Design of Magnetic Levitation Assisted Landing and Take-off mechanism of Aircraft using Hammock Concept

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ABSTRACT – For safe, efficient landing and take-off of aircraft in future magnetic levitation assisted TOL could turn out to be best alternative to conventional landing gear system. Thus in this paper design and working principle of the magnetic levitation assisted TOL is being purposed using hammock concept. Hammocks used in this concept are slings made up of high strength fibre and steel cables, often used in the construction of bridges. The hammock will be attached to a sledge at which the aircraft is placed during TOL operation. The sledge is also provided with wheels and can be detached from the hammock for ground operations like taxiing, hanger operations etc. There will be the provision of joining two sledges together vertically in order to increase the length of the sledge for larger aircraft. The tracks based on the principle of electrodynamics suspension is used here to drive the hammock and sledge unit during TOL operation and the source of power is electricity.

Keywords:- Magnetic levitation,Take-off and Landing, Halbach Arrays ,Hammocks, sledge, steel cables, Barricade.

INTRODUCTION

Magnetic Levitation system uses a magnetic force to levitate the aircraft on a rail and to accelerate it during take-off. When landing, this system can be utilized to decelerate the aircraft. If an aircraft is assisted with magnetic levitation system during take-off and landing excessive amount of impact force, vibration and shock will be produced. In conventional system hydraulic shock absorbers are used for this purpose, which nearly consumed 7% weight of the total aircraft and complex hydraulic mechanism is required. Thus in magnetic levitation system hammocks can be utilized for the purpose with which can reduce the weight and it is a good shock, vibration and impact force absorber.

Generally used hammock is a sling made of fabric, rope, or netting, suspended between two points, used for swinging, sleeping, or resting. It normally consists of one or more cloth panels, or a woven network of twine or thin rope stretched with ropes between two firm anchor points such as trees or posts.

Usually in aircraft carries, emergency recovery system called barricade are widely used. It consist of upper and lower loading strap joined together to arrest the motion of aircraft and it looks like the hammock. Similarly bridges are constructed through high strength suspended cables which holds the entire weight of the bridge and the payload. Thus designing a magnetic levitation assisted sledge mechanism with hammock for TOL operation could be reliable and cost effective mechanism.

The magnetic levitation system consist of a special arrangement of the permanent magnets which augments the magnetic field on one side of the array and cancelling the other side nearly equal to zero, this special arrangement is known as halbach arrays and this array concept was developed by Klaus Halbach of the Lawrence Berkeley National Laboratory in the 1980s for use in particle accelerator.

The figure 1 shows the linear Halbach Array:

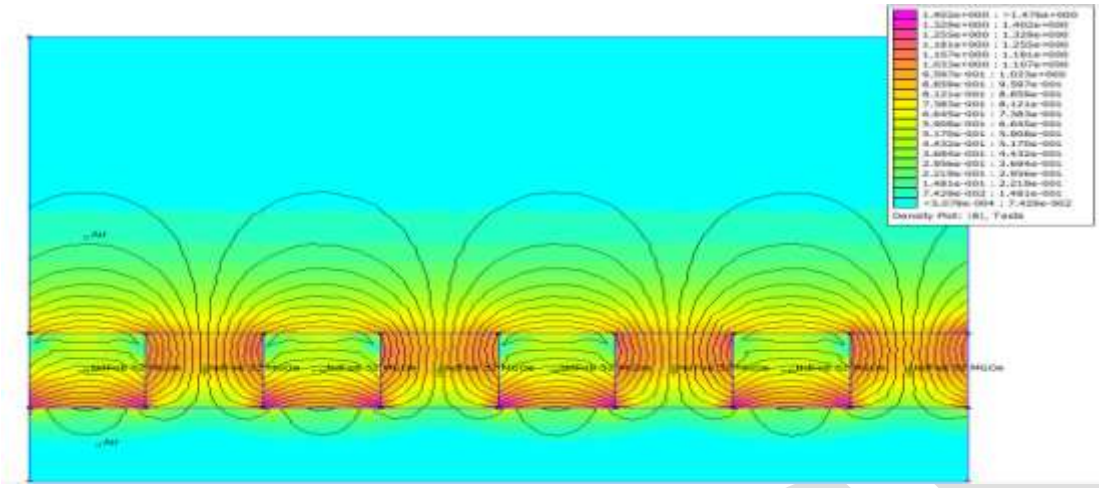

Fig 1.Linear Halbach Arrays

Methodology

A. Aircraft

For this project the conventional landing gear system has to be removed and the belly of the aircraft has to be redesigned, since the aircraft will be carried on the sledge.

B. Basic design concept of magnetic levitation assisted sledge with hammock

Here the main components are Sledge, Hammock, and Electromagnetic Rail. The length and other specification of the sledge, hammock and rail can be varied according to various factors such as length of the aircraft, weight etc. Thus for this project only the basic conditions of TOL mechanism are considered. The length and various other specification used here are all assumption. The basic design of this mechanism is represented schematically by the figure 2.

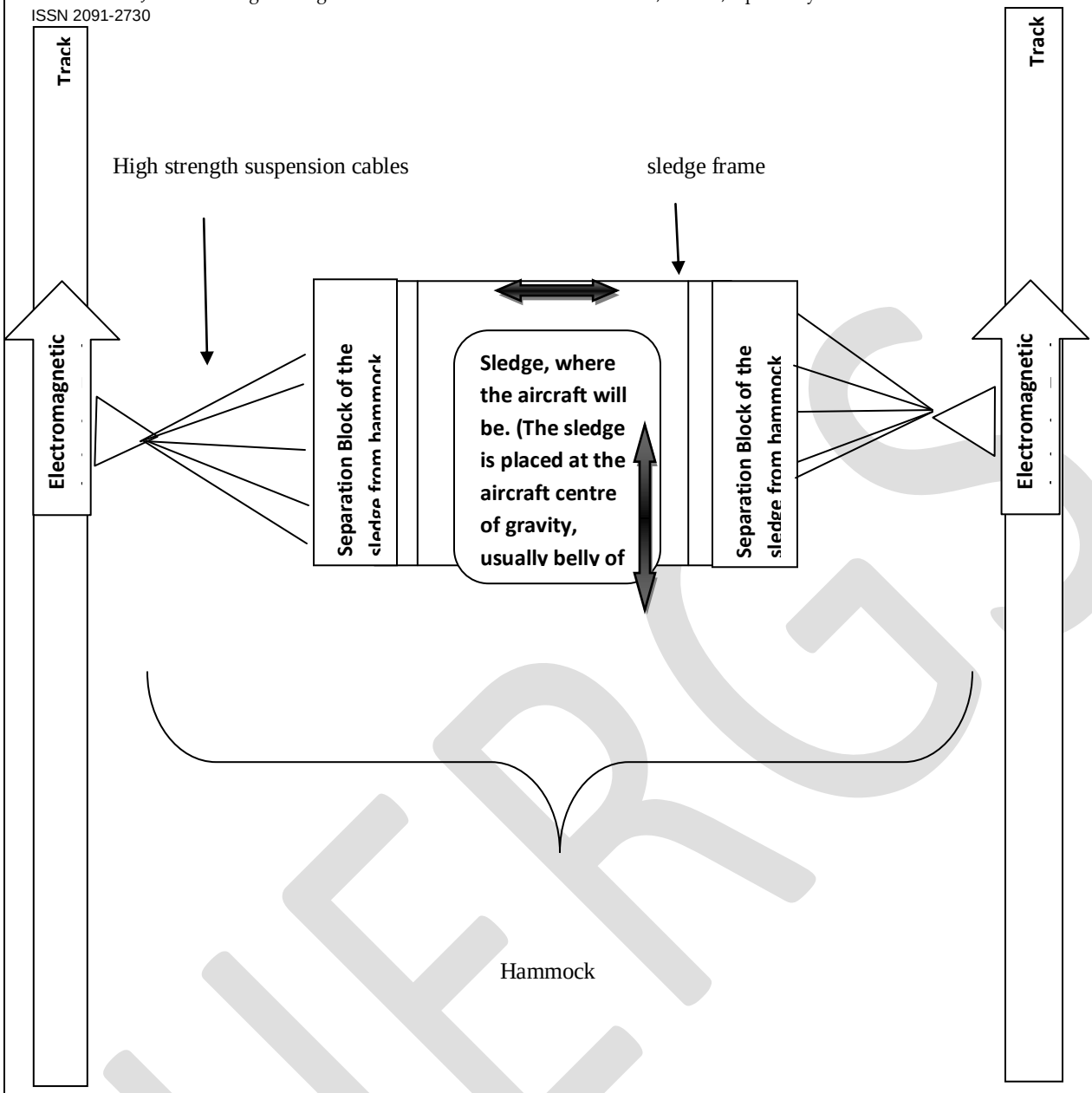

Fig. 2: Basic design concept of magnetic levitation sledge with hammock.

C. Designing the sledge

Sledge is the main portion where the entire aircraft will be supported. Hence the sledge will be assisted with the following elements:

At the starboard and portside of the sledge a latching mechanism will be provided which will attach and detach the sledge to the hammock.

Similarly at forward and backward of the sledge similar latching mechanism will be provided whose purpose is to attach and detach the sledge with another so that the length of the sledge could be increased or decreased depending upon the size of the aircraft.

The midsection of the sledge is provided with hydraulic actuators so that the section could be moved horizontally and vertically for the increasing the precision and the frame of the sledge will remain stationary.

Various electrical sensors are implemented to ensure the functioning and safety condition of the sledge and other mechanism.

Electric motor driven wheel will be provided to the sledge system so that the aircraft could be moved from the track to the hanger or for performing ground operation.

The wheels will be of retractable type, because fixed wheels increases drag.

The 3D view of the sledge with its components is shown in the figure 3.

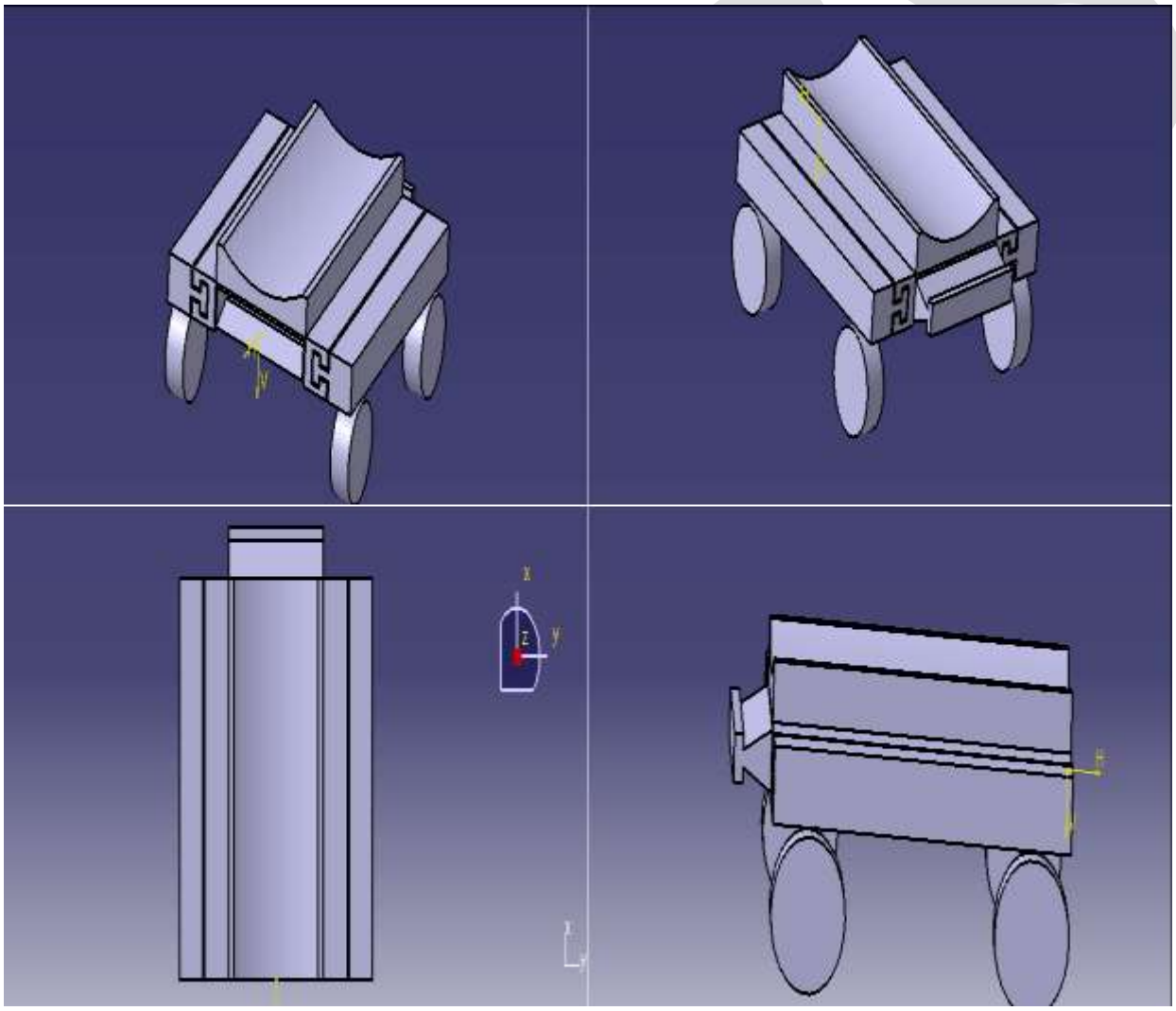

Fig 3. 3D view of sledge

D. Aerodynamics of sledge

In order to reduce the drag and excess noise aerodynamic cowling should be designed, this could also be made retractable during the time of landing because for landing excess drag is more essential for braking effect.

E. Designing sledge slot

The sledge slot is nothing but the same sledge and it is added in addition to the main sledge in order to comfort the TOL operation of the larger aircraft. Each sledge is unique and contains all components, they are similar but slotted according to length and breadth.

F. Designing the hammock

Barricade are the good example for designing the structural concept of the hammock. The hammock will be constructed with fibre and cables having high tensile strength and good stiffness factor such as those used in the construction of bridges. The bunch of high strength steel cables will be combined together to form a suspension cable so that the fail safe design could be achieved (i.e.) whole system will not be affected due to failure of a single cable from bunch. The figure 4 illustrates the design of cable system for fail safe and figure 5 is the picture of commercially available steel cable.

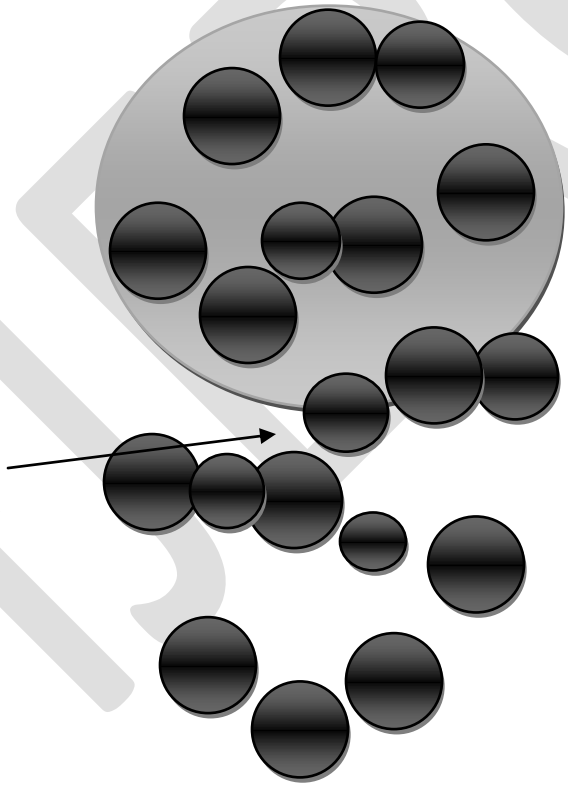

Fig 4. Suspension cable design for hammock

Fig 5. Commercially used steel cable

Working Principle

The working principle can be defined according to various operational states of the components used in this mechanism.

Magnetic Levitation track

Magnetic levitation track provides levitation and traction to the entire setup. The magnetic levitation induct track is constructed through the series of halbach arrays which can produce a flux density of more than 1T. At the operation speed of the sledge, the levitation force of the induct track acts like a stiff spring. Thus more than 2cm clearance between the sledge and the track can be produced. Since no friction force is acting on the system, the sledge can be accelerated to its maximum speed, which is the required speed of the aircraft to produce lift. Hence lift produced by the wing takes off the aircraft and the sledge will be finally detached from the aircraft.

Hammock

Here the hammocks acts as the shock absorbing agents or they can be called as the replacement of the hydraulic system. Though some parts used here in this project are provided with hydraulic system for the purpose of safety and to increase the efficiency. Hammocks are the slings connecting the track to the sledge. The sledge can be detached from the hammocks with the help of detach and attach hinges. Hammocks play vital role during landing operation.

Sledge

Sledge is the main component used for holding the aircraft and it is the main function of the sledge. The provision of moving the sledge horizontally and vertically with respect to sledge frame provides the precision landing and take-off of the aircraft and also plays vital role in gust wind landing. According to the total length of the aircraft additional sledge slots can be attached or detached. And it works similar to the concept of attaching and detaching the train compartments.

Attach/detach hinges

They are provided in starboard and port side for the hammock purpose. The hinge at forward and backward is for the provision of addition of sledge slots.

The figure 6 and figure 7 shows the flowchart for take-off and landing operation.

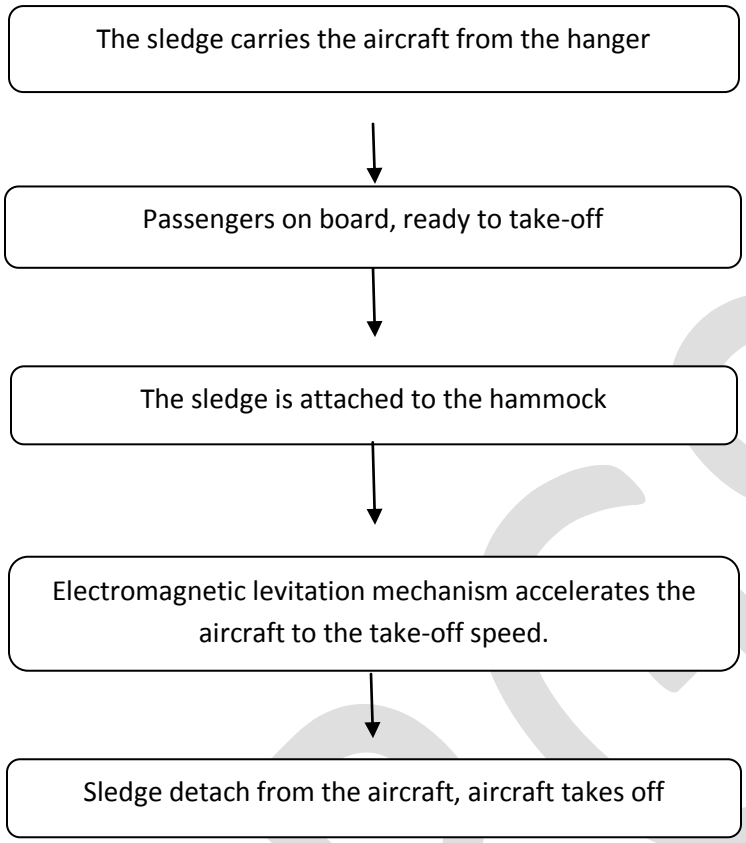

Fig 6.Flow chart of take-off operation

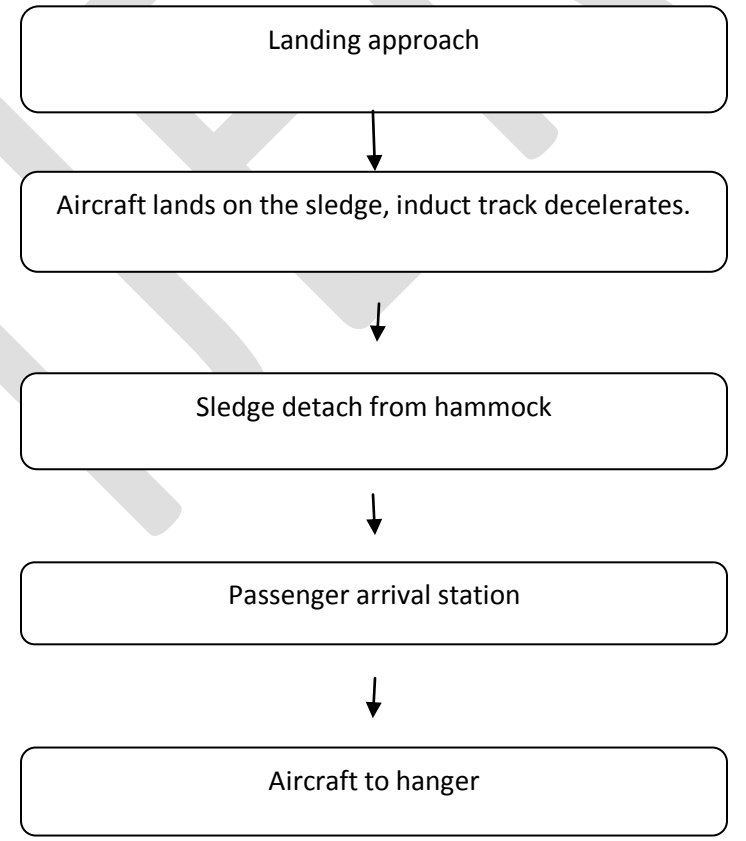

Fig 7. Flow chart of landing operation

CONCLUSIONS

This paper gives the idea of design of the hammock concept with magnetic levitation assistance for TOL operation of aircraft. This method could increases the fuel efficiency of aircraft since take-off and landing is done through ground assisted power source, thus smaller engines can be used, Removal of conventional landing gear could reduce 7% weight of the aircraft, less noise production so that airports can be built nearer to the cities.

Finally I conclude that more than more, this method is the most cost effective method because of the use of less hydraulic mechanism and can reduce runway length. This is the best alternative solution to conventional TOL mechanism. This could enhance the aviation industries go green.

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