ISSN (O): 2393-8609

International Journal of Aerospace and Mechanical Engineering
Volume 1 – No.1, September 2014

Birdstrike Simulation of an Aircraft Wing

Rahul Sharma
Student, B.Tech, Department of Mechanical Engineering,
Chandigarh Group of College
Gharuan, Mohali, Punjab, India
Sharma.rsrs.rahul@gmail.com

Sandeep Sharma
Technical Head,
AeroSphere, Chandigarh, India
sandeep@aerosphere.in

ABSTRACT
The wing of an aircraft is a very predominant section which produces a useful lift to drag ratio for any flight. The objective was to reveal the computational testing methodology of birdstrike analysis of an aircraft wing with the use of Ansys 14.0 &Autodyn as analysis tool. The middle section of wing was used where a SPH bird model strikes at velocity of 280 m/s. The conclusion was identified that when the bird strike at some velocity against the wing section then the wing was not damaged.

KEYWORDS
Aluminium alloy AL5083H116, Wing section, Modeling in CATIA V5, SPH bird model, FEA analysis in ANSYS 14.0, Solver AUTODYN.

1. INTRODUCTION
In the modern era of aviation, clash between bird and aircraft is unavoidable and highly disastrous. Due to these clashes aviation sector suffering from huge losses.The U.S. civil and military aviation bears annually over $700 million loss due to bird and wildlife strikes. Additionally, since 1988 these incidents of bird strikes have been killed over 250 passengers and crew members of aircraft. As a result, the vigorous efforts need to make an aircraft structures highly resistant towards birdstrike.The objective was to reveal the computational testing methodology of birdstrike analysis of an aircraft wing with the use of Ansys 14.0 &Autodyn as analysis tool.The geometry of wing section is modeled in CATIA V5. The meshing, connections and material properties are defined in Ansys 14.0. The bird is molded in Autodyn using Smooth Particle Hydrodynamic technique with gap size of 1.5mm. Then the validation of bird model is carried out by impacting the bird at velocity of 280 m/s on selected wing section and the simulation results are studied.

2. METHODOLOGY
Today, the interactive CAD, Simulation and FEA applications are very popular in automotive, aviation and other industries for original crash simulations due to their less expenditure rather than prototype testing. In this study of birdstrike, some important components or interactive tools are also used for obtaining the results. Following tools and formulations was used in this study.

2.1 CATIA V5
CATIA V5 is a prominent product development tool from all original equipment manufacturers to small independent manufactures. It is a multi-platform CAD/CAM interactive application tool and a 3D product lifecycle management software suite. It consists the multiple stages of computer aided design (CAD), computer aided manufacturing (CAM), and computer aided engineering (CAE). CATIA V5 is accomplished to use in wide range of industries, for instance, aerospace, automotive, plant design, shipbuilding, industrial machinery, electronics, electrical and consumer goods including designs of jewelry and fashion design. It also provides engineering solutions in surface and shape design, mechanical engineering and equipment and system engineering. Catia V5 is used for the modelling of wing section of an aircraft in this study.

It has following benefits:

1. Saves time in today’s competitive market.
2. Protects cost for prototype design and simulation.
3. Increases speed and accuracy for manufacturing.
4. Provides better solution to the complex problems.

2.2 ANSYS 14.0
ANSYS 14.0 is a finite element analysis software. It offers engineering simulation solutions for any type of design simulation problems.This software is widely used by most of companies in every sector like aerospace, automotive, equipment manufacturing etc. Ansys has an ability to solve those problems which are performs into the extremely severe conditions such as bomb blast testing of ship, car clash with truck etc. before produce into physical object. Workbench platform of ansys also comes in its software suite which provides advance engineering simulation technology. It is a very intelligent software as a result if any project is stopped while performing simulation then it automatically detect error and guide the user for correction of problem. Ansys Workbench platform provides extraordinary output by connecting with CAD, finely automated meshing system, update mechanism and other integrated applications. Ansys was used as a pre-processor for the explicit dynamics simulation of the wing section in this study.

2.3 AUTODYN
ANSYS Autodyn software is an analysis tool which comes with the Ansys 14.0 software suite. It is a multi-explicit analysis tool that has ability to produce 3d models for nonlinear dynamics of solids, fluids, gases and their combinations. In this interactive application, we can perform simulation of any system with ease, less effort, low labor cost and in low time. This solver is multi problem solver as a result, it provides solutions to computational structural dynamics problems, fast transient computational fluid dynamics etc. Autodyn provides solutions to intricate problems of smooth particle hydrodynamic with mesh free particles of high velocities. It also consist various materials in library with different models which are coupled with thermodynamic inside the software suite. We can also share and scatter the series and parallel computation on memory systems in this application. Combined problem of finite element,

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computational fluid dynamics and smooth particle hydrodynamic can also be solved by the multi solver autodyne. But here this application is used as post processor or solver of bird strike problem. It has the following characteristics:

1. Easy to use
2. Quick to learn
3. Natural and friendly graphical interface

2.4 SPH FORMULATION

In Autodyn, analysis can be carried out using different formulations like Lagrangian, Eulerian, Arbitrary LagrangianEulerian (ALE) and Smooth Particle Hydrodynamics (SPH) technique. But in this study only SPH formulation was used for making a water body of bird model. Smooth particle hydrodynamics is a computational method used for simulating fluid particles and flows. It is a mesh free method in which coordinates move with the fluid without having physical contact in particles. It is working by dividing the fluid into a group of small different elements, known as particles. The smooth length of particles varies due to tension and compression. The every particle has its own mass in this technique. The soft body impact simulation using SPH formulation is shown in fig.1 at different instants of time.

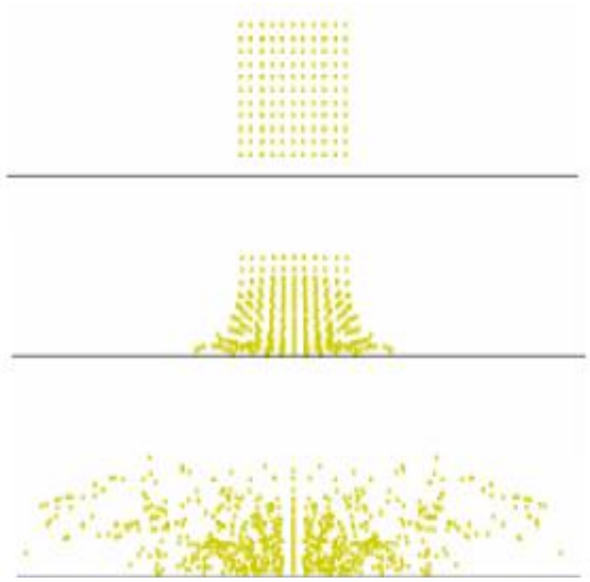

FIG.1 Soft Body Impact in SPH Formulation

2.5 EXPLICIT DYNMICS

Explicit dynamics is a tool which provides solutions for complex loading problems in Ansys 14.0. Those products which have critical design with critical loadings like impacts or short duration, high pressure loadings are solved by explicit dynamic solver.It is a very advance analysis tool which provides perfect solution to complex design considering problems which bears severe loadings. Too expensive or impossible physical testing becomes easier for manufacturing industries with the help of explicit dynamic solver. This software suite of explicit dynamics also provides solution for products that undergone highly nonlinear, transient dynamic behavior. Anyone can also study the response of designed products under severe loadings. Explicit dynamic also calculate accurate results for large material deformations and failure and interactions between bodies and fluids with briskly changing surfaces. Merits:

1. Easy to use with the aid of workstations.
2. Provide accurate results.
3. Increases productivity.

2.6 FEA OF WING SECTION

In order to make sure that the wing is safe against bird strike, it is necessary to carry out the FE analysis. The main scope of this FE analysis was to carry out safety of wing analysis against bird strike with available commercial FE analysis tool ANSYS 14.0 & AUTODYN then predicted the safety & damage of aircraft wing under the given loading conditions against the material.

The main tasks in the FE analysis include:

1. Generate Finite element model by importing from Catia V5 in Ansys 14.0.
2. Apply material to the wing's ribs & skin & bird.
3. Define the required connections appropriately, especially the interface between the adjacent components.
4. Apply of boundary conditions based on the working principle in ANSYS 14.0.
5. Apply the loads at appropriate locations such as bird strike velocity in ANSYS 14.0.
6. Perform Finite Element Analysis by choosing appropriate solving methods in AUTODYN.
7. Study animations and verify behavior of the assembly under the given loads and boundary conditions in AUTODYN.

3. RESULTS AND DISCUSSION

3.1 WING AL5083H116 PROPERTIES

1. Bulk Modulus = 5.833E+10 Pa
2. Poisson's Ratio = 0.3
3. Density of material = 2700 kg/m3
4. Initial Yield Stress = 1.67E+8 Pa
5. Shear Modulus = 2.692E+10 Pa

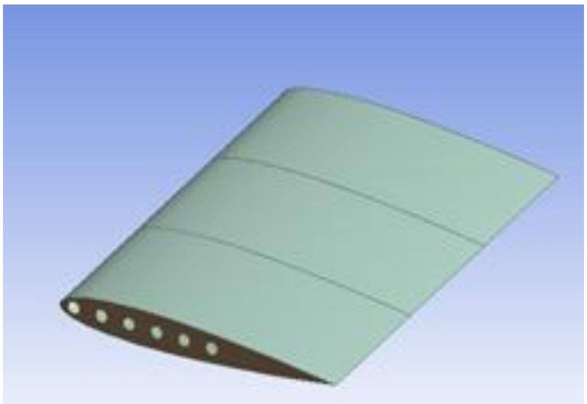

FIG.2 Wing Section

3.2 WING GEOMETRY PROPERTIES

Acc. To Bounding Box:

1. Length X = 1.492m
2. Length Y = 0.224m
3. Length Z = 1.5m

3.3 BIRD-a water body MATERIAL PROPERTIES

1. Density = 1000 kg/m3
2. Shear Modulus = 0 Pa
3. Maximum Tensile Pressure = 0 Pa

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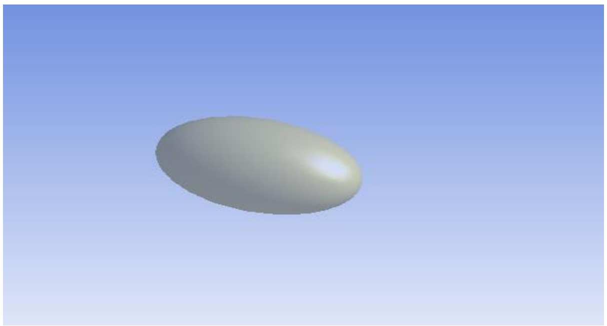

FIG.3 SPH Bird Model

3.4 ASSUMPTIONS

1. Material is homogeneous and isotropic.
2. Analysis carried out was steady state.
3. Current design will be considered as baseline design.

3.5LOADS AND BOUNDARY CONDITIONS

1. Bird strikes the wing at velocity of 280m/s.
2. Bird model which is created is of 15mm in size.
3. Interaction between bird particle & wing have 1.5mm of gap.

3.6 FEAOF BASELINE DESIGN

The FE Analysis of the baseline bird strike against wing model was done using ANSYS 14.0 and AUTODYN.

Wing damage plot is shown as follows when the Skin thickness is **1mm** of material AL5083H116 & the bird strike at velocity **V=280m/s:**

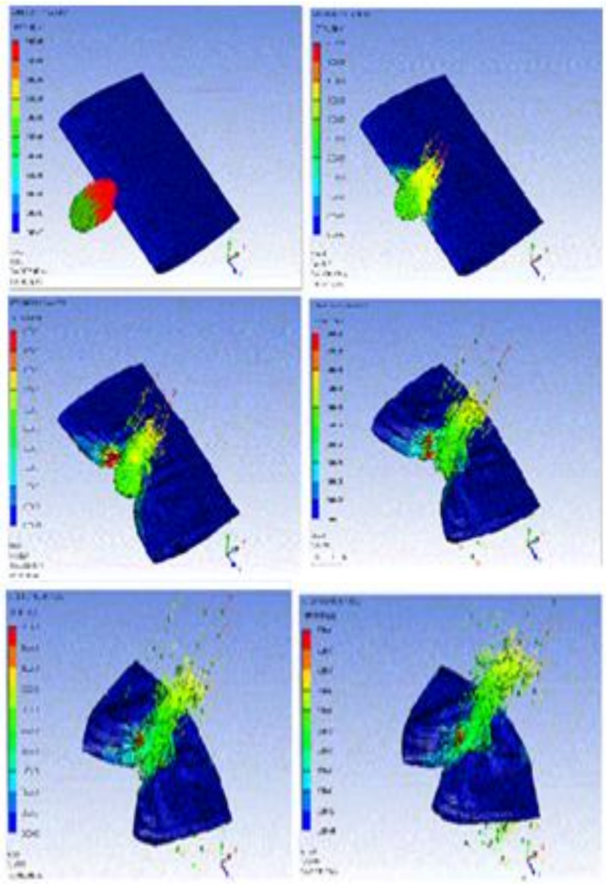

FIG.4 Wing Damage Plot of Baseline Design

Results

Sr. No.	At RIB Thickness	Result
1.	1 mm	Damaged

TABLE. 1

Remarks: A bird of 15mm in size is impacted with velocity of 280 m/s on the wing of rib thickness 1mm is shown in above table and **results** are analyzed by the plot which shows that the wing gets damaged. So, the design modification is recommended.

3.7 FEA OF DESIGN ITERATION 1

Following results are shown for design iteration 1- Changing the RIB thickness & SKIN thickness remains same.

Wing damage plot is shown as follows when the Skin thickness is **1mm** of material AL5083H116 & the bird strike at velocity **V=280m/s:**

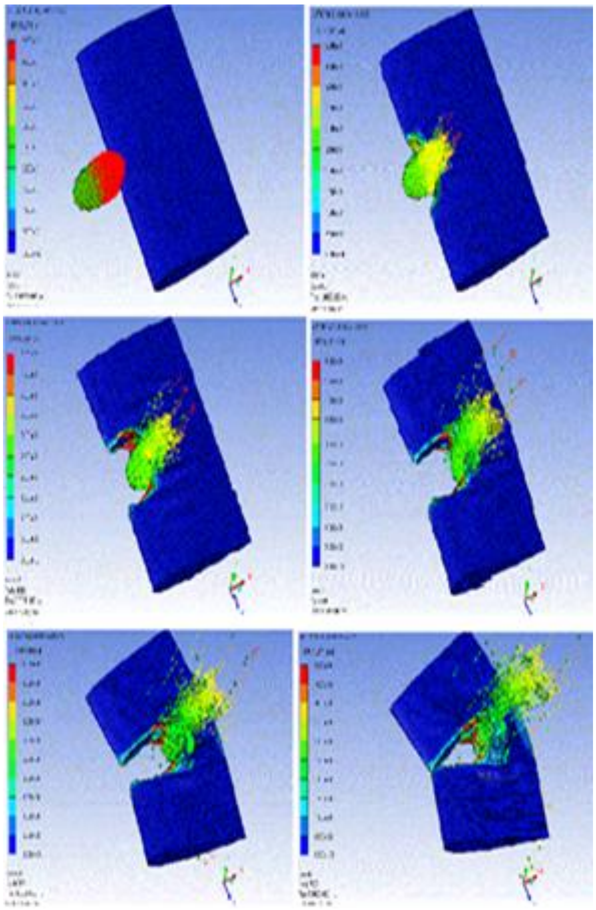

FIG.5 Wing Damage Plot of Design Iteration 1

Results

Sr. No.	At RIB Thickness	Result
1.	5 mm	Damaged

TABLE.2

Remarks: A bird of 15mm in size is impacted with velocity of280 m/s on the wing of rib thickness 1mm is shown in above table and results are analyzed by the plot which shows that the wing gets damaged. So, the design modification is further recommended.

3.8 FEA OF DESIGN ITERATION 20

Following results are shown for design iteration 20 and the results for design iteration 2 to design iteration 19 are shown in the conclusion of this study.

Wing damage plot is shown as follows when the Skin thickness is **12mm** of material AL5083H116 & the bird strike at velocity **V=280m/s:**

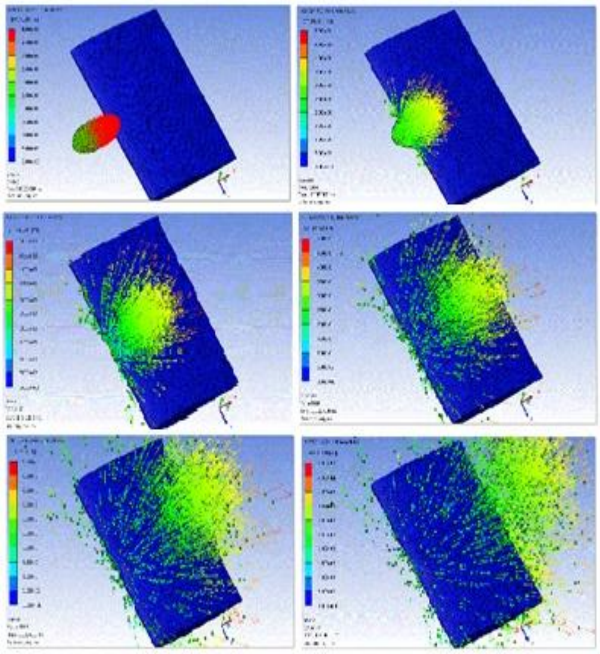

FIG.6Wing Damage Plot of Design Iteration 20

Results

Sr. No.	At RIB Thickness	Result
1.	1 mm	**Not** Damaged

TABLE.3

Remarks: A bird of 15mm in size is impacted with velocity of 280 m/s on the wing of rib thickness 1mm is shown in above table and **results** are analyzed by the plot which shows that the wing gets not damaged. So, the design was safe.

4. CONCLUSION

The best case was identified that when the bird strike at velocity of 280m/s against the wing of RIB thickness 1mm & SKIN thickness 12mm then the wing was not get damaged. The comparison is shown in the table below and the best case is highlighted.

TABLE.4

Sr. No.	Material	Rib Thickness	Skin Thickness	Result
Baseline Design	AL5083 H116	1 mm	1 mm	Damaged
1.	AL5083 H116	5 mm	1 mm	Damaged
2.	AL5083 H116	8 mm	1 mm	Damaged
3.	AL5083 H116	12 mm	1 mm	Damaged
4.	AL5083 H116	16 mm	1 mm	Damaged
5.	AL5083 H116	1 mm	3 mm	Damaged
6.	AL5083 H116	5 mm	3 mm	Damaged
7.	AL5083 H116	8 mm	3 mm	Damaged
8.	AL5083 H116	12 mm	3 mm	Damaged
9.	AL5083 H116	16 mm	3 mm	Damaged
10.	AL5083 H116	1 mm	6 mm	Damaged
11.	AL5083 H116	5 mm	6 mm	Damaged
12.	AL5083 H116	8 mm	6 mm	Damaged
13.	AL5083 H116	12 mm	6 mm	Damaged
14.	AL5083 H116	16 mm	6 mm	Damaged
15.	AL5083 H116	1 mm	9 mm	Damaged
16.	AL5083 H116	5 mm	9 mm	Damaged
17.	AL5083 H116	8 mm	9 mm	Damaged
18.	AL5083 H116	12 mm	9 mm	Damaged
19.	AL5083 H116	16 mm	9 mm	Damaged
20.	AL5083 H116	1 mm	12 mm	Not Damaged **BEST CASE IDENTI FIED**

5. FUTURE SCOPE

- Strength can be improved if another wing section material is used.
- Bird strike velocity and particle size can be changed for different results.
- This testing methodology can also be used to perform the certification test analysis.
- For making wing bird proof variation can be done in wing design.

6. ACKNOWLEDGMENT

I am highly grateful to Mr. Sandeep Sharma,Technical head, Aerosphere, Chandigarh for providing this opportunity to carry out the research work. I would like to expresses my gratitude to Aerosphere for providing facilities, academic inputs, guidance & encouragement throughout this period. I would like to express a deep sense of gratitude and thank to my colleagues and friends without them it would have not been possible to pursue my research work in this manner. I also would like to thank to my mom for her steady support. Finally, I express my indebtedness to all who have directly or indirectly contributed to the successful completion of my research work.

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