11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

The Study on Impact Response of Diesel Engine Based on Finite Element Method

Shi Dongyan.[1,*], Gao Shan[2]. Author [2] and Song Jingyuan[3].

[1] College of Mechanical and Electronic Engineering, Harbin Engineering University, Harbin,150001,shidongyan@hrbeu.edu.cn
[2] College of Mechanical and Electronic Engineering, Harbin Engineering University, Harbin,150001,gaoshan@hrbeu.edu.cn
[3] College of Mechanical and Electronic Engineering, Harbin Engineering University, Harbin,150001,songjingyuan@hrbeu.edu.cn

Key Words: *diesel engine; modal analysis; impact response; integration.*

The diesel engine's ability to function well under impact is directly related to sailing and operating of ship. Therefore, the study on impact response of diesel engine has great meaning. This paper first builds the finite element model of diesel engine. Then the modal analysis of diesel engine and its parts has been performed. By conducting the modal analysis not only the finite element model has been verified, but the dynamic characteristics have been acquired. The results show that the assembly has the lowest frequencies of low order modes while the cylinder head has the highest frequencies of low order modes. This investigation provides a valuable reference to estimate the response of diesel engine under impact.

As the finite element model has been verified, the investigation on impact response of diesel engine has been conducted. This paper adopts dynamic design analysis method (DDAM) and real time simulation method to analyze the impact response of diesel engine separately in frequency domain[1] and time domain[2]. The load in DDAM method is a spectrum based on frequency domain that is acquired by empirical formula which is proposed by American naval laboratory[3]. Real time simulation method is based on the stress wave propagation theory.[4]The load in real time simulation method is described by sine wave. The response of diesel engine under impact from different direction has been analyzed in both methods. The stress distribution in both methods has been shown in Fig. 1 and Fig. 2. The stress distribution shows that the trends of stress distribution in both methods are similar. The maximum stress in DDAM method is a little higher than that in real time simulation method. It is because that DDAM method is a conservative method and can only consider the liner elastic behavior of material. The response of diesel engine in real time simulation method is much closer to the real solution.

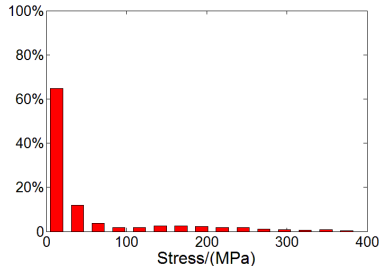

Fig. 1 stress distribution in DDAM method

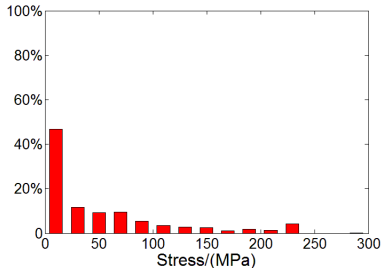

Fig. 2 stress distribution in real time simulation method

Then the influence of ship on impact response of diesel engine has been discussed. The diesel engine has lumped parameter system characteristics according to modal analysis. The abstract model has been built as shown in Fig. 3. The acceleration of diesel engine in coupled model and uncoupled model has been shown in Fig. 4. The results shows that the maximum

acceleration is smaller and the period is longer in coupled system. Therefore, it is necessary to consider the flexibility of the ship.

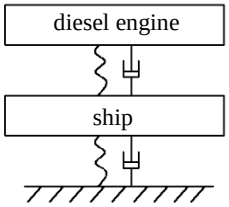

Fig. 3 abstract model

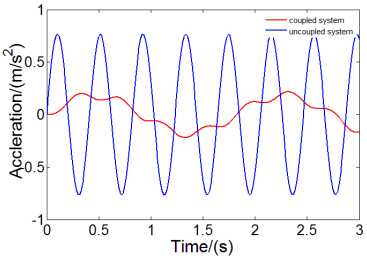

Fig. 4 accerleration of diesel engine in both models

Finally the diesel engine has been assembled on the hull. In real case, diesel engine is connected to the shock absorber. This paper adopts an appropriate way of simulating the link constraint based on flexible coupled system theory. The shock absorber is simulated by spring element. The degrees of freedom of mounting are coupled with spring element and the degrees of freedom of spring element are coupled with hull. Then diesel engine and ship become integration. In this method, the impact is no longer from one direction, and the interaction between diesel engine and hull has been considered. The results show that the stress is smaller in integration model, which agrees with the results in abstract model. The spectral analysis of stress in both models has been shown in Fig. 5 and Fig. 6.

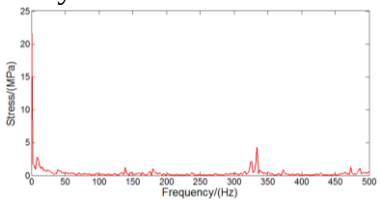

Fig. 5 spectral analysis of stress in non-integration model

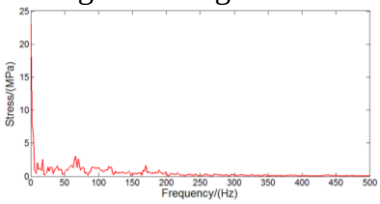

Fig. 6 spectral analysis of stress in integration model

The stress in non-integration model mainly distributes in frequencies of 300Hz-350Hz, while the stress in integration model mainly distributes in frequencies of 50Hz-100Hz. The spectral analysis shows that the stress of integration model distributes in lower frequency ranges than of non-integration model. This illustrates that response period in integration model is longer than that in non-integration model, which accords to the results in abstract model. The investigation of impact response in integration model shows that the flexibility of ship cannot be ignored. This paper provides a valuable method to study the dynamic response of marine equipment under underwater explosion impact.

References:

[1]. Tao, J., et al. The analysis on shock design spectrum of shipboard equipments. 2009.
[2]. Noels, L., L. Stainier and J.P. Ponthot, Energy conserving balance of explicit time steps to combine implicit and explicit algorithms in structural dynamics. Computer Methods in Applied Mechanics and Engineering, 2006. 195(19 – 22): p. 2169 - 2192.
[3]. Tao, J., et al. Simulation of Resistant Shock Capability of Missile Launcher Based on DDAM The analysis on shock design spectrum of shipboard equipments. 2009.
[4]. Noh, G. and K. Bathe, An explicit time integration scheme for the analysis of wave propagations. Computers & Structures, 2013. 129(0): p. 178 - 193.