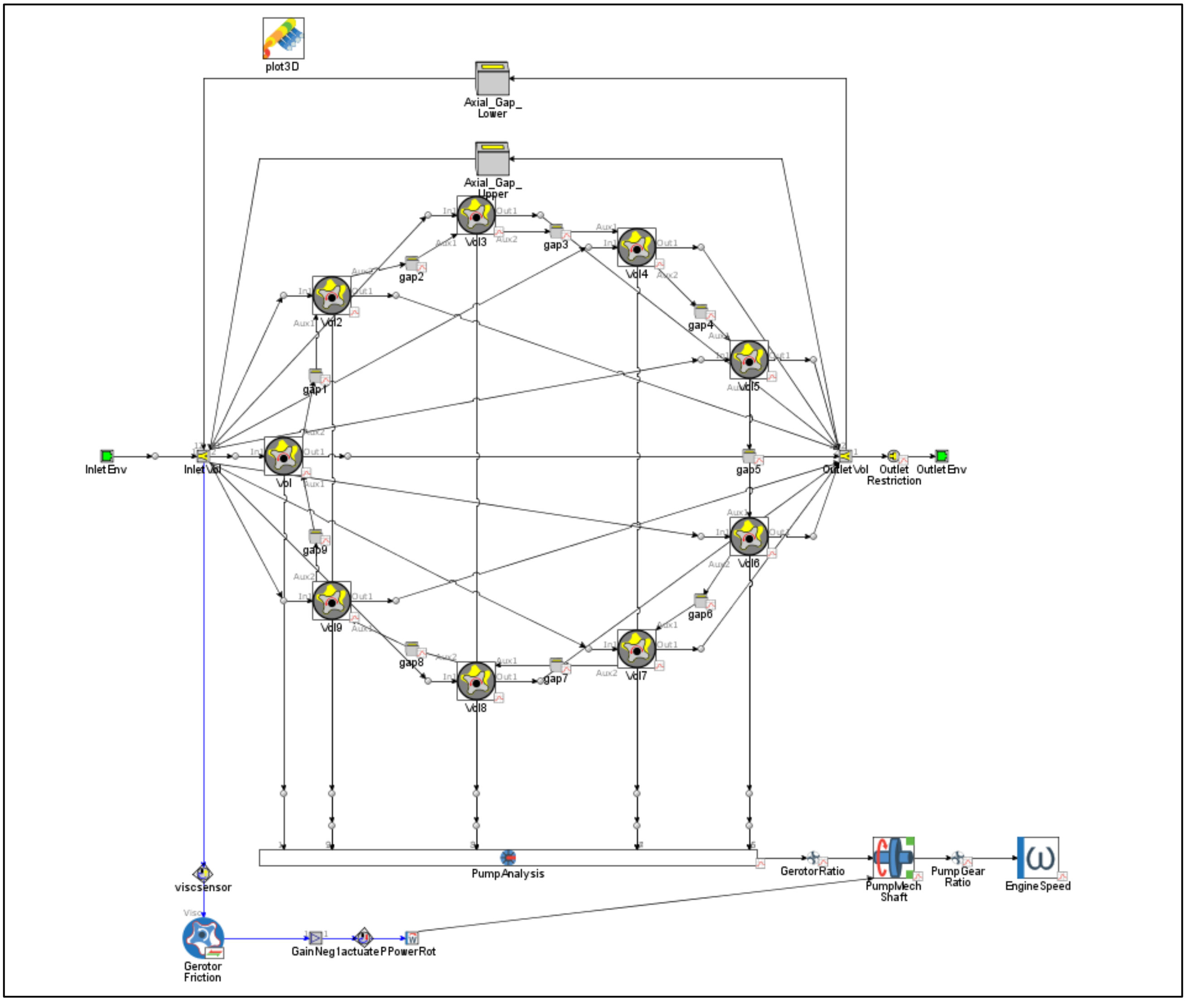
- Step files of Inner rotor, Outer Rotor and all porting are created
- Gem3D processor (part of the GT-SUITE package) is run in the background to create a baseline model of the relevant geometry
- The baseline GT model is modified by GDS to include information not part of the geometry
  - Axial & Tip Clearances
  - Shaft size
  - Etc
- The Case Setup page is created to include 36 cases
  - 6 cases for each speed in the Speed Range
  - x 6 cases for each pressure rise in the Pressure Range
- The Case Setup also includes parameters for
  - The fluid selected from the dropdown list in the GT-SUITE panel (so this can be manually changed if necessary)
  - Temperature of the fluid and mechanical parts (wall temp)
  - Tip clearance
  - Axial clearance
  - Radial clearance
  - Coefficient of friction
  - Rotor diameter
  - Rotor width (thickness)
  - Shaft bearing clearances
  - Shaft bearing length
  - Shadow porting
- Having these features parameterised allows the user to quickly perform simulations on common features not directly related to the profile geometry itself.

Once the model is fully complete, GT-SUITE will open automatically (if not already opened) and the model will appear on the GT-SUITE user interface.

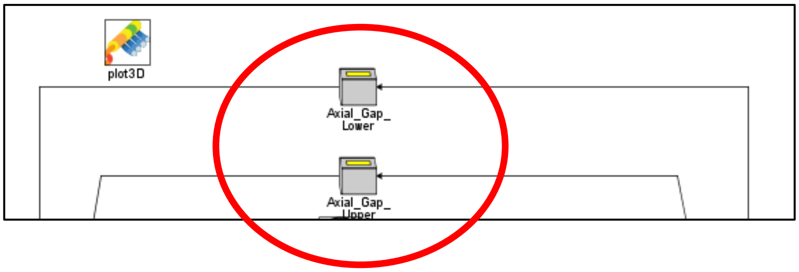
NOTE: the GT model will be deposited in a “GT_files” folder, within your GDS program folder. If the model is run from this location, any results will also appear in this folder. Models created based on the same GDS filename will be numerically appended so not to overwrite earlier versions, e.g.:

Gerotor_Test
Gerotor_Test – 1
Gerotor_Test – 2
etc.

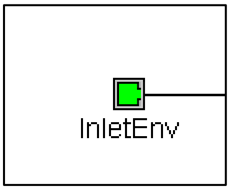
An example of a completed model in the GT-SUITE user interface:

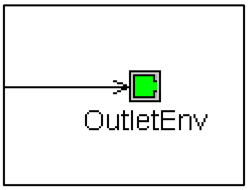


Explanation of objects:
The purpose of this section is to give an overview of the GT-SUITE model objects and their function. It is not necessary to understand the details behind this in order to run a GT model, but is for information only. Double-clicking the objects will show the data they contain.

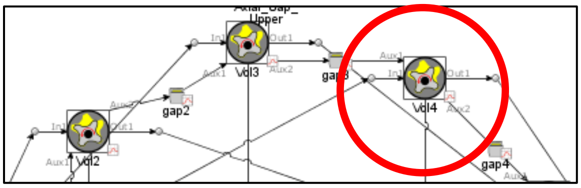


These two leakage objects represent the axial leakage either side of the gerotor set.
They can have different values to each other depending upon the porting arrangement being simulated.

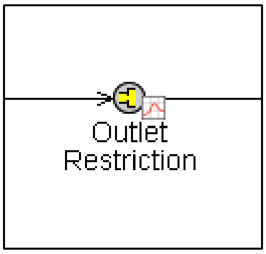




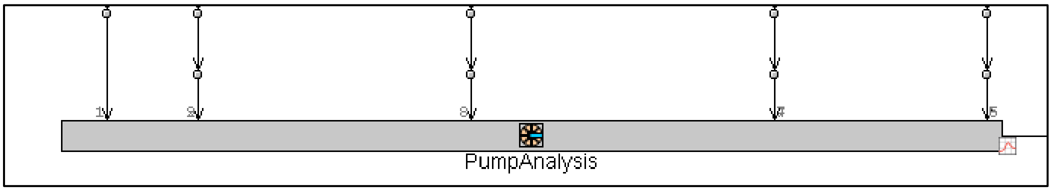
The Inlet and Outlet Environments represent the environments beyond the boundaries of the pump model. In effect the world outside the pump – usually this is equivalent to atmospheric pressure, but can be set to other values (especially the InletEnv) if the suction side is operating in a low pressure region. The OutletEnv is normally set to 1bar (absolute) to allow calculation of the outlet pressure of the pump.



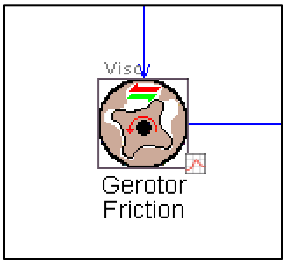
Each gerotor chamber is represented by a Volume object. Each volume is connected to its adjacent volumes by Gap objects which represent the tip clearance between chambers.
Each Volume object is connected to the Inlet and Outlet Volumes (representing the inlet and outlet porting).



The Outlet Restriction is the control parameter for the pressure generated within the pump. Its value (cross sectional area) is automatically calculated within the Case Setup page in an attempt to reach the pressure drop for that case, given the speed and anticipated volume flow of the pump (for that case). This value is therefore different for each speed / pressure condition. It can be manually modified if required (to obtain closer pressure values to desired) or can be used as a variable in an optimisation study to obtain exact pressure conditions.



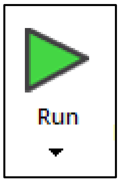
The Pump Analysis object contains information regarding the geometry of the gerotors and porting. This information has been calculated during the conversion from GDS to GT-SUITE and aligns the rotation of the gerotors against the porting interfaces.



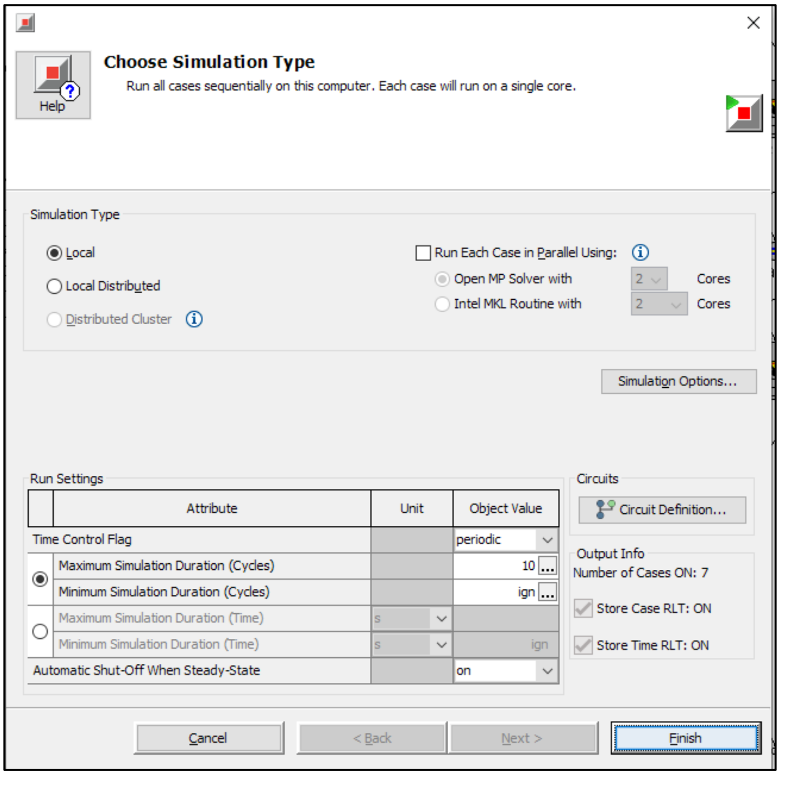
The Gerotor Friction object contains the parameters which affect the dynamic friction of the pump, including axial clearances, face areas, friction torque radii, rotor width and shaft information.
Although shaft details are not needed for the GDS software, when a GT model is created some assumptions are made based on the shaft diameter entered. These can be manually modified if required.

Running the model:

Once the GT-SUITE model is created, the simulation can be run without any further interaction from the user by simply clicking the green arrow 'Run' button on the top ribbon bar:

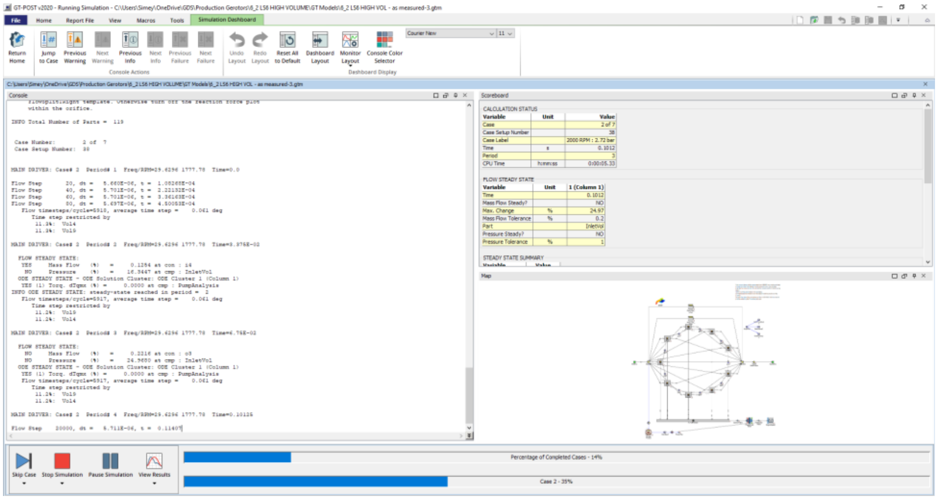


A 'Choose Simulation Type' dialog box will open:



Normally this does not need any further input, just click the 'Finish' button.

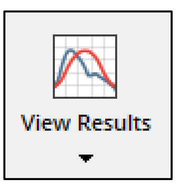
GT-SUITE will perform some checks on the model and license and then proceed to open the Simulation Dashboard, which is part of the GT-POST utility:



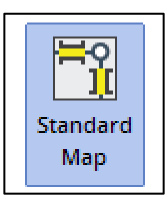
This simulations will run and their status is shown by the blue progress bars at the bottom of the screen.

Viewing the Results

Once all cases have been completed, the 'View Results' button can be clicked (bottom left of the screen):



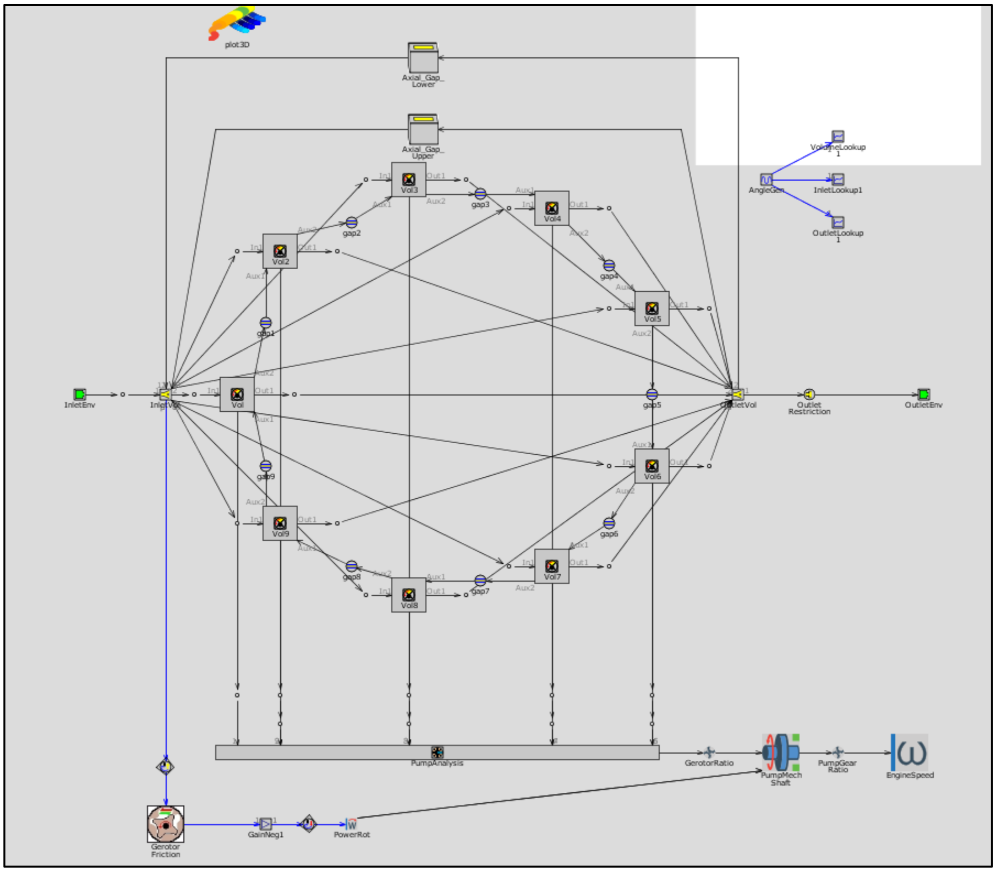
A new tab within GT-POST will open. If not already showing the model map, click on 'Standard Map' in the ribbon bar:

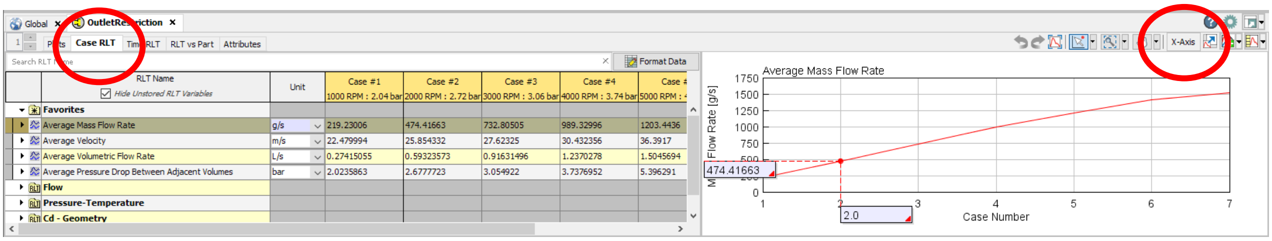


A representation of the GT model will be shown. Scroll up / down to see the complete model.

All the simulation results can be obtained from this view; there is a huge amount of data available within each object, too much to cover in this walkthrough. The key results, commonly required, are shown overpage:

Double-clicking any of the objects will show a series of results for that object at the bottom of the screen, in numerical and graphical form.

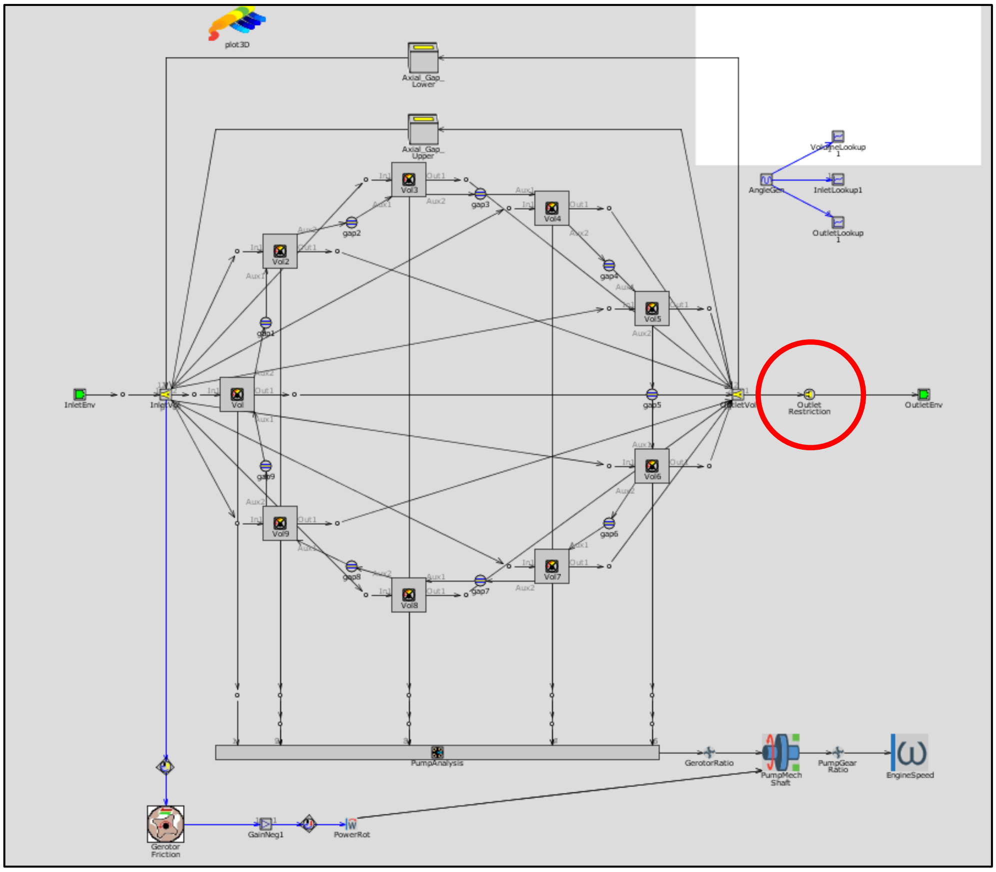




Click the 'Case RLT' tab along the top of the results pane to show the results summarised by case.

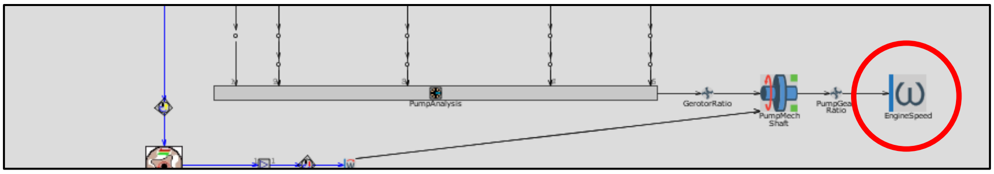
The different result series are shown on the left hand side. The units can be changed in the dropdown boxes next to each series description.

The X axis can also be changed by clicking the 'X-AXIS' box above the graph and selecting a different source (note: selecting 'parameters-main' in the subsequent selection window will show you all the parameters in the case setups. Normally you may want to display the X axis as pressure drop or speed – these are selectable here).



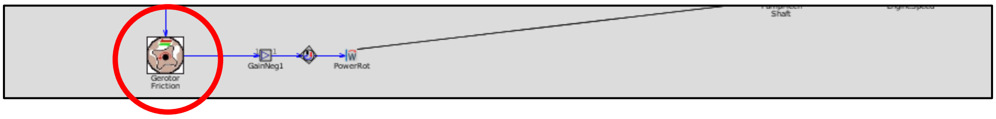
Outlet Restriction

This is the outlet of the pump, measured through an orifice, and the pressure across this restriction and the flow through it can be seen.



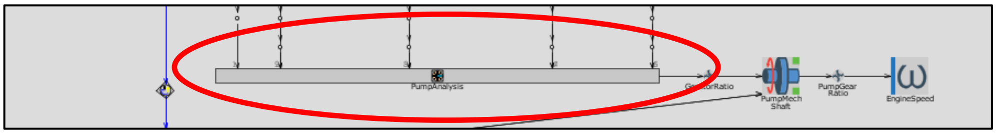
Drive Power

Details for power and torque can be seen in the EngineSpeed object.



Friction

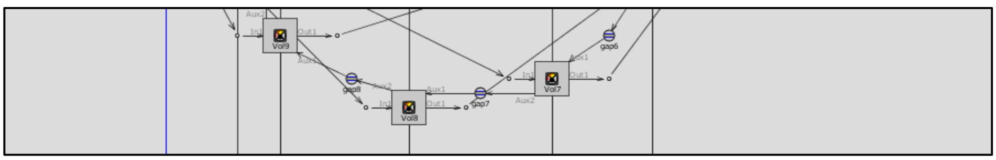
Rotor and bearing friction can be seen in the GerotorFriction object, including a breakdown of inner and outer rotor derived friction.



Geometry and port interactions

Clicking the ‘PumpAnalysis’ object will show the results relating to the geometry of the rotors and their porting.

The ‘Plots’ tab will show how the chamber volume and inlet & outlet port volumes interact with each other against pump angle.



Chamber Volumes

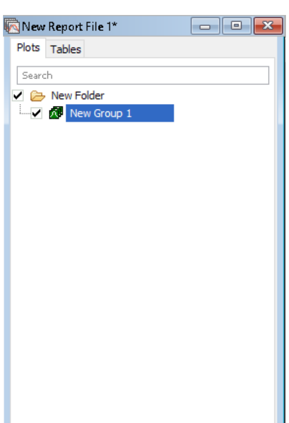
Each of the ‘Vol’ objects represents one chamber in the gerotor. Click on any of these objects and select the ‘Plots’ tab. This will show the volume change, pressure ripple and gaseous fraction results for the chamber selected against pump rotation angle. Plots can be viewed for each of the different cases run.

Creating Graphs

The easy way to make graphs and edit axes, titles etc is as follows.

Please note, this is not intended to be a tutorial on how to use GT-POST, but is some useful info on how to get graphs quickly for use in presentations / reports etc.

The easiest method to create graphs is to create a new ‘Report File’ and then insert the graphs of interest into it. From the ‘Home’ tab in the top left of GT-POST, click ‘New’ then ‘New Report File’.



A small window such as this will appear.

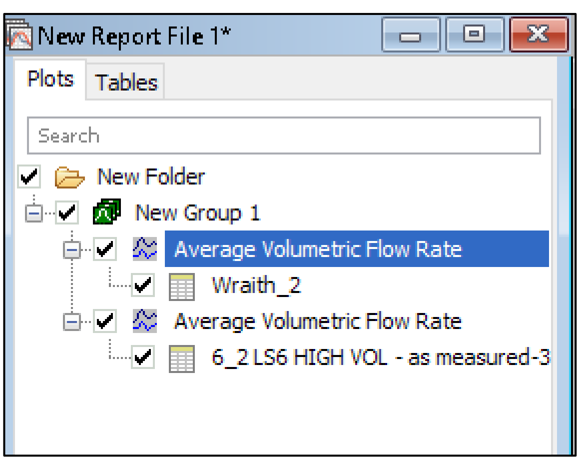
The ‘New group’ will be a collection of graphs. You can rename this to suit the collection as required.

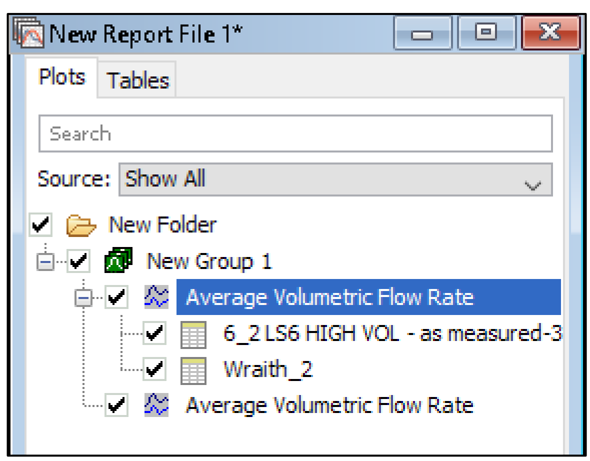
Select the graph you wish to insert into the report file. Above the graph is a series of action buttons (see above). Click the button 'Send to Report File' (shown circled) and the graph data will be sent to the report file just created.
You can send as many graphs as required to the new report file.
The collection of graphs can be seen when you click on the report file name.
Larger versions of each graph can be seen when you click on their individual name.

You can edit the axes titles etc by double-clicking and making changes as necessary.

Do not forget to save your new report file before exiting GT-POST.

You can also add data from multiple simulations into the same report file, this is useful for comparing designs.
When adding data from a second source file, it will initially be added as a separate graph (see below left). To show both sets of data on the same axes, simply drag and drop the data set from one result into the other, as shown below right.
Click on the heading of the combined data set to show both graphs on the same axes.





Manufacture of Prototype and Series Parts

Gerotor Design Studio have in-house facilities enabling us to support our customers for manufacture of prototype and low volume series parts. We can, and do, manufacture pump housings and complete assemblies as well as the gerotor elements.

Our manufacturing capacity is from one set to 2000 / year. We can also assist with the engineering development of sinter tooling, and offer a complete outsourced design consultation service if required.

Contact simon@GerotorDesignStudio.com for a discussion for your requirements!

Gerotor Design Studio

Further information and support can be obtained directly from Gerotor Design Studio.

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