The application of the electromagnetic shielding technology in the design of the heat dissipation of the shipboard cabinet

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Abstract. The Paper summarizes the electromagnetic shielding technology and introduces structure form and key points of thermal design of a kind of forced-air-cooling closed cabinet and structure composition of electrical system cabinet of a shipboard device. Calculate and analyze heat dissipation and select draught fan and shielding ventilation board according to calculation. Take various electromagnetic shielding measures in structure design of cabinet to make the electrical system meet the requirement of electromagnetic compatibility of ship to equipment, which has effectively solved heat dissipation problem of servo-driving cabinet.

1 Introduction

Thermal design of cabinet is one of the basic conditions to guarantee normal operation of system and thermal design controls system in specified temperature limit range in operation environment by controlling whole temperature of cabinet and tries to reduce temperature change and disperse and dissipate heat generated in cabinet in optimal dissipation method, minimal heat-flow passage and the fast speed to ensure reliability of cabinet. With wide application of electric and electronic equipment in various fields of communication, radar and navigation, troops step into information age. Simultaneously, because of wide application of electronic equipment or system on ship, electromagnetic environment on ship is more complex gradually and electromagnetic interference problem is more severe day by day. It has attracted highly attention of troops on how to guarantee normal operation of electronic shipboard equipment in complex electromagnetic environment and decrease electromagnetic pollution of equipment to environment and the Paper mainly researches application of electromagnetic shielding technology to structural design of shipboard cabinet. For present electronic shipboard equipment cabinet, forced air cooling is main method for equipment cabinet cooling for the advantages of simple design, convenient use, high reliability and low cost, etc. Under high-temperature shipboard environment, heat load capacity of open-type forced-air-cooling cabinet adopted previously is relatively low and failure probability of circuit is high and equipment reliability is low because circuit module in cabinet is directly exposed to atrocious weather environment on sea and is influenced by high temperature, humidity, salt mist, mycete and dust, etc. comprehensively.

2 Structural designs of electromagnetic shielding technology and cabinet

In structure design, an important method to suppress electromagnetic interference is to adopt electromagnetic shielding technology. Shielding is a kind of measure to prevent or decrease transmission of electromagnetic energy by making use of shield. There are two purposes for

shielding: one is to limit leakage of electromagnetic energy in internal radiation area; the other is to prevent external radiation from entering its own area. If external body of equipment is designed as completely closed conductive shell, above two shielding purposes can be realized better. However, in consideration of heat dissipation and maintenance, it is impossible to be designed as complete closed shell and gap, opening and hole are inevitable. These gap, opening and hole lead to local discontinuous current of shield, which is main cause for decrease of shielding performance. As shown in Figure 1, structural form of cabinet is three-layer extension-set structure layout of high-density assembly, which is complete closed type and adopts circulation air cooling. Air inlet of ventilation system is set in bottom of two-side door plank of cabinet; air outlet is set above door plank in the back of cabinet and air inlet and outlet are installed with metal honeycomb shield ventilation board, which meets of the requirement of ventilation, dust prevention and electromagnetic shielding simultaneously. Arrange equipment reasonably and rank equipment that does not emit heat or emits little heat with low heat-resistant performance in upstream of cold air and high-power equipment is ranked in the bottom of cabinet on the premise of meeting electrical performance.

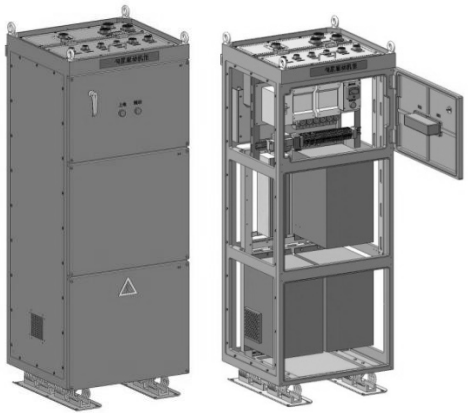

Fig. 1 Appearance and Internal Organization Chart for Serve--driving Cabinet

Electrical system of a device is composed of servo-driving cabinet and follow-up control cabinet. 2 drivers in servo-driving cabinet are main consideration factors for design of electromagnetic compatibility. Follow-up control cabinet includes composition equipment of power supply, stabilizer and control unit, etc., which decreases electromagnetic radiation by using box-type and modularization design. Fig. 2 and Fig. 3 are schematic diagram of internal structure of cabinet after removing door plank.

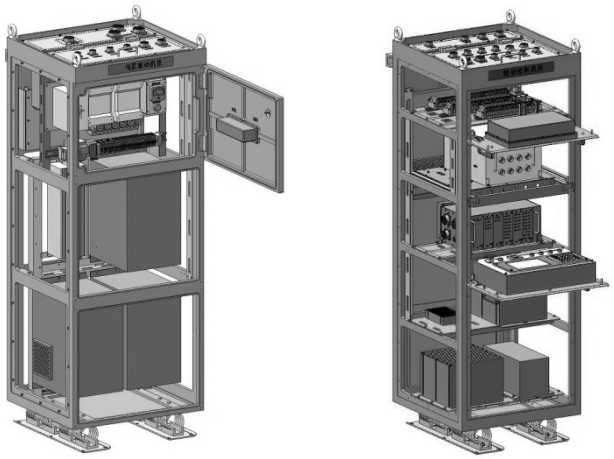

Fig. 2 Structure of Servo-driving cabinet Fig. 3 Follow-up Control Cabinet Structure

3 Heat dissipation calculation of cabinet

(1) Calculation of air duct

Size of servo-driving cabinet is: height× width× depth=1600mm × 609mm × 550mm, internal width size 569mm, internal depth size is 495mm, internal height size 1454mm and width size of two drivers in internal of cabinet is 250mm × 300mm. Q =Φ/ρ

Where, Q is air volume (/s), Φ is dissipation heat quantity (W), ρ is density of air (kg/) ρ=1.165 kg/, is specific heat of air (J/kg·℃) =1005 J/kg·℃ and is temperature rise (℃). According to design requirement, assume Φ=330W, = 10℃ (according to = 30℃、= 40℃), therefore, Q = 0.031/s≈ 112/h

Ventilation quantity of cabinet is determined according to 150/h in consideration of air leakage of cabinet and vent line and cold leakage of cabinet under high temperature environment.

Calculation of minimal ventilation area of air duct:

A = Q/3600ν

Where, A is area (), Q is air volume (/h) and ν is air speed (m/s). In consideration of noise and wind pressure, etc., assume air speed in cabinet ν=3m/, then, A=150/ (3600×3) ≈ 0.0138

It can be known from above calculation that ventilation area of air duct in cabinet shall be larger than 0.0138; assume ventilation area of inlet and outlet of cabinet shall not be less than 0.0138 during design; select 2 140mm × 140mm honeycomb shield ventilation board for air inlet and select 1 164mm × 164mm honeycomb shield ventilation board for air outlet; there is air duct with minimal area of cross section 0.132 meeting design requirement.

From calculation results, it is feasible to meet requirement of calorific value of equipment in cabinet by adopting forced air cooling.

(2)Selection of draught fan

There are two kinds of forms for forced air cooling of the complete machine: blast cooling and ventilation cooling. Characteristics of blast cooling are large wind pressure, intensive air volume, which is applicable to condition where heat distribution is uneven in unit, wind resistance is relatively large, while components and parts are relatively numerous. Characteristics of ventilation cooling are large air volume, little air pressure, relatively even air volume distribution and occupation space is relatively little generally. Calculate resistance of air volume below. Because Reω×（d/ν）=1.25×, less than; therefore, calculate pressure loss △P by adopting the following formula:

Total pressure of draught fan is used to overcome resistance of air duct and generate certain speed in outlet, namely:

P =△P +ρ/2=28.5(Pa)

According to foresaid calculation result and size of space in cabinet, selected draught fan is axial flow fan with large air volume, low air pressure and little occupation space. According to requirement of air volume and wind resistance of characteristics curve, in consideration of error of model simplification in calculation process, certain margin shall be added and parallel connection application of two 145FZY2NYD5-2F type fans that are produced by Suzhou Siaoke for draught fan.

4 High-low temperature environment test and conclusion

Fig. 4 Photo for High-low Temperature Test of Cabinet

According to design modeling requirement of certain device and according to GJB150-1986 Environmental Test Methods for Military Equipment, servo-driving cabinet has passed special-project high-low temperature environment test, which has proved that thermal design of the cabinet completely meets actual requirements and thermal analysis of cabinet is reasonable and selection of draught fan and air duct design also meet requirements.

5 Electromagnetic shielding measures

(1) Shielding design for increasing contact surface

Front gate of servo-driving cabinet keeps favorable electric connection of contact surface by adopting shielding design of concave-convex butt joint to reduce linear size of shield. As shown in Fig. 5, in improvement process of model machine, process circumference flange in servo-driving cabinet body and form clip connection with slotting part of front gate of cabinet and concave-convex butt joint form can keep two planes contact with each other, which increases electrical continuity of cabinet. After actual measurement, the improvement measure largely reduces electromagnetic radiation leakage in internal cabinet.

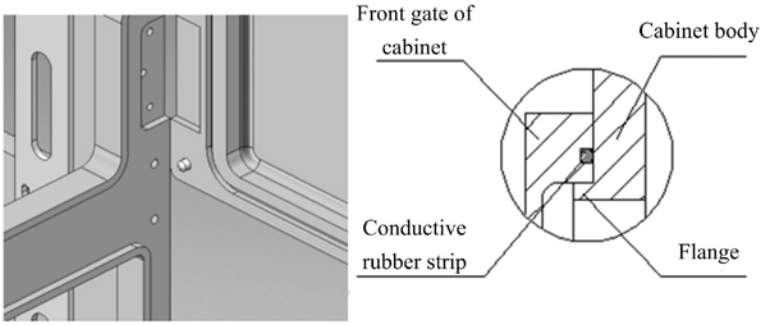

Fig. 5 Front Gate of Servo-driving Cabinet

(2) Influence of ground connection on electromagnetic shielding

Favorable ground connection of shield shall be ensured during electric shielding and influence of grounding quality on shielding performance is great and connection resistance of shield with ground shall be less than $2\mathrm{m}\Omega$ generally and connection resistance shall be less than $0.5\mathrm{m}\Omega$ under strict occasion. Contact place of all installed door planks with cabinet body shall be disposed conductive oxidization and shall be installed with conductive rubber strip to ensure favorable ground connection.

(3) Application of shielding window

Design of shielding window: elements, such as display of electronic equipment, indication header on panel and index dial; their installation parts shall open up opening or hole with corresponding size and suppress its leakage quantity by adopting shielding glass to shield electromagnetic leakage of this kind of opening and hole and its installation method is shown as Fig. 6. It shall be noted that in installation structure of shielding glass, adopting conductive-rubber bound form can prevent fragmentation of glass in application process and from influencing shielding efficiency for adverse factors, such as stress and vibration, etc. Select shielding glass with screen mesh density of 250 holes per inch and light transmittance of 40% to ensure visual effect and improve shielding effectiveness simultaneously.

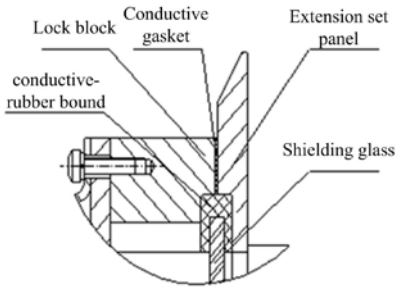

Fig. 6 Installation Structure of Shielding Window

(4) Module shielding

Module shielding means installing veneer or module with large radiation or poor interference resistance capability separately in shielding box. Module shielding not only is easy to be realized with low cost, but also can reduce mutual interference between veneer and module and realize electromagnetic compatibility between modules in internal system. Module shielding is a kind of solution with relatively ideal comprehensive performance, which is recommended to be used in most products.

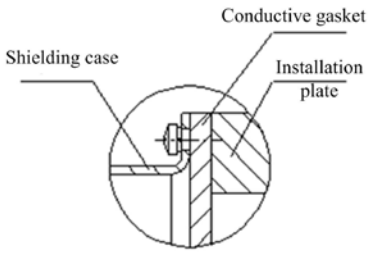

Fig. 7 Shielding module Structure

Fig. 8 Shielding Structure with Feed-through Capacitor

Some operation, input and output and display elements are usually installed in panel of electronic equipment, such as switch, header, indicator light and connector base, etc. and opening is required on panel. To prevent electromagnetic leakage in openings, shielding case can be installed in rear of these elements and feed-through capacitor can be installed in addition by lead through shielding case and lead connects with elements by feed-through capacitor through shielding case. Ensure electric contact of shielding case with panel during design and installation.

6 Conclusion

Electromagnetic interference problem has become an important index that influences electronic

shipboard equipment performance and also an important factor that influences fighting capacity of ships. Passing electromagnetic compatibility experiment is one of the preconditions for design modeling of products to solve electromagnetic compatibility of shipboard equipment. Therefore, electromagnetic design of electronic shipboard equipment is a systematic and whole concept, which runs through the whole process of electronic shipboard equipment design. Calculate and analyze heat dissipation and select draught fan and shielding ventilation panel according to calculation, which has effectively solved heat dissipation problem of servo-driving cabinet.

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