A study on fatigue fracture under non-constant load

불균일 하중을 받는 피로 파괴에 관한 연구

천안공업대학 조재웅*, 이은종

Jae- Ung Cho*, Eun- Jong Lee
Cheonan National Technical College

국문요약

실무 현장에서 피로 파괴가 잘 일어나고 있는 상황이다. 그런데 그 하중도 불규칙적으로 일어나고 있어 예측이 불가능하여 언제 파괴가 일어나는지를 잘 알 수가 없는 상황이다. 본 연구에서는 그러한 불규칙적인 피로 하중을 시뮬레이션하여 그 재료의 안정성과 수명 관계를 Ansys workbench 프로그램을 이용하여 이론적으로 해석하여 보았다. 이러한 결과들을 실제 구조물에서 응용하면 그 파손 방지 및 내구성을 예측하는데 활용이 크다고 본다.

Abstract

There are fatigue fractures at the practical area. The fatigue load happens non- constantly. As it is impossible to be predicted, it can not be known when the fracture happens. Non -constant fatigue load is simulated in this study. The stability and the life of the material are analyzed theoretically by the program of Ansys workbench. These results are greatly applied as the practical structures to predict the prevention of failure and the endurance.

Ⅰ.Introduction

It is estimated that 50-90% of structural failure is due to fatigue. Thus there is a need for quality fatigue design tools(1-2). In this study, the fatigue tool is available in providing both flexibility and usefulness comparable to other types of analysis tools. This is why many designers and analysts use "in-house" fatigue programs which cost much time and money to develop. It is hoped that these designers and analysts, given a proper library of fatigue tools could quickly and accurately conduct a fatigue analysis suited to their needs. Its focus is to provide useful information to the design engineer when fatigue failure may be a concern. Fatigue results can have a convergence attached. A stress-life approach has been adopted for conducting a fatigue analysis.

Several options such as accounting for mean stress and loading conditions are available.

2. Model and material

The dimensions of the specimen are shown in Fig. 1 (unit:mm). Its mesh is also shown in Fig. 1. The numbers of nodes and elements are 4631 and 912. The material property of the specimen is shown in Table 1. Its constraint is fixed at the upper and the mean pressure is applied on the upper of the specimen by 100 MPa.

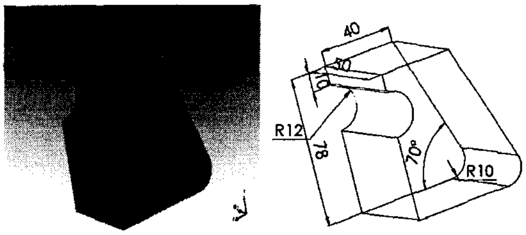


Fig. 1. The mesh and dimensions of the specimen (unit: mm)

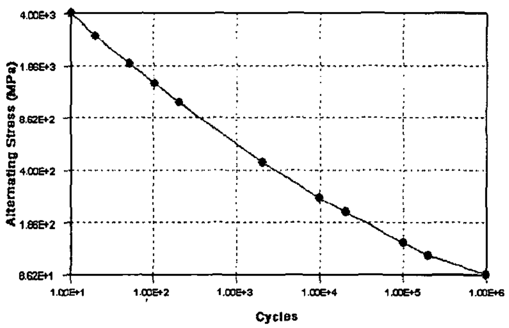


Fig. 2 S-N curves in fatigue

3. Analysis

A large part of a fatigue analysis is getting an accurate description of the fatigue material properties. Since fatigue is so empirical, sample fatigue curves are included only for structural steel and aluminum materials(3). These properties are included as a guide only with intent for the user to provide his own fatigue data for more accurate analysis(4-5).

Fatigue material data stored as tabular alternating stress vs. life points. Fig. 2 is a screen shot showing a fatigue material data graphically. Fatigue results can be added before or after a stress solution has been performed. To create fatigue results, a fatigue tool must first be inserted into the tree. This can be done through the solution toolbar or through context menu.

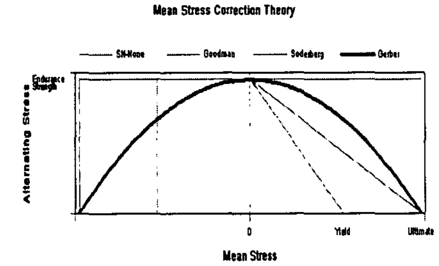
The detailed view of the fatigue tool is used to define the various aspects of a fatigue analysis such as loading type, handling of mean stress effects and more.

In this study, instead of using a single load ratio to calculate the alternating and mean stress, the load ratio varies over time. Cumulative damage calculations including cycle counting and damage summation need to be done. The load scaling comes from an external data file provided by the user and is simply a list of scale factors. Several sample load histories can be found in the "Load Histories" directory under the "Engineering Data" folder. Setting the loading type to "History Data" in the fatigue tool specifies non-constant amplitude loading. Several analysis options are available for non-constant amplitude loading.

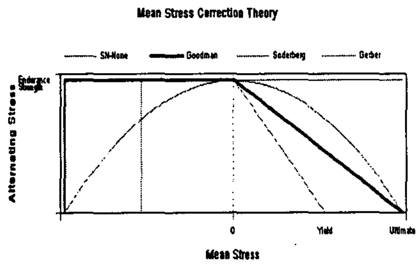
The value of infinite life will be used if the alternating stress is beyond the limit of the SN curve. Setting a higher value will make small stress cycles less damaging if they occur many times. An infinite life is 10^9 cycles in this study.

Each output will now be described and compared in the loads of SN-None, Goodman, Soderberg, and Gerber as shown in Fig. 3.

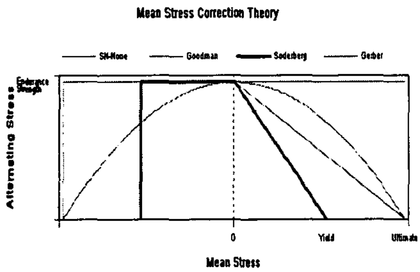
Several results for evaluating fatigue are available to the user. Some are contour plots of a specific result over the model while others give information about the most damaged point in the model(or the most damaged point in the scope of the result). Outputs include fatigue life, damage and damage matrix output.



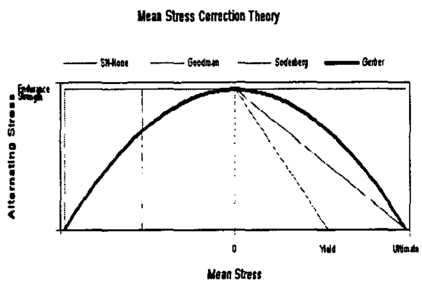
(a) SN -None



(b) Goodman



(c) Soderberg



(d) Gerber

Fig. 3 Mean stress correction theory

4. Conclusions

The results of computer simulation in fatigue analysis of this study are as follows;

1. The life and damage of on the every part of the fatigue specimen can be known.
2. The available lives are compared with every loading variation type.
3. The damage matrix results can be helpful in determining the effects of small stress cycles in any loading history. The damage matrices also illustrate the possible effects of infinite life.
4. The safety and the stability of fatigue specimen according to the non-constant loading can be estimated by fatigue tools of Ansys workbench.

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