Conceptualizing naval helicopter landing gear engineering essay

The landing gear is an important part of an aircraft as far as the take-offs and landings are concerned. The landing gear mechanisms (or structures) are pretty simple in case of the commercial helicopter as compared to the commercial airplanes. But, that is not the case for the naval helicopters. Because of the not-so-friendly landing conditions, the naval helicopter must have sophisticated landing gear mechanism connected with its fuselage. The design of the landing gear mechanism for the naval helicopter should be such that the helicopter can land safely in aircraft carrier as well as in ground; also, the mechanism should not fail under the sea wave excitation, while in ground condition.

b. Research on landing gear

During the initial days of the human flying history, the flyers used to have the Skids as landing gears. The skids are still very much in use for commercial helicopters. But, for the airplanes and for the naval helicopters wheels are used mostly for the landing gears. The wheels are connected with the shock absorbers to form the landing gears. The landing gear, then, get connected with the fuselage in various fashions based upon the size of the aircraft.

All the wheel based landing gears can broadly be categorized in three main categories:

Conventional

Tri-cycle

Tandem

Fig. 1: Showing three basic types of wheel based landing gears

Two front wheels and a rear tail wheel are used to form the conventional landing gear. The older aircrafts still have this type of landing gear. Ground handling is bit difficult here.

The tri-cycle configurations has two (or multiple of two) wheels at rear and minimum of one nose wheel (s) at front. It gives better ground handling comfort and used widely for small sized aircrafts. On the basis of the wheel arrangements, different types of tri-cycle arrangements are possible (as shown below)

Fig. 2: Showing different types of Tri-Cycle configurations (as per Federal Aviation Administration nomenclature)

The multiples of landing gears are placed in line to form a complex tandem landing gear system. Different combinations of tandem are possible (as shown below):

Fig. 3: Showing different types of Tandem configurations (as per Federal Aviation Administration nomenclature)

c. Conceptualizing Naval helicopter Landing Gear

After studying different types of available landing gears configurations, I have decided to develop the landing gear concept of Single wheel main gear with dual wheel nose gear configuration. It s a kind of tri-cycle configuration.

Fig. 4: Showing the rough landing gear concept

I have decided to use only torsion spring as shock absorbing elements for the concept.

d. Preliminary Design Calculations

In order further developing the concept, I have used the following data:

Total mass of the helicopter = 5126 Kg

Sprung mass on each spring, m = 2563 Kg

Distance between the front and rear gear = 5 m

Distance between the two rear gears= 2m

Normal landing:

Vertical descent speed of the helicopter = 0. 5 m/sec

Vertical deck speed = 0

So, the relative speed between the deck and the helicopter, v = 0. 5 m/sec= 500 mm/sec

So, the kinetic energy of the helicopter, KE = 0. 5*m*v^2 = 320375000 kg-mm^2/sec^2

The energy stored in the torsion spring, SE= 0. 5*k*r^2 = 0. 5*k

Where, k= spring rate in N-mm/degree

r= deformation of the spring = 1 degree (assumed)

Now, as

KE = SE . eqn. 1

So, k= 640750000 N-mm/Degree

I will use this spring rate for rest of the two landing conditions to find out the deformations of the torsion springs.

Hard landing:

Vertical descent speed of the helicopter = 3 m/sec

Vertical deck speed = -3 m/sec

So, the relative speed between the deck and the helicopter, v = 6 m/sec= 6000 mm/sec

K= 640750000 N-mm/degree

So, by using the eqn. 1:

r= 12 degree

Crush landing:

Vertical descent speed of the helicopter = 15 m/sec

Vertical deck speed = 0m/sec

So, the relative speed between the deck and the helicopter, v = 15 m/sec= 15000 mm/sec

K= 640750000 N-mm/degree

So, by using the eqn. 1:

r= 30 degree

So, I will start my ADAMS design with the values obtained from this hand calculation and gradually fine tune the values in order to meet the landing criteria.

e. Converting the Conceptual Design to ADAMS Mechanisms

I have used the MSC ADAMS software for preparing two landing gear mechanism design options out of the conceptual design and the hand calculations. The two design options differ in terms of heights. Parametric design advantage of the ADAMS software is utilized for creating the two design options.

While creating the two mechanism design options, the following ADAMS options are utilized:

Point : Points are used for creating basic locations of all the important elements of the design (like centre of the wheels etc.)

Torus : Wheels of the landing gears are created using the torus option.

Link : All the structural members (like top frame, axels etc) are created using this option.

Box : This tool is used for creating the landing deck of the air craft carrier.

Torsion Spring : This is for creating the front and rear torsion springs.

Hinge Joint : This option is for creating all the revolute joints of the mechanism.

Translational Joint : This option is used for creating the translational joints.

Contact : The contacts between the wheels and the deck are created using this option.

e. 1. ADAMS Mechanism Option-1

The mechanism option-1 looks like below:

Fig. 5: Showing the ADAMS Mechanism option-1 Arrangement

The points table for the mechanism option-1 looks like below:

Fig. 6: Showing the point table for the mechanism option-1

e. 2. ADAMS Mechanism Option-2

The mechanism option-2 looks like below:

Fig. 7: Showing the ADAMS Mechanism option-2 Arrangement

The points table for the mechanism option-2 looks like below:

Fig. 8: Showing the point table for the mechanism option-2

e. 3. Selecting the Optimum ADAMS Landing Gear Mechanism

The selection of the best design out of the two options is done by observing the acceleration values. The acceleration plots for the hard landing conditions (descent velocity of the helicopter = 3 m/sec and upward deck speed = 3m/sec) for both the concepts are shown below:

Fig. 9: Showing the hard landing condition acceleration plots for both the concepts

The above plot is showing that the maximum acceleration value for the design -2 is more than

50 m/sec2.

The acceleration plots for the crush landing condition (descent velocity of the helicopter = 15 m/sec and upward deck speed = 0 m/sec) for both the options are shown below:

Fig. 10: Showing the crush landing condition acceleration plots for both the concepts

The above plot is showing that the maximum acceleration value for the design option-2 is much higher in case of the crush landing condition.

So, on the basis of the above two tests, it can be concluded that the design option-1 is better among the two options. Hence, I have selected the design option-1 for further analysis.

f. Testing the Selected ADAMS mechanism (design option-1) Against the Specified Landing Conditions

Normal Landing Condition: The acceleration plot for normal landing condition (descent velocity of the helicopter = 0. 5 m/sec and upward deck speed = 0m/sec) for the design option-1 is shown below:

Fig. 11: Showing the normal landing condition acceleration plots for the Design Option-1

The above plot is showing that the maximum acceleration value for normal landing condition for the design option-1 is 7. 5 m/sec2.

Hard Landing Condition: The acceleration plot for normal landing condition (descent velocity of the helicopter = 3 m/sec and upward deck speed = 3m/sec) for the design option-1 is shown below:

Fig. 12: Showing the hard landing condition acceleration plots for the Design Option-1

The above plot is showing that the maximum acceleration value for hard landing condition for the design option-1 is 48. 1 m/sec2.

Crush Landing Condition: The acceleration plot for normal landing condition (descent velocity of the helicopter = 15 m/sec and upward deck speed = 0m/sec) for the design option-1 is shown below:

Fig. 13: Showing the crush landing condition acceleration plots for the Design Option-1

The above plot is showing that the maximum acceleration value for hard landing condition for the design option-1 is 119. 6 m/sec2.

g. Running the Vibration Analysis for the Selected ADAMS Mechanism

The vibration analysis is performed for the Design option-1 using the ADAMS vibration plug-in. For simulating the sea wave oscillations, two acceleration actuators are used at front and the rear axles. One output channel is created at the COG of the top frame. The output channel is used for measuring the acceleration at the COG of the frame.

Fig. 14: Showing the Frequency Response Analysis plot for the Design Option-1

The pick of the above frequency response plot indicates the resonating frequency for the design option-1. So, the resonating frequency here is 64. 5 Hz.

h. Consolidated Results for Design Option-1

Parameters Values

Maximum Normal Landing Acceleration (m/sec2) 7. 5

Maximum Normal Landing Acceleration (m/sec2) 48. 1

Maximum Normal Landing Acceleration (m/sec2) 119. 6

Resonating Frequency (Hz) 64. 5

i. Discussion

Task-1: This task is covered in the section-c and section-d.

Task-2: This task is covered in Section-f.

Task-3: This task is covered in section-g.

Task-4: This task is covered in section-e.

j. Conclusion

The ADAMS is a powerful tool for creating and testing a mechanism under specified conditions. The parametric feature of ADAMS helps creating different design iterations easier.

The design option-1 passed all the landing conditions specified for the assignment. Also, the resonating frequency observed for the design option-1 is 64. 5 Hz.

k. References

http://www. faa. gov/airports/resources/publications/orders/media/Construction_5300_7. pdf

http://www. allstar. fiu. edu/aero/flight14. htm

http://www. helis. com/howflies/skids. php

http://www. aoe. vt. edu/~mason/Mason_f/M96SC. html