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Design Analysis And Application Of Magneto-Propelled Space Launcher

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***Abstract*—Magneto-Propelled space launcher focuses on another method of providing extra lift capacity rather than the usual rocket propulsion that is in use today. It uses the repulsion provided by magnetic fields to generate thrust. The device makes use of Le Chatelier's principle such that: when a stress is brought to bear upon any system which is in equilibrium, the system will move in such a way as to undo the stress upon it. Two magnets of like poles have a repulsive force on one another. This results in a motion that is opposite each of the two magnetic fields. This can be likened to the analog Multi-meter which consists of a coil of fine wire wound on a drum mounted between the poles of a permanent magnet. When direct current flows in the coil, the magnetic field of the coil reacts with the magnetic field of the permanent magnet. The resultant force turns the drum with its pointer. In this basic tool, it can be observed that the motion is not indefinite as long as the current is on and constant. In this case magneto-propelled launcher, motion is indefinite, as long as the energy maintaining the body's instability is not removed. Magneto-propelled launcher has a navigation system that depends on varying the forces that make the body balanced. If three forces are able to keep a body horizontally balanced and one of the forces is altered, then the body will tilt to an angle.**

1. Introduction

Global warming is now considered one of the major threats to nature. The world is aiming at cutting its temperature by 2^{o}C or extreme weather events might continue to occur. There are predictions that if CO_2 emissions are not cut, there will be drought in some parts of the world [1]. Typhoons, hurricanes and other weather events are becoming more extreme. Tens of thousands of liters of jet fuel are burnt every second and around a million liters of rocket fuel are burnt to put an average spacecraft into space [2]. The spacecraft industry is only accountable with increasing global temperature by 2% which it directly emits right into the ozone layer as it makes its journey to the outer space. Magneto-Propelled Launcher (MPL) solves this problem of space travel pollution by employing a system that grossly reduces rocket propulsion hours of the spacecraft.

Apart from reducing CO_2 emission, space crafts are also set to travel at a greater speed when incorporated with MPL than when propelled by ordinary fuel fired space launchers thereby enabling deep space exploration. By calculating how much force is needed to propel a certain mass to a certain velocity and finding the relationship between the net force (in the upward direction), the velocity and weight of spacecraft; a formula can be derived that would enable the calculate of the amount of force needed for a specific velocity of travel [3]. In recent years, countries use high energy laser mobile demonstrator to destroy, damage sensors, or make missiles fly off its trajectory [4]. The machine uses sensors to identify incoming missiles and fires at it, destroying it before it strikes the ground. The maneuvering technology can be done by using current alternations in the electromagnets. The cost of sending a spacecraft into orbit will be greatly reduced with the introduction of the magneto-propelled launcher. MPL will have a lower construction cost than many other proposed non-rocket propulsion systems and it will have the advantage of using existing technology.

Keywords: Launcher, electromagnetic, rocket, permanent magnet, downward force

2. Propulsion systems

All space launchers function with the principle of Newton's third law of motion that action and reaction are equal and opposite [5]. Force applied in one direction pushes the spacecraft in the opposite direction. Hydrazine or other forms of rocket engine fuels are used to provide this thrust in the downward direction pushing the spacecraft in the opposite direction [6, 7]. Liquid, solid and gaseous fuels have been developed over the years. Thousands of liters of jet fuel are burnt to put one spacecraft into orbit around the earth or for space exploration. Other forms of launch materials can be used as long as the propulsion system is able to provide thrust in the upward direction. Apart from air, the conventional means of providing lift is by using Newton's third law of motion. The Magneto-propelled launcher achieves this lifting capability by using the force provided by magnetic fields.

3. Motion

Applying energy on a body doesn't necessarily mean that motion will result. Motion only results when the resultant forces acting on a body is greater than zero. When the resultant force on the body is greater than zero, motion in the direction of the greatest force will occur. Ancient philosophers and physicists, Isaac Newton, Galileo Galilei said that it is natural for a body to stop moving when the force providing its motion is removed [8]. Motion can continue indefinitely as long as the force which provides the motion does not stop.

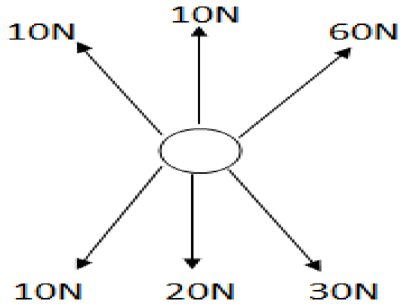

Fig. 1. Magnitude and direction of forces

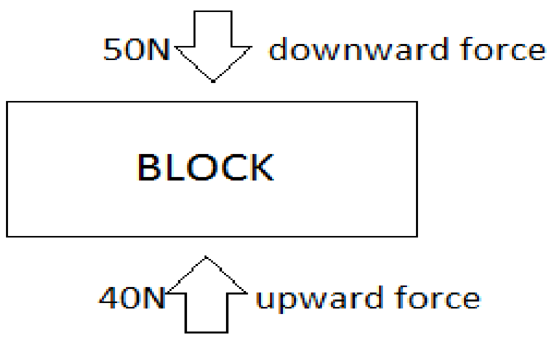

Fig. 2. Opposing forces

If force is applied by a man to lift a 5kg block up and the onset force happens to be 40N which is smaller than the minimum force needed to lift the block, the block cannot be lifted. If the man's force is increased from 40N to 55N the block can finally be lifted up. If the block is being lifted by the man, then the overall downward force acting on him is his weight and the weight of the block. He may not move downwards because he is standing on a stable structure, the force can be measured when he stands on a weighing balance with the block still on his head, which of course increases his weight. The overall force acting on the block has a resultant whose direction is upwards whereas the overall force acting on the man is acting downwards. Forces can act constructively or destructively: it acts constructively when the forces are acting in the same direction, their effect will be maximized. It acts destructively when the forces are acting in different directions, it will create minimum or negligible effect. Fig. 2 shows a system of 6 forces acting on a body through a central point. Three forces are acting upwards while the remaining three are acting downwards. The total force acting upwards is 80N while the total force acting downwards is 60N. A resultant force of 20N is directed upwards. Net force = Total upward force - Total downward force = 80N - 60N = 20N. A resultant force of 20N is directed downwards.

4. Balanced forces

A body moving upward will have to overcome the body's weight. Once upward force is greater than downward force on a body; the body will be lifted up. This can be demonstrated using the crane shown in fig. 3.

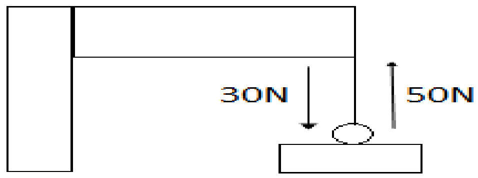

Fig. 3. A crane

If another block of 20N is added to the block in fig. 3, the upward force exactly equals the downward force. This makes the total downward force of 50N which equals the total upward force of the crane. At this point, the forces are said to be equipotential and such a body will likely float in the midair. If the block is placed on a balance the weight will read zero, nevertheless no motion occurs. It would be as if the block was never there. This is as a result of balanced forces. This can further be explained with weight changes when one measures one's weight while accelerating against gravity and with gravity like being in an elevator. An iron ball is placed at the centre of two magnets of equal strength. At this point, the ball will not move as though there was no force exerted on it. This is as a result of destructive interference. When one magnet is moved to a greater distance, the forces seize to be balanced and the ball moves to the direction of the closest magnet. The movement of the ball to the closer magnet shows that motion is as a result of unbalanced forces acting on a body.

5. Analysis of motion under force fields

Magneto propelled launcher works on the principle of a known theory: Le Chatelier's principle. This principle explains why any body that gains energy will seek to release it. When air is blown into a balloon and released, the balloon flies off in a direction opposite to that of the outgoing air. If the balloon has an infinite supply of air, it would never stop moving up. If there was a device that pumps air into the balloon just as fast as the air is pumped out, the motion of the balloon will indefinitely go on. The balloon will only fall when it has run out of air which propels it forward. This is an example of depleting energy. Earlier it was stated that motion is as a result of unbalanced forces acting on a body. Unbalanced forces on a body mean that force acting in one direction is greater than other forces acting in other directions thus producing motion. When energy is applied to a body, the body moves (the movement is a way of relieving itself of the energy put into it, in other words conservation of energy). When like poles are brought closer, their interactions are that of repulsion; each one tries to throw the other out of its field. Two forces are pushing each other in different directions, but the weaker magnet will eventually fly out in a direction away from the stronger magnet's field. The weaker magnet will stop when it has moved out of the stronger magnet's field (that is out of the other magnet's disturbance).

This principle is applied in the ongoing description of magneto-propelled rocket launcher. Component description of the magneto-propelled space launcher is shown in fig. 4.

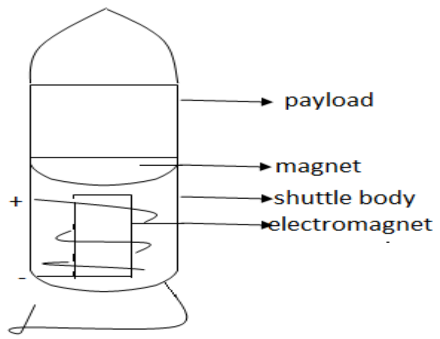

Fig. 4. Magneto-propelled launcher configuration

All values are assumed:

Weight of payload = 50kg

Weight of magnet = 5kg

Weight of Electromagnet = 6kg

Weight of shuttle = 2kg

The forces acting on the space shuttle can be grouped into two, namely: those acting in the upward direction and those acting in the downward direction.

(a). Upward force (provided by Electromagnet) = 900N

(b). In this case, there are two notable forces acting downward, namely:

(i) Downward force (provided by the magnet) = 200N

(ii) Total force of the launcher which acts downwards = M*a

= (50+5+6+2)*10 = 630N

Resultant forces acting downward= 630+200 = 830N

Resultant forces acting in both directions = 900N – 830N =70N

Motion always takes place in the direction of the applied force as long as the applied force is greater than the retarding force.

Motion will not continue forever due to friction and other retarding factors. By controlling the instability of a body, a body will move indefinitely without stopping. A body can never emit energy unless it is unstable and anybody that gains energy (no matter how small the energy) is practically unstable.

6. The findings

The Magneto-propelled launcher operates on the principle that like poles are always repulsive toward one another, each tending to eliminate the other from its field. This force between the like poles tends to create motion in direction opposite to their fields. When a powerful electromagnet is placed under a permanent magnet and the two combined such that the motion of one also produces motion to the other one below it, the two will fly off together. Le Chatelier's principle plays a role by suggesting that a body will tend to stabilize itself from an external force and even internal disturbance by any means possible [9]. When the electromagnet repels the permanent magnet, they both move and none of the two leaves the field. This results in a constant state of disturbance resulting in constant motion.

Based on the above findings, the following results are available:

a) Repulsive interaction of like poles is employed to provide motion.

b) The repulsive force of the electromagnet must be that it is able to carry the general weight of the set-up. That is, it must be greater than the force of gravity on the body and the downward repulsion by permanent magnet.

c) Controlled instability is employed to ensure the permanent magnet does not fly out of the field of the electromagnet so that the energy interaction does not stop.

d) The weight above the permanent magnet must be greater than the weight below it.

7. Calculation of the forces provided by magnets

Velocity will decrease if the strength of the electromagnet is constant and the overall weight is increased. The magnetic field can be considered to be constant since its value does t change. Velocity will increase with increase in the current supplied to the electromagnet. The strength of a given magnet is sometimes given in terms of its *pull force:* its ability to move (push/pull) other objects. The pull force exerted by either an electromagnet or a permanent magnet at the air-gap (i.e. the point in space where the magnetic field ends) is given by the Maxwell equation [10, 11].

$\boldsymbol{F} = \frac{\boldsymbol{B^2 A}}{\boldsymbol{2\mu_0}}$,(1)where F is force (Newton), A is the cross sectional area of the pole in $m^2$and B is the magnetic flux exerted by the permanent magnet (Tesla). Therefore, if a magnetic force is acting vertically, it can lift a mass m in kilograms given by the simple equation:

$m = \frac{B^2 A}{2\mu_0 g_n}$, (2)where the μ_o is the permeability of free space; its value is $4\pi\times10^{-7}$ Wb.A.m^{-1}, g_n is the acceleration due to gravity (ms^{-2}). To find the amount of current needed for a certain force to be attained, the following equation can be applied

$$F = BILsin\theta, \text{ (3)}$$

where I = current and L = length of the conducting wire.

8. Weight placement

It is a well-known fact that the electromagnet pushes up anything that is above it, and those below it are dragged up by the weight of those above it and not by the force provided by the electromagnet. If the weight above is not at least 20kg more, the weight downward will keep it down. But when the weight above the electromagnet is greater than the weight below it, the body will lift. The following observation can be explained thus: When wind blows, an A4 paper is carried away. Normally, a common plastic sharpener will not be carried by the wind because its area is compact though its weight is lower than the A4 paper. The A4 is able to be carried by the wind because it has a wide area to be influenced by the wind. This is somewhat the principle of boats and airplanes. When the wind is blowing, it carries the paper but left the sharpener. When the sharpener was tied to the bottom of the paper, the wind carried the paper as well as the sharpener. When a mathematical set was tied to the paper, it could not lift it. This is because it is heavier than the paper, so the paper cannot use its weight against it. This is the reason why it is better to pull a weight than to push it, because our weight acts against the body we are pulling and so in pulling less force is needed.

9. Experimental verification

Aim: To prove that a body can use its weight against another body

Materials method: A balloon, 1kg weight, a burner and a jar of propane gas.

Trial 1: **[12]** For a typical atmospheric condition 25^{o}C, a hot air balloon heated up to 99^{o}C requires about 3.91m^{3} of envelope volume to lift 1kg. The weight is attached underneath the balloon. **Trial 2**: The weight is attached to the top of the balloon.

Observation: At trial 1 when the weight was attached underneath the balloon, the balloon lifted. At trial 2 when the weight was kept on top of the balloon, the balloon could not lift up. In trial 1, the air pushes up the balloon and the balloon drags along the weight. And in trial 2, the air has to both lift off the weight and the balloon and the available force was not sufficient to carry both masses so the balloon could not be lifted. The burners supply heated air to the balloon envelope, this makes it light enough to move through the air according to Archimedes principle [13]. The upward force is exerted on the balloon and not on the basket but because the basket is attached to it, the basket is also dragged up. This is just the working mode of Magneto-propelled launcher; the force is applied only on the magnet, this is sufficient enough to provide motion for the magnet but the electromagnet and the rest is dragged up because they are attached to the magnet.

10. Navigation of magneto-propelled launcher (mpl)

Other space vehicles change direction by firing rocket fuel at a direction opposite to the direction they want to turn to [14]. If the spacecraft wants to go forward, the rocket fuel is fired backward, if it wants to turn left, it is fired at right and if it wants to slow down, it is fired at the direction of motion, making it to slow down. To better understand MPL's navigation, then the rate an angle of a body tilts when force on one side is increased or decreased is considered.

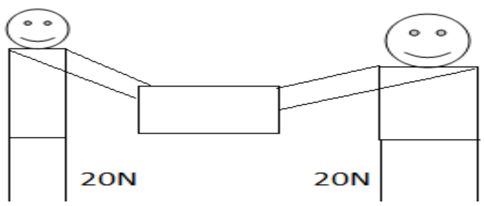

Fig. 6: Navigation at equal forces.

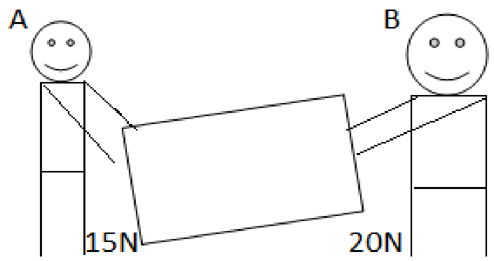

Fig. 7: Navigation at unequal forces

The diagram of Fig. 7 shows the same boys but one of them has dropped his force to 15N and the table will no longer be balanced since forces are no longer equal. The table will tilt proportionately depending on the level of reduction of force by Boy A. Generally, a body will tilt when weight is constant and force on one side is increased or decreased.

11. Navigation of magneto-propelled launcher

MPL's navigation is quite different from that of an ordinary spacecraft. This device operates by using electromagnetic gears (E-gears). An MPL model should have more than one E-gear, three, five, seven or more. All MPL models must have odd number of E-gears. For a three E-gear model of MPL with E-gears A, B, C, with the middle one B located at the centre of gravity of the body, A located at the right of B and C located at the left of B. To turn MPL to the right, the current in the right E-gear is reduced which will make the device to incline horizontally to the right. In the same manner speed can be increased or reduced by varying the amount of current in the electromagnets. Each of the electromagnet should be shielded from others by a material that allows low penetration of magnetic field. The magnetic shielding is to limit the amount of destructive interference that would result in the electromagnets. The three E-gears support the body moving vertically. When the current in one of the electromagnets is lowered (example the current in C is lowered) the spacecraft will tilt to the right, since the forces needed to keep the spacecraft balanced is changed. The space craft's mass is still the same but the forces are changed. This can be compared with adding weight to one side of a balance. The balance will tilt to an angle θ because weight on both sides is no longer balanced. The point labeled C_g denotes the

B = 100N B = 100N B = 100N B = 100N B = 100N center of gravity of the body. To find the angle the spacecraft will tilt to with a given reduction of force in C the weight supported by the electromagnet C should be known, that is the overall weight of the spacecraft Angle of tilt, ϴ can be defined as the distance moved in the x-y plane when there is a noticeable force reduction or increase at any point in the body.

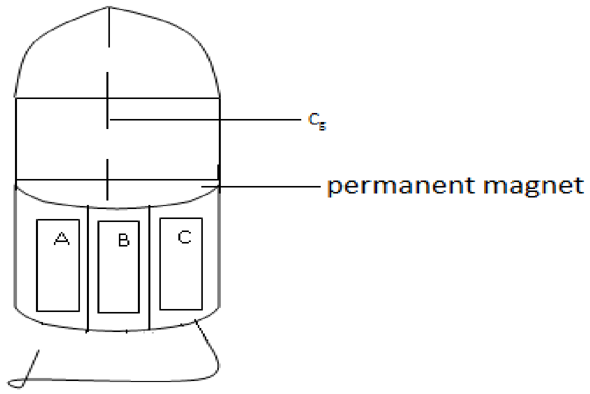

Fig. 8. MPL navigation (where A, B, C, represent electromagnet armature)

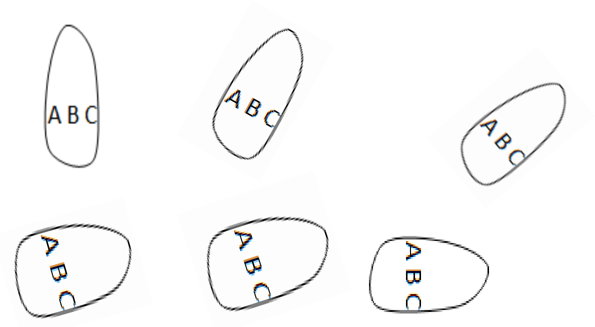

Fig. 9. MPL's navigation model

Table 1.0 Angular position of Armature C with respect to Armature B

Angle	0°		10°		15°		20°		25°	
Armature	A	100	A	100	A	100	A	100	A	100
	B	100	B	100	B	100	B	100	B	100
	C	100	C	80	C	40	C	20	C	0
	t_1		t_2		t_3		t_4		t_5	

At 0° (t_1), the entire navigation armatures are 100% positioned in parallel with one another which shows a linear motion – equal forces are on the armatures. At an inclination of 10° (t_2), the force on armature C decreases to about 80%. At 15° (t_3) and 20° (t_4), the forces on C decrease accordingly and at 25° (t_5) all the forces in armature C become zero which gives the maximum wheeling of the spacecraft. To turn to the other side, the procedure for Armature C is reversed for Armature A.

12. The navigation model

Magnets are measured with their power rating in Ampere/m.

$P = \frac{F \times d}{t}$ (4)

$P = \frac{mad}{t}$ (5)

$P = mav$ (6)

$where\ V = \frac{d}{t}$ (7)

where P = power, m = mass, a = acceleration, v = velocity, d= distance, t- time

By getting the power of the magnet, the downward pull it has on the electromagnet can be calculated.

The other downward force is the weight of the spacecraft.

$F = ma$ (8)

The third force is the upward push of the electromagnet.

$F = Bil$ (9)

$B = \frac{\mu i}{2\pi r}$ (10)

Where B is the flux density, μ_o is the permeability, i is the current, l is the length of the wire and r is the radius of the wire.

To find the current that would be generated by a copper of a particular area, A, length, l,

the following formula can be applied:

$R = \frac{\rho l}{A}$ (11)

where ρ is the resistivity of copper which is equal to $1.72\times10^{-8}\Omega m$ [15] .

To achieve lift the downward force provided by the magnet and the total weight of the system above the magnet should be less than the upward force provided by the electromagnet.

13. The potential force

An electromagnet is most likely to lift a body of like pole to a certain height into the air before pushing it off.

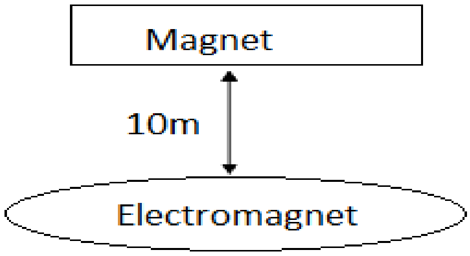

Fig.11. Repulsion between like poles

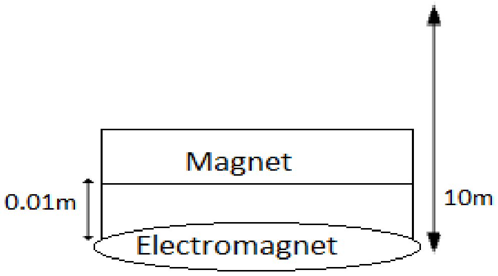

Fig.12: Controlled repulsion of like poles

An electromagnet lifted the piece of magnet with a mass of 10kg, 10m into the air. This height rests on two things; the weight of the magnet and the strength of the electromagnet. When another weight is added to the magnet, the distance between the electromagnet and the magnet will decrease. When the strength of the electromagnet is increased; the distance between the electromagnet and the magnet will increase. At that height of 10m, the magnet has a greater potential energy than at lower height. The potential energy at this height is 10×10×10 (mgh) which is equal to 1000 Newton. This is the same magnet and electromagnet but in this case the magnet is attached to the electromagnet and is positioned at a height of 0.01m from the electromagnet. The magnet cannot go further than this 0.01m. At 0.01m, the potential energy of the magnet is 10×10×0.01=1N.

Therefore, the energy not expended should be equal to the final expected force minus the apparent controlled force. This energy is 1000N-1N = 999N of force unexpended. The law of conservation of energy states that energy can neither be created nor destroyed though can be transformed from one form to another **[16]**. This means that the 999N energy cannot be wasted. If the force is enough to lift both the magnet and the electromagnet, both will fly off. This motion will be constant because no matter the motion, the final expected force minus the apparent controlled force will always be equal to 999N. The above postulations are justifiable through the following example: Suppose that a magnet is placed on top of an electromagnet such that it generates a repulsive force of 4000N per meter. The whole system is aimed at being propelled vertically upward. This goal would be accomplished when the spatial separation between the bodies is adjusted such that the upward repulsive force is greater than downward gravitational force (F_{grav}).

14. Experiment and results

This paper discussed the experiment on the feasibility of magnetic propulsion system. A solenoid made from copper wire wound round an iron bar was used to increase the magnetic field produced.by the solenoid. The top of a can was cut out and the electromagnet was placed inside it. The can was shut tight with the two heads of the copper wire sticking out. Next, an iron magnet and another weight were fixed on top of the can with a tape. The tape did not run over the magnet but instead under it. When the copper wire was connected to a 12V d.c. battery, the whole set-up lifted.

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