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# Research on Design of Electric Cabinet in Driver's Cab of Urban Rail Vehicle

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**Abstract:** This paper introduces the structural characteristics and device layout design of driver's cab electrical cabinet of Metro Line 2 project in a city, which also expounds the modular design concept of driver's cab electrical cabinet. It provides reference for the design of electric cabinet in driver's cab of similar urban rail vehicles in the future.

**Keywords:** Modular Design; Urban Rail Vehicle; Driver's Cab Electrical Cabinet

## INTRODUCTION

With the rapid development of urban rail transiting cause in China, the speed and performance of urban rail vehicles have been greatly improved. The cab electrical cabinet is an important part of the urban rail vehicle control system. It is arranged in the cab. The cabinet contains network, traction, PIS, fire alarm and other devices, including about 80% of the driver's cab electrical devices and control logic unit.

The design of driver's cab electrical cabinet mainly includes two aspects: firstly, the structural design of the cabinet body, which mainly includes the confirmation of the overall dimension and the strength design of the cabinet; secondly, the internal design of the electrical cabinet, which includes the installation and layout of electrical components, wiring and outgoing lines in the cabinet and other auxiliary design.

Taking the electric cabinet in the driver's cab of a Metro Line 2 project as an example, the design scheme of the electrical cabinet in the driver's cab is briefly described. The actual electrical cabinet in the driver's cab can be shown in Fig.1

Fig. 1 Driver's Cab Electrical Cabinet

## STRUCTURAL DESIGN OF FRAME

### Frame Structure Design

According to the overall design requirement of the vehicle, the electric cabinet in the driver's cab of Metro Line 2 project in the city can adopt an open and riveted frame with the overall dimension of 795mmx615mmx1950mm (Length x Width x Height). The cabinet body is fixed with the car body through two 12mmx40mm long round holes at the top with four 12mmx50mm long holes at the bottom. In order to realize the lightweight design concept, the main frame of the cabinet is made of T = 4.0mm aluminum alloy (5754 H111) bending structure. The cabinet frame can be shown in Fig.2

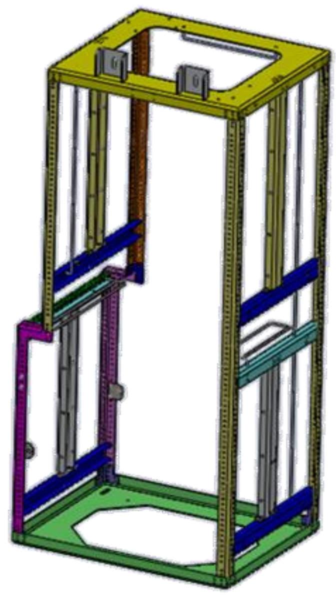

Fig. 2 Cabinet Frame

**Simulation Calculation**

In order to avoid structural design defects, the finite element method is used to calculate and analyze the cabinet.

Establishment of Simulation Model

The structural model of driver's cab electrical cabinet can be shown in Fig.3. The material properties can be shown in Table 1.

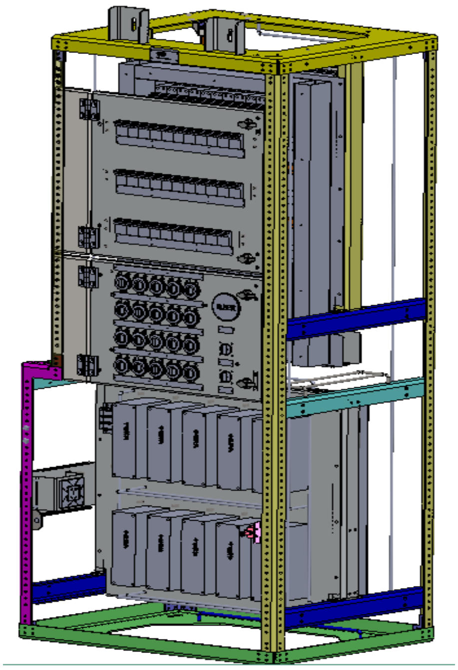

Fig.3 Structure Model of Electrical Cabinet

Table 1 Material Properties

| Material | Elastic Modulus (GPa) | Poisson's Ratio | Density (kg / m3) | Yield Strength (MPa) |
|---|---|---|---|---|
| 5754 H111 | 70 | 0.3 | 2700 | 80 |
| SUS304 | 210 | 0.3 | 7850 | 205 |

According to the structure of the electrical cabinet in the driver's cab, the sheet metal parts are simulated by SHELL181 unit, and the thickness is taken as the design value; the electrical parts are simulated by SOLID185 unit; the mass parts are simulated by MASS21 unit according to the actual weight, and the contact between the parts is established for bearing force; the beam element is used to simplify the connection of bolts and rivets. The size of the whole model element is about 6mm, there are about 0.28 million structural elements and 0.3 million joints. The finite element model can be shown in Fig.4

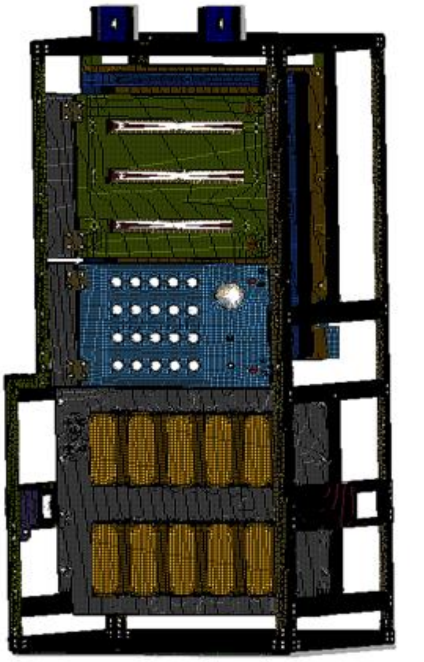

Fig.4 Finite Element Model of Cabinet

Simulation Conditions and Evaluation Standard

According to the actual operation of the subway, five load cases for static strength analysis and three load cases for fatigue strength analysis are determined, which can be shown in Table 2.

Table 2 Load Condition of Electrical Cabinet

| Name of working condition | Vertical acceleration (g) | Lateral acceleration (g) | Longitudinal acceleration (g) |
|---|---|---|---|
| Static strength working condition 1 | -1.0 | | 3.0 |
| Static strength working condition 2 | -1.0 | | -3.0 |
| Static strength working condition 3 | | 1.0 | -1.0 |
| Static strength working condition 4 | | -1.0 | -1.0 |
| Static strength working condition 5 | | | -3.0 |
| Fatigue strength working condition 1 | 0.15 | 0.15 | -0.85 |
| Fatigue strength working condition 2 | 0.15 | 0.15 | -1.15 |
| Fatigue strength working condition 3 | 0.15 | 0.15 | -0.85 |

Analysis on Simulation Result

The stress size and distribution of driver's cab electrical cabinet under various load conditions are analyzed by ANSYS software. The analysis results can be shown in Fig. 5 and Fig. 6. Thus, Fig. 5 shows the stress nephogram of electrical cabinet under static strength working condition from 1 to 5. Fig.6 shows the stress nephogram of electrical cabinet under fatigue strength working condition from 1 to 3.

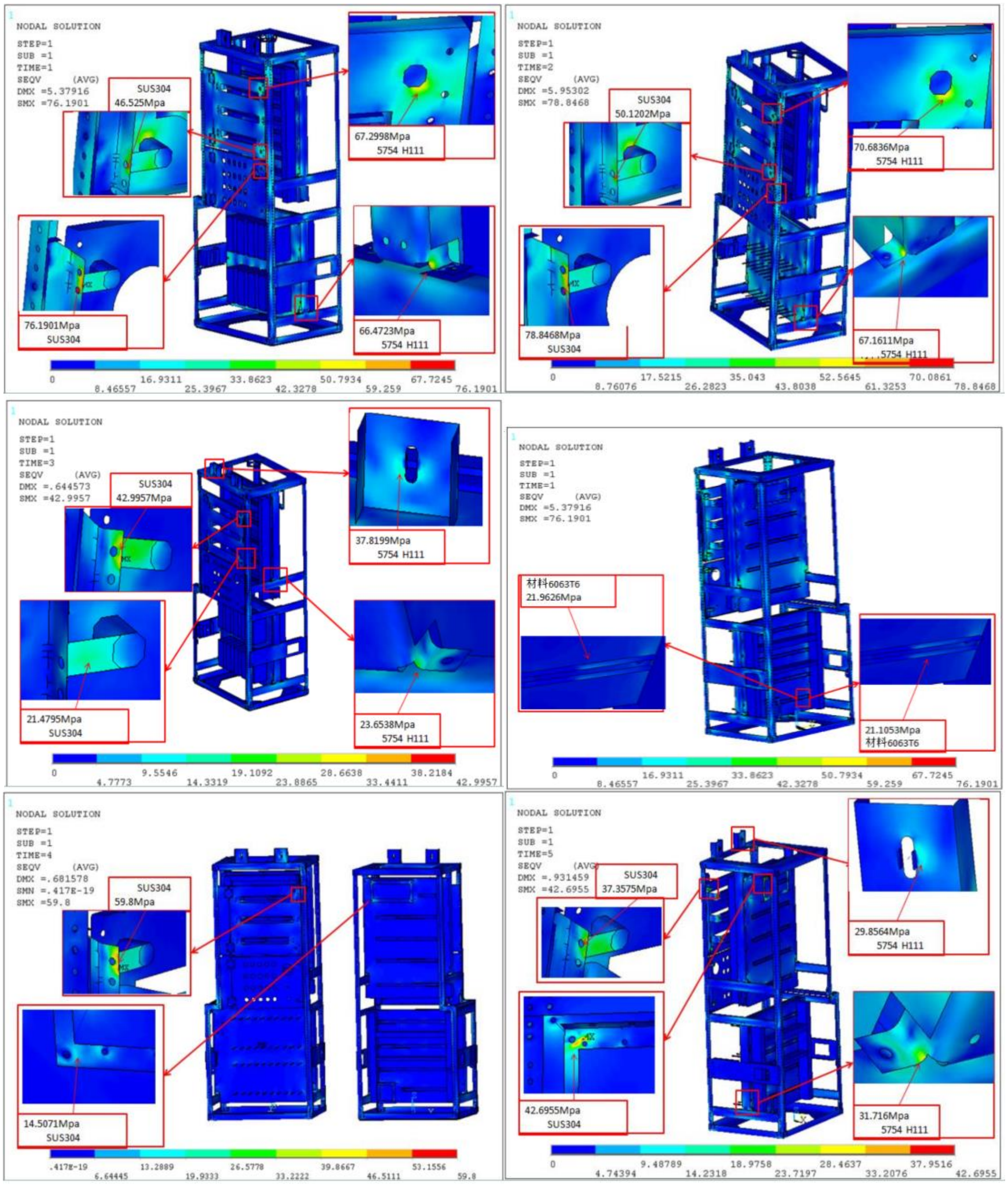


Fig. 5 Stress Nephogram of Electrical Cabinet under Static Strength Working Condition from 1to 5

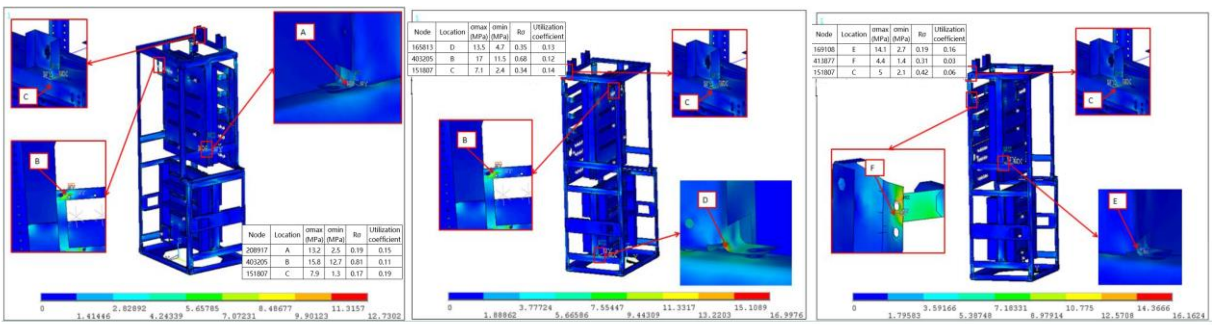

Fig. 6 Stress Nephogram of Electrical Cabinet under Fatigue Strength Working Condition from 1 to 3

Under different working conditions of static strength and fatigue strength load, the strength calculation results of electrical cabinet can be shown in Table 3 and Table 4.

Table3 Strength Calculation Results of Electrical Cabinet (Static Strength Working Condition)

| Calculating working condition | Maximum stress of components (MPa) | Material of components | Yield limit (MPa) | Evaluate |
|---|---|---|---|---|
| Static strength working condition 1 | 76.2 | SUS 304 | 205 | Qualified |
| Static strength working condition 2 | 78.9 | SUS 304 | 205 | Qualified |
| Static strength working condition 3 | 43 | SUS 304 | 205 | Qualified |
| Static strength working condition 4 | 59.8 | SUS 304 | 205 | Qualified |
| Static strength working condition 5 | 42.7 | SUS 304 | 205 | Qualified |

Table 4 Strength Calculation Results of Electrical Cabinet (Fatigue working condition)

| Calculating working condition | Maximum equivalent stress (MPa) | Maximum equivalent stress (MPa) | Stress ratio Rσ | Notch grade | Utilization coefficient |
|---|---|---|---|---|---|
| Fatigue working condition 1 | 15.8 | 12.7 | 0.81 | A | 0.11 |
| Fatigue working condition 2 | 17 | 11.5 | 0.68 | A | 0.12 |
| Fatigue working condition 3 | 14.1 | 2.7 | 0.19 | A | 0.16 |

Through calculation and analysis, the static strength and fatigue strength of the electrical cabinet can meet the design requirements.

## CABINET DESIGN

### Device Layout

On the premise of meeting the needs of customers, it is particularly important to realize modular design and reasonable and compact device layout. Circuit breakers, relays, contactors and other devices can be placed according to different power supply modes and functional groups.

The equipment installed on the driver's cab side mainly includes: terminal block, circuit breaker, relay, relay module and MVB junction box. The equipment on the installation board of electrical cabinet at passenger compartment side mainly includes: terminal block and relay. In order to observe the operation of the vehicle, the panel structure can be added at the cab side, which can be directly observed through the open window on the inspection door. The electrical components installed on the panel mainly include buttons, knobs, voltmeters and circuit breakers. The panel can be shown in Fig.7.

### Wiring Design

There are three kinds of wiring modes commonly used in electrical cabinet: wire binding board, cable pole and wire slot. Wire binding board and cable pole is a kind of wiring way that the wire is bundled into bundles by using the binding tape. The feature is that the space in the driver's cabinet can be fully utilized, but the disadvantages are that the binding workload is heavy and the maintenance is difficult. The advantages of trunking are easy construction and easy maintenance, but the disadvantage is that it can take up a lot of space. In order to facilitate wiring, trunking is preferred when the wiring space is satisfied.

In addition to the shortest path and aesthetics, the wiring of electrical cabinet can also consider electromagnetic compatibility. In order to avoid electromagnetic interference, different types of cables in the trunking can be placed separately or isolated by shielding network management. The wiring of electrical cabinet in the cab can comply with EN50343, and the cables can be divided into three categories, which can be shown in Table 5. Different types of cables can be laid separately, and the minimum distance can be shown in Table 6.

Fig.7 Panel of Driver's Cab Electrical Cabinet

Table 5 Cable Categories Related to EMC

| Cable Level Based on EMC Classification | Cable Type |
|---|---|
| A | High Voltage Cable, Engine Cable, Brake Resistor, Filter Cable, etc |
| B | Battery Cable, Control Cable, etc |
| C | Data Communication Bus Cable (MVB, WTB), ATC Antenna Cable, loudspeaker Cable |

Table 6 Minimum Distance between Different EMC Cables

| Type of EMC Cable | Isolation Distance (m) |
|---|---|
| A and B | 0.1 |
| A and C | 0.2 |
| B and C | 0.1 |

## CONCLUSION

In the future, the modular design and the concept of lightweight design on electrical cabinet are particularly important. In terms of structure, more mature profiles are existed such as "L" type, "U" type, angle aluminum, channel aluminum and so on. We also need to learn and absorb the design concept of new cabinet structure, such as "Rittal Cabinet" nine fold type profile etc. Through the elaboration of the frame design, electrical design and wiring design of the cab electrical cabinet, it further introduces the concept of modular design in this paper. Moreover, the design concept has been applied to the design of cab electrical cabinet in many urban rail metro projects, which has achieved certain effect.

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