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Design and Development of Magnetic Type Landing Gear for Quadcopter

K. K. Nithiyanantham[1*], G. Anitha[2] and R. Venkataswamy[3]

[1] Department of Aeronautical Engineering,KCG College of Technology,Chennai
[2] Department of Aerospace Engineering ,Madras Institute of Technology Campus, Anna University, Chennai- 600044, India, Email:nithiz2005@gmail.com

ABSTRACT

The purpose of this Research is to develop a Neodymium magnetic type landing gear of quadcopter to reduce shock and vibration of vehicle which is also improve the landing of quadcopter. The detailed report of this Research is to study and analysis the output response of the Quadcopter system during landing condition on the ground. It uses two or three neodymium magnets (the main concept is like poles of a magnet repel and unlike poles of a magnet attract each other) inside a non-magnetic cylinder to reduce shock and vibration of Quadcopter in order to improve the landing of quadcopter. The merit of this magnetic type landing gear system has no leakage of oil like hydraulic shock absorber and also requires less maintenance than other type of shock absorber. Experimental testing reveals that the magnetic type landing gear system can land safely with sufficient stability.

KEYWORDS: Neodymium magnets, landing gear system, Shock, Magnetic type Suspension, Magnetic poles.

*Corresponding author

K.K. Nithiyanantham

Assistant Professor (Sr.Scale)

Department of Aeronautical Engineering,

KCG College of Technology, Chennai- 600097

TamilNadu, India. Email:nithiz2005@gmail.com

INTRODUCTION

Landing gear system is one of the vital subsystems of an Unmanned Aerial Vehicle which provides a suspension system at the time of landing. The designer has faced major challenge to design landing gear systems which are landing gear with minimum weight, minimum volume, materials selection etc. The development of landing gear takes into consideration of various requirements strength, stability, damping under all possible attitudes of the aircraft. Flyball (co-axial rotorcraft) is an air vehicle that used for vertical takeoff and landing (VTOL).The frame of flyball itself acts like landing gear system which is also used to improve the safety of the vehicle. The quadcopter is also amphibious so that it could float, takeoff, land on water. The UAV landing gear shock vibration control proposes the momentum exchange principle (MEID) for reducing the shock vibration response of an UAV at the time of the landing process. The overall performance of the impact damper is to be satisfactory after adding a pre-straining spring to the damper system. The UAV dynamics is first modeled (the main wheel, nose wheel and main body) and analyzed as a simple lumped mass translational vibration system. The UAV landing gear mechanisms without damper and with pre-straining spring MEID are simulated. The performance of damper is evaluated from the maximum acceleration and force transmission to the main body. The energy balance calculation is conducted to verify the performance of PSMEID. The simulation results confirm that the proposed PSMEID method is used to reduce the maximum acceleration and force transmission of UAV at the time of impact landing. The purpose of suspension in an aircraft is to prevent shock during landing phase or rough road condition and also to enhance traction force between road surfaces.

The top level design inputs of landing gear system such as minimum weight, minimum size, and greater reliability are required to design of an aircraft. This is achieved by selection of suitable material according their properties, use of modern composite material and also magnets instead of conventional system. Finally, these results in aircraft with minimum weight, better performance and greater reliability. The conceptual design of aircraft landing gear with magnets (maglev aircraft) can developed and obtained with minimum weight, better performance, less maintenance and high reliability. In order to maintain structural integrity and effectiveness, RC helicopters and quadrotors are commonly integrated with Flexible Landing Gears (FLG).They are made (use the mechanical properties of the material) but it does not depend on heavy hydraulics in order to absorb the energy of landing. electromagnetic suspension is one of the alternative for conventional suspension system which uses passive suspension system (linear motor used in the suspension) for passenger vehicle.

The controlled linear force from linear motor, the reliability of fully active suspension system for vehicle also highlighted in.

1. SUSPENSION SYSTEM

The magnetic type landing gear suspension system contains magnets, freely moving inside the cylinder with their same poles facing each other. Since the magnetic poles repel each other while moving closer, the oscillating spring action is obtained. Generally landing gear systems used are pneumatic and oleo strut which requires additional components for producing the required pressure level, which automatically increases the weight of the landing gear system and also increase the overall weight of the entire aircraft and therefore decrease the fuel efficiency of the aircraft, which can be overcome by the proposed design.

The outer cylinder material, piston, magnets are required to construct the magnetic suspension type landing gear system. The concept behind this design is simple, that the magnets with the same poles facing each other will be subjected to a repulsive force. This repulsive force will withstand the load acting on the magnet. The idea was proved as a failure in early discussions since the spacing provided between the magnets is very less approximately 2cm, which can be dangerous when loads are acted upon, but in this design, the above mentioned disadvantage is overcome by using a series of magnets instead of a single pair of permanent magnets. The number of magnets depends on the spacing and repulsive force required. When the number of magnets used is more, with each magnet facing another magnet of same pole facing each other, then the spacing increases and the repulsive force also increases there by increasing the cushion effect which is a very important aspect of a landing gear.

1.1 *Neodymium Magnet*

A neodymium magnet also called as Neo magnet which is a permanent magnet from alloy of neodymium, iron and boron to form the $Nd_2Fe_{14}B$ tetragonal Crystalline structure. Neodymium magnets are the strongest and greater strength type of permanent magnet which is used for suspension for landing purpose of UAV.

1.2 *Application of ND Magnet*

Neodymium magnets have been used in many of the myriad applications in modern technology. It has greater strength that allows the use of smaller, lighter magnets for Head Actuators for computer hard disks, Magnetic Resonance Imaging, Electric Motor for wind turbines.

1.3 *Cylinder*

The outer cylinder material used in this research must be a non-magnetic Thefore either a composite material or a non-metallic alloy can be used for this development. PVC pipes used to make the cylinder for magnetic type landing gear based on the required dimension.

1.4 *Magnetic Shielding*

Magnetic shielding is used to reduce low-frequency electromagnetic interference (EMI).Magnetic shielding materials re-direct a magnetic field so it lessens the field's influence on the item being shielded which does not eliminate or destroy magnetic fields. However, provide an easy path for the magnetic field to complete its path. Shielding is used to isolate electrical devices from their surroundings. Electromagnetic shielding also called as RF shielding that blocks radio frequency electromagnetic radiation .The unique properties (electromagnetic field shielding characteristics, very high magnetic permeability, its ability to absorb magnetic energy.) of this MuMETAL and other shielding alloys results in the highest possible attenuation of low frequency EMI.

1.5 *Board*

Board (plywood) is the base which is attached to the magnetic suspension system. After another end of the board is also attached or integrated with the UAV base structure. Here the magnetic suspension system can be attached directly on the UAV structure, but using a board will make it easier to detach it from the UAV system and so in case of any system failure, the landing gear system can be detached easily and also requires less maintenance during servicing. The board should also be non-magnetic since it might affect the performance of the magnets used in the landing gear suspension system.

Design- Catia 3D Model

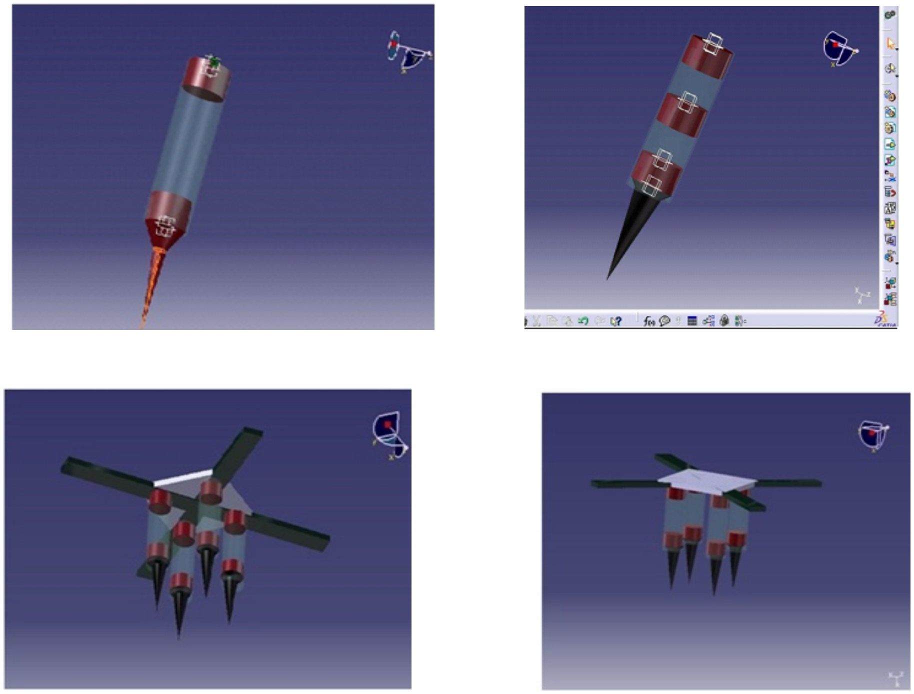

Figure 1: Design of landing gear system with two or three magnet

Figure 1.Shows the CATIA Design of landing gear system with two or three magnets.

2. EXPERIMENTAL CALCULATION

We calculated the spacing between two magnets by applying various loads and Figure 2 (a) & (b) have shown the spacing diagrams for various loads as follows

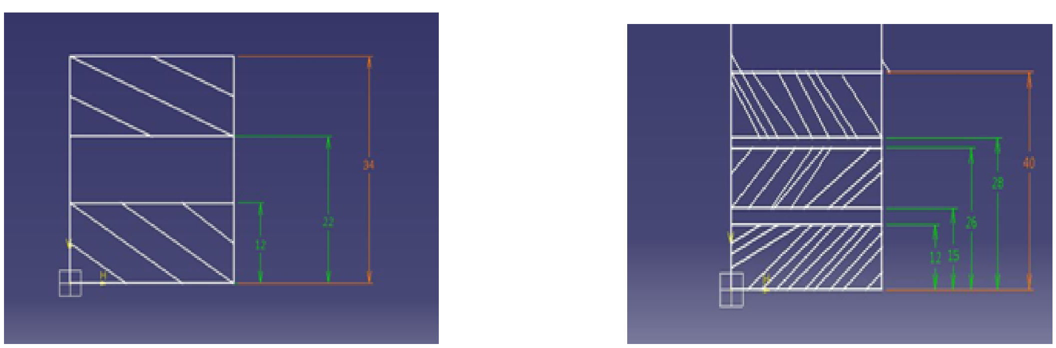

Figure 2: (a) Spacing for 1Kg is 10mm (two magnets)

(b) Spacing for 1.5Kg is 5mm (three magnets)

Table 1: Load & Spacing between 2 magnets

Load (Kg)	Spacing (mm)
3.5	2
3	4
2.5	5
2	6
1.5	7
1	10
0.5	14

Based on the above values of two magnets and three magnets(from the table 1), the three magnets are comparatively withstanding more suspension than two magnets and a number of magnets increases, the suspensive power also increases, we will get better result than previous. Thus we consider 2 magnets as our model is in small scale (quad copter).

3.ANALYTICAL CALCULATION

According to Gilbert model we assumed that the magnetic forces between magnets are due to magnetic charges near the poles. While physically incorrect, this model produces good approximations that work even close to the magnet when the magnetic field becomes more complicated and more dependent on the detailed shape and magnetization of the magnet than just the magnetic dipole contribution.Table 2 and Figure 3 represents estimation of magnetic spacing and magnetic force.If Spacing between magnet decreases, magnetic forces increases gradually.

Table 2: Estimation of magnetic spacing and magnetic force (full model)

Spacing (mm)	Magnetic force (N)
33	0.003
23.4	0.011
18	0.023
15.5	0.035
14.5	0.042
13.5	0.051
12.5	0.062
12	0.069
11	0.086
10	0.11
10	0.11
9.75	0.117
9.5	0.125
9.25	0.133
9	0.143

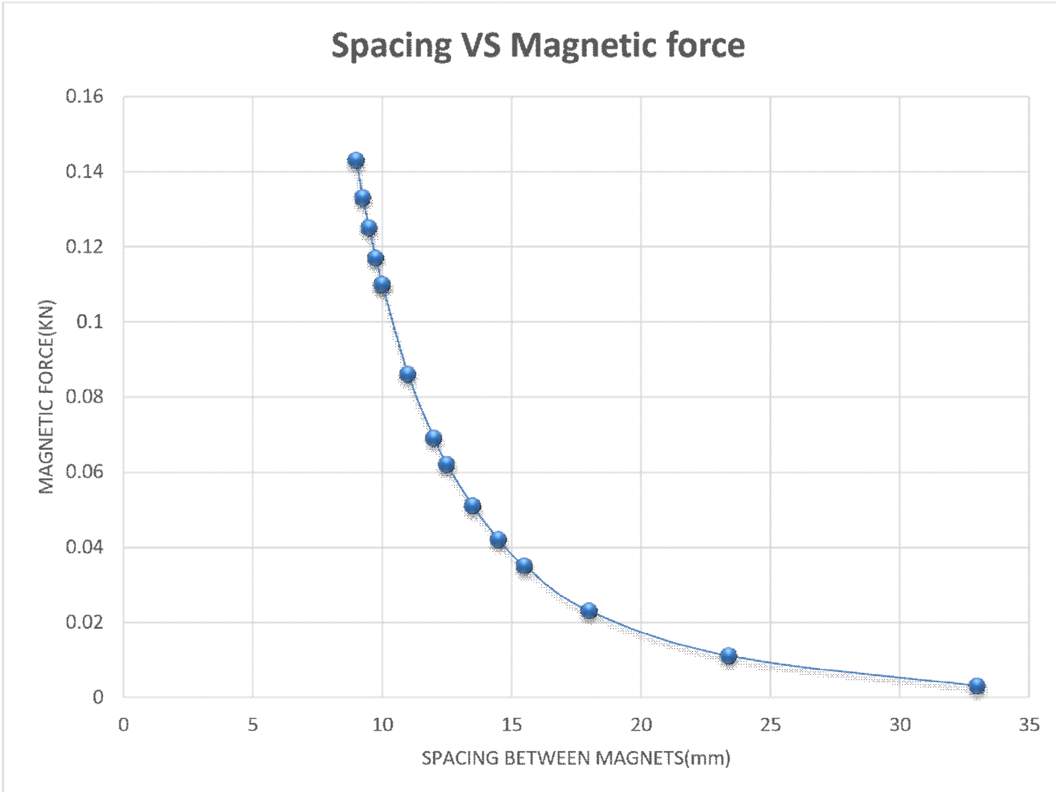

Figure 3: Spacing VS Magnetic force (full model)

4. COMPARSION OF VARIOUS LANDING GEAR SYSTEMS

4.1. *Comparison of Magnetic Type Landing Gear System with Normal UAV Landing Gear System*

The normal landing gear system used in UAV is strut type such that the strut takes up the load and shock during landing. If the strut is too rigid, then the shock during landing affects the frame of the UAV.If the strut is too week, it might break during heavy landing, hence the strut has to be designed properly to take up all loads and it fails to act efficiently as a damping system during landing. While our landing gear can take up loads up to 7kg for a given model and it can withstand even more load when stronger magnets are used, hence for a given UAV, corresponding to its configurations, magnets can be selected and used efficiently. It also acts as damping system during landing.

4.2. *Comparison of Magnetic Type Landing Gear System with Conventional Oleo Strut System*

The currently used pneumatic type oleo strut landing gear uses the same set up as ours, except they use compressed nitrogen for cushion and oil in another chamber through an orifice as a damper. This system has many drawbacks such as requirement of air producing equipment and the air to be compressed properly to meet certain criteria such dry, clean and required lubricant. Pressurized air has tendency to leak easily, air thrown out produces noise, and the pressurized air has tendency to condense. Air cannot be used since it might lead to corrosion and separate oil must be used as a damping system, these increase the cost and complexity of the oleo strut system.

O-Rings are used in the landing gear system have tendency to be damaged due to fatigue over a certain number of landing hence they have to be replaced often this will also increase the cost included. Our landing gear system also acts as damping system thus reducing complexion and it is cost effective. The permanent magnets have to be magnetized if they are demagnetized, Neodymium magnets have the most coercivity i.e., ability to resist demagnetization and magnetic shielding also reduces the tendency for the magnet to be demagnetized.

4.3. Final *Model of Magnetic Type Landing Gear*

Figure 4: (a) Full Model with 0.5Kg loading (b) Full model with 1 kg loading

Figure 5: Magnetic shock absorber landing

Figure 4 .shows (a) Full Model with 0.5Kg loading (b) Full model with 1 kg loading.Figure 5 .shows Magnetic shock absorber landing used to reduce shock while landing.

CONCLUSION

The development of magnetic type landing gear is to reduce the vibration produced in quadcopter during landing phase successfully. Not only vibration, it also to reduce the drag component in quadcopter. The real time confirms that better results on the reduction of drag and vibrations caused in the landing gear. It also observed that good output response of magnetic type landing gear for various loads. The demerit of the system is weight only. In order to reduce the weight, we develop the neodymium magnetic landing gear system in less weight material in future work.

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