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Analysis of Bird Strike Impact to Prevent From Emergency Landing Using Ansys

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ABSTRACT:- *The interest in development of new composite material is growing nowadays, as the existing aircraft skin takes much damage due to the impact of bird strike. Due to this many air accidents occur and cause economical problem. The aim of this project is to introduce a hybrid composite so as to resist impact damage. Carbon fiber is one of the widely used materials accounted for its strength and stiffness. Kevlar is an organic fiber which has the property to resist impact. The bird strike can not only damage the skin or punctures it; it also damages internal structure and even is a reason for accident. Most of the material having high strength has low resistance to sudden impact of a high load in short duration. Such impact causes crack, deformation and even holes. In this project we have chosen Kevlar/Carbon combination of material as the hybrid composite by various analyses which include individual impact strength. It is combined with epoxy resin as a matrix material. We have designed and analyzed a flat plate made from hybrid composites under impact load. The impact load is calculated using the impact speed and angle. These results are compared with other skin material and the analysis is done using ANSYS LS-DYNA software. The same hybrid material is fabricated by using hand layup process and is tested with Charpy impact testing machine.*

Keyword:- *Carbon, Kevlar, composite, charphy, bird impactor, ANSYS*

I. INTRODUCTION

Aircraft Bird strikes are present since the early days of flight, 100 years ago. The number of strikes annually reported to the FAA has increased 5.8 - fold from 1,851 in 1990 to a record 10,726 in 2012. For the 23 -year period (1990–2012), 131,096 strikes were reported to the FAA. Birds were involved in 97% of the reported strikes. Every bird strike incident results in loss of 121.7 flying hours and costs $32,495/incident amounting an economic loss of ~$350 Million in 2012, excluding other monetary losses include such as lost revenue, the cost of putting passengers in hotels, re -scheduling aircraft, and flight cancellations. [1, 2]. Composite materials are increasingly being used for aeronautic primary structures such as wing components or fuselage panels. However, their major drawback is their vulnerability against transversal impact loads, which may lead to internal delaminations or intralaminar fiber/matrix failure. Such loads may arise from numerous impact scenarios, with bird strikes being one of the most relevant load cases. The focus of the current study is on the numerical modeling and simulation of high velocity impact loads from soft body projectiles on composite structures with ABAQUS/explicit [3]. The bird impact on a composite wing leading edge is treated. Adequate modeling methods for the composite material (stacked shell model), delamination failure (cohesive elements), preloading (implicit -explicit coupling) and soft body impactor modeling (coupled Eulerian - Lagrangian approach) are assessed [4]. A 1.82kg homogenous bird model with a simplified geometrical shape is modeled using the Lagrangian formulation. The reliability of the bird model is validated by comparing the numerical result with experimental results of a real bird of similar mass impacting normally at an impact velocity of 116m/s onto a flat rigid panel. Results are compared in terms of pressure profile, Huguenot and stagnation pressure at the centre of the impact and the bird trajectory after the impact. The obtained numerical results are found to be comparable in terms of pressure profile and the bird trajectory [5,6].

The effect of curvature, of an aircraft windscreen, on the impact response in terms of effective stress at the center of the impact is also investigated. Analysis is made based on the obtained numerical results. However experimental results are not available to substantiate the conclusions made from the numerical results [7]. There are many advantages that polymeric adhesives can offer compared to the more traditional methods of joining such as bolting, brazing, welding, mechanical fasteners, etc. and epoxy adhesives represent the most common type of structural adhesive. When polymerized, epoxy adhesives are amorphous and highly -cross linked materials and this microstructure results in many useful properties for structural engineering applications, such as a high modulus and failure strength, low creep, and, by careful formulation, good performance at elevated temperatures [9,10].

Kevlar/alumina/epoxy resin laminated composites were prepared by using low pressure technique. The single layer and two layer wit thickness of 1 mm were prepared. The mechanical properties, density, hardness, and impact of the composites were measured. It has been found that the amount of % by weight of the $AL_2 O_3$ have affected the properties of the laminates composite and the densities of the sample were in the range of 1.124 -1.499 g/cm3. The hardness (HV30) and impact of the samples were in the range of 12.5-72.5 and 3.1-4.3 J, respectively [11]. Impact, compression after impact, and tensile stiffness properties of carbon fiber and Kevlar combination sandwich composites were investigated in this study. The different samples consisted of impact -side face sheets having different combinations of carbon fiber/Kevlar and carbon fiber/hybrid. The bottom face sheets remained entirely carbon fiber to maintain the high overall flexural stiffness of the sandwich composite [12].Composite micromechanics and macro mechanics and the miniature Izod impact test are used to investigate the impact resistance of unidirectional composites. Several composite systems are examined both theoretically and experimentally. The composites are classified theoretically relative to their impact resistance for longitudinal, transverse, and shear modes. Experimental results are reported only for Izod impact with the fibers either parallel or transverse to the cantilever longitudinal axis. Investigation is used to design hybrid composites with improved impact resistance [13, 14]. Epoxy resins have very important chemical and mechanical properties, however they have a small elongation at break, poor impact strength and resistance to crack propagation i.e. they exhibit a brittle behavior [15].

The current study focuses to determine if any improvement in impact properties existed as a result of replacing the impact -side face sheet layers of carbon fiber with Kevlar or hybrid. Impact tests were conducted on different sample types to obtain information about absorbed energy and maximum impact force. The elastic module of carbon fiber, Kevlar, and hybrid were determined from tensile testing. This data was used to characterize the reduction in stiffness from replacing carbon fiber layers with the Kevlar or hybrid layers.

II. EXPERIMENTAL PROCEDURE

1. Material Selection

The reinforced composite fiber with different combinations of Kevlar and carbon fiber impact-side face sheets were subjected to low velocity impact of 135 m/s. These fibers are chosen by analytical validation of the impact. Due to the requirement of high performance the combination of these materials has been chosen. Various properties required for the analysis of the materials are given in Table 1.

Table 1 Properties of Kevlar, Aluminum, and Carbon Fibers

Mechanical properties	Carbon	Kevlar	Aluminium
Major Poison Ratio	0.1	0.2	0.21
Ultimate Compressive Strength 90˚ (Mpa)	570	190	284
Young‟s Modulus 0˚ (Gpa)	70	130	72
Density (g/cc)	1.6	1.4	2.8
Tensile Strength (Mpa)	110	400	460
Compressive Strength (Mpa)	110	400	460

Kevlar is an organic fiber which has a unique combination of high strength, high modulus, toughness and thermal stability. The notable properties of the Kevlar fibers are that they have a density of, tensile strength of 3,600 Mpa and breaking strength of 264 N.Carbon-fiber-reinforced polymer or carbon-fiber-reinforced plastic (CFRP or CRP or often simply carbon fiber), is a very strong and light fiber-reinforced polymer which contains carbon fibers. It has a tensile strength of 110 Mpa, which is comparatively very low when compared with that of the Kevlar and aluminium.

2. Stress And Deformation

Kevlar withstand to the maximum stress, where as the others have relatively low stress and aluminium takes the second of the list and carbon takes the last spot. The same happens in the deformation that occurs in the materials; Kevlar have a least deformation and aluminium takes second place and the carbon in the extreme. The comparison of stress, strain and deformation of materials given in table 2.

Table 2 Comparison of Deformation, Stress, Strain of Aluminium, Kevlar and Carbon

	Aluminium	CFRP	Kevlar
Deformation(m)	0.21165	0.57063	0.21481
Stress (Gpa)	14.063	9.0854	15.880
Strain	0.65032	0.88049	0.6077
Time(ms)	1.5677	1.8525	1.5910

3. Weight Consideration and Order of Layer

Weight of each combination have been briefly studied and are shown below in table 3.

Table 3. Possible layer configuration with Kevlar as first layer

Abb.		Sample Type	Weight (g)
CF	4	Carbon Fiber Layer	60.8
1K	1	Kevlar – 3 Carbon Fiber Layer	59.7
2K	2	Kevlar – 2 Carbon Fiber Layer	60.5
3K	3	Kevlar – 1 Carbon Fiber Layer	59.8
4K	4	Kevlar Layer	58.4

On the impact-side face sheet, the very top layer is placed with Kevlar to prevent the initial penetration of the object. Different possible order layer with Kevlar at top are given in Figure 1.

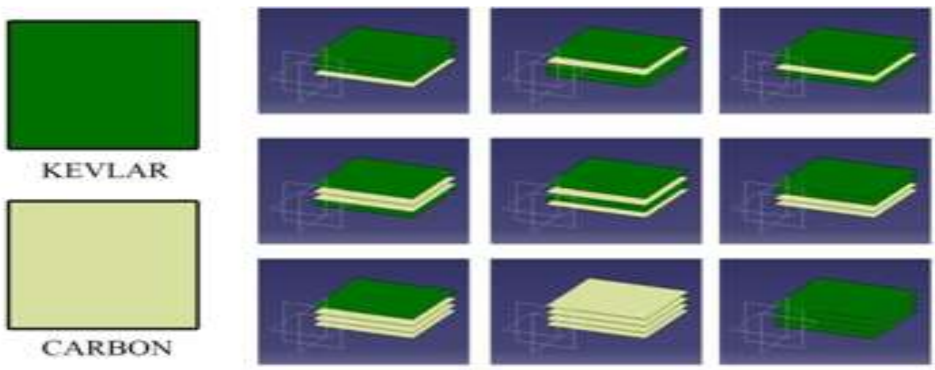

Fig.1 Carbon, Kevlar Arrangement

4. Modeling of Specimen plate and the bird impactor

For the analysis of bird strike on composite material, specimen has to be first modeled using any modeling software or workbench. According to the Mechanical Testing and Evaluation, Volume 8 of the ASM Handbook specimen for impact testing should be of 500 mm (19.6 in.) wide by 500 mm (19.6 in.) long. Figure 2,3 represents the specimen plate and bird impactor modeling.

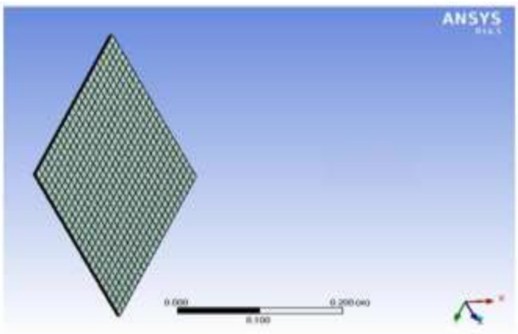

Fig.2 Specimen Plate

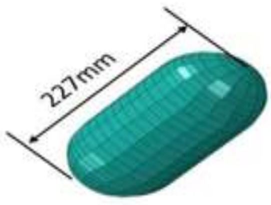

Fig.3 Bird Impactor model

The material specimen has been modeled using ANSYS LS-DYNA and the bird impactor is designed based on the surface of nodes and meshes.

III. RESULTS AND DISCUSSION

The solution of the analysis is directly obtained from the explicit dynamics. The solution includes the total deformation of specimen under impact, maximum stress produced at the section of the plate and the maximum strain produced. The Figure representation shown below represents the analysis report in Fig.4, 5, 6, 7 & 8.

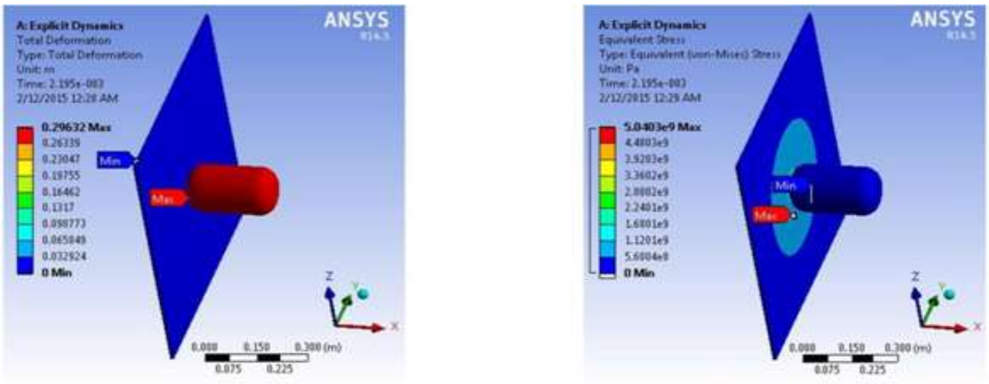

Fig.4 Stress and Deformation in 0 Kevlar Configurations

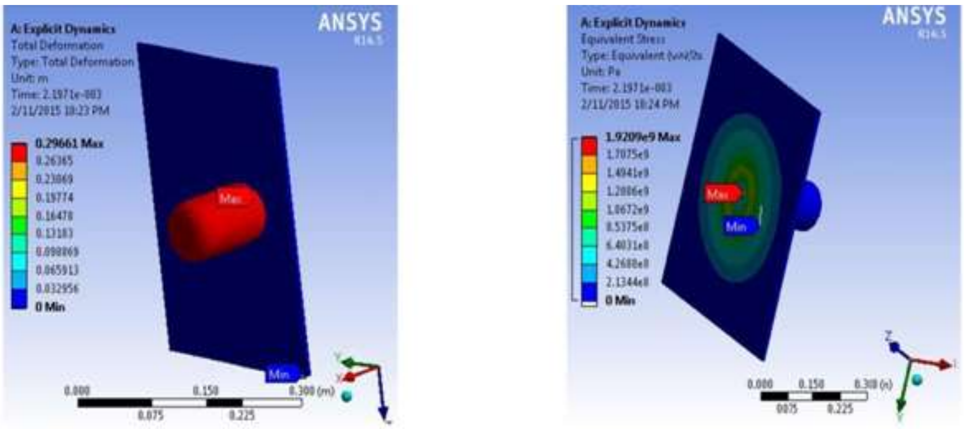

Fig.5 Stress and deformation in 1K configuration

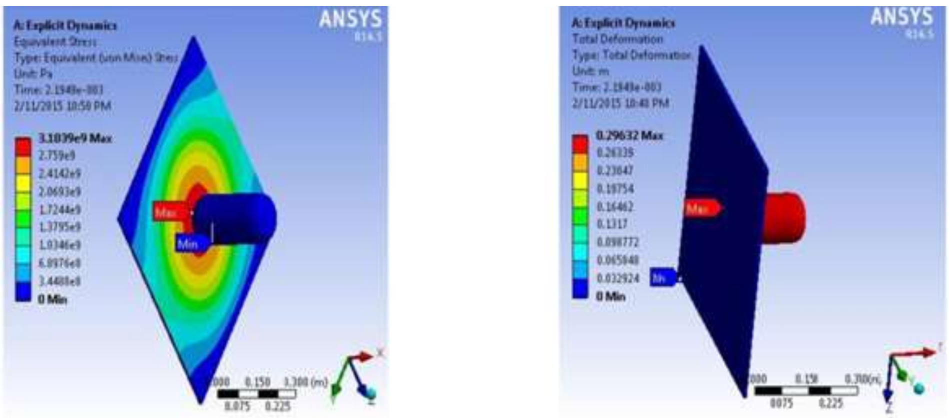

Fig.6 Stress and deformation in 2K configuration

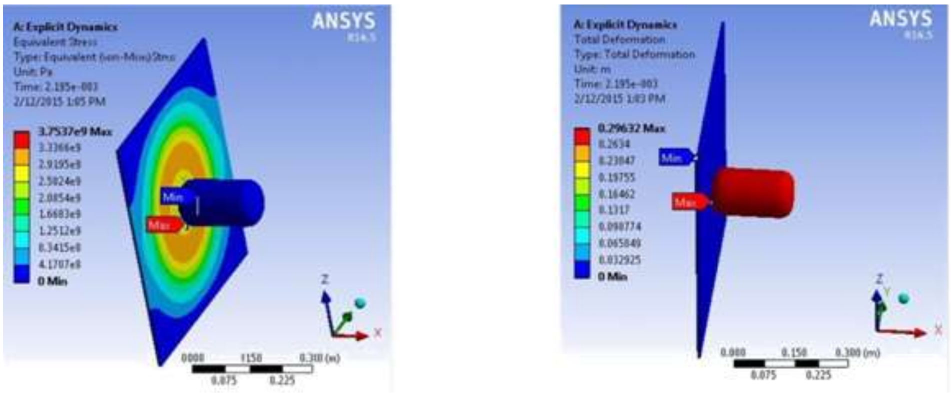

Fig.7 Stress and deformation in 3K configuration

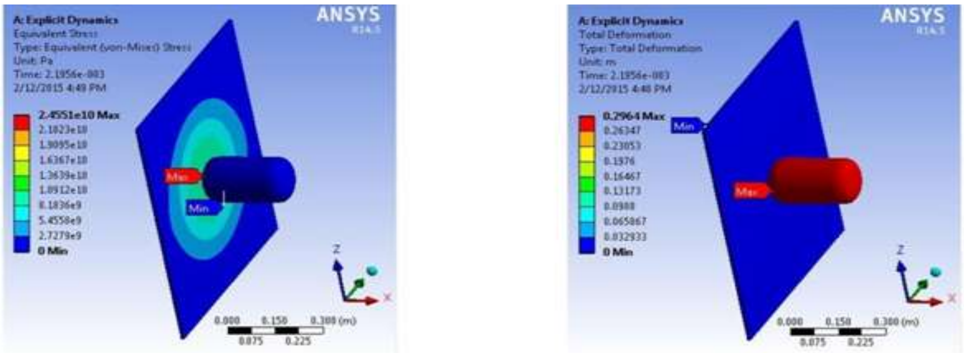

Fig.8 Stress and deformation in 4K configuration

Table Result of various layer Configuration

Type of layer	Stress(GPa)	Strain	Deformation(m)
C-C-C-C	1.9209	0.027809	0.29661
K-C-C-C	3.1039	0.023896	0.29632
K-K-C-C	15.491	0.024665	0.29635
K-K-K-C	3.7537	0.028908	0.29632
K-K-K-K	5.0403	0.038790	0.29632

1. Impact Test

Carbon fiber is placed over a cover coated with PVA which prevent the stiffening of materials during curing process in the mould. Then a layer of carbon fiber is placed over it and a coat of resin mixed with hardener in the ratio of 1:1.5 which enables a faster curing process. Then the second layer i.e. Kevlar fiber is placed at an angle of 90□ degree. The excessive resin is removed using the roller brush which will be pressed over the material. The same process is continued for the four layer of material.

Fig. 9 Prepared Composite Plate

Table.5 Test Results of Charphy

S.No	Sample Id	Specimen Temp	Thick mm	Width Mm	Length mm	Charpy impact energy, J			
						1	2	3	Avg
1.	Unidirectional carbon fiber sheet with epoxy resin + epoxy hardner	Room Temp	3.10	10.0	55.00	2	2	2	2
2.	Unidirectional Kevlar fiber sheet with epoxy resin + epoxy hardner	Room Temp	3.10	10.0	55.00	6.7	6.7	6.7	6.7
3.	Unidirectional carbon fiber sheet and Kevlar sheet with epoxy resin + epoxy hardner	Room Temp	3.10	10.0	55.00	8	8	8	8

IV. CONCLUSION

The experimentation and calculation to find the impact strength of the new material which they are verified through Charpy impact testing method.

1. The combination of Kevlar/carbon composite proves a better option for the replacement of aircraft skin in leading edge, nosecone, and radome and even in engine cowl. By the use of this material, we can help in reduction of structural damage and aircraft accident due to bird strike.
2. The Kevlar, Carbon material with four layer arrangement and all layer with normal orientation is the newly designed. By analytical calculation on the K-K-C-C layer using explicit dynamic method and gives a maximum equivalent stress of 15.491 GN/m and deformation of 0.29635 m/m.
3. The K-K-C-C material is fabricated using hand layup process gives the maximum stress of 8 J under the impact velocity of 112 m/s.
4. The fabricated material is one of the better possible solutions for replacement of aircraft skin. The strength and deformation produced by the material is much lesser compared to that of the existing aluminium aircraft skin.

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