SPH FOR BIRD STRIKE ANALYSIS OF SINGLE PIECE WINDSHILD: A REVIEW

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***Abstract*— Many times Collision between bird and aircraft leading components like windshield is occurs during flight. In order to make effective design of windshield which can sustain the impact of bird during aircraft flight ,number of computational methods are used from last more than 25 years. At different velocities, a bird acts as a soft body. During collision it flows over windshield like fluid. Material get deformed and spread.**

The submitted paper describes the SPH method for bird strike analysis of single piece windshield.

***Keywords*— Bird strike, SPH, windshield, bird geometry, bird impact theory**

I.INTRODUCTION

During flight bird strike to aircraft components create damage to aircraft components and loss to human life. As windshield is a leading component, it gets distort due to collision.

Aircraft should be design in such way that it should complete a flight after crash with bird. This is also a requirement of FAA airworthiness regulation. Design of aircraft components like windshield should be capable to sustain impact of standard size bird.

Bird proof design of aircraft component is made. The procedure adopted for this is Design the component, Manufacture it, Assembled it, experiment it then design again if necessary then experiment again. This consume more time and money[34].

In order to made light weight birdproof design of windshield numerical computational methods are used which avoid waste of time and use of computational methods are economical.

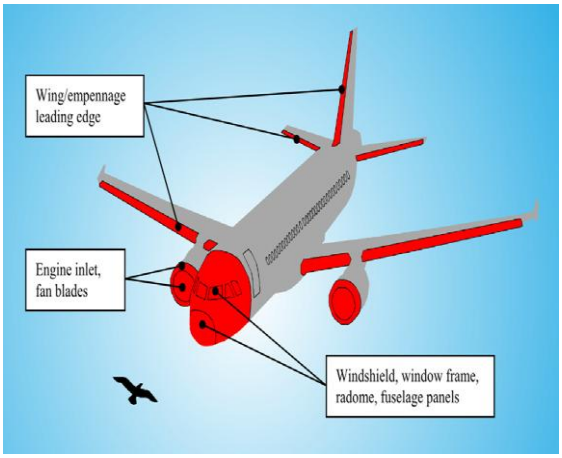

Fig. 1. Illustration of aircraft components exposed to the risk of bird strike.

II. THEORY

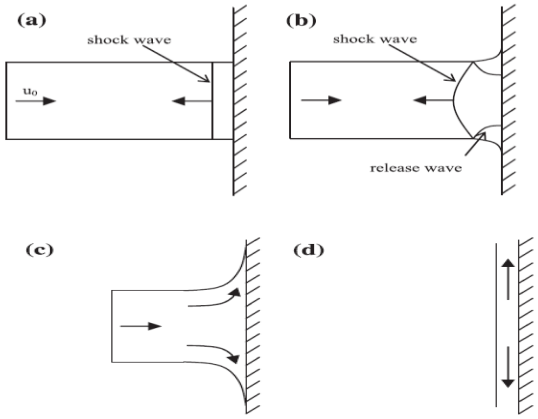

Fig.2. Illustration Shock and release wave in a soft body impactor

Impact behaviour consists of (a) initial shock at contact (b) Impact shock decay(c)Steady flow and (d) Pressure decay (fig.2)[2,3]

when the impactor is made impact on surface, the material which is at contact point is brought to rest immediately and shock waves are produced .These shock waves are travel in similar direction that of surface and in at right angles to the surface and pass through impactor body. At outside surface a important pressure gradient is developed becauseshock load on one side and free surface on other side. Material element have outer acceleration as well as release wave is produced which reduces pressure at contact point of impactor and surface during collision. Hence maximum primary pressure tip ends at the middle of impact during very less time[3,4]. After some time pressure and velocity of impactor is constant and material flows steadily. The reality of steady flow depends upon length/diameter relation of impactor. For very small impactor length /diameter ratio 2 is recommended. Primary velocity of impactor is less than velocity of shock and release wave. During steady flow phase ,shock wave is continuously weaken by release wave until bird and its trace are reduced to zero.Fig.3 shows a typical pressure curve for impact between soft body impactor and target plate.

Here

uo = primary velocity of impactor

us = Velocity of shock wave

ρ0=Density ofImpactor

thenhugoniot pressure(PH) is primary pressure tip in the contact point in a at right angles impact given by

PH = ρ0 uo us

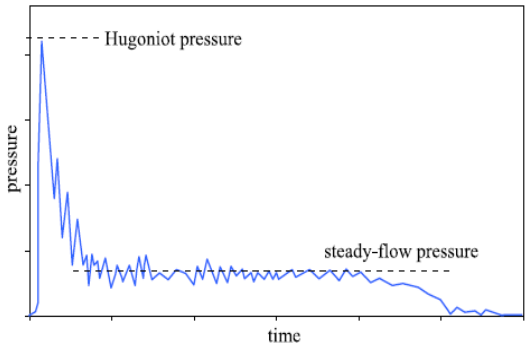

Fig.3 –Typical pressure curve for soft body impact on a rigid plate

The steady-flow pressure PS can be given by the Bernoulli equation:

Ps=1/2ρ0 u02

III BIRD MODELLING USING SPH

A. SPH bird model

since a difference to the Lagrangian and Eulerian flexible body impactormodeling approaches, where a usual finite element mesh is used, many meshless element scheme were developed, aiming at the freedom of mesh distortion problems and computational efficiency.

Anghileri [6,7] examine a generalization of the bird modeling in the before time 2001s by telling the impactor by means of only nodes with added lump mass and primary velocity. This move towards the discrete element method (DEM). Contact definitions apply the load against the impacted structure. The advantage is the decrease of the CPU time by the factor 10 with no result on the time step range along with the capacity to simply cover harsh deformations and segregate of the impactor. The drawback of this technique is the be short of of inner interface of the nodal masses that direct to the not have dissipation mechanisms and therefore to an impractical bird actions [8].Ref. [9] tells that this piece mass model apply maximum frequency force peaks, having a tough negative influence on local structural reply.

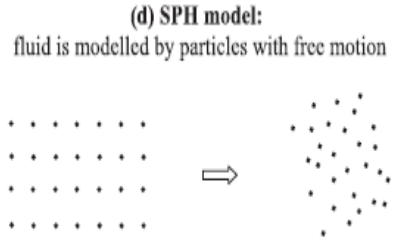

Fig.4-Finite element modelling method for soft body projectile

Additional use of particle methods are acknowledged in [1,2]. Spherical fluid elements among a centrally located node were developed in the code WHAM for the impactor representation in a fan blade impact study. The spherical elements are gather in a closest-packed arrangement with no structural connection, create the flexible body impactor shape. Contact algorithms keep away from infiltration of the elements and produce reaction forces. an additional particle method was proposed in the before time 2001s in [30] based on the DEM. The gelatine impactor is shown by spherical inflexible particles in combination among a visco-elastic–plastic penalty type of Hertzian contact law. The factor of this interaction law thus manage the universal fluid-like actions of the projectile. Hopeful results were obtained, though the spread of the bird was a little under predicted.

One more particle method was firstly developed plus useful for astrophysical inconvenience in the 1971s: the SPH

(Smoothed Particle Hydrodynamics) method [13-16]. It trapped desirability for the spray simulation of fluids add attention for bird strike modeling in current years.

B. Characteristics of Smooth particles Hydrodyanamicsmodeling

This method is a meshfreeLagrangianprocedure , stand on interpolation assumption and smoothing kernel functions [17]. The fluid is characterize like a set of discrete interacting constituent part (Fig. 4d), which are autonomous from each other, being capable to cover big deformations with no problem of mesh distortion.

Every constituent part has a mass, velocity as well as material rule allocate to it, It is based on smoothing kernel function and B-spline approximation [17-19], describe manipulation of the particle. Ground variables of an each particle are computed during interpolation of the adjacent particles, while a particle is believe a neighbour As it is positioned inside the smoothing length of another particle [16]. Since it is stand on a Lagrangian procedure, it can simply be correlated to conventional Lagrangian finite element models, avoid feasible material interface trouble connected with Eulerian codes [18].

In case of lagrangianmethod ,as element deformed ,time step reduce accordingly.For SPH model,time step is neighter raise nor reduce.for accuracy in result enough partical density is needed and maximum memory resources are required that affect CPU time.[21,22].The control of the SPH mesh density was Examined from each point of view in [23,24], by the conclusion of a maximum control on the flexible body pressure curve in collision simulations on a plane plate(Fig. 8). Rössler [25] could also show that the time step has an influence on the bird's flow behaviour and therefore on the pressure curve.Rössler [25] explain that the birds flow action and pressure curve are influenced by time step.In general, the SPH method need less elements, avoids the material interface problems connected through it and usually has a less result time .A drawback of the SPH method, since examine in [22,26], it does not have of sharp boundaries, that produces complications in the use of boundary conditions

other problems arise if the impacted area is not standardize butit is required for pressure calculations, as SPH element do not have a foot print, hence the actual impact area remains undefined.

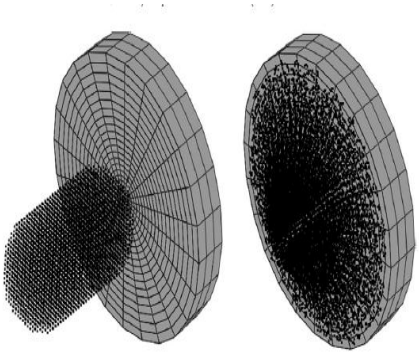

Fig.5- Bird strike simulation on rigid plate with SPH impactor model.

C. Application of SPH model for bird strike simulations

SPH method was used during 1990-2000 for bird strike simulations. [31,32].Bird strike analysis by using SPH method is utilised in code PLEXUS..

In [33]impactor and target plate both are modeled with the SPH method .due to this time step is decrease as compared to simulation with lagrangean plate. LS-DYNA and PAMCRASH uses smooth particle hydrodyanamic approach for bird strike analysis and find improved stability, excellent potential of bird divide and less

cost of the simulations. . [17,18,19].

VI .Advantages of Smooth particle Hydrodyanamic

1) No mesh distortion, steady time step
2) simulations are Numerically stable.
3) Difficult bird splitting activity can be simulated.
4) Excellent illustration splashing action .
5) Less computational cost.

V.Disadvantages of Smooth particle Hydrodyanamic

1)tensile behaviour is absent.
2) model generation is not easy task.
3) Previous to mesh distortion there is higher CPU time required compared to lagrangian.

VI. Geometry of Bird for bird strike analysis

Cylinder, the cylinder with hemispherical ends, the ellipsoid and the sphere are the most established geometries which are used for impact analysis as shown in fig.

Fig.6.Different substitute bird geometry

As per [35]Out of these geometries the cylinder with hemispherical ends Produces correct results.Therefore in bird strike analysis on single piece windshield cylinder with hemispherical ends used as a substitute gelatine bird.

VII. Bird material

Real bird is made up of water.therefore water like hydrodynamic response can be assume as correct approximation for validation. Equation of state are use for modelling of bird impactor[17,33]

VII.Conclusion

In recent year, research work proves that use of SPH provide accurate results for bird strike analysis on single piece windshield.It has valuable advantages like consistency,Less computational cost,meshfree, accuracy compare to other numerical methods.

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