

Dynamic Effects on Stress Concentration around Defects within a Thick Steel Plate

Tadashi Shibue , Takashi Hayami

School of Biology Oriented Science and Technology, Kinki University
Kinokawa, Wakayama, JAPAN

Shinji Nakano

Mitsubishi Automotive Engineering Co.,Ltd.
Okazaki, Aichi, JAPAN

ABSTRACT

Dynamic effects on stress concentration around defects within a thick steel plate are considered based on a series of numerical simulation using a multi-purpose finite element code 'LS-DYNA'. The simulation assumes a defect within a thick steel plate which composes a ship structure, and an impact load due to a collision or an explosion is applied to the plate to see the stress distribution around the defect. As the phenomena are very complex to deal with, a linear elastic stress-strain relation is employed in the numerical simulation to get better understanding. A part of a thick steel plate is selected as the simulation block. That is a 60mm long square bar with 20mm edge length. One end of the bar is fixed and a stepping load with 1 microsecond duration is applied at the other end. It is assumed that a defect has a solid of revolution shape obtained by a rounded rectangle with its rotation axis in thickness direction and its center is placed at the center of the rectangular cross section at the center of bar length. A series of numerical simulation is carried out with two parameters. One is the diameter of a defect in its rotation axis and the other is the diameter in the surface normal to the rotation axis.

KEY WORDS: impact; stress concentration; defect; plate; simulation; ship structure; collision; FEM; LS-DYNA

INTRODUCTION

The demand for the strength evaluation of the structures under the transient loading is increasing. The strength evaluation of such structure is not so easy, because the actual stress in the structure under the transient loading is difficult to estimate. The difficulty increases when some defects are included within the structural members. There are many studies done on the static stress concentration problems, and the results are commonly used for the design of the structures. There are many studies done on the dynamic stress concentration problems also. Because of the large variety of factors affect to the dynamic stress concentration, such as the ratio between diameter of the defect and thickness of the plate, the wave form of the applied load, etc., the results are not commonly used for the design of the structures.

This study deals with dynamic stress concentration effects on the 20mm thick steel plate, commonly used for the ship and marine structures, by using a finite element method for transient analysis. We assumed the defects to have the shape of solid of revolution obtained by a rounded rectangle, and to be placed at the center of the thickness of the steel plate, which simulate the blow holes within the weld joints. A series of numerical simulation is carried out to estimate the dynamic stress concentration by changing the size and the shape of defects under the very short duration of 1.0 microsecond impulse load applied at the one end section of the plate. The reason why we employed the very short duration impulsive load is to avoid the effects of the reflecting stress wave from the other end section of the plate. We assume that mass density of the bond metal is same to that of the mother material, and neglect the boundary between the bond metal and the mother material. As a result, the graphs for the estimation of the dynamic stress concentration are obtained showing the effects of size and shape of defects.

PROPAGATION OF IMPACT FORCES

Impact forces applied to a ship body are generated mostly by collisions between a ship body and a quay or by explosion accidents. They are also generated by collisions between a ship body and a sea water surface.

The impact force is characterized as the force varies with time which works within a very short time. The value of impact force varies from very small value to very large value. When the impact force is initiated by a collision or an explosion, the dissipated energy is determined depending to the situations. In case of a collision, the energy is determined by the mass of colliding object and the colliding velocity. In case of an explosion, the energy is determined by the mass of explosives and the distance from the explosives.

When a certain amount of energy is transmitted within a very short time, the value of applied force must be very large. This is one reason why marine structures tend to fail or deform under the impact forces.

When the impact force is applied to the thick steel plate, the applied force is transmitted through the plate as stress waves. When a stress wave arrives at the surface of a plate, the stress wave reflects at the surface of the plate and the stress wave changes its wave form