A Combined Inflated Airbed and Additional Booster System for Emergency Landing

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***Abstract*— The technique has presented for a multi-objective way to the aircrafts. This method helps the aircraft to reduce its runway length by attaching the identical solid propelled boosters at the fuselage section and an airbed is provided during Emergency landing. That helps in reducing structural damage and life lost. The combinations of these two methods are implemented for safety and performance aspect of an aircraft. This method also eliminates the limitations of ballistic rescue parachute system. It is possible by the combination of these combined system of airbed and identical solid rocket booster systems the reaction time of opening of the airbed in fastened by the system adapted from the opening of evacuation slides. Thus a combination of these methods helps in saving the aircraft from structural damage and life cost of passengers thus helps in increasing the safety of air travel and reusage of aircraft in these modern eras.**

Keywords- Belly landing, Design of airbed, Airbed, landing gear, Solid rocket propellant booster system, ANSYS AUTODYN

1. INTRODUCTION

During emergency landing and belly landing of six seated or four seated commercial aircraft the landing crash will be reduced by the energy absorption of airbed. These methods are grouped into two general categories. The first category consists of deployable devices such as airbed, which is deployed by pyrotechnic ignition system. When the pilot switch on the emergency landing system, the pyrotechnic igniter ignites the solid propellant consist of sodium azide. When the sodium azide starts burn it produce large amount of nitrogen gas.

External airbag systems have been utilized in many different aerospace applications. The most notable examples include the F-111 crew-escape module (plug-vented air bags), and the Mars Pathfinder (non-vented air bags). Typically, non-vented airbag systems have an inherent degree of springiness due to the residual gas pressure, which causes the vehicle to bounce several times before it comes to a complete rest. To offer adequate protection, the airbag is required to cover the entire vehicle, which generally leads to a heavier and more complex system. Because of sequential energy absorption (bouncing), non-vented airbag systems are not suitable for manned applications. Vented bags are generally more efficient energy dissipaters, when compared to non-vented systems.

The second category consists of a simple solid rocket booster, which is external attached to the aircraft. After the landing gear touch the booster is ignites and produces the thrust in opposite direction. So, the solid propellant booster acts as a thrust reversal.

The external booster system is utilized in different military application. The most notable examples is JATO which has an additional rocket used during the takeoff and landing of the aircraft. It is attached externally or retracting system in the aircraft. These rockets used are solid propellant rocket which are identical and used to provide additional thrust to the aircraft when it is overloaded.

1.1 AIRCRAFT LANDING GEAR

Aircraft landing gear usually includes wheels equipped with shock absorbers for solid ground, but some aircraft are equipped with skis for snow or floats for water, and/or skids or pontoons (helicopters). The undercarriage is a relatively heavy part of the vehicle, it can be as much as 7% of the takeoff weight, but more typically is 4-5%.

1.2 BELLY LANDING

A belly landing or gear-up landing occurs when an aircraft lands without its landing gear fully extended and uses its underside, or belly, as its primary landing device. Normally the term gear-up landing refers to incidents in which the pilot forgets to extend the landing gear, while belly landing refers to incidents where a mechanical malfunction prevents the pilot from extending the landing gear.

During a belly landing, there is normally extensive damage to the airplane. Belly landings carry the risk that the aircraft may flip over, disintegrate, or catch fire if it lands too fast or too hard. Extreme precision is needed to ensure that the plane lands as straight and level as possible while maintaining enough airspeed to maintain control. Strong crosswinds, low visibility, damage to the airplane, or unresponsive instruments or controls greatly increase the danger of performing a belly landing. Still, belly landings are one of the most common types of aircraft accidents, and are normally not fatal if executed carefully.

1.3 SURVEY OF AIRCRAFT ACCIDENTS

In the period of October 2001 to October 2012, and for which the Board conducted investigations, the number of accidents and serious incidents involving small aero planes was 81 (accidents 62 and serious incidents 19), and among these cases, we have made investigation reports public for 74 cases (accidents 55 and serious incidents 19).

The above is the statistics on the situations of these accidents and serious incidents involving small aero planes for which the Board conducted investigation.

By the accident type, the number of crashes was 20 (32.3%), damage to aircraft when landing 14 (22.6%), belly landing 9 (14.5%) and others. Also, the total number of damage to aircraft was 28 (45.2%).

During the belly landing condition of aircraft, the pilot will have to press the airbed controller switch. Then the solid propellant is ignited and it will produce large amount of gas. These gases make passes into the airbed to inflate from the hull of the aircraft. Then make the aircraft landing with the airbed on the hull to reduce the damages of aircraft. After the airbed touches the ground the JATO equipment will activate and this will act as a thrust reversal equipment and create thrust reversing in aircraft to reduce the runway length of aircraft during landing. Totally our proposal will increase the safety percentage during the belly landing of aircraft.

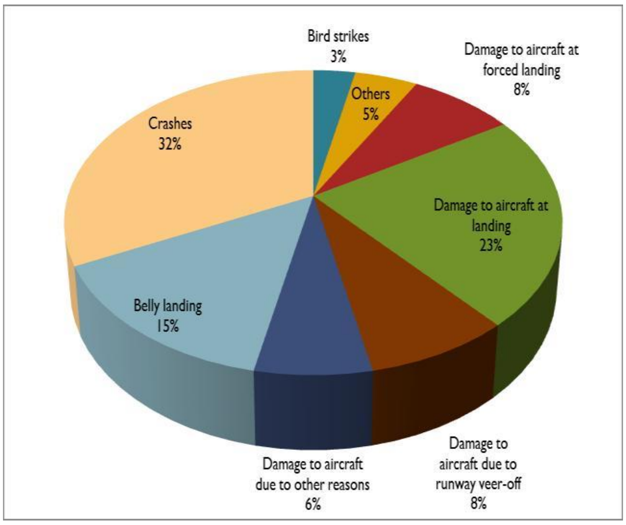

Figure 1. Type of accidents

2. LITERATURE REVIEW

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2.1 NASA Crash Tests 'Airbed' Helicopter

For analysis purpose we have taken a honey-comb structured material which is used by NASA.

NASA is looking to reduce the deadly impact of helicopter crashes on their pilots and passengers with what the agency calls a high-tech honeycomb airbed known as a deployable energy absorber.

So in order to test out its technology NASA dropped a small helicopter from a height of 35 feet to see whether its deployable energy absorber made up of an expandable honeycomb cushion could handle the impact stress. The test hit the ground at about 54MPH at a 33 degree angle, what NASA called a relatively severe helicopter crash astronauts may end up in helicopters to help prevent injuries. We have taken same material property of honey comb structure used by NASA for our airbed material.

At first, the folded airbed materials are placed above the hull of the aircraft with the deploying solid propellant. Then the airbed inflation controller is placed near the pilot in the cockpit.

Figure 2. A sort of 'honeycomb airbag' created to cushion future

2.2 ENERGY ABSORBER AIRBAG DESIGN

The external deployable airbed consist of two set of airbag are main Vented Air Bag and inner vented airbag. The inner anti bottoming airbag is placed inside the main vented air bag. The main vented airbag and inner vented airbag both are made up of polyurethane coated nylon fabric.

The main vented airbag is balloon like structure is only act as a shock absorber during landing, when the aircraft touches the ground. The safety pressure relief valve is attached to the main vented airbag which is used to relief the pressured gas from the airbag to maintain the pressure inside the airbag at certain limit.

The inner vented airbag is used to take the weight of aircraft during whole runway distance of aircraft. The inner vented airbag is designed like reinforcement structure to withstand the aircraft weight. It is placed inside the main vented airbag safely until whole landing energy of aircraft is dissipated. The reinforcement structure increases the stiffness of airbag.

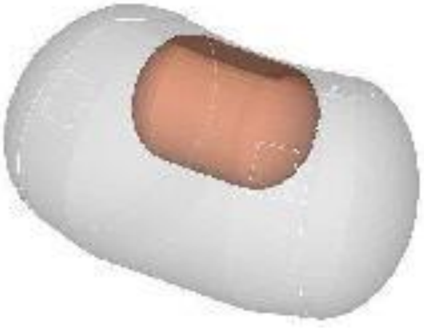

Figure 3. Design of airbag

2.3 INFLATION SYSTEM OF AIRBAG

The inflation systems consist of solid propellant canister of sodium azide. When the sodium azide burns it produce the large amount of nitrogen gas. The nitrogen gas is non-inflammable gas because 70% of air is filled with nitrogen gas. So, nitrogen gases more safety for using inflation.

Once the electrical circuit has been turned on by the sensor, a pellet of sodium azide (NaN3) is ignited. A rapid reaction occurs, generating nitrogen gas (N2). This gas fills a nylon or polyamide bag at a velocity of 150 to 250 miles per hour. This process, from the initial impact of the crash to full inflation of the airbed, takes only about 40 milliseconds. Ideally, the body of the driver (or passenger) should hit the airbed just after inflation – in fact while the airbed begins to deflate. Otherwise, the high internal pressure of the airbed would create a surface as hard as stone.

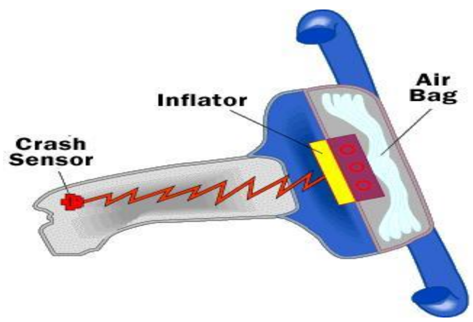

Figure 4. Airbag inflation system before inflation

So, the gas-generator inside the airbag contains a mixture of NaN_3, KNO_3, and SiO_2.Sodium azide (NaN_3) can decompose at 300^oC to produce sodium metal (Na) and nitrogen gas (N_2). The signal from the deceleration sensor ignites the gas-generator mixture by an electrical impulse, creating the high-temperature condition necessary for NaN_3 to decompose. The nitrogen gas that is generated then fills the airbag. The purpose of the KNO_3 and SiO_2 is to remove the sodium metal (which is highly reactive and potentially explosive), by converting it to a harmless material. First, the sodium reacts with potassium nitrate (KNO_3) to produce potassium oxide (K_2O), sodium oxide (Na_2O), and additional N_2 gas. The N_2 generated in this second reaction also fills the airbag, and the metal oxides react with silicon dioxide (SiO_2) in a final reaction to produce silicate glass, which is harmless and stable.

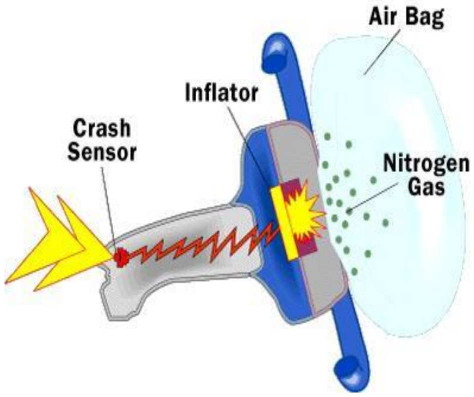

Figure 5. Airbag inflation system after inflation

Reaction 1: $2NaN_3 \rightarrow 2Na + 3N_2$

Reaction 2: $10Na + 2KNO_3 \rightarrow K_2O + 5Na_2O + N_2$

Reaction 3: $K_2O + Na_2O + SiO_2 \rightarrow Na_2K_2SiO_4$ **(Alkaline silicate glass)**

When the 130grams of sodium azide produces the 70 litres of nitrogen gas. Its reduces the additional weight for the emergency landing system.

3. DESIGN OF AIRBED

CATIA V5 features a parametric solid/surface-based package that uses NURBS as the core surface representation and has several workbenches that provide KBEsupport. Commonly referred to as 3D Product Lifecycle Management software suite, CATIA supports multiple stages of product development (CAx), including conceptualization, design (CAD), manufacturing (CAM), and engineering (CAE). CATIA facilitates collaborative engineering across disciplines, including surfacing &shape design, mechanical engineering, and equipment and systems engineering. CATIA provides a suite of surfacing, reverse engineering, and visualization solutions to create, modify, and validate complex innovative shapes, from subdivision, styling, and Class Surfaces to mechanical functional surfaces.

3.1 MATERIAL DESIGN

The material used for the airbag is polyurethane coated nylon fabric. The polyurethane coated nylon fabric is made up of 1050 denier ballistic nylon is coated on one side with a polyurethane coating. This fabric is light weight, flexible in cold temperature and has highest resistance to abrasion (44,000 cycles in wizen beck test). No stretch or shrinkage.

3.2 SAFETY PRESSURE RELIEF VALVE

The pressure relief is used to control the pressure of gas within the limit inside the airbag. The pressure is relived by allowing the pressurized fluid to flow from an auxiliary passage out of the system. The relief valve is set open at predetermined pressure limit set inside the airbag. The relief valve is act as shock absorber during the landing of aircraft. When emergency landing of aircraft the airbag is inflated and the airbag touches ground the high pressure produced on the airbag. It leads to the blasting of airbag. The safety valve which releases the high pressured gas inside the airbag to out and it also absorbs the shock of landing. It also reduces the bouncing effect of the aircraft. The safety pressure relief valve only placed on the main vented airbag.

3.3 ASSEMBLY

The Assembled Airbed & the Runway designed on CATIA V5 & the Aircraft IGS file format is imported into ICEM-CFD.

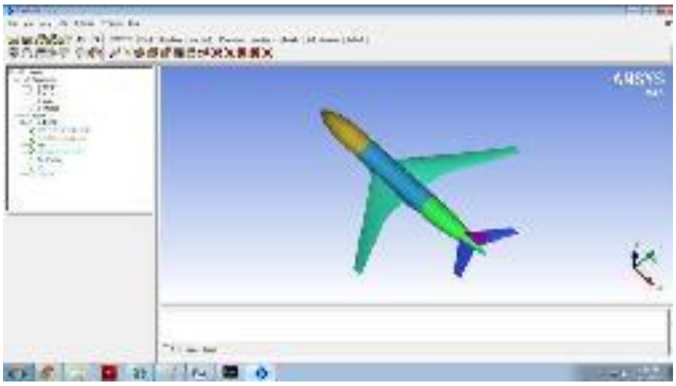

Figure 6. Imported model aircraft on ICEM CFD

The Final Assembly is carried out in ICEM – CFD Workbench by the application of Transformation tools on the imported Components.
The imported Airbed is aligned to the aircraft and merged into the fuselage hull and the surfaces are trimmed.

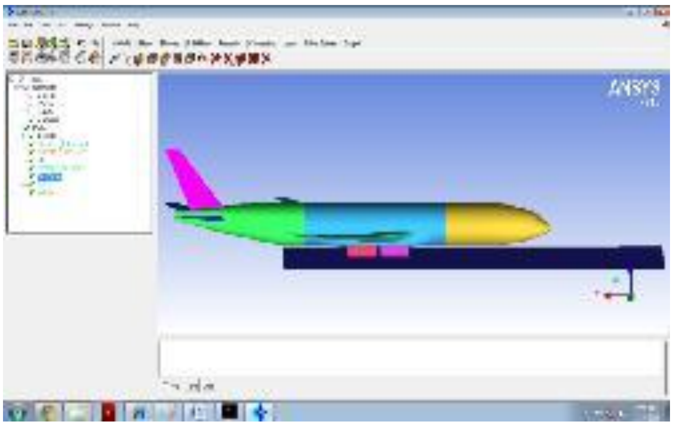

Figure 7. Total assembly for analyzing

3.4 SOLID ROCKET BOOSTER SYSTEM

The solid rocket propellant booster system is utilized in different military application. This system is named as JATO (Jet Assisted Take Off). When the each booster is 70kgs and it produce thrust of 1000lb (4450N). These types of boosters are used for our proposal. The boosters are placed to produce thrust on opposite direction. During landing condition, after the aircraft touches the ground the solid propellant boosters are act as thrust reversal and reduce the landing runway distance of the aircraft. It increases the safety percentage of aircraft during emergency landing. This system is singularly used during short runway landing etc.

4. INTRODUCTION TO ANSYS ICEM CFD

ANSYS ICEM CFD provides advanced geometry acquisition, mesh generation, and mesh optimization tools to meet the requirement for integrated mesh generation for today's sophisticated analyses.

Maintaining a close relationship with the geometry during mesh generation, ANSYS ICEM CFD is used especially in engineering applications such as computational fluid dynamics and structural analysis.

ANSYS ICEM CFD provides a direct link between geometry and analysis. In ANSYS ICEM CFD, geometry can be input from just about any format, whether from a commercial CAD design package, 3rd party universal database, scan data or point data. Beginning with a robust geometry module which supports the creation and modification of surfaces, curves and points, ANSYS ICEM CFD's open geometry database offers the flexibility to combine geometric information in 30.

A key benefit of ANSYS Explicit STR software is the workflow advantage of operating within the ANSYS Workbench environment. While many different simulation processes are possible, below is an example of the typical steps a user might take:

- Select materials to be used from the ANSYS Workbench native Engineering Data library
- Generate geometry in ANSYS® Design Modeler™ software or use the bidirectional, parametric connections to all major CAD systems to import geometry into the ANSYS Workbench framework
- The explicit preference option automatically selected by powerful ANSYS meshing solutions creates a mesh with reasonably uniform element sizes that is well suited for explicit analysis
- Automatically create part-to-part contact with the body interactions tool
- Fine-tune contact specifications if desired by utilizing breakable bonds to connect parts
- Load and/or support an assembly and/or parts as usual
- Solve interactively either in the background or via remote solution manager (RSM)
- With a single mouse click, reproduce all of these steps if the CAD model is changed
- View progress of a solution in real time using the concurrent post-processing capability available in the ANSYS Workbench environment.

5. ANALYSIS

ANSYS explicit dynamics engineering simulation solutions are ideal for simulating physical events with severe loading that occur in a short period of time and may result in material damage or failure. These types of events are often difficult or expensive to study experimentally. Simulation provides insight and a detailed understanding of the fundamental physics taking place and gives engineers chance to make necessary changes before their products are put into service, when mistakes in design can be costly.

Based on fifers principles, ANSYS explicit dynamics products solve the conservation equations of mass, momentum and energy using explicit time integration.ANSYS® Explicit STR™, ANSYS® AUTODYN® and ANSYS® LS-DYNA® solutions collectively offer the full range of capabilities needed to address complex explicit problems.

ANSYS AUTODYN software is an advanced explicit analysis tool for modelling complex nonlinear dynamics involving solids, fluids, gases and their interactions. It is a powerful, multi physics explicit program that provides a wide range of capabilities for simulating problems involving severe loadings in a short period of time, such as high-speed impacts and explosions.

ANSYS AUTODYN software offers multiple solution methods including Lagrange, Euler, arbitrary Lagrangian-Eulerian (ALE) and smoothed-particle hydrodynamics (SPH), a mesh-free solver. ANSYS AUTODYN software is fully integrated with an intuitive, easy-to-use GUI that is further enhanced with all of the features available in the ANSYS Workbench platform. These features enable users too easily and quickly prepare models from CAD geometry, create a mesh well suited for explicit analysis, and set up multiple calculations using parameters based on geometry, details, material models and initial conditions.

We have carried out the Impact Testing using ANSYS – Explicit Dynamics Workbench which has exclusive tools as AUTODYN & LS DYNA.

The Material Properties of Concrete (Runway), Aluminum Alloy (Aircraft) & Kevlar-129 (Airbed) are specified in the Engineering Data.

6. RESULTS AND DISCUSSION

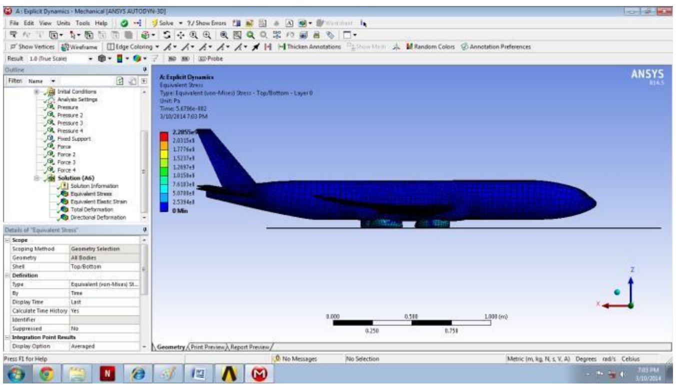

Figure 7. Total force applied on aircraft

RESULTS COLLECTED FOR CASE 1

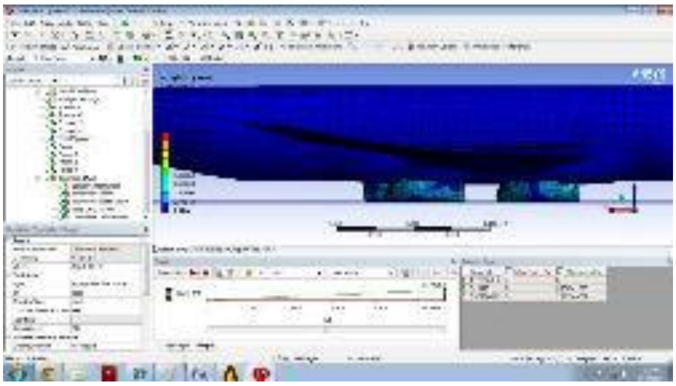

Figure 8. Total force applied on airbed

Force applied for each airbag – 78480N
Pressure applied inside of each airbag - 1.8259e+006 Pa

RESULTS COLLECTED FOR CASE 2

Force applied for each airbag – 98100N
Pressure applied inside of each airbag - 2.2824e+006 Pa

RESULTS COLLECTED FOR CASE 3

Force applied for each airbag – 117720N
Pressure applied inside of each airbag - 2.7389e+006 Pa

CONCLUSION

We have proposed a new designed airbed using Kevlar 129 material property and analyzed the designed airbed in the ANSYS – AUTODYN software. we analyzed the design with four different cases depend on the load and pressure applied in the proposed model and we have concluded that the proposed model with Kevlar 129 property would withstand more loads during belly landing condition of aircraft. This will also increase the safety percentage of the aircraft during belly landing condition.

The advantages which over comes the normal emergency landing and belly landing of the aircraft are following

- This proposal will reduce the crashes of aircraft during belly landing.
- It is used during the landing gear and gear door malfunctioning situation.
- It is more safety than the Whole plane parachute recovery system because the parachute recovery system makes reduce the aircraft controls.
- It increases the aircraft floating time during the aircraft landed on the sea due the airbag is inflated with gas.
- It will make the short distance landing of aircraft using solid propellant boosters.
- It will increase the aircraft life time and reduces the repairable cost.

- This method will increase the aircraft safety percentage.

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