Research on Parametric Design and Feature Modeling of Freight Ropeway Running Car of Transmission Line

ZHU MinJie\textsuperscript{1a}, LI JianHua\textsuperscript{1b}, XU KeYang\textsuperscript{1c}, LIU Chen\textsuperscript{2d,}\textsuperscript{*} and WANG Fei\textsuperscript{2e}

\textsuperscript{1} State Grid Zhejiang Electric Power Co., Ltd. Taizhou Power Supply Company, Zhejiang, China
\textsuperscript{2} China Electric Power Research Institute, Beijing, China
\textsuperscript{a}21288467@qq.com, \textsuperscript{b}mathmech@126.com, \textsuperscript{c}675580827@qq.com, \textsuperscript{d,*}Corresponding author: liuchen@epri.sgcc.com.cn, \textsuperscript{e}929903299@qq.com

Abstract. To improve the freight ropeway components design efficiency, the component structure design is carried out for the components of freight ropeway of transmission line using 3d design software by using parameter modification method. The parametric design and feature modeling of freight ropeway running car is proposed to realize components modelling, and analyse its force conditions to meet the strength requirements. The proposed method can improve the efficiency of freight ropeway structural design.

1. Introduction
Powerful 3D modeling software comes into being with the continuous development of computer technology. At present, the main structural design method is to build the finite element simulation model by modifying the model geometry data one by one, It has the disadvantages of high development cost and large workload [1-2]. Through the parametric modeling method, the structural dimension relationship can be established and the parametric modification can be realized, it can improve the structural design efficiency [3-6].

At present, there are few standardized specifications and models of freight ropeway components, which cannot be flexibly configured according to the load during construction site, lack of standardized component design methods, and three-dimensional visual display of components in freight ropeway selection design [7-8]. Therefore, the study on parametric modeling of freight ropeway components can provide support for freight ropeway selection and design.

2. Component structure of running car
The running car is a vehicle for carrying materials on the freight ropeway. The types of running car include running car of one bearing rope, two bearing ropes and four bearing ropes.

2.1. Running car of one bearing rope
The one bearing rope running car is mainly composed of frame, road wheel, running car shaft and rope holder, as represented in figure 1.
2.2. Running car of two bearing rope
The two bearing rope running car is mainly composed of frame, running car, running car shaft and rope holder, as represented in figure 2.

2.3. Running car of four bearing rope
The four bearing rope running car is mainly composed of frame, road wheel, running car shaft and rope holder, as represented in figure 3.
3. Parametric modeling of running car

3.1. Frame

The modeling parameters of frame are represented in table 1, the diagrammatic sketch of modeling parameters of frame is represented in figure 4.

| Number | Modeling parameter                  | Parameter value (mm) |
|--------|-------------------------------------|----------------------|
| 1      | Height of frame TF-H                | 500–1000             |
| 2      | Section length of frame TF-L        | 80–150               |
| 3      | Section width of frame TF-W         | 80–150               |
| 4      | Section thickness of frame TF-T     | 5–15                 |
| 5      | Shaft hole of frame TF-D            | 5–15                 |

Figure 4. Diagrammatic sketch of modeling parameters of frame.

3.2. Road wheel

The modeling parameters of road wheel are represented in table 2, the diagrammatic sketch of modeling parameters of road wheel is represented in figure 5.

| Number | Modeling parameter                  | Parameter value (mm) |
|--------|-------------------------------------|----------------------|
| 1      | Length of road wheel TW-L           | 250–500              |
| 2      | Width of road wheel TW-W            | 80–250               |
| 3      | Shaft hole of road wheel TW-D1      | 30–80                |
| 4      | Diameter of road wheel TW-D2        | 100–160              |

Figure 5. Diagrammatic sketch of modeling parameters of road wheel.
3.3. Running car shaft
The modeling parameters of running car shaft are represented in table 3, the diagrammatic sketch of modeling parameters of running car shaft is represented in figure 6.

| Number | Modeling parameter | Parameter value (mm) |
|--------|--------------------|----------------------|
| 1      | Diameter of running car shaft TP-D | 30–80 |
| 2      | Length of running car shaft TP-L   | 150–400 |

**Figure 6.** Diagrammatic sketch of modeling parameters of running car shaft.

3.4. Rope holder
The modeling parameters of rope holder are represented in table 4, the diagrammatic sketch of modeling parameters of rope holder is represented in figure 7.

| Number | Modeling parameter | Parameter value (mm) |
|--------|--------------------|----------------------|
| 1      | Length of rope holder TH-L | 120–300 |
| 2      | Width of rope holder TH-W  | 80–250 |
| 3      | Thickness of rope holder TH-T | 10–40 |

**Figure 7.** Diagrammatic sketch of modeling parameters of rope holder.

4. Simulation check calculation of running car
The main modeling parameters of running car are represented in table 5. The material of frame, road wheel and rope holder is Q355, and the material of running car shaft is 40Cr. The parametric modeling grid model of running car is represented in figure 8.
Table 5. Parametric modeling of running car

| Number | Modeling parameters                  | Modeling parameters 1 (mm) | Modeling parameters 2 (mm) |
|--------|-------------------------------------|---------------------------|---------------------------|
| 1      | Height of frame TF-H                | 450                       | 665                       |
| 2      | Section length of frame TF-L        | 80                        | 100                       |
| 3      | Section width of frame TF-W         | 80                        | 100                       |
| 4      | Section thickness of frame TF-T     | 6                         | 6                         |
| 5      | Diameter of road wheel TW-D2        | 95                        | 106                       |
| 6      | Diameter of running car shaft TP-D  | 40                        | 50                        |
| 7      | Length of running car shaft TP-L    | 450                       | 588                       |

Figure 8. Finite element model of running car.

The running car bears the weight of materials.

4.1. Modeling parameters 1
By finite element simulation, the maximum load input of the running car is 75kN, and the maximum stress of the running car is 502MPa which occurs at the end of transport material of the frame, as represented in figure 9. The overall stress of the running car can meet the requirements of the ultimate strength.

Figure 9. Stress nephogram of running car.

The safety factor of the running car is 3, the rated load of the running car is 25kN.

4.2. Modeling parameters 2
The rated load of the running car with modeling parameter 2 is 35kN according to the finite element calculation.

The stress of component of running car is represented in table 6.
### Table 6. Stress of component of running car

| Number | Modeling parameters  | Modeling parameters 1 | Modeling parameters 2 |
|--------|----------------------|-----------------------|-----------------------|
| 1      | Applied load (kN)   | 75                    | 105                   |
| 2      | Maximum stress (MPa)| Frame: 481            | 498                   |
|        |                      | Rope holder: 480      | 270                   |
|        |                      | Running car shaft: 313| 203                   |

5. Conclusion

Combined with three-dimensional design software, the parametric modeling method of transmission line freight ropeway components are proposed. The parametric model of freight ropeway running car is established and the strength of designed components is checked and analyzed.

The parametric modeling method can achieve fast solid 3D model building by modifying modeling parameters.

Acknowledgments

This study is funded by Science and Technology Project of State Grid Zhejiang Electric Power Co., Ltd. (Research on Modular Centralized Control Freight Ropeway Technology of State Grid Zhejiang Taizhou Power Supply Company 2021-2022). The project number is SGZJTW0JSJS2100570.

References

[1] Zongbo Hu, Xiaofeng Tang, Xuncheng Wu and Xin Jiang 2013 Application of implicit parametric modeling technology in early CAE analysis Journal of Shanghai University of Engineering Science 27(04) pp 328-332
[2] Yanan Li, Caifu Qian 2019 Stress analysis and strength assessment of high pressure heater based on VB and ANSYS parametric modeling Pressure Vessel Technology 36(1) pp 48-53
[3] Xiaoli Su, Zisheng Lian, Chunyu Zhang 2013 Design Method of Parameterization and Analysis for Roller of Conveyor Based on ANSYS and VB Coal Mine Machinery 34(11) pp 234-236
[4] Pian Hu 2014 Parametric Design of Yacht's Shape Based on CATIA Ship Electronic Engineering 34(6) pp 160-162
[5] Mingxia Zhang, Shuaishuai Qin, Zhengbin Zhao, Shenglei Fu and Bingbing Han 2019 Parametric Modeling of Hull and Calculation of Stability Based on CATIA Ship Engineering 41(1) pp 48-52
[6] Xu Yang, Ying Liu, Xin Qiao 2018 Research on Light Weight Of Implicit Parametric Engine Hood Structure Automobile Applied Technology (18) pp 179-182
[7] Ming Jiang 2020 Design of Double Cable Freight Ropeway System Considering Coupling Effect between Cables Machinery Design & Manufacture 355(09) pp 87-91
[8] State Grid Corporation of China 2008 Q/GDW 11189-2018 Special aerial material ropeway with transit materiel of over head transmission line engineering China Electric Power Press