Integrate AutoLisp and Solidworks to develop a parametric Geneva mechanism component design system

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***Abstract*—The intermittent transmission mechanism is a mechanism that converts the continuous rotational motion of the active part into the intermittent rotational motion of the passive part. It is widely used in various automated machinery and equipment. The most common intermittent transfer mechanism is the Geneva mechanism. However, the design and calculation of the Geneva mechanism involves geometric parameters such as the number of grooves, rotation angle, center distance, radius, etc., as well as the relationship between speed and acceleration in kinematics. In order to design the Geneva mechanism accurately and efficiently, this article integrates the features of AutoLisp and Solidworks software to develop a parametric Geneva mechanism design system to ensure the accuracy and reliability of the active and passive parts of the generated Geneva mechanism.**

Keywords—Geneva, parametric mechanism

I. INTRODUCTION

Geneva mechanism is an intermittent motion mechanism in mechanical engineering that can convert continuous rotational motion into intermittent rotational motion. Its applications range from movie projectors to industrial automation equipment. This function is very important for systems that require precise control of motion steps. For example, on a production line, products need to be gradually moved to the next processing station, and each step must be accurate. The Geneva mechanism can precisely control this intermittent movement to ensure that the distance and angle of each movement are consistent. In addition, the design of the Geneva mechanism must also ensure that the driven wheel can be accurately positioned at a specific position after each intermittent rotation. This precise positioning capability is particularly important in applications requiring high-precision control. For example, in a movie projector, each frame of the film must be accurate to ensure smooth and continuous viewing by the audience. The Geneva mechanism ensures precise alignment of the film after each intermittent movement.

The Geneva mechanism can also adjust the rotation speed of the driven wheel and the duration of each interval by designing different notch numbers and intervals. This makes it adaptable to different application needs. For example, in some automated equipment, the working speed needs to be adjusted according to different operating rhythms. The flexibility of the Geneva mechanism enables it to meet these requirements. This is also one of the focuses of the development of this design system. And because the design of the Geneva mechanism is relatively simple, there are no complex mechanical components, and the entire mechanism only involves the geometric design of the driving part and the passive part. This simple structural design means that it can still maintain good performance during long-term operation and is suitable for equipment that requires long-term stable operation.

Therefore, this article integrates the features of AutoLisp and Solidworks software to develop a parametric Geneva mechanism design system to ensure the accuracy and reliability of the active and passive parts of the generated Geneva mechanism.

II. DESIGN PRINCIPLES

The design and calculation of the Geneva mechanism involves geometric parameters such as the number of grooves, rotation angle, center distance, radius, etc., as well as the relationship between speed and acceleration in kinematics. These formulas and relationships help ensure the precise operation and reliability of Geneva institutions. These parameters therefore need to be carefully considered during the design process to avoid sticking or wear problems during operation. The following uses an n-slotted Geneva wheel to illustrate the general design principles of this system, as shown in Figure 1.

Assume that the radius of the Geneva wheel is Rp, the number of grooves of the Geneva wheel is n, the diameter of the driving pin on the driving wheel is Dc, and the allowable clearance between the driving wheel and the Geneva wheel is Uc (including the contact between the driving pin and the groove of the Geneva wheel), then;

- Radius of rotation of the driving pin (distance between Oc and Dp) Scc = Rp x tan(180/n).
- Center distance between the driving wheel and the Geneva wheel (distance between Oc and Op) Scp = Rp / cos(180./n).
- Length of the center line of the groove on the Geneva wheel (distance between Dp and Gc) Sgc = Scc + Rp – Scp.

- The width of the groove on the Geneva wheel W = Dc + Uc.
- Stop arc radius on Geneva wheel Rs = Scc– 1.5 * Dc.
- The radius of the matching convex ring on the driving wheel Rcs = Rs – Uc.
- Radius of interference-avoiding groove on the driving wheel Rav = 1.01 * Rp + Uc.
- Driving wheel body radius Rcb = (Scc + Rcs) / 2.

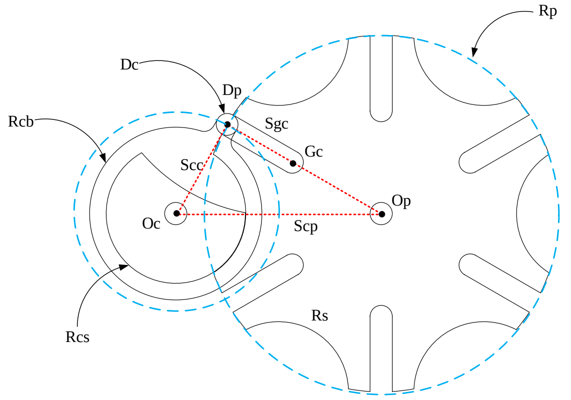


Figure 1 Related diagram of Geneva institutions

III. Steps to structuring organizations in Geneva

Based on the above design principles, the following takes the 6-slot Geneva mechanism as an example to gradually explain the entire mechanism construction process. First, assume that the radius of the Geneva wheel Rp = 80 mm, the number of grooves of the Geneva wheel is 6, the diameter of the driving pin on the driving wheel Dc = 9.8 mm, and the allowable clearance between the driving wheel and the Geneva wheel Uc = 0.2 mm.

Step 1: Calculate the rotation radius Scc of the driving pin, the center distance between the driving wheel and the Geneva wheel (the distance between Oc and Op) Scp.

Scc = Rp x tan(180^{o}/n) = 80 x tan(180^{o}/6) = 46.188

Scp = Rp / cos(180^{o}/n) = 80 / cos(180^{o}/6) = 92.376

Step 2: Draw the position of the driving pin and the centerline direction L1 of the Geneva wheel groove, as shown in Figure 2.

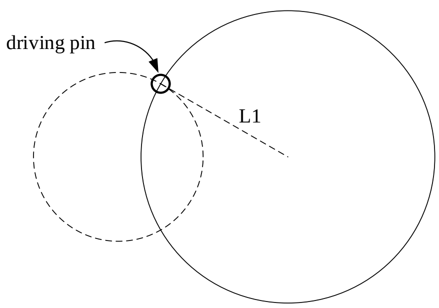


Figure 2 Location of driving pin

Step 3: Calculate the centerline length Sgc of the groove on the Geneva wheel and the groove width W on the Geneva wheel, and use the offset and trimming commands to complete the shape of a single groove on the Geneva wheel, as shown in Figure 3.

Sgc = Scc + Rp – Scp = 46.188 + 80 – 92.376 = 33.812

W = Dc + Uc = 9.8 + 0.2 = 10

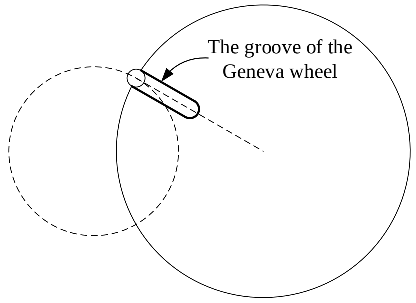


Figure 3 Single Geneva wheel groove

Step 4: Calculate the radius Rs of the stopping arc on the Geneva wheel, and use circle and trim commands to complete the shape of a single stopping arc on the Geneva wheel, as shown in Figure 4.

Rs = Scc – 1.5 x Dc = 46.188 – 1.5 x 9.8 = 31.488

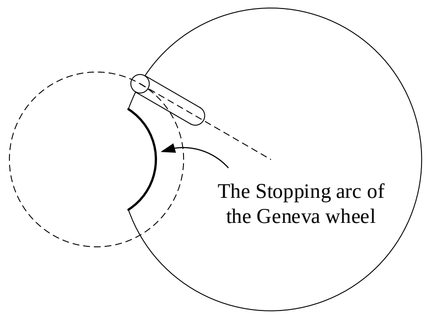


Figure 4 Single Geneva wheel stopping arc

Step 5: Use the array and trim commands to complete all grooves and stop arcs, and finally draw an assembly hole in the center of the Geneva wheel. This completes the important dimensions and shape of the Geneva wheel transmission, as shown in Figure 5.

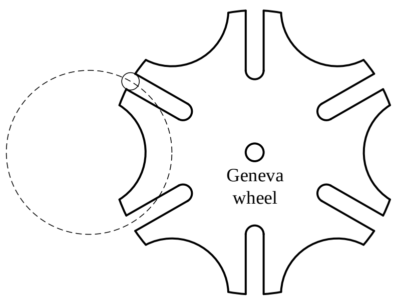


Figure 5 Geneva Wheel

Step 6: Calculate the radius Rcs of the matching convex ring on the driving wheel, and use the circle command to complete the drawing, as shown in Figure 6.

Rcs = Rs – Uc = 31.488 – 0.2 = 31.288

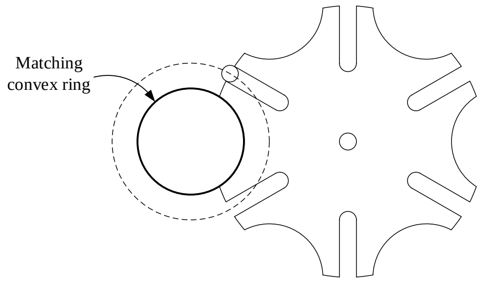


Figure 6 Matching convex ring on the driving wheel

Step 7: Calculate the radius Rav of the interference-avoiding groove on the driving wheel, and use the circle and trim commands to draw it, as shown in Figure 6.

Rav = 1.01 * Rp + Uc = 80 * 1.01 + 0.2 = 81

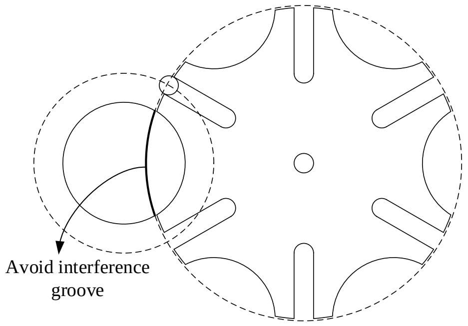


Figure 7 Interference-avoiding groove on the driving wheel

Step 8: Rotate the driving wheel counterclockwise $90^{o} - (180^{o} / n) = 90^{o} - (180^{o} / 6) = 60^{o}$, as shown in Figure 8.

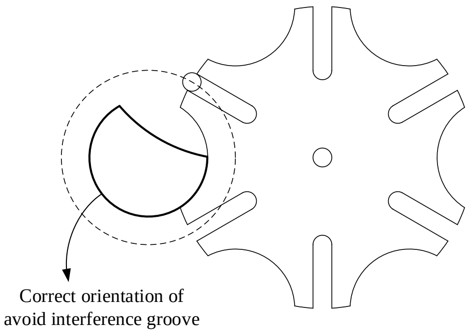


Figure 8 the correct position of the interference-avoiding groove on the driving wheel

Step 9: Calculate and draw the driving wheel body radius Rcb, as shown in Figure 9.

Rcb = (Scc + Rcs) / 2 = (46.188 + 31.288) / 2 = 38.738

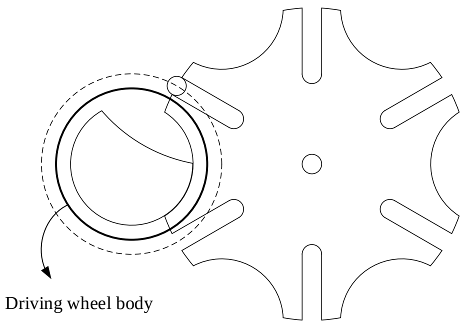


Figure 9 Driving wheel body

Step 10: Use the straight line, trim and fillet commands to complete the overall shape of the driving wheel body. Finally, draw an assembly hole in the center of the driving wheel body. This completes the important dimensions and shape of the driving wheel transmission, as shown in Figure 10.

Step 11: Then import this file into Solidwork software as a reference graphic for sketching, and then you can quickly complete the construction of various elements of the entire Geneva mechanism.

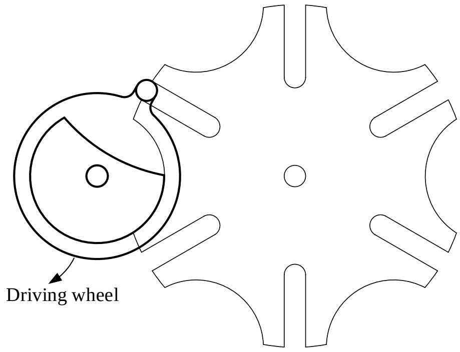


Figure 10 Overall appearance of the driving wheel

IV. SYSTEM VERIFICATION

As mentioned before, if the files generated by AutoLisp are import into Solidwork software as reference graphics for sketching, the construction of various components of the entire Geneva mechanism can be quickly completed. The following uses the radius of the fixed Geneva wheel Rp = 80 mm, the diameter of the driving pin on the driving wheel Dc = 9.8 mm, and the allowable gap Uc = 0.2 mm between the driving wheel and the Geneva wheel as an example to construct different numbers of grooves. Geneva institution to verify the feasibility of this system.

A. 6-slot Geneva mechanism

Calculated by the system;

Scc = Rp x tan(180^{o}/n) = 80 x tan(180^{o}/6) = 46.188

Scp = Rp / cos(180^{o}/n) = 80 / cos(180^{o}/6) = 92.376

Sgc = Scc + Rp – Scp = 46.188 + 80 – 92.376 = 33.812

W = Dc + Uc = 9.8 + 0.2 = 10

Rs = Scc – 1.5 x Dc = 46.188 – 1.5 x 9.8 = 31.488

Rcs = Rs – Uc = 31.488 – 0.2 = 31.288

Rav = 1.01 * Rp + Uc = 80 * 1.01 + 0.2 = 81

Rcb = (Scc + Rcs) / 2 = (46.188 + 31.288) / 2 = 38.738

The plan view of the relevant transmission dimensions of the 6-slot Geneva mechanism is shown in Figure 11.

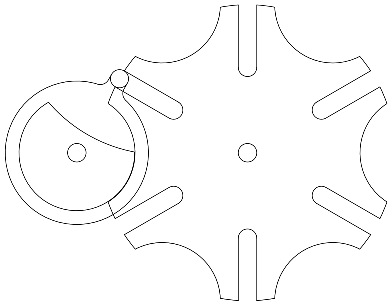
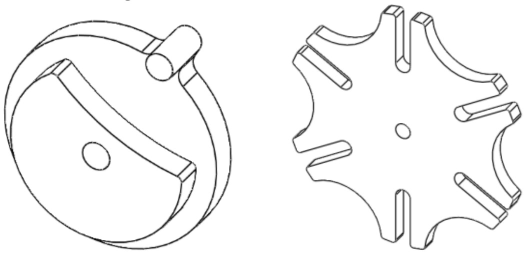


Figure 11 Plan view of relevant transmission dimensions of 6-slot Geneva mechanism

Import this file into Solidwork software as a reference graphic for sketching. The components and assembly status of the completed Geneva mechanism are shown in Figures 12 and 13.



(a) Driving wheel (b) Geneva wheel

Figure 12 6-slot Geneva mechanism elements

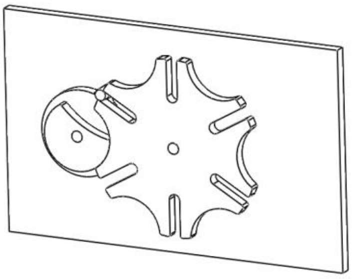


Figure 13 Assembly status of Geneva mechanism with 6 slots

If the driving wheel rotates at 12 RPM, the angular velocity change relationship of the Geneva wheel is shown in Figure 14.

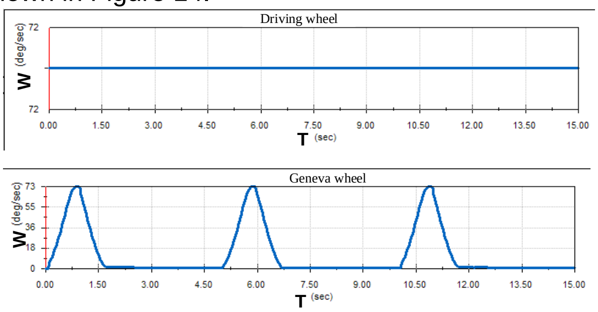


Figure 14 Angular velocity change diagram of the 6-slot Geneva mechanism

B. 5-slot Geneva mechanism

Calculated by the system;

$Scc = Rp \times \tan(180^o/n) = 80 \times \tan(180^o/5) = 58.123$

$Scp = Rp / \cos(180^o/n) = 80 / \cos(180^o/5) = 98.885$

$Sgc = Scc + Rp - Scp = 58.123 + 80 - 98.885 = 39.238$

$W = Dc + Uc = 9.8 + 0.2 = 10$

$Rs = Scc - 1.5 \times Dc = 58.123 - 1.5 \times 9.8 = 43.423$

$Rcs = Rs - Uc = 43.423 - 0.2 = 43.223$

$Rav = 1.01 * Rp + Uc = 80 * 1.01 + 0.2 = 81$

$Rcb = (Scc + Rcs) / 2 = (58.123 + 43.223) / 2 = 50.673$

The plan view of the relevant transmission dimensions of the 5-slot Geneva mechanism is shown in Figure 15.

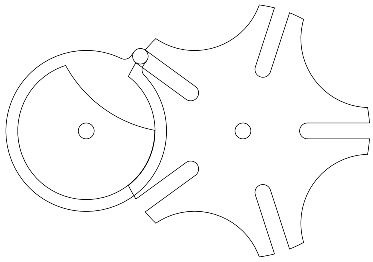
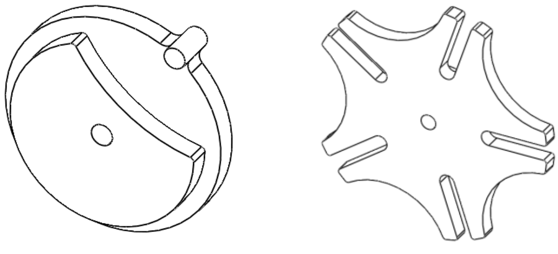


Figure 15 Plan view of relevant transmission dimensions of 5-slot Geneva mechanism

Import this file into Solidwork software as a reference graphic for sketching. The components and assembly status of the completed Geneva mechanism are shown in Figures 16 and 17.



(a) Driving wheel (b) Geneva wheel

Figure 16 5-slot Geneva mechanism elements

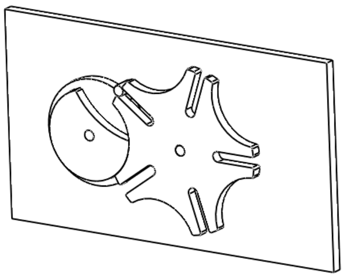


Figure 17 Assembly status of Geneva mechanism with 5 slots

If the driving wheel rotates at 12 RPM, the angular velocity change relationship of the Geneva wheel is shown in Figure 18.

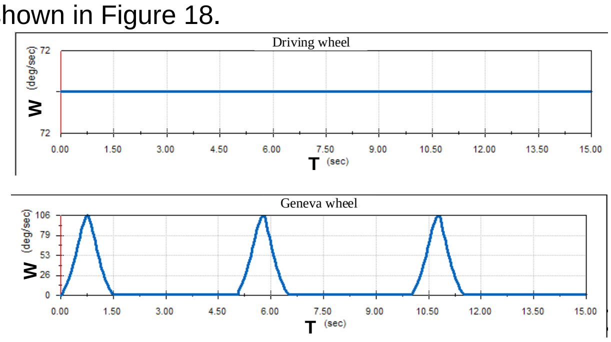


Figure 18 Angular velocity change diagram of the 5-slot Geneva mechanism

C. 4-slot Geneva mechanism

Calculated by the system;

$Scc = Rp \times \tan(180^o/n) = 80 \times \tan(180^o/4) = 80$

Scp = Rp / cos(180^o/n) = 80 / cos(180^o/4) = 113.137
Sgc = Scc + Rp – Scp = 80 + 80 – 113.137 = 46.863
W = Dc + Uc = 9.8 + 0.2 = 10
Rs = Scc – 1.5 x Dc = 80 – 1.5 x 9.8 = 65.3
Rcs = Rs – Uc = 65.3 – 0.2 = 65.1
Rav = 1.01 * Rp + Uc = 80 * 1.01 + 0.2 = 81
Rcb = (Scc + Rcs) / 2 = (80 + 65.1) / 2 = 72.55

The plan view of the relevant transmission dimensions of the 4-slot Geneva mechanism is shown in Figure 19.

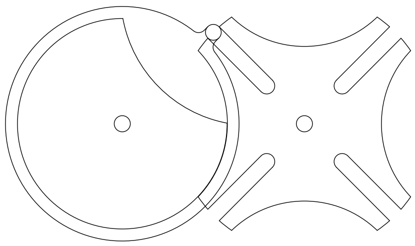
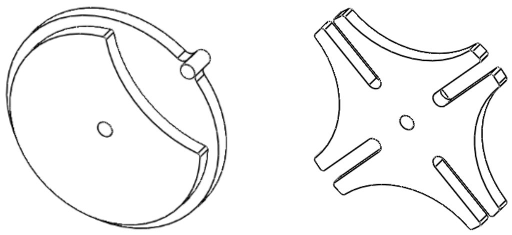


Figure 19 Plan view of relevant transmission dimensions of 4-slot Geneva mechanism

Import this file into Solidwork software as a reference graphic for sketching. The components and assembly status of the completed Geneva mechanism are shown in Figures 20 and 21.



(a) Driving wheel (b) Geneva wheel

Figure 20 4-slot Geneva mechanism elements

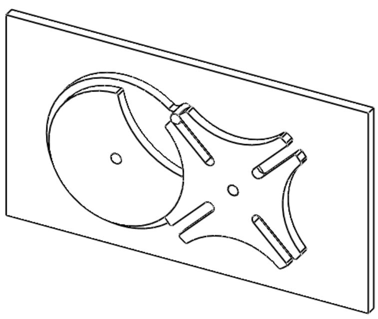


Figure 21 Assembly status of Geneva mechanism with 4 slots

If the driving wheel rotates at 12 RPM, the angular velocity change relationship of the Geneva wheel is shown in Figure 22.

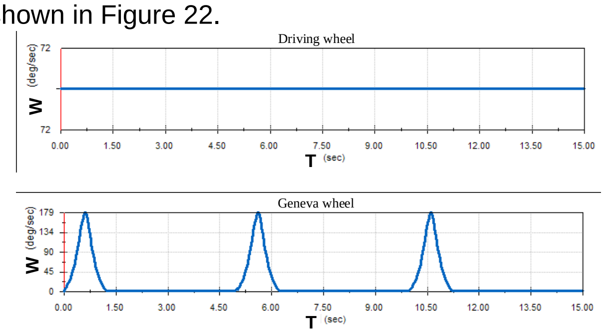


Figure 22 Angular velocity change diagram of the 4-slot Geneva mechanism

V. Conclusion

The main function of the Geneva mechanism lies in its intermittent motion conversion, precise positioning, speed and time control, improved production efficiency, simple and reliable structure, etc., making it an ideal choice for various mechanical systems that require precise control of intermittent motion. Whether in industrial automation, movie projectors, mechanical watches, or other precision equipment, Geneva institutions play an irreplaceable role. This article successfully integrates the features of AutoLisp and Solidworks software and develops a parametric Geneva mechanism design system to ensure the accuracy and reliability of the active and passive parts of the generated Geneva mechanism.

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