International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 10 Issue 10 ǁ October 2022 ǁ PP. 235-242

A Study of Dynamic Cabin Loading Based on Modelica

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***Abstract*:** *In order to explore the composition of the ship's cabin load, the specific composition of the load of its sheathing parameters, especially the outdoor radiation load, is explored. Firstly, we analyzed the composition principle of MixedAir in the Buildings library, and then used UML to analyze the object file relationship, added the input of the modification of heading, and finally made the cabin change load with the change of heading.*
Keywords: *Modelica; Heading change; Cabin load*

Date of Submission: 24-09-2022 Date of acceptance: 08-10-2022

I. INTRODUCTION

With the continuous development of ship engineering, more and more attention has been paid to the living environment of the people on board, while the comfort and air quality in the ship's cabin have also received more attention. The environmental quality of the ship's cabin space will directly affect the physical and mental health and work efficiency of the crew. Suitable cabin environment can not only keep the crew in good mental condition and ensure efficient work, but also effectively prevent the occurrence of respiratory system diseases. Unlike land buildings, the geographical location and orientation of ships change in real time with the route, latitude and longitude. The change of building load on land has regularity, but there is no regularity at all on ships. There is no software to simulate the change of ship load on a route.

As far as the simulation system is concerned, there is no software to carry out the simulation system of the ship navigation change cabin load simulation. The simulation system built using Modelica language is highly scalable and modifiable, very suitable for co-simulation of complex physical systems, allowing the user to quickly understand the system, optimize the system and system equipment selection. At the same time the continuous development of the system will complement the market gap.

Meteorological Data Selection

Compared with the immobility of land-based buildings relative to the ground, the ship will move relative to the earth's coordinates. There is also a difference in the area and distance a ship sails, with inland and outland routes, ocean routes, short-distance routes, and long-distance routes. During sailing, both ocean temperature, relative wind speed, solar radiation intensity, etc. will change with the ship's movement. In the limited weather data, it will be slightly powerless in the face of the infinitely changing reality. In this case both long and short distance routes should be selected close to the meteorological data.

The meteorological conditions of a ship are different when it is docked and when it is not. For inland routes it is sufficient to use weather data from inland cities, while for ocean routes it is necessary to use data from similar monitoring points on the ocean as far as possible.

II. Base Compartment Model

The most important thing in the chamber model is the transformation of the load in it. For the definition of load in the cabin model, we mainly follow the principle of heat balance. In this paper, we only consider the summer cooling load.

If the ship's voyage is divided into two categories: short-distance round trip and long-distance voyage. Short-distance voyage is such as in cross-river passenger ships and ferries, where the load tends to change regularly and rapidly due to the alternating changes of the sun-illuminated surface; long-distance voyage ships are bulk carriers[1] or container ships[2] for domestic south-north or international cargo transportation, where the load changes more gently.

Assume that the base compartment is set up in the same way as the ground building room. Use Buildings.MixedAir to expand the design.

The cold load is the heat that should be removed from the room at a certain moment to maintain a constant room temperature. During the ship's voyage, the personnel and lighting cooling load remains constant, while the bulkhead thermal conductivity, ventilation and radiation loads change significantly with different sailing areas, and the ventilation load changes the most [3]. The cold load is formed by the heat gain, and the instantaneous heat gain is mainly composed of two parts: the sensible heat gain and the latent heat gain part. The envelope and indoor objects also absorb and store heat in three ways, and when the surface temperature of the envelope and indoor objects is higher than the indoor temperature, heat is released and mixed to get the instantaneous cold load of the room.

2.1 Composition of the heat load of the basic compartment

The heat gain of the foundation compartment can be composed of the following heat gains:
(1) Heat input through the envelope.
(2) Solar radiation heat entering through the exterior windows.
(3) Heat dissipated by the human body
(4) heat dissipated by lighting
(5) Heat dissipation from equipment, appliances, pipes and other internal heat sources
(6) heat dissipation from food or materials
(7) heat carried in by infiltrating air.
(8) The latent heat generated by various moisture dissipation processes.
Ventilation is the most important factor causing the total load variation in the ship's compartment, bulkhead heat conduction and radiation account for a small percentage of the total load and do not have a significant effect on the total load variation, and personnel and lighting are also factors that affect the total load [3].

2.2 About the cold load caused by outdoor enclosure

The cold load caused by the outdoor environment can be analyzed by the heat gain from the external surface of the impervious envelope. This part of heat gain has three components: convective heat exchange between the outdoor air and the wall, radiant heat exchange between the outdoor environment and the wall, and radiant heat from the sun to the wall. One of the most important changes for the compartment is the change of solar radiation. The other calculations are basically unchanged. In the following we will systematically dissect the calculation method of solar radiation.
To calculate the solar radiation, parameters such as surface azimuth and surface tilt are defined, as shown in Figure 1 Figure 2 Figure 3 below.

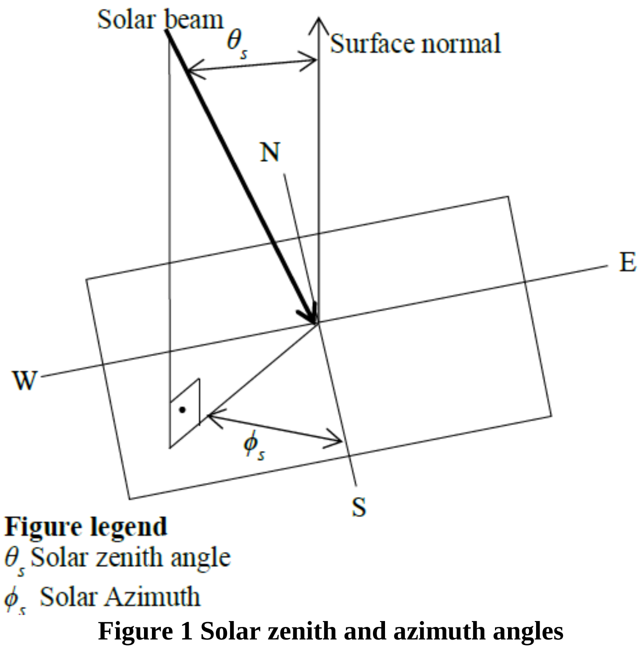

Figure 1 Solar zenith and azimuth angles

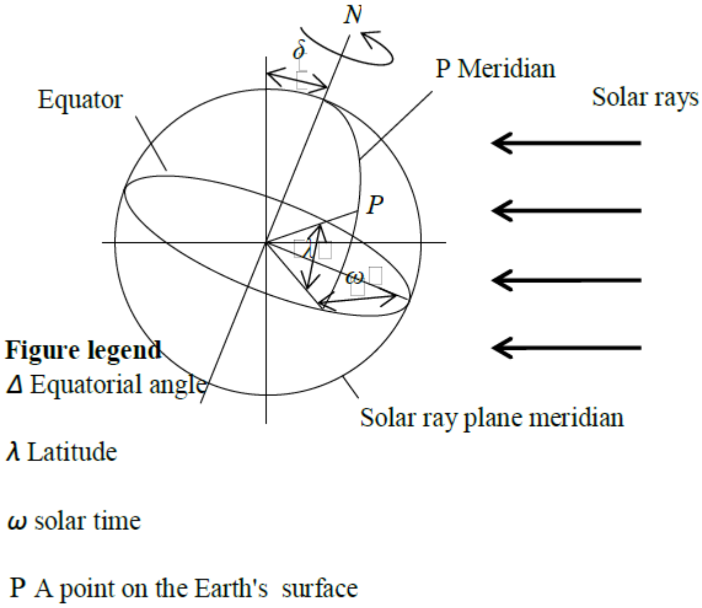

Figure 2 Various angular relationships between the Sun and the Earth

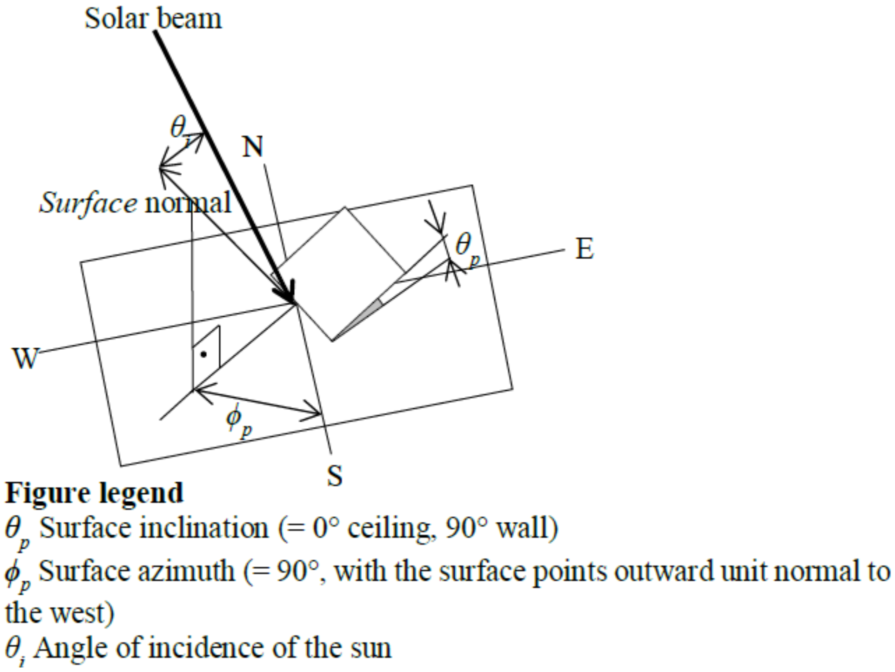

Figure 3 Angle between solar rays and building surface

Regarding the solar azimuth we define 0 when the sun is due south and positive if it is in the west. For the calculation of the solar azimuth, the formula[4] is available.

$$\cos\phi_s(t) = \frac{\sin\lambda\cos\theta_s(t) - \sin\delta(t)}{\cos\lambda\sin\theta_s(t)} \qquad (1)$$

We will now present the model for irect radiation $H_{dir,til}(x,t)$ and scattered solar radiation on inclined surfaces $H_{dif,til}(x,t)$ 。 The model input data are global horizontal radiation $H_{glo,hor}(t)$ and Diffuse horizontal radiation $H_{dif,hor}(t)$. $H_{glo,hor}(t)$ and $H_{dif,hor}(t)$ Included in the meteorological data.

The zenith angle θs(t) can be calculated from equation (2)

$$\cos\theta_s(t)=\cos\lambda\cdot\cos\delta(t)\cdot\cos\omega(t)+\sin\lambda\cdot\sin\delta(t) \quad (2)$$

Cosine of the angle of incidence of direct solar radiation on an inclined surface

$$\begin{aligned}&\cos\theta_i(x,t)\\&=\cos\theta_p\left(\cos\delta(t)\cos\omega(t)\cos\lambda+\sin\delta(t)\sin\lambda\right)\\&+\sin\theta_p\sin\phi_p(x)\cos\delta(t)\sin\omega(t)\\&+\sin\theta_p\cos\phi_p(x)\left(\cos\delta(t)\cos\omega(t)\sin\lambda-\sin\delta(t)\cos\lambda\right)\end{aligned} \quad (3)$$

（1） Direct radiation

Direct solar radiation on the horizontal surface is

$$H_{dir,hor}(t)=H_{glo,hor}(t)-H_{dif,hor}(t). \quad (4)$$

To obtain direct solar radiation from inclined surfaces $H_{dir,til}(x,t)$， We use Lambert's cosine law, which states that the radiation received by a surface is equal to the solar radiation intensity multiplied by the projected surface area. Thus, the direct component of the solar intensity is

$$I_{dir}(t)=\frac{H_{dir,hor}(t)}{\cos\theta_s(t)} \quad (5)$$

$\theta_s(t)$ is the solar zenith angle.so， If $\theta_i(x,t)$ denotes the angle of incidence of solar radiation on an inclined surface, then the irradiance of direct solar radiation per unit of real area is

$$H_{dir,til}(x,t)=I_{dir}(t)\cos\theta_i(x,t). \quad (6)$$

（2） Scattered solar radiation

Obtaining diffuse solar radiation on inclined surfaces $H_{dif,til}(x,t)$， A simple isotropic model and a more detailed Perez model were implemented. Both models have been validated by Ineichen et al [5].

For the cold load calculation of the exterior windows this study is not studied in this research.

The formula for calculating the total heat transfer coefficient of multi-layer wall is

$$K=\frac{1}{\frac{1}{\alpha_1}+\sum_{i=1}^{n}\frac{\delta_i}{\lambda_i}+\frac{1}{\alpha_1}} \quad (7)$$

in the formula：

α1 is the outdoor side wall surface heat transfer coefficient，W/（m2·K）；

α2 is the indoor side wall surface heat transfer coefficient, W/ (m2·K) ;

δiis the wall thickness of each layer, m, can take into account the insulation effect of the air layer;

λiis the thermal conductivity of each wall layer, W/ (m·K) ;

III. Real Cabin

There is almost no difference in the composition of the internal heat source between real cabins and buildings on land. Compared with the above-ground buildings, the ship moves. Here the movement has three meanings, i.e., there is a change in the navigation area, a change in the navigation direction, and a change in the navigation speed.
A change in the sailing area can be characterized using the collection points of that sailing area.
A change in sailing speed changes the velocity of the air relative to the wall.
A change in sailing direction causes a change in the various sun angles, along with a change in the angle of the air relative to the wall.
In this paper, we will focus on the changes in the direction of travel and the sun angle.

3.1 Change in heading angle

The change in heading angle is in essence a change in relative azimuth to the sun.
Heading angle: The extension line is made in front of the longitudinal axis of the carrier, which is the heading line, and the angle from the carrier warp clockwise to the heading line is called the heading (HDG-Heading) [6].
The heading angle can have an effect. The azimuth angle of the sun changes with respect to each side of the ship due to the change of time. During the navigation of the ship, the change of heading causes the azimuth angle of the sun relative to the ship to change, and the superposition of the change of solar azimuth angle on each face on the ship, the intensity of solar radiation directly on each face on the ship will also change. The change of angle is a linear calculation. So it is possible to modify on the basis of the original orientation.

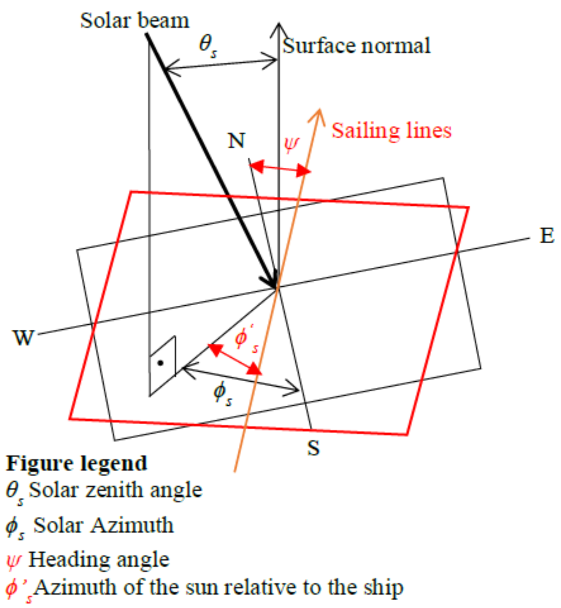

Figure 4 Azimuth of the sun relative to the ship

$$\phi_s^{'} = \phi_s - \psi \tag{8}$$

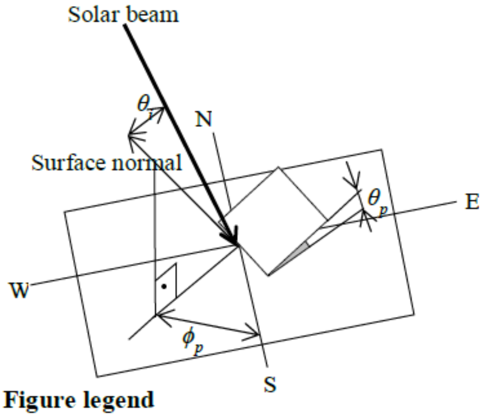

Figure legend

θ_p Surface inclination (= 0° ceiling, 90° wall)

ϕ_p Wall-sun azimuth (= 90°, i.e., the surface points outward unit normal to the west)

θ_i Angle of incidence of the sun

Figure 5Angle between solar rays and building surface

ϕ_p , Wall-solar azimuth, the angle between the projection of solar radiation on the horizontal plane and the normal to the wall;

ϕ_s , Solar Azimuth;

γ , Wall-course azimuth, the angle at which the wall deviates from the reverse extension of the heading;

α , Wall azimuth, the angle at which the wall deviates from the south direction. Wall azimuth = wall - heading azimuth + heading.

$$\alpha = \psi + \gamma \tag{9}$$

3.2 Real Cabin Model Implementation

The real cabin needs to be re-implemented because of the change in heading angle. For this reason the new room model in this paper needs to replace the original ExteriorBoundaryCondition component. This model was copied and modified to build the MyinAng component shown in Figure 6. The figure incAngW and incAngS are the original Building component, and the three inAng latitudes in the figure are set to Shanghai, which are all set to the wall. For MyincAng set to wall facing the reverse of the heading, the initial setting of the ship's heading is due north direction, in 43200 seconds the heading turns due east. For incAngW set to wall facing west, for incAngS set to wall facing south. The simulation is obtained in Figure 7.

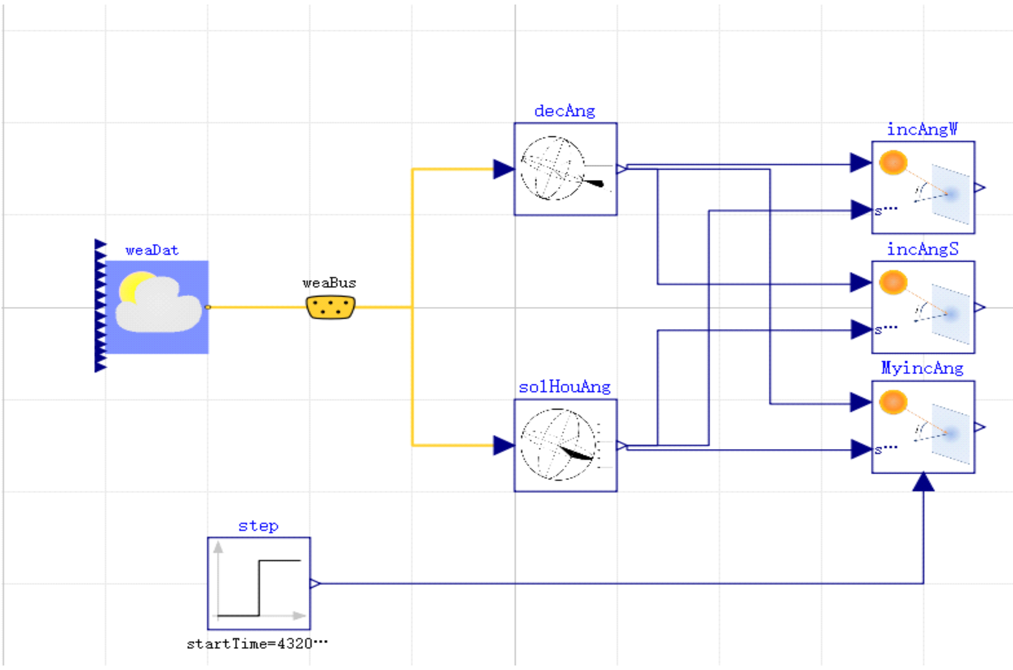

Figure 6 Incidence angle test chart

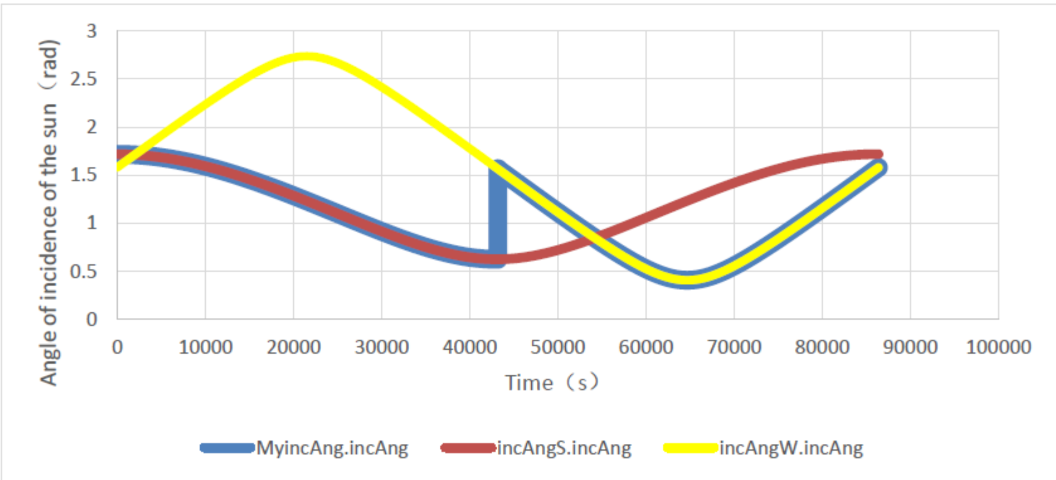

Figure 7 Variation of solar incidence angle graph

3.3Real Cabin Model Simulation

The indoor temperature is 26°C and the outdoor temperature fluctuates sinusoidally. Assume 100mm insulating foam 200mm concrete is used for the wall. Consider a 15m2 wall as facing the opposite direction of the heading. The horizontal radiation intensity is set as a sinusoidal function of clipping negative half-axis with a frequency of 1/86400Hz, and the maximum value is taken at 12:00 noon. The location is set in the sea near Shanghai place.

When the ship's course turns from north to east on the fifth day. The load caused by the wall changes from high to low, which is equivalent to the original south-facing wall becoming a west-facing wall. The time of high radiation intensity is reduced.

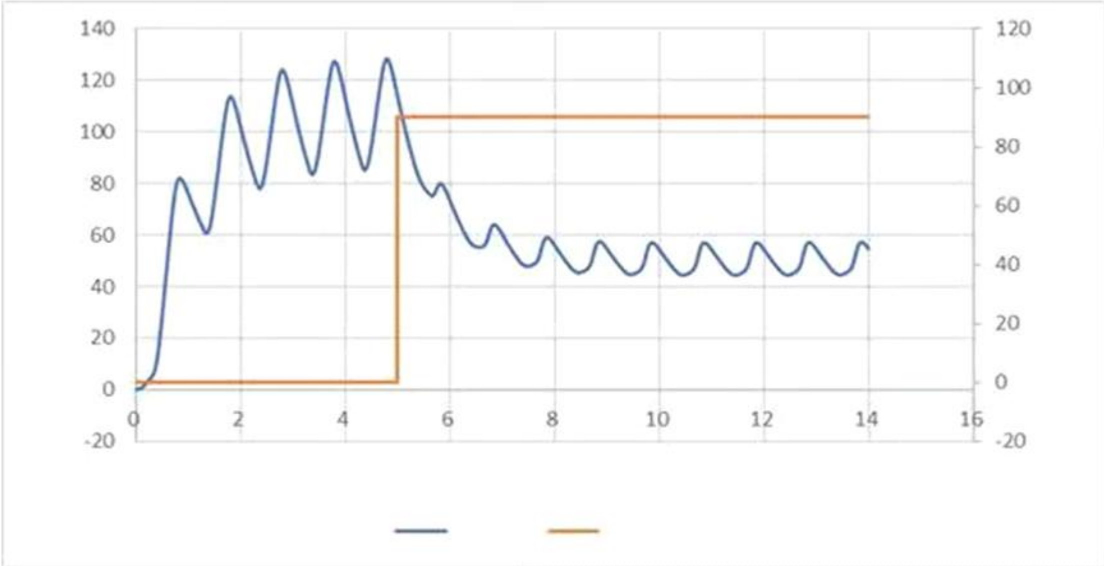

Figure 8 Wall load variation with heading

IV. Conclusion

This paper introduces the use of outdoor meteorological parameters in the Buildings library in the openmodelica software, for which the room is modified. Firstly, the principle of the composition of MixedAir in the Buildings library is analyzed, then the method of calculating the load on the external envelope of the room is analyzed, especially the method of calculating solar radiation, and then the modification of its heading is carried out. So that the cabin with heading angle change load is realized.

References

[1]. Xie Xinlian, Niu Dongxiang, Zhao Ruijia, et al. Study on the allocation of LNG marine transportation routes under the combined transportation mode of resource pool[J]. Journal of Chongqing Jiaotong University (Natural Science Edition): 1-6.

[2]. Yang ZZ, Dong XADAN, Guo LQ. Optimization of container shipping route network on Yangtze River [J/OL]. Journal of Dalian Maritime University, 2014, 40(03): 1-7+12. DOI:10.16411/j.cnki.issn1006-7736.2014.03.011.

[3]. Cheng H, Zhao ZC, Shi Z, et al. Dynamic load simulation analysis of ocean-going ship air conditioning system[J]. Journal of Jiangsu University of Science and Technology (Natural Science Edition), 2015, 29(01): 64-69.

[4]. SELLERS W D. Physical climatology.[M]. Chicago: University of Chicago Press, 1965.

[5]. INEICHEN P, PEREZ R, SEALS R. The importance of correct albedo determination for adequately modeling energy received by tilted surfaces[J/OL]. Solar Energy, 1987, 39(4): 301-305. DOI:10.1016/S0038-092X(87)80016-6.

[6]. Chen Yingyi. Research on micro-inertial heading and attitude system [D/OL]. North Central University, 2005[2022-03-11]. https://kns.cnki.net/KCMS/detail/detail.aspx?dbcode=CMFD&dbname=CMFD0506&filename=2005050407.nh&v=.