한국소성가공학회 2008년도 춘계학술대회 논문집 pp. 391~394

수치적 접근을 통한 CID필터 형상이 내력에 미치는 영향 분석 연구

부이히엔빈[1]· 김상목[1]· 구태완[2]· 김 정[2]· 강범수[#]

Analysis of Parameters Affecting on Durability of CID Filter using Numerical Method

V. H. Bui, S. M. Kim, T. W. Ku, J. Kim, B. S. Kang

Abstract

Durability of product is an important technical parameter of a current interception device (CID) filter. This parameter is influenced by several factors, such as: environment condition, external force, shape of device, heat and so on. In this study, the effect of the geometry of the device on durability was carried out. The effect of shape on durability of device is presented by force-carrying capacity that a device can sustain a maximum external force. Studied parameters of the CID filter's geometry include clearance, thickness, and corner radius. Fracture criterion of Cockcroft and Latham was also used to predict the maximum force-carrying capacity of device.

Key Words : Fracture criterion, force-carrying capacity, clearance, corner radius.

1. Introduction

Nowadays, battery is a prevalently used device in most electronic equipment, so the safety of the battery should be concerned. The CID filter is a device used to prevent battery from explosion. Therefore, determining what parameters affect durability of the CID filter is important task so that the force causing the break in the CID is definitely predicted. he shape of the CID filter determines the force-carrying capacity causing a failure in the device. Therefore, the result of studying the effects of the shape on the CID filter's durability is very useful so that we can choose an appropriate shape for this device. In order to determine the force-carrying capacity of the CID filter, several experiments were carried out, Fig.2 is the model of experiments. The force was applied at the center of device, and the maximum force that the

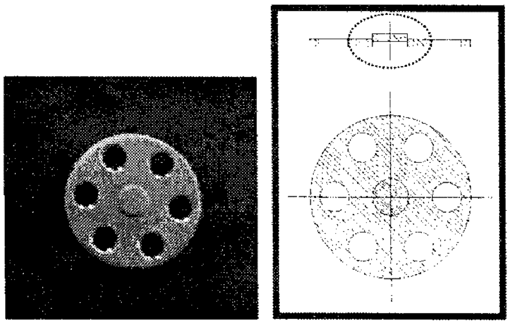


Fig.1 The figure of the CID Filter

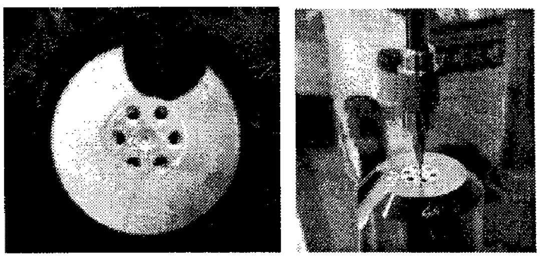


Fig.2 Force test experiment

1. 부산대학교 항공우주공학과 대학원
2. 부산대학교 항공우주공학과
교신저자: 부산대학교 항공우주공학과,
E-mail : bskang@pusan.ac.kr

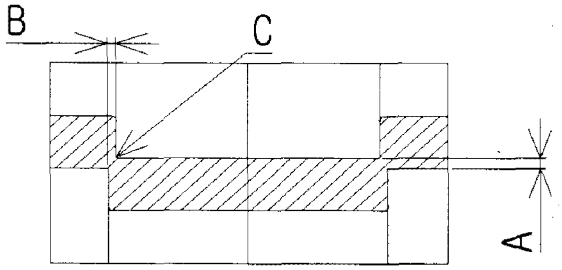


Fig.3 Shape of the center hole

Table 1 Material properties of Al 1050H16

Yield stress, σ_Y (MPa)	117.44
Ultimate stress, σ_u (MPa)	126.49
Module of Elasticity, E (GPa)	69
Yield strain, ε_Y	0.0039
Elongation (%)	5.25

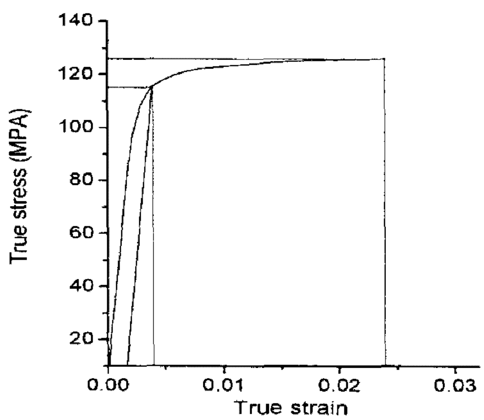


Fig.4 Stress-strain curve

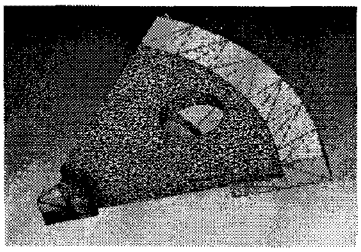


Fig.5 Initial mesh of specimen

product can sustain would be obtained for every case. Besides determining this force by experiment, which takes lots of time and the cost, another prevalent method can also be used is numerical analysis. In recent years, numerical simulations have been used to reduce the time and cost for production and optimal processes. In numerical analysis the failure of a specimen will also be implied by using fracture phenomenon. The fracture phenomenon occurs when the history of stress caused by the applied force meets the threshold value of fracture criterion. The commercial code used to simulate was DEFORM Version 8.0 [1]. The geometry of the CID filter included three parameters: thickness (A), clearance (B) and corner radius (C) shown in Fig.3.

2. Experiment and simulation method

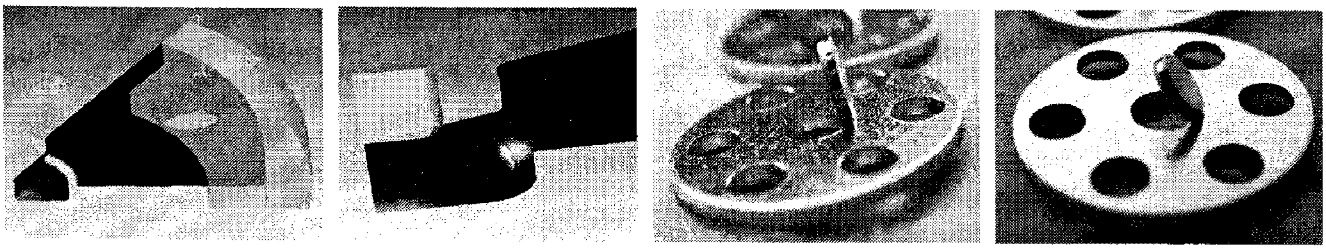
2.1 Mechanic properties of the material

The used material of the CID filter is aluminum 1050H16. Uni-axial tensile tests for a dog-bone specimen of 200 mm of length, 12.5mm of width, and 0.5mm of thickness were carried out to obtain mechanical properties of the material. Table.1 shows the tensile mechanical properties of the material. The stress-strain relationship was shown in Fig.4.

2.2 Simulation model

In this study a numerical model similar to model of experiment was used to study the effect of shape on durability of the CID filter. 1/6 of the CID filter was simulated in 3D model so the quantity of elements was reduced to diminish the time for calculation during simulation. Tetrahedral elements were used for finite element method. According to the experiment, the crack occurred at the weakest region of specimen. In other words, the crack would be occurred at the regions having smallest thickness so these regions would be meshed with fine mesh and the other regions would be meshed with coarse mesh. The initial mesh of specimen was depicted in Fig.5. The material of specimen was considered as a rigid-plastic object, and the tools were defined as rigid bodies. The process was considered quasi-static, and hence the effects of strain rate were neglected.

During simulation, re-meshing was needed step when elements undergo large distortion in the weak region, at that time the Jacobian matrix is negative, and the



(a) (b)

Fig.6 (a) Simulation result (b) experiment result

old mesh can not be used any more. In order to continue the analysis at that stage, a new mesh would be generated.

2.3 Simulation condition

The used material was Aluminum 1050H16 of 0.5mm thickness and the blank has 11 mm of outer diameter. It was assumed that the mechanical properties of the material are isotropic and its deformation behavior follows the Von-Mises yield criterion. The used flow stress equation is given with a constitutional model as following:

$$\bar{\sigma} = f(\bar{\varepsilon}, \dot{\bar{\varepsilon}}, T) \qquad (1)$$

where, $\bar{\sigma}$ is the effective stress, $\bar{\varepsilon}$ is the effective strain, $\dot{\bar{\varepsilon}}$ is the effective strain rate, and T is the temperature. The friction contact between sheet and tool follows Coulomb's law:

$$\tau_f = \mu \sigma_n \qquad (2)$$

where, τ_f is the friction force, σ_n is the normal stress, and μ is the friction coefficient. The friction coefficient between the tool and the material was assumed to be 0.2, which corresponding to the no-lubrication condition.

In order to know the quantity of force that the device can sustain, the finite element method will be linked with fracture criterion. In the analysis, the Cockcroft and Latham expression [2] modified by Jeong et al.[3] was used to calculate the history of stress, implied by damage value:

$$C = \int_0^{\bar{\varepsilon}_f} \frac{\sigma_{max}}{\bar{\sigma}} d\bar{\varepsilon} \qquad (3)$$

where, $\bar{\varepsilon}_f$: the equivalent fracture strain, σ_{max} the maximum principle tensile stress, $\bar{\sigma}$: the equivalent stress, C is the damage value. The fracture occurs when C meets the criteria value. The fracture criterion C=0.0073 was calculated from experiment.

3. Result and discussion

The dangerous regions or the region that the crack occurs were depicted by the distribution of fracture criterion C calculated from equation (3) in numerical simulation. Fig.6 showed the maximum value of C, for all cases the initial fracture site was occurred at the corner of bottom of specimen.

3.1 Influence of parameter A

In order to analyze load-carrying capacity of specimen influenced by the thickness parameter A, the maximum force that the specimen can sustain for various A was obtained. The parameter A was changed A= 0.1, 0.17, 0.2 and 0.25 mm with B= 0 mm and C= 0.03 mm.

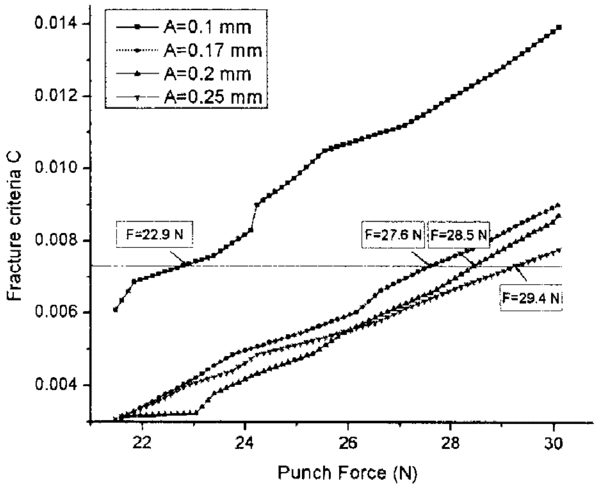


Fig.7 Distribution of fracture criteria *C* v.s A

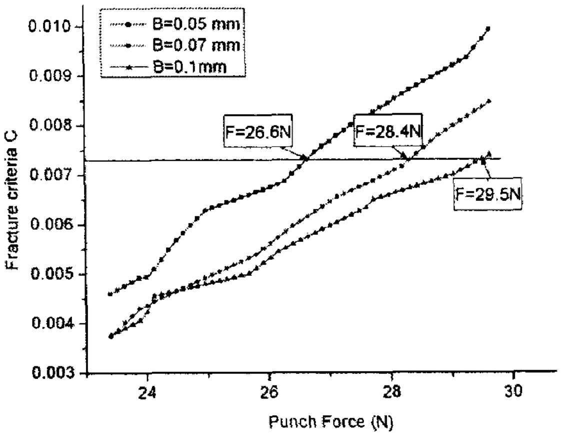


Fig.8 Distribution of fracture criteria *C* v.s B

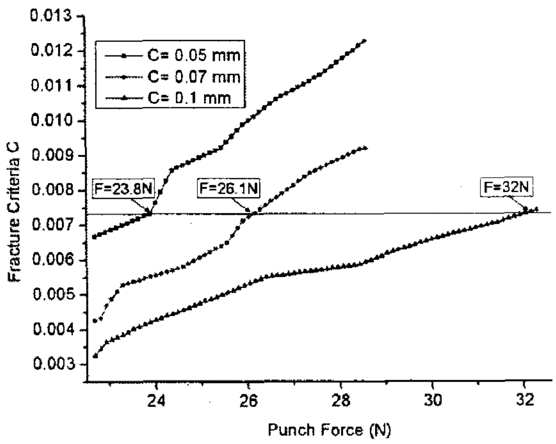


Fig.9 Distribution of fracture criteria *C* v.s C

Fig.7 presents the distribution of maximum integral *C* for each case. For all case, the integral *C* over step 0.0073 implied the failure of the specimen, and the predicted failure region was in good agreement with the experiment, Fig.6. It is easy to realize that the force that the specimen can sustain increases with the increase in thickness A. The maximum force that the specimen can sustain was also showed in Fig.7.

3.2 Influence of parameter B

In order to analysis the effects of clearance B, the diameter of center hole was reduced to increase the clearance. The clearance B was 0.05, 0.07, and 0.1 mm proper to clearance 10%, 14%, and 20%. Distribution of maximum integral *C* was depicted in Fig.8. The figure showed an increase in clearance B causes an increase in force-carrying capacity of device.

3.3 Influence of parameter C

Parameter C indicated corner radius of device, and was changed C= 0.05, 0.07, and 0.1 mm for both corner (inside and outside). Fig.9 showed distribution of *C* for each case of corner radius C. Similarly, force-carrying capacity of device was also increase with the increase in corner radius C.

4. Conclusion

In this study, the CID filter, the effect of shape on durability of device was obtained from the simulation result and experiment result. We can conclude some effects of the shape on durability of device as following:

(1) The influence of thickness causes the increase in force-carrying capacity of the CID filter if we increase this thickness.

(2) Force-carrying capacity of the CID Filter increases with the increase in clearance B.

(3) Similarly, when product-corner C increases, the maximum force that the device can sustain is also increased.

Acknowledgements

This work was completed with the support of the project of the Laboratory of Excellence by the MOE, the MOCIE and the MOLAB. The second author would like to acknowledge the support of the research program, the second stage of Brain Korea 21 project in 2008. And the last author would like to thank the partial support by grants-in-aid for the National Core Research Center Program from MOST/KOSEF (No. R15-2006-022-02002-0).

References

[1] DEFORM user's guide, Science forming technologies corporation, Columbus, OH, 1993

[2] M.G Cockcroft, D.J. Latham, National Engineering Laboratory, Report No.240, 1996.

[3] S.H. Jeong, J.J. Kang, S.I. Oh, in: Proceeding of the Fifth ICTP II, 1996, p.631.