Anti-shock Analysis of Marine Ventilation Grid inTime Domain

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Abstract: Based on the modern impact theory, an anti-shock model of the marine ventilation grid was built to simulate its anti-shock performance in time domain with the consideration of the contact stress. The stress was obtained from the anti-shock simulation which could be useful for the anti-shock design and evaluation. The results indicated that the design of the ventilation grid met the requirements of anti-shock.

Introduction

The marine ventilation grids are the interfaces between the environment and the intake/exhaust pipes used for the marine main engine, which plays an important role in the safeguard of the ship's normal working.

With the increase of the requirements on the ship survivability, more and more attentionshave been focused on the anti-shock performance of ship's auxiliary equipment[1-3]. At present, the impact theory can be divided into frequency-domain and time-domain[4-5]. The frequency-domain method is also named DDAM (Dynamic Design Analysis Method, DDAM). In this paper, the anti-shock performance of the marine ventilation grid was analyzed in the time domain.

Impact theory in time domain

According to the impact theory, the shock spectrum in time domain can be equivalent to doubling triangle or doubling half-sine time history curves. Since the triangle time history curve is closer to shockresponse and more convenient for the input, the doubling triangle time history curve is used as the shock spectrum in this simulation.

According to the standardsand specifications, the values of the relevant parameters in the shock spectrum are assigned as follows.

(1)If the quality of the equipment is less than 5 tons, the values of the equivalent parameters used in the shock spectrum are shown in Table 1[6].

Tab 1 Shock spectrum in time domain

Installation position	Type I	
Orientation	Vertical	Horizontal
Equivalent Acceleration Spectrum/A_0(g)	320	280
Equivalent Speed Spectrum/V_0(m/s)	7.0	6.0
Equivalent Displacement Spectrum/D_0(cm)	4.3	3.0

(2)If the quality of the equipment is greater than 5 tons, theequivalentspeed and acceleration in the shock spectrum are required to reduce. The reduction formulas are shown in below.

$$\frac{A}{A_0}=\left(\frac{m}{m_0}\right)^{-0.537} \qquad (1\text{-}1)$$

$$\frac{V}{V_0}=\left(\frac{m}{m_0}\right)^{-0.4} \qquad (1\text{-}2)$$

In above formulas, the variable m means the quality of equipment and its unit is t.The variable m0 means the constant quality,which is constantly equal to 5t. The variable A means theequivalent acceleration value after reduction and its unit is g. The variable V means the equivalentspeed value after reduction and its unit is m/s.

Numerical model

Geometry model

The assembly of the ventilationgrid consists of turbogrid plates, gasket ring, mounting base plate, connecting bolt and nut. Based on the commercial CAD software, the three-dimensional geometry models of the parts in ventilationgrid assembly were built. According to theirinteractive connecting relation, the assembly model of the ventilationgrid was obtained, as Figure 1 shows.

Mesh model

The mesh model of the assembly was obtained by the special pre-processing commercial software Hypermesh. Most of the meshes in the assembly arehexahedral elements C3D8as Figure 2 shows.The high quality of the mesh ensures the accuracy of the results.

Fig. 1 CAD model of ventilation grid assembly

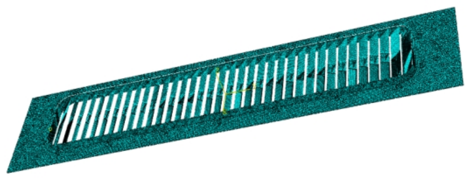

Fig.2 Mesh model of ventilation grid assembly

Material Properties

The parts in ventilation grid assembly are made of different material. The values of different metal material property parameters used in the numerical modelare assigned in accordance with relevantmechanical design manual. The gasket ring is made of silicon rubber and the most widely used Mooney-Rivlin constitutive model is used in the numerical model. The material coefficient value is defined as C01/C10=0.25, C10=0.485MPa, C01=0.1206MPa. The compressibility coefficient value is defined as D1=2.5E-5. The yield strength$\sigma_s$is defined as 4MPa.

Boundary conditions

(1)The boundary conditions of the contact interfaces between the connecting bolt and the mounting base plate, turbogrid plates were defined as Tie, which is a type of contact relation between the interfaces.

(2)The boundary conditions of the contact interfaces between gasket ring and turbogrid plates, mounting base plate were defined as Tie.

(3)In the impact model, all the degrees of freedom on the side surfaces around the mounting base plate were constrained. The longitudinal, transversal and vertical impact load were applied respectively. When the impact load was applied at a direction, the constraints on the side surface of the mounting base plate should be released at that direction.

Results and discussion

According to the shock spectrum in time domain, the vertical impact load is maximum in three directions. However, the transversal rigidityof the ventilation grid is weakest. So the results of stress contoursunder thetransverseimpact load were shown in below.

(1)Turbogrid plates

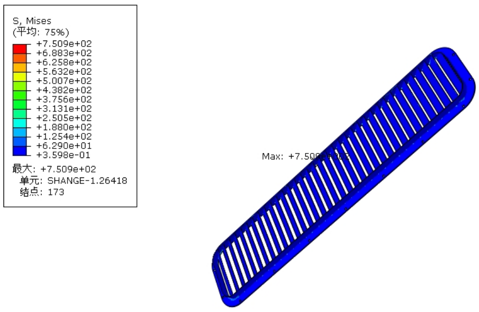

Fig.3.Stress contours ofturbogrid plates under thetransversal shock in time domain

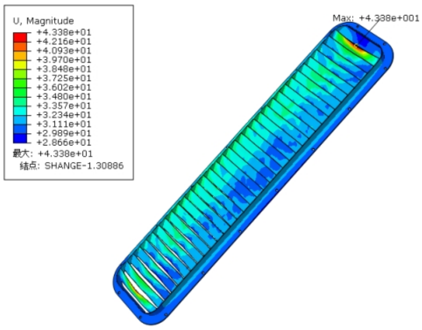

Fig.4Strain contours ofturbogrid plates under thetransversal shock in time domain

(2) Gasket ring

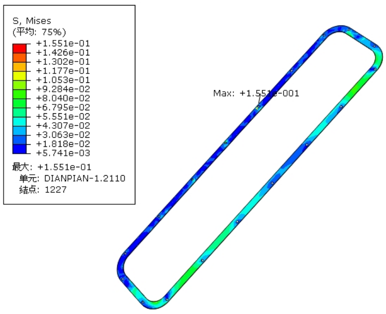

Fig.5Stress contours of gasket ring under the transversalshock in time domain

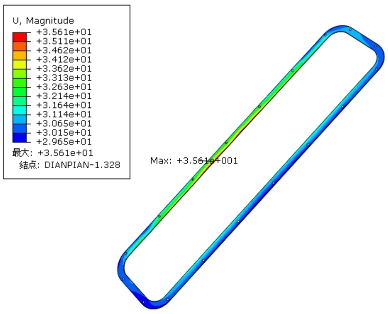

Fig.6Strain contours of gasket ring under the transversal shock in time domain

(3) Ventilation grid assembly

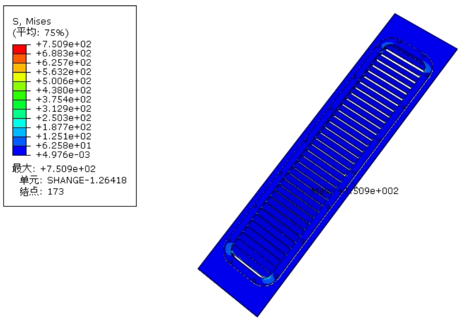

Fig.7Stress contours of ventilation grid assembly underthetransversal shock in time domain

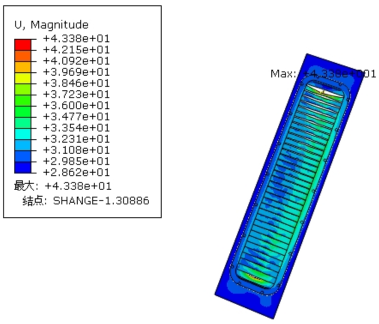

Fig.8Strain contours of ventilation grid assembly under thetransversal shock in time domain

The results of the maximum stress and strain of the parts in the ventilation grid assembly under three directional impact load in time domain were list in the Tab2. For convenient for comparing, the yield strength of the different material were also list in the same table. By comparison, it can be seen that the maximum stress values of all the parts in the ventilation grid assemblyare lower than the yield strength of the material.

Tab 2Maximumstress and strain of parts under three directional impact load in time domain

component		turbogrid plates	gasket ring	bolt	nut
yield stress /MPa		900	4	900	200
vertical impact	maximumstress/MPa	550.00	0.10	231.30	80.00
	maximum strain/mm	8.35	0.06	0.85	0.03
horizontal impact	maximumstress /MPa	438.00	0.16	289.50	136.90
	maximum strain/mm	14.76	6.99	4.64	4.59
longitudinal impact	maximumstress /MPa	80.90	0.08	9.73	10.54
	maximum strain/mm	0.10	0.09	0.19	0.12

Conclusion

In this paper, an anti-impact numerical model of the ventilation grid assembly was built and its anti-shock performance was analyzed under three directional impact load in time domain. The maximum stress and strain in the parts were obtained. From the results, the conclusion can be drown as below.

The maximum stress values in the parts of ventilation grid assembly are lower than the yield strength of the material. So it can be drown that the parts of ventilation grid assembly meet the requirement of the relevant shock standards and specifications.

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