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A STUDY ON CUSHIONING CHARACTERISTICS OF AIRBAG WITH CONSTANT VENTING AREA

Wen Jin-peng[1(*)], Xue Jiang[1], Zhang Si-Cai[1], Li Bin[2]
[1]Institute of Systems Engineering, China Academy of Engineering Physics, Mianyang, China
[2]School of Aeronautics, Northwestern Polytechnical University, Xi'an, China
[(*)]*Email:* 401wenjp@caep.cn

ABSTRACT

In the study of the cushioning characteristics of airbag with constant venting area, based on the energy conservation principle and thermal dynamics equations, an analytical model of airbag with constant venting area was proposed and validated by LS-DYNA and experiment. Then the cushioning characteristics of vertical cylindrical airbag with constant venting area were investigated with this model. A series of calculations were conducted to find out the influence of initial inflation pressure, venting area and the triggering condition of the venting orifice on cushioning properties.

Keywords: aerospace structure and design, impact attenuation, airbag, cushioning.

INTRODUCTION

As an attractive means for soft landing and heavy airdrop delivery, cushioning airbag is attracting more and more research attention. Various airbags have provided a good cushioning protection in the soft landing field of space vehicles or unmanned aerial vehicles. At present, the working performance of the cushioning airbag can be evaluated by means of experimental research and numerical analysis. Most of the work is based on the peak overload during the cushioning process, and the energy absorption rate of the cushioning system is less involved, and cannot fully reflect the airbag cushioning system performance. In this paper, the energy conservation principle and thermal dynamics equations are used to establish the analytical model of the airbag with constant venting area. The cushioning characteristics of the vertical cylindrical airbag are studied.

For the airbag with constant venting area, assume that the gas inside the airbag is the ideal gas. In the processing of airbag compression stage and gas bleed stage, the energy conservation equation can be expressed as:

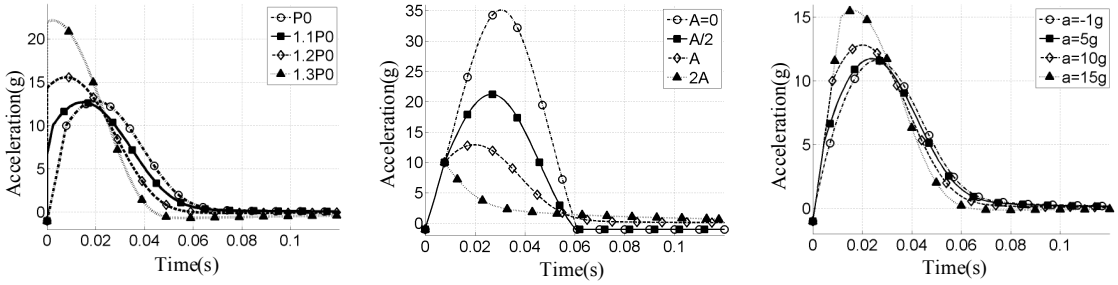
$$\Delta W + \Delta Q_l = \Delta E_k + \Delta E_p + \Delta U + \Delta E_f \tag{1}$$

Where ΔW is the work done by the external force on the system, ΔQ_l is the internal energy of the gas flowing out of airbag, ΔE_k is the kinetic energy change of the system, ΔE_p is the potential energy change, ΔU is the change in airbag gas internal energy, ΔE_f is the change in airbag fabric stretch potential energy.

RESULTS AND CONCLUSIONS

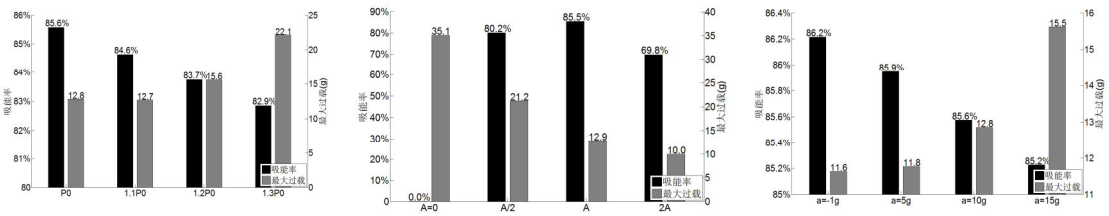
The influences of the parameters of the vertical cylindrical airbag on cushioning characteristics are shown in Fig. 1. And the influences on energy absorbing ratio and peak

acceleration are shown in Fig. 2. The airbag parameters considered include initial inflation pressure, venting area and the triggering condition of the venting orifice. Numerical results show that the initial inflation pressure and the triggering condition of the venting orifice are key parameters to affect the cushioning properties, and when the initial inflation pressure was less than the initial limit pressure, the appropriate increase of initial inflation pressure and the appropriate triggering condition can reduce the volume of the airbag and maintain peak overload of the equipment at a reasonable level. The reasonable venting area can improve the energy absorbing ratio, reduce the peak overload and prevent the airbag rebound.



a) initial pressure b) venting area c) the triggering condition of the venting orifice

Fig. 1 - Effect of the parameters of the vertical cylindrical airbag on cushioning characteristics



a) initial pressure b) venting area c) the triggering condition of the venting orifice

Fig. 2 - Effect of the parameters of the vertical cylindrical airbag on energy absorbing ratio and peak acceleration

In this paper, the dynamic model of cushioning airbag with constant venting area was established and verified by comparing with LS-DYNA and experiment. Then the dynamic method was used to perform a parametric study of vertical cylindrical airbag. The influence of the parameters on energy absorbing ratio and peak acceleration were concluded. At last, the design principle of the cushioning airbag with constant venting area was proposed.

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