Computational Modelling of Bird Strike Impact on an Aluminium Alloy Plate via Coupling of FE-SPH

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ABSTRACT

This paper proposes a parametric mechanics study in determining the relationship between the parameters of the aerospace structure during a bird strike impact. A commercial software of LS-Dyna is used to compute the numerical modelling demonstrated in this research. Technically, an idealised bird is modelled as a cylindrical shape with hemispherical ends to maintain the homogeneity and symmetry using Smoothed Particle Hydrodynamics (SPH) approach. At the same time, an aluminium alloy plate is developed as a shell element plate in the finite element model. Such conditions are considered in this research from the view of bird strike impact under various conditions (structural thickness) and constraints (bird size). The obtained computational results are in close agreement with the experimental results published in another literature.

Keywords: Bird Strike, Smoothed Particle Hydrodynamics (SPH), Impact.

INTRODUCTION

Bird strike occurrence is common and can pose a significant threat to a moving aircraft. In one accident occurred during an air display routine, a bird flew into the propeller of the Edge 360 aircraft, which lead to a crash (Thorpe, 1996). The plane was damaged beyond repair, and the pilot suffered two cracked vertebrae. Aircraft manufacturers felt the need to study the effects of bird strike on different parts of the aircraft to find the right material that can withstand the impact. In the bird strike experimental point of view, real birds are not preferred to be used in bird strike tests are the lack of repeatability, unable to control the orientation and lack of symmetry (Wilbeck & Rand, 2009). In one experiment, a killed chick on the spot was used to replicate a bird (Hu et al., 2016). For instance, the chick was wrapped in a plastic sheet to prevent debris from spreading after the impact. It is mentioned that this approach is applied to maintain the symmetry and orientation for the impact test.

Moreover, in some research, the real bird has been substituted by other material, such as gelatin with 15% microballoons (Wilbeck & Rand, 2009) and rubber in the form of a ball (Baughn & Graham, 2008). However, the adoption of rubber as a replacement had some shortcomings which were proved by Wilbeck & Rand, 2009. The usage of gelatin as the experimental bird model for the test is also conducted by several researchers as well (Labeas & Kermanidis, 2008; Lavoie et al., 2010; Smojver & Ivančević, 2010). One of the advantages of using gelatin is that it has the same density as of in real birds which is around 900 – 950 kg/m3.

In an experiment conducted by Lavoie et al., (2010) gelatin was used as the projectile. 1 kg of gelatin was impacted with a rigid steel plate with 12.7 mm thickness. The experiment conducted on a steel plate was to test whether the gelatin was suitable to be used as the projectile. Until now, there are three approaches have been widely used in computational modelling of bird strike impact, which are the Lagrangian method, the Arbitrary Lagrangian-Eulerian (ALE) method and the Smooth Particle Hydrodynamics (SPH) method. The Lagrangian method has a disadvantage when the structural deformation is found to be huge since it will increase the difficulty to compute the state and stress in the elements due to the time step. Thus, the accuracy of the results obtained had decreased. In that sense, the ALE method is commonly applied as a standard approach to bird impact modelling since the method did not create much deformation (Lavoie et al., 2007).

COMPUTATIONAL MODELLING

In this work, an aluminium alloy plate is modelled by using shell elements. The dimensions for the sides of the plate was set to be equal that is 600 mm x 600 mm with 2 mm thickness as the experimental work done by (Hu et al., 2016). The structural plate contains 60 shell elements in the x-direction (horizontal) and 60 elements in the y-direction (vertical). For the boundary condition, the plate is fixed at all sides and in 6 degrees of freedom so that there will be no recoil of the bird strike impact.

Table 1. Mechanical properties of aluminium alloy

Density, ρ (kg/m^3)	Young's Modulus, E (GPa)	Poisson Ratio, v	Yield Stress, σ_y (MPa)
2768	73.08	0.33	280

RESULTS AND DISCUSSION

In this subsection, the benchmarking sample of the plate has been investigated related to its thickness variation. The material used for the plate is aluminium 2024 T3, also known as Aerospace Alloy. The thickness of the plate is varied from 2 mm to 4 mm, 6 mm, 8 mm and 10 mm. The objective of this research is to study the effects of the bird strike on the plate with different thickness. The displacement-time graph is plotted for all thickness shown in Fig 9.

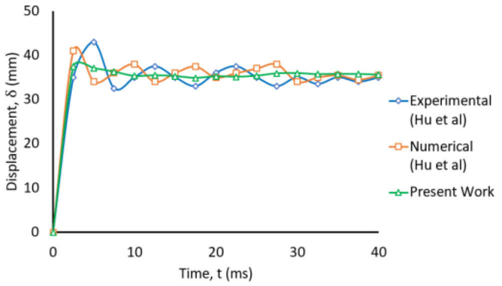

Fig. 1 Validation of displacement vs time.

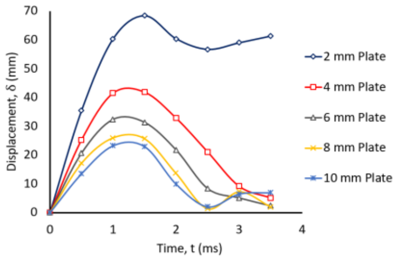

Fig. 2 Comparison of displacement vs time for various plate thickness.

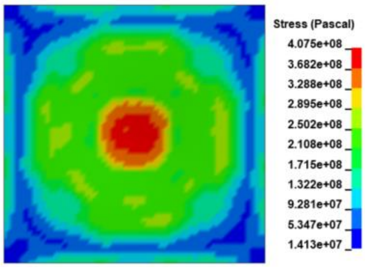

Fig. 3 Von Mises Stress Distribution at 0.5 ms (Pascal)

CONCLUSION

This research proposes a numerical technique in evaluating bird strike impact on aerospace alloy structure by determining the relationship between the parameters of the thickness of the plate during bird strike impact simulation. Smoothed particle hydrodynamics (SPH) was used to model the bird, which has less computational time to simulate and does not have the problems that are caused by distortions after the bird impact. Such conditions are considered in this research from the view of bird strike impact under various conditions (structural thickness) and constraints (bird size). The results of the bird strike impact obtained are validated with the research conducted by Hu et al. (2016). The obtained results show a good agreement with an average percentage error of 4.598% compared with the experimental results.

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