Mechanics analysis of gears system for peeler device during live operation of 10kV distribution network overhead line

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Abstract. According to the market research, the existing gear transmission device of peeler has complex structure, processing and assembly process difficult, designed a more enclosed gear transmission mechanism. The new device to reduce the labor intensity of operators, improve the operation efficiency of practical significance. By using the SolidWorks 3d modeling, based on ANSYS Workbench to intensity check and optimize the design of the gear, the four gear simulation results show that the gear displacement decreases gradually from the outside to the inside and increases with prolonged time, the maximum displacement occurs in the gear contact area and the contact area is always changing. The maximum stress of a gear occurs where the top of the tooth and the root of the tooth contact.

1. Introduction
With the improvement of people’s living standards, government factories and people’s lives are increasingly dependent on electricity. The contradiction between the power outages required for the maintenance and transformation of the distribution network and the people’s uninterrupted power demand has become increasingly prominent. The service commitment to the power supply company encouragement brings tremendous pressure. Strengthening daily maintenance, preventing accidents, rushing to repair when problems occur, establishing a safety defense system for the power system and dealing with various problems are the top priorities. Power failure for maintenance and overhaul is the safest and most reliable method. However, power failure will have a significant impact on industrial production and will greatly reduce production efficiency. Therefore, vigorously carrying out live work has become an extremely important core work of all grassroots power supply companies. [1-5]

Cable peeling is an indispensable part of all aerial live operation projects. Aiming at the characteristics of low efficiency, complex technology, various tools used in various operations and high skill requirements for live operators, a new type of four-gear transmission device was designed. Then, the strength analysis and optimization design of the gear transmission mechanism are carried out by ANSYS Workbench software.

2. Four gear rotating mechanism design of peeling device
This solution (as shown in Figure1) uses two idler gears added to the gear drive assembly, cancels the closed switch gear on the incoming large gear, reduces the processing difficulty, and the gear transmission can ensure a constant instantaneous transmission ratio and load High capacity, high
transmission efficiency, long life, high reliability, and its small size and wide application range. The number of teeth of the gear is 40, 20, 17, 17, and the module is 2mm. The minimum number of teeth is 17 to avoid undercutting during processing while ensuring the minimum size. At the same time, it is also to ensure that the gear has a long life and the gear cannot be too large. During operation, the operator presses the remote control device, and power is input to the rotating drive gear, which drives the entire assembly to rotate, and inputs power to the clamping and peeling assembly. After the stripped cable enters the large gear with the gap, The gear and the peeling component can rotate and peel around the wire [6-9].

![Drive gear assembly model](image)

The relative positional relationship of the four gears is shown in Figure2:

![The relative positional relationship of the four gears](image)

3. Finite element analysis based on ANSYSWORKBENCH

3.1 The simulation model of transmission mechanism

To simplify the model, Mapping between models to where contacts need to be added, delete excess chamfer and fillet in the structure. Import the simplified model of SolidWorks into the ANSYA WORKBENCH as shown in Figure3.
Figure 3 Simplified model

Bolted connections are simulated by adding binding contacts between components and components. The contact formula adopts the MPC algorithm, because this algorithm uses internal constraint equations to connect the displacement of the contact surface between the components, and the MPC algorithm is not based on the penalty function method. Or Lagrange multiplier method, but directly deals with the way of binding the contact surface of the contact area. During the test, the input torque of the driving wheel must be greater than 7N·m measured by the torque tester. After conversion, the load of the driven wheel is 13.3N·m, the open gear applies a torque of 13.3N·m, and the cutter head applies a fixed constraint.

3.2 Stress calculation results and analysis of stripper drive mechanism

According to the above-established model, the stress cloud diagrams of the split gear and the large support plate are respectively calculated, as shown in Figure 4. From Figure 4(a), it can be seen that the stress on the left side of the split gear is larger, and the other areas are smaller, with the maximum stress at 11.5MPa, this is because the left side is fixedly connected with the support plate to bear the main cutting force. From Figure 4(b), it can be seen that the maximum stress of the large support plate occurs at a right angle, indicating that there is a large stress concentration here, it should be optimized.

(a) Stress of Open Gear  (b) Stress of large support plate

Figure 4 Stress cloud diagram of each part

3.3 Transient dynamic analysis of rotating drive gear

Create a transient dynamics analysis module and set the material properties. POM is used here. The four gears have two symmetrical idlers. In order to make the analysis easier and faster, one idler is reduced in the model, only three gears are retained, and the geometric model is imported. The contact surface selects all the meshing surfaces of the driving wheel, the target surface selects all the meshing surfaces of the driven wheels, the contact relationship is set to friction contact, the friction coefficient
is set to 0.1, the solution time is set to 1s, the initial substep is set to 50, and the minimum substep is set to 20, and the maximum substep is 10000.

![Stress cloud](image1)

![Stress curve](image2)

**Figure 5** Stress cloud diagram and curve diagram of gear

It can be seen from Figure 5 that since the contact area changes when rotating, the stress on the tooth tip of the pinion gear and the tooth root of the large gear is relatively large, the contact part between the tooth tip and the tooth root produces the greatest stress, the maximum stress is 29.473MPa, the minimum stress is only 1.1555e-5MPa.

![Displacement cloud](image3)

![Displacement curve graph](image4)

**Figure 6** Displacement cloud and curve of gear

It can be seen from Figure 6 that the tooth tip displacement of each gear is the largest, and the innermost only rotates, so the displacement is very small. When rotating, the innermost gear is static at first, and then the gear starts to rotate, and the outer displacement gradually becomes larger. The inner displacement becomes smaller and the innermost displacement is the smallest, the maximum displacement also increases with the prolong time, and the maximum displacement is also in the area where the gear contacts.

![Speed cloud](image5)

![Speed curve](image6)

**Figure 7** Speed cloud and curve of gear
It can be seen from Figure 7 that the speed at the beginning fluctuates with time and then tends to a stable value. The maximum speed reaches 74.717 mm/s. This is because the open gear has a torque load, which is the same as the driving wheel speed, which will cause the speed to slowly decrease and finally tend to a constant value.

4. Conclusions

This article innovation has designed a four gear mechanism adapted to the peeler, and then uses SolidWorks for three-dimensional modeling, the maximum stress of each part was obtained by ANSYS Workbench statics analysis of the rotating part, and the position of the stress concentration is found. For a closed four gear mechanism as a transient dynamic analysis, it is found that the gear displacement decreases gradually from the outside to the inside and increases with prolonged time, while the maximal displacement occurred between gears contact area is always changing, the speed of the gear will fluctuate with the passage of time, but eventually tends to be less than the stable initial speed.

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References
[1] Bai Chenxu, Zhou Lei, Bai Chenyang, et al. Research on common methods and applications of distribution line inspection [J]. Computer Products and Circulation, 2020, (03): 63.
[2] Huang Ping. Overhead insulated power distribution lines Analysis of construction safety issues[J].Scientific Consulting (Technology•Management), 2020, (03): 60.
[3] Li Wenzhou. Analysis of operation failures of distribution lines in rural areas and optimization of preventive measures[D]. Jilin University, 2019.
[4] Liu Baoquan. Common failures and causes of 10kV distribution lines and analysis of operation inspection management[J]. Value Engineering, 2020, 39(07): 143-145.
[5] WU Shaolei, FENG Yu, WU Kai, et al. Construction and Simulation Analysis of 3D Electrical Contact Model of Rough Surfaces Based on Finite Element Method [J]. Journal of Hefei University of Technology (Natural Science), 2018, 41(11):1441-1445.
[6] WU Shaolei, FENG Yu, WU Kai, et al. Analysis and Improvement of Entrapment Installation Operation of Insulation Puncture Line [J]. Electric Power Safety Technology, 2018, 20(09):62-65.
[7] Gao Zhixiang. Multi-strand wire stripping device [J]. New technology and new technology, 1992 (01): 25.
[8] Shi X, Wang W, Liu Kun, et al. Finite element model construction and contact analysis of microscopic random rough surface [J]. Lubrication Engineering, 2020, 45(05):25-29.
[9] WU Shaolei, FENG Yu, SHI Xun, et al. Construction and analysis of puncture clamp model for 10kv insulation line based on finite element[J]. Journal of Physics: Conference Series, 2019, 1303:012007.