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Research on 3D Modeling Method of Herringbone Gearbox Based on Solid works Software

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Abstract: *Toinvestigate the structural characteristics and transmission performance of herringbone gearboxes, this paper proposes a systematic 3D modeling and assembly method based on the Solidworks platform. By setting the basic geometric parameters of the gears, key dimensions such as addendum circle diameter and dedendum circle diameter are calculated. Three-dimensional models of the driving gear, driven gear, transmission shaft, and gearbox housing are established respectively, and precise meshing assembly is completed. This method features clear parameters and a streamlined process, providing a reliable model foundation for subsequent dynamic simulation and structural optimization of the gearbox.*
Keywords: *Herringbone gearbox; Solidworks; 3D modeling; Gear meshing*

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I. Introduction

Herringbone gearboxes are widely used in fields such as rail transportation, mining machinery, wind power generation, ship propulsion, and large-scale metallurgical equipment due to their advantages of high load capacity, smooth transmission, and axial force self-balancing [1]. The operational reliability of key equipment such as high-speed train transmission systems, shearer cutting sections, and wind turbine gearboxes is closely related to the dynamic performance of the gearbox [2]. Research has shown that traditional helical gear transmissions generate significant axial forces during operation, directly leading to severe unbalanced loads on the supporting bearings on both sides [3]. Moreover, this imbalance intensifies with increasing operating speed, seriously affecting the service life of the equipment. In contrast, herringbone gears consist of two helical gears with opposite hands of helix. During meshing, the axial forces generated by the teeth on both sides cancel each other out, fundamentally solving the axial load problem. This provides significant advantages in improving system load capacity, reducing gearbox vibration and noise, and achieving lightweight transmission devices [4].

With the rapid development of digital design and simulation technologies, gearbox modeling and dynamic analysis based on 3D CAD software have become core means of modern mechanical product development [5]. As a mainstream parametric design platform, SolidWorks provides powerful 3D modeling capabilities and motion simulation interfaces, effectively supporting the entire development process of gear systems from conceptual design to virtual verification [6]. Meanwhile, the combined application of multi-body dynamics simulation tools such as ADAMS and finite element analysis software such as ANSYS and ABAQUS has made it possible to analyze tooth surface contact stress, calculate time-varying meshing stiffness, and predict gearbox vibration responses [7.8]. Wang et al. [2] established a finite element model of a gearbox considering fluid-structure interaction using ANSYS, conducting in-depth analysis of the vibration transmission characteristics of herringbone gear systems. Zhang et al. [3] systematically carried out finite element analysis of the dynamic meshing performance of herringbone gears, revealing the influence laws of system damping, rotational speed, and load on meshing impact characteristics.

This paper takes a pair of herringbone gears and their gearbox as the research objects, following the technical route of parameter setting, part modeling, assembly meshing and motion simulation. It systematically elaborates the 3D modeling and simulation analysis method of herringbone gearboxes based on the Solidworks platform. Accurate geometric modeling of gears is achieved through parametric modeling, and kinematic and dynamic simulations are conducted using the Solidworks Motion plug-in to verify assembly correctness and transmission stability, providing a basic model support for subsequent optimization design and fatigue life evaluation of the gearbox.

II. Basic Parameter Setting of Gears

2.1 Basic Geometric Parameters

A pair of driving gear and driven gear is selected, with basic parameters as follows:The geometric design includes module, number of teeth, pressure angle, and helix angle.These parameters determine the gear's pitch diameter, center distance, and face width.The values are chosen based on load requirements and standard design guidelines.Table 1 lists the basic geometric parameters.

Table 1. Basic geometric parameters of gears

Parameter	Driving Gear	Driven Gear
Pressure angle/(°)	20	20
Helix angle/(°)	18	18
Normal module/mm	6	6
Gear center distance/mm	380	380
Dedendum coefficient	0.35	0.35
Addendum coefficient	1	1
Number of teeth	35	85
Modification coefficient	0.225	0.024
Engagement width/mm	66	65
Undercut width/mm	10	10

2.2 Calculated Parameters

The main dimensions are calculated according to gear geometric formulas,Table 2 presents the calculated dimensions.

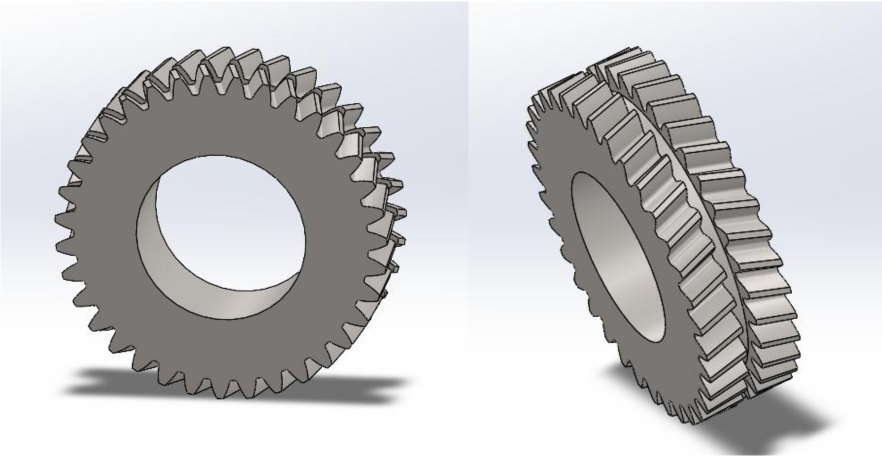
Table 2. Calculated dimensions of gears

Parameter	Driving Gear	Driven Gear
Addendum circle diameter/mm	235.504	548.527
Dedendum circle diameter/mm	207.304	520.327
Gear inner diameter/mm	120	200
Tooth profile	Standard tooth profile	Standard tooth profile

III. 3D Model Modeling

3.1 Gear Modeling

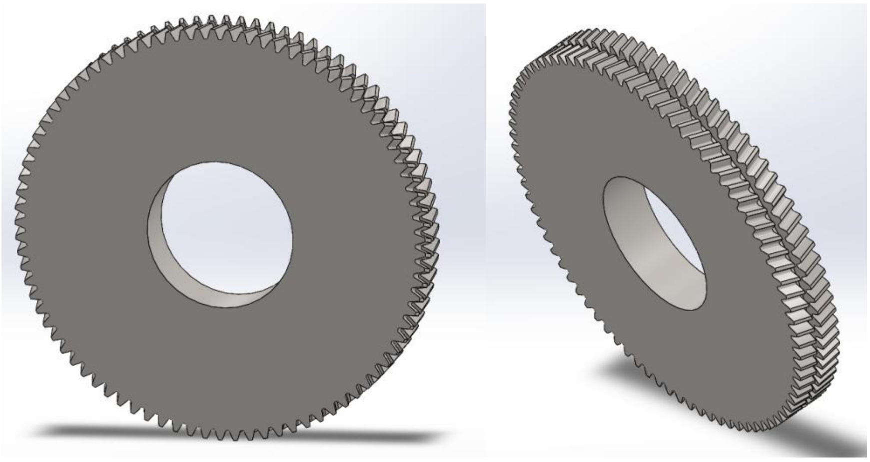
In Solidworks, the involute tooth profile is generated through Toolbox or Gear Plugin, and the gear solid modeling is completed by combining features such as extrusion, cutting, and chamfering.Figure 1(a) shows the front view of the driving gear, displaying the tooth profile, addendum circle, dedendum circle, and inner hole; Figure 1(b) shows the isometric view, displaying the complete gear structure, including the web plate and undercut.



(a) (b)

Figure 1. 3D model of driving gear (front view and isometric view)

The driven gear has a larger outer diameter and more teeth, with a slightly different web plate thickness to accommodate larger torque transmission.The driven gear has a larger outer diameter and more teeth, with a slightly different web thickness to accommodate higher torque transmission (Figure 2). The bore-shaft fit for the driving gear is designed as H7/h6.

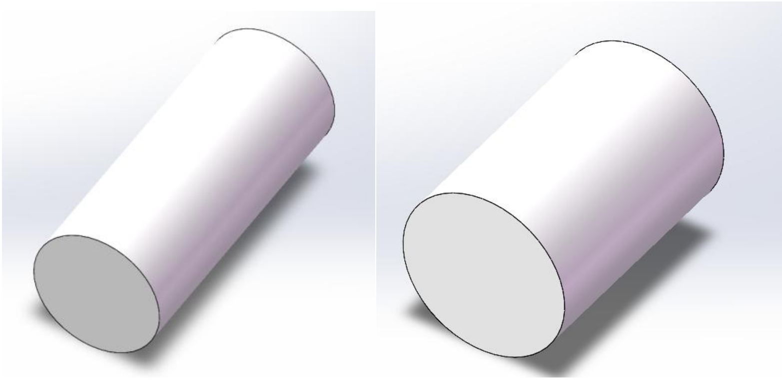


(a) (b)

Figure 2. 3D model of driven gear (front view and isometric view)

3.2 Shaft and Gearbox Modeling

As displayed in Figure 3, the transmission shaft model is established based on the gear inner diameter, using the "Concentric" mate relationship. The gearbox is designed based on the center distance of 380 mm, addendum circle diameter, and gear width, using features such as extrusion, shelling, and stiffeners.



(a) (b)

Figure 3. Transmission shaft models (driving shaft and driven shaft)

The driving shaft has a diameter of 120 mm, and the driven shaft has a diameter of 200 mm. Keyways are provided at the shaft ends for circumferential positioning.

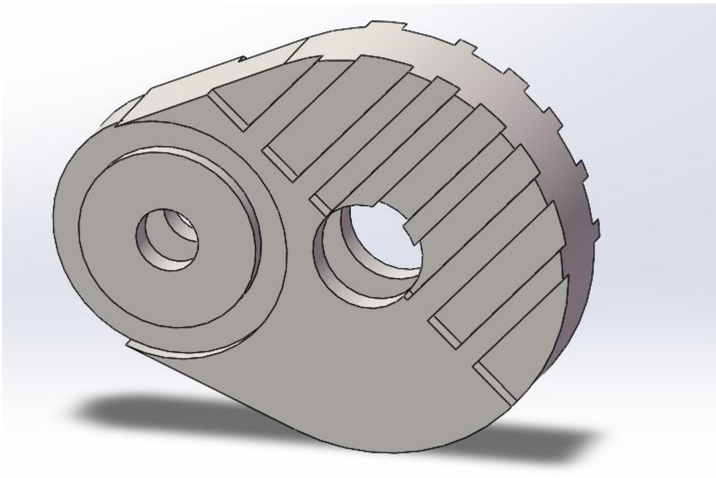


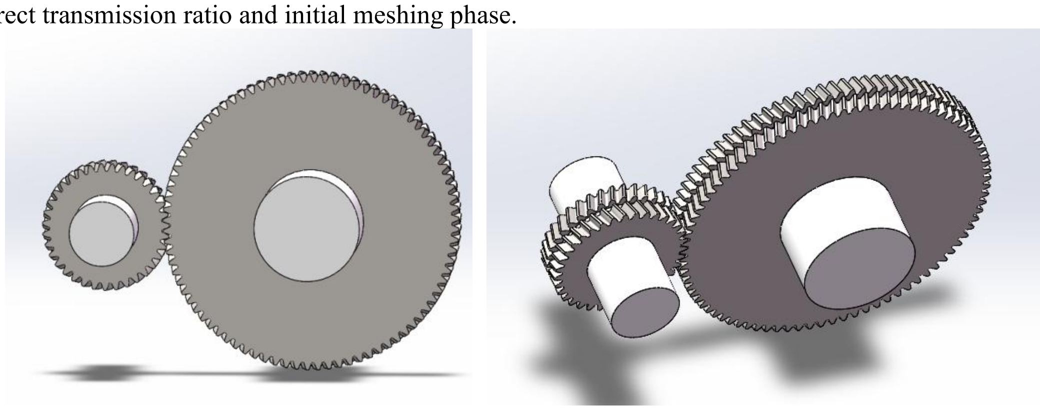
Figure 4. Gearbox housing model

The gearbox adopts a split upper and lower structure, equipped with bearing seats, inspection windows, stiffeners, and anchor bolt holes. The gearbox wall thickness is 15 mm, and the center distance of the bearing seats is 380 mm, as shown in Figure 4

IV. Parts Assembly and Gear Meshing

4.1 Assembly Strategy

In the Solidworks assembly environment, the "Concentric" and "Coincident" constraints between the gears and shafts are first completed. The center distance of 380 mm is achieved through the distance constraint between the two shafts.Subsequently, the "Gear" mechanical mate is applied between the two gear pitch circles to define the correct transmission ratio and initial meshing phase.



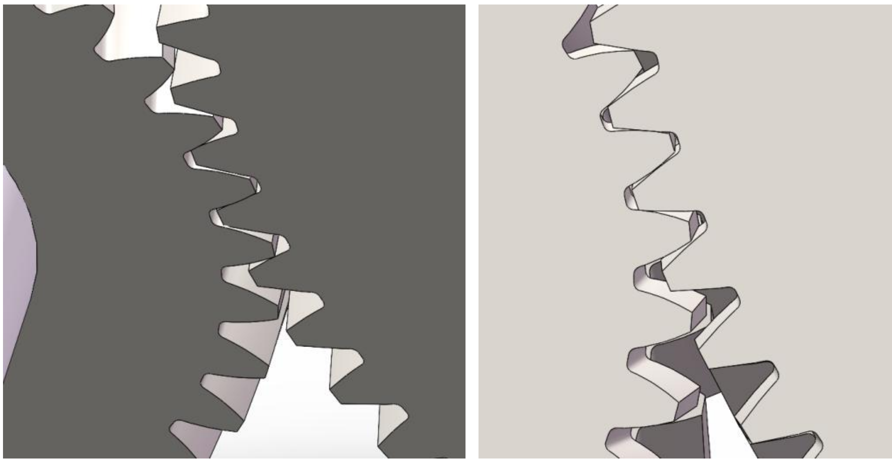
(a) (b)

Figure 5. Schematic diagram of gear and shaft assembly mate

An interference fit is used between the driving gear and the driving shaft, while a clearance fit with a key connection is used between the driven gear and the driven shaft, as shown in Figure 5.

4.2 Gear Meshing Implementation

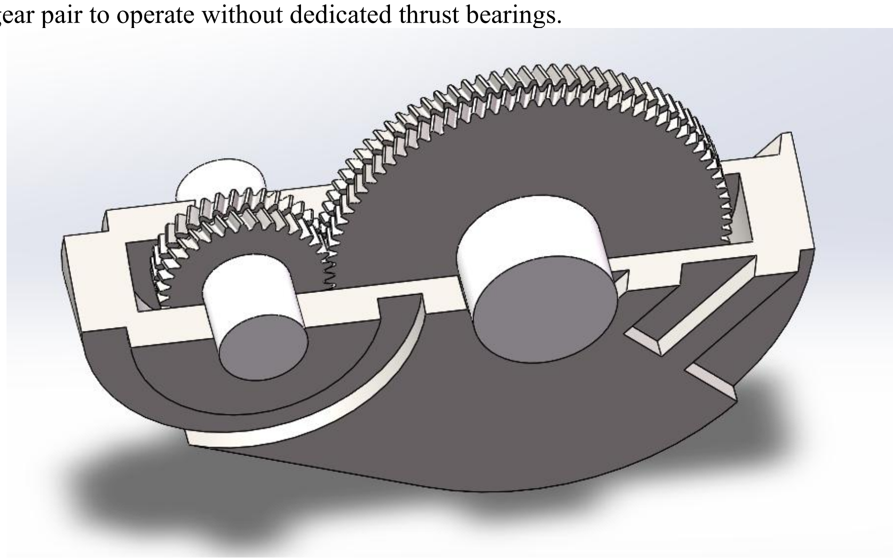
The "Gear Mate" function under "Mechanical Mates" is adopted, with a tooth ratio of 35:85. The initial phase angle is manually adjusted to ensure correct meshing.



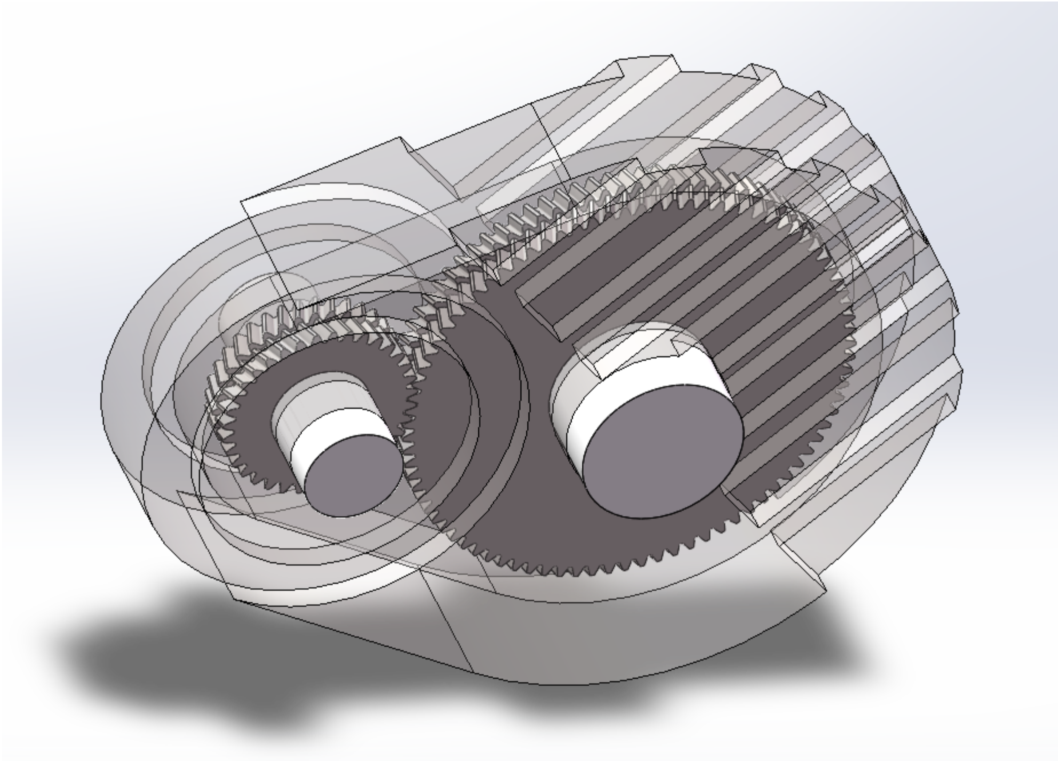
(a) (b)

Figure 6. Partial enlarged view of gear meshing state

As displayed in the figure, itshows the contact state when a pair of teeth enters the meshing region. The tooth surface contact line is parallel to the axis, conforming to the meshing characteristics of herringbone gears.This parallel contact line configuration enables the opposing helical teeth to automatically cancel axial thrust loads, allowing the gear pair to operate without dedicated thrust bearings.



(a)



(b)

Figure 7. Overall assembly of gearbox

As shown in the above figures, it includes the driving gear, driven gear, driving shaft, driven shaft, gearbox housing, bearings, and end covers. The overall structure is compact, and the transmission chain is clear.

V. Conclusions

Based on the Solidworks platform, this paper completes the 3D modeling, assembly, and motion simulation analysis of a herringbone gearbox. The main conclusions are as follows:

(1) Parameter-driven modeling: By clarifying parameters such as module, pressure angle, helix angle, and modification coefficient, dimensions such as addendum circle diameter and dedendum circle diameter can be accurately calculated, improving modeling accuracy and modifiability.

(2) Assembly and meshing: Using the gear mate function of Solidworks combined with center distance constraints, precise meshing can be achieved and interference avoided.

(3) Validation through motion simulation. Motion simulation (performed using the SolidWorks Motion add-in) verifies stable transmission with consistent angular velocity, providing a valid model basis for subsequent finite element analysis of dynamic response.

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