

## Simulation of Flow Field Inside the Gerotor Pump

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### Abstract

**Objective:** The purpose of this study was to use The Pumplinx software to simulate the internal fluid of the Gerotor pump, which can provide accurate flow field distribution for the subsequent optimization of pump internal parameters. **Background:** The Gerotor pump is widely used in the lubrication system of vehicle and ship equipment because of its compact structure, stable operation, small pulsation and high volume efficiency. The Gerotor pump outlet pressure and flow characteristics are affected by a variety of internal factors such as temperature and the type of hydraulic oil, the domestic and foreign scholars in the geometry, kinematics and dynamics characteristics and numerical simulation are carried out a lot of research work, in order to make the follow-up research on internal pump more convenient, this paper use the pumplinx software on the internal flow field analysis. **Method:** Fluid handling quality directly affects the overall performance of the Gerotor pump, the internal flow field distribution of precision analysis is critical. In this paper, we use SCDM2019R1 software to extract the fluid area inside the pump, then in Pumplinx software properly split and combine, generate mesh and interaction surface, and finally through the module selection of related parameters set for simulation flow field inside the Gerotor pump. **Results:** With the operation of the simulation, the internal fluid of the pump is first entered through “inlet in” and then out from “outlet out” under the action of an internal and external rotor. Since the moving part of the Gerotor pump are internal gear and external gear, the outlet pressure of the pump first gradually increases and then gradually becomes stable, and pulsates within a certain range. Pump outlet flow also exists certain pulsation. **Application:** The Pumplinx software is used to simulate the internal fluid of the cycloid pump, which can provide accurate flow field distribution for the subsequent optimization of pump internal parameters.

### Keywords

The Gerotor pump, The internal flow field, Outlet pressure, Outlet flow.

### 1. Introduction

The Gerotor pump is widely used in the lubrication system of vehicle and ship equipment because of its compact structure, stable operation, small pulsation and high volume efficiency [1]. Rotor pump according to its structure can be divided into internal meshing rotor pump and external meshing rotor pump. In this paper, the internal engagement of the rotor pump, when the internal rotor around the external rotor rotation, the pump suction chamber and the volume of the oil chamber with the rotation of the gear and periodic change, so that the outlet flow and the pressure in the rotor are periodic pulsation, this instability makes the liquid impact pump body vibration noise [2]. Scholars at home and abroad have done a lot of research on geometry, kinematics and dynamics and numerical simulation. In the cycloid profile, SAEGUSA Y, et al [3] introduced the formation of rotor profile of cycloid oil pump, KUMAR M S, et al [4] analyzed the influence of rotor speed, fluid viscosity, flow channel number and other important parameters of pollution-free oil on pump flow at room and high temperature. Zheng Wang et al [5]. used AMEsim software to simulate and analyze the pressure pulsation of the cycloid pump and compared it with the experiment. In general, Gerotor pump flow pulsation is influenced by the number of internal and external rotor teeth, the same displacement of the pump more teeth flow pulsation is smaller. However, the number of teeth will lead to the increase in the size of the rotor, the size of the corresponding oil pump increases, weight increases, resulting

in increased energy consumption, which is not allowed in the overall design of the automatic transmission. So the rotor size is limited by the given space of the oil pump in the transmission, and the number of teeth cannot be too much <sup>[6]</sup>. In this paper, the internal fluid of a Gerotor pump is simulated by using the pump internal fluid simulation software to observe its internal flow state and outlet pressure pulsation characteristics.

## 2. The rotor model

### 2.1 Extract the mainstream domain

The parameters of the Gerotor pump simulated in this paper are: The number of inner teeth is 6, The number of outer teeth is 7, The radius of inner rotor addendum is 24mm, The radius of internal rotor tooth root is 17.5mm, The radius of external rotor tooth root is 24.6mm.

Extract the mainstream domain:

Firstly, hide all parts except inner and outer rotors in SCDM2019R1 software, in the sketch drawing, the center of the outer gear is the center, and the radius of the root of the outer gear is the radius of a circle, in the edit window, the volume was added on the basis of the original model with the pull tool, and the model as shown in the figure below was obtained, see Figure 1.

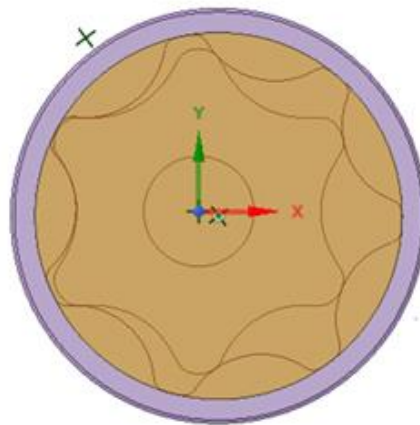


Figure 1. The mainstream domain.

The main drainage basin is the fluid area between the inner and outer rotors of the Gerotor pump. The inner rotor rotates around the outer rotor in the working process of the Gerotor pump, so that the fluid inside the pump flows in from the inlet and then flows out through the outlet channel under the action of the inner and outer rotors. The pressurization and acceleration of the fluid are performed in this region, the pumping fluid domain software is used to extract it in order to simulate it separately in the next step.

### 2.2 Extract the auxiliary fluid domain

In order to build the overall region required by simulation, in addition to the above mainstream region, the inlet and outlet basin of the Gerotor pump and the basin at the oil trough under the gear should also be extracted. Some drainage basins unrelated to the simulation process will be extracted during the extraction of auxiliary drainage basins. The drainage basin model needs to be processed in SCDM software to make it more in line with the actual operation process. Select volume extraction in the preparation bar and select closed circular extraction, select all the holes in the periphery of the entire Gerotor pump with the mouse, and then click the extraction fluid field. The auxiliary fluid domain is generated as shown below.

After the auxiliary fluid domain is extracted, In order to make the simulation more realistic, it is necessary to modify it appropriately in SCDM software so that it will not be too chaotic in grid generation.

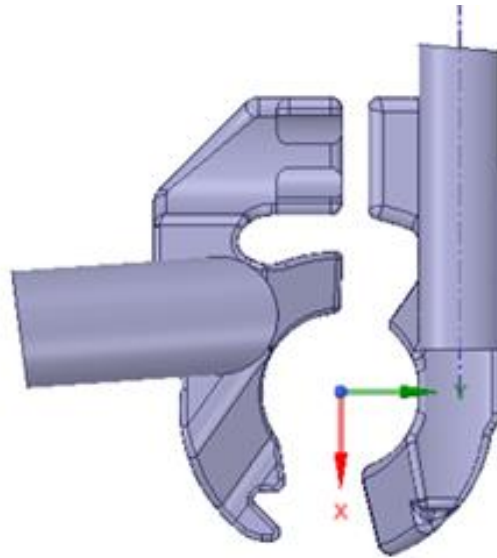


Figure 2. The auxiliary fluid domain

### 3. Preprocessing of simulation operation

After extracting the internal fluid of the Gerotor pump in SCDM software, save it as STL file. The fluid domain needs to be further processed before the simulation analysis of the fluid inside the pump is started in pumplinx software. The mainstream domain and the auxiliary fluid domain were split and combined, divide them into “in rotor”, “out rotor”, “inlet\_in”, “inlet\_wall”, “outlet\_out”, “outlet\_wall”, “groove” and some mgi faces. The steps of the model simulation pre-processing flow are: Open the pumplinx software, create a new file, and click “import/Export Geometry or Grid” to import the STL file of the rotor main basin and the STL file of the Gerotor pump secondary basin respectively, since the unit of the model in SCDM software is mm and that in the fluid simulation software is m, select all the basins and click “transform Geometry or Grid” to multiply the model size by 1000. Before grid division, main and auxiliary basins should be split by Angle first. Main basins are divided into “in rotor” and “out rotor”, as shown in Figure 3 below. Auxiliary basin is divided into the pump oil imports (inlet in), import interaction surface (inlet groove mgi), inlet passage interaction on the surface (inlet mgi top), the feed way of surface (inlet mgi bot) and export (outlet out), oil exports interaction surface (outlet groove mgi), the oil path interaction surface (outlet mgi top), the oil way interaction under the surface (outlet mgi bot), it is concluded that the following diagram is shown in figure 4.

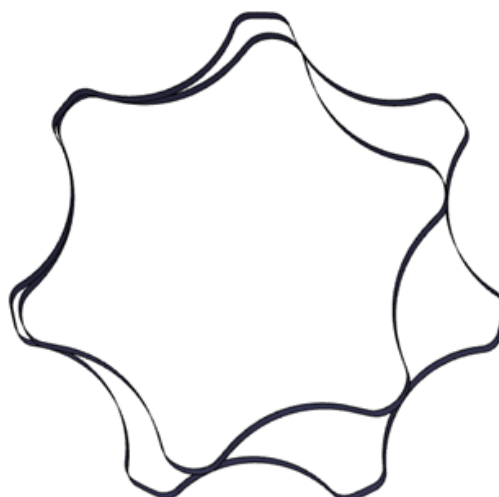


Figure 3. In rotor and out rotor

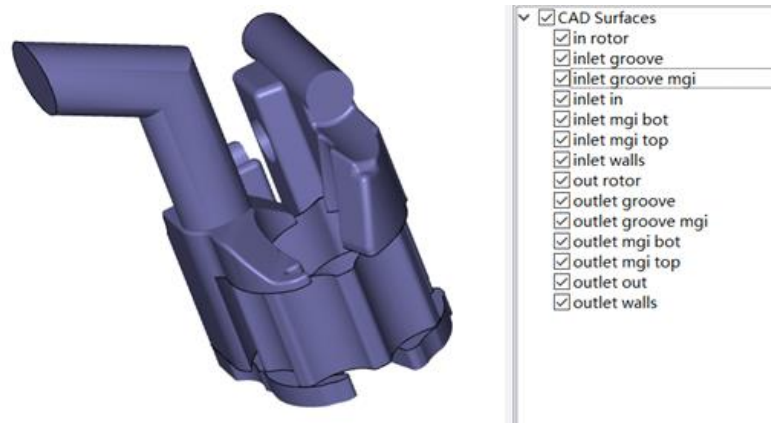


Figure 4. Mainstream and auxiliary domain

## 4. Grid generation and generation of interaction surfaces

### 4.1 Grid generation

Gerotor pump fluid domain is divided into inlet area, rotor area, groove area, export area. The inlet area, groove area and outlet area can be directly generated by General Mesher, and the following grid figure can be obtained.



Figure5: Inlet area and groove grid

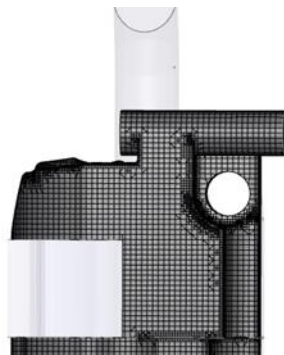


Figure6: Outlet area and groove grid

The Rotor region basin needs to use the Rotor Template Mesher in the panel to generate. In the process of generating, the Rotor surface inside and outside and the Rotor center coordinates of the Rotor inside and outside are selected and measured in SCDM software, and the coordinates are input into Pumplinx to generate the following mesh. The in rotor was selected in Pumplinx to change its

size and shrink around the center by 0.992 times, with the purpose of leaving a gap between the rotor and the rotor to make it more practical.

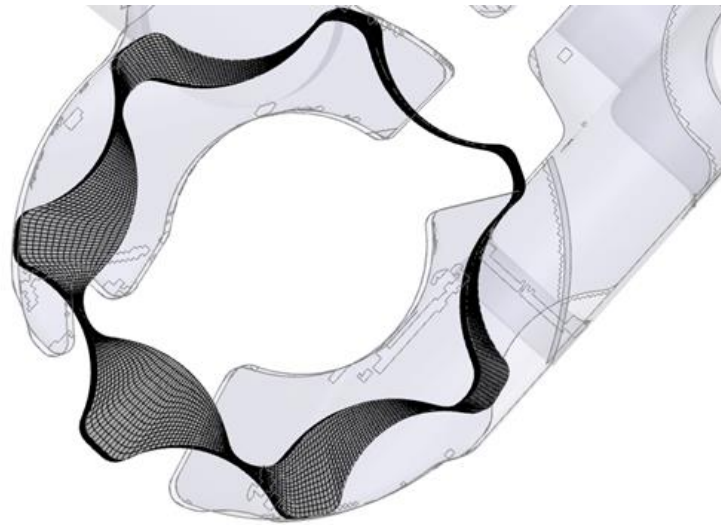


Figure7: Rotor grid

#### 4.2 Interaction surface creation

In the process of pump operation, there are four interactions between the fluid in the rotor area and the upper fluid, namely the interaction between the inlet area and the upper surface of the rotor, the interaction between the inlet oil groove and the lower surface of the rotor area, the interaction between the outlet oil groove and the lower surface of the rotor area, and the interaction between the outlet area and the upper surface of the rotor. During simulation, there cannot be two surfaces in the same area, so interaction surfaces need to be created after all grids have been created. Within boundaries, select the inlet mgi top, outlet mgi top, and the upper surface of the rotor to generate the interaction surface. Select the inlet mgi bot, outlet mgi bot, and the lower surface of the rotor to generate the interaction surface.

#### 5. Parameter setting

Since the gap between the inner and outer rotors in the model is zero, the gap needs to be changed in parameter setting to be more in line with the actual situation; otherwise, the error of the inner rotor crossing the outer rotor area will occur during the simulation operation. In this paper, the internal rotor was set to shrink 0.992 times. Click Select Modules in the Model template, Select cavitation, turbulence and streamline to prepare for the later simulation, and set the pump speed to 4000r/m. Before the simulation is run, the boundary conditions shall be set. Click geometric entity and click boundaries respectively to set both inlet and outlet out. In this paper, the inlet and outlet are set at 101325pa and 501325pa respectively. Finally, select body Volumes and set the properties of hydraulic oil in the property panel. Oil density, viscosity and temperature can all be modified here, and certain modifications can be made here in future studies. Default parameters are adopted in this paper.

#### 6. Simulation operation and post-processing

In order to study the characteristic value and characteristic curve of a certain point inside the Gerotor pump, it is necessary to insert a monitoring point at this point to monitor before the simulation operation. This simulation establishes a Monitoring Point in the exit runner. Click Create a Monitoring Point button. During the simulation operation, you can click the Point and display the pressure curve and flow at this Point.



Figure8: Monitoring point

On the simulation panel, make the final preparation before simulation, set the number of rotation cycles of the Gerotor pump as 5, and the result saving frequency is 20. The result saving frequency represents the saving frequency of the result. Save the result once every 20 times, and the saved result can be used to make the simulation animation. Finally, press the start button to carry out the simulation. In the Results panel variable, select pressure to view the cycloid pump pressure nephogram, as shown in the figure below.

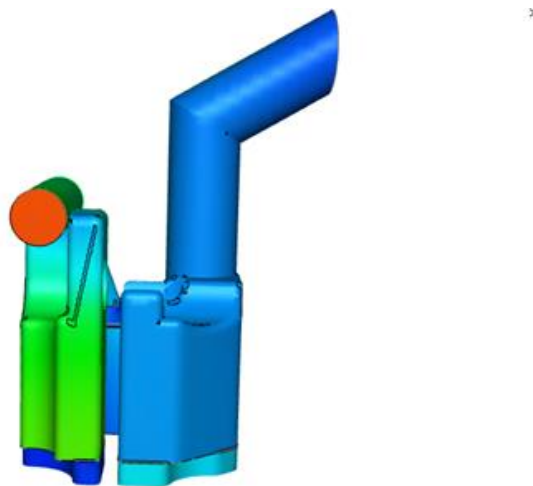


Figure9: Pressure nephogram

The rotation of the inner rotor around the outer rotor in the pump will cause pulsation of flow and pressure at the pump outlet. In order to observe this phenomenon, this paper plots the flow curve and pressure curve at the pump outlet respectively.

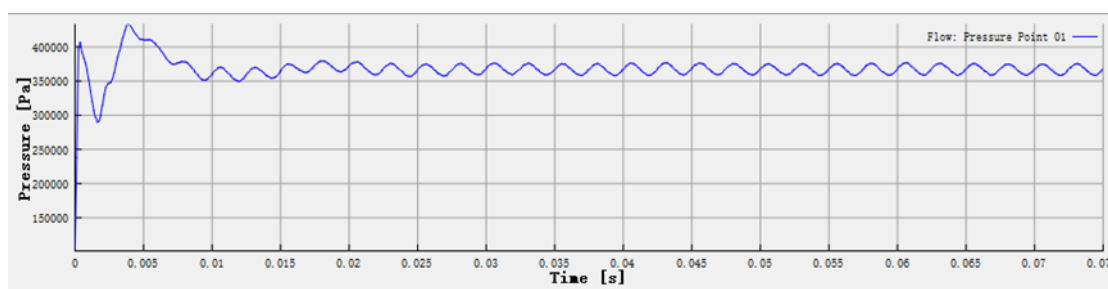


Figure10: Pump outlet pressure diagram

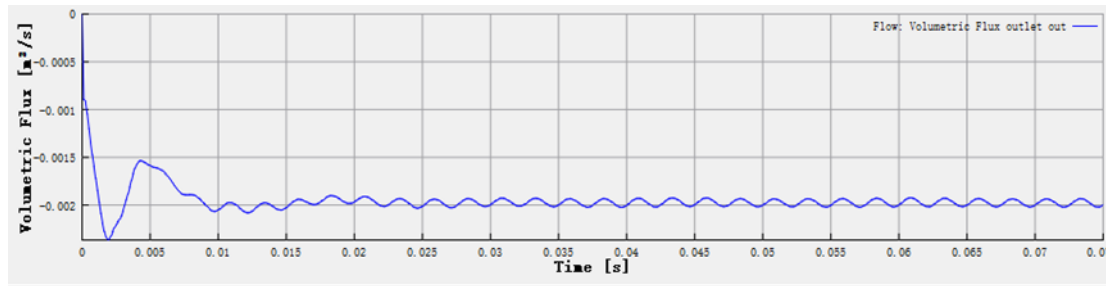


Figure 11: Pump outlet flow diagram

By the above analysis we can see that in 0 ~ 0.005 seconds pump outlet pressure and flow rate were significantly changed, this is because the pump just running internal pressure and flow parameter characteristic is not stable, cycloid rotor pump due to the internal moving parts into two gears, the gear meshing process of pump in the oil suction and discharge of oil, due to the gear mesh will lead to the pump outlet pressure and flow will produce some regular pulse, from the above it can be seen as the pump, pressure and flow rate are produced on a small scale fluctuation, conform to the actual operation situation.

## 7. Conclusions

In this paper, combined with SCDM and PumpInx software, the fluid flow inside the Gerotor pump was simulated, and the flow and pressure curve at the pump outlet and the pressure cloud map inside the pump were obtained, which deepened the learning inside the pump and laid a foundation for the subsequent improvement of the parameters of the components inside the Gerotor pump and the development of subsequent pumps. If it is necessary to study the influence of oil tank unloading tank on pump outlet pressure, it can be operated on the oil tank in SCDM software and studied according to the research process in this paper.

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