World Academics Journal of Engineering Sciences
Vol.7, Issue.1, pp.45-49, March (2020)

Research Paper

E-ISSN: 2348-635X

Vibratory Rotation of a Spherical Body due to Residual Magnetism during Electro-magnetization by A.C.

N. C. Pandey

Department of Physics, Th. D. S. B. College Nainital, Kumaun University, Uttarakhand, India

Available online at: www.isroset.org

Received: 16/Mar/2020, Accepted: 31/Mar/2020, Online:10/Apr/2020

Abstract- Rotatory motion of a rigid body is achieved by the application of a torque developed by a thrown force. The throwing force is derived from the concept of residual magnetism. Although, the property of a magnet is well known about it's behavior to attract other iron species. But, in case of the iron crore placed inside the electromagnetic coil for the magnetization by a. c, the compensating force is seen to apply by the crore on a circular iron disc plate kept over it. The compensating force is the result of a repulsive force faced by the plate due to its residual magnetism. Due to it, the circular plate remains magnetized in the same direction even after the change of magnetizing field towards the opposite direction acted by a.c electromagnet. This repulsive force is able to throw an iron made spherically rigid body for setting the torque for itself necessary for the rotatory motion. Thus, the vibratory rotational type of motion is associated with the presentation of this scientific model.

Keywords : Elector- Magnetization, AC

I. INTRODUCTION

According to Newtonian classical mechanics, the mass of the body is the measurement of it's inertial property. In the absence of any external force, the body does not change it's state of motion. In this type of motion F = m a. The body goes to a linear motion. A very high magnitude of force is necessarily required to change a state of linear motion of a body having high property of inertial mass [1]. A little force appears as negligible. In the same way, the moment of inertia is the measurement of rotatory motion of a body. In the absence of any moment of a force, the body can not change it's state of rotation. In the other words, the body requires a torque to rotate about an axis. For rotatory type of motion $\tau = F \times r$, where r is the position vector [2]. The total moment of a force acting on the body is equal to the sum of torques acting on it's particles for orbital motion around the various points which are found to be situated in that rotational axis which passes through the centre of the gravity of the body.

$$\tau = \tau 1 + \tau 2 + \tau 3 + \tau 4 + \dots$$

$$= F1 \times r1 + F2 \times r2 + F3 \times r3 + F4 \times r4 + \dots$$

$$= m1\ a1\ r1 + m2\ a2\ r2 + m3\ a3\ r3 + m4\ a4\ r4 + \dots$$

now, $(a = r\ \alpha)$

$$= m1\ r1^2\ \alpha + m2\ r2^2\ \alpha + m3\ r3^2\ \alpha + m4\ r4^2\ \alpha + \dots$$

$$= \alpha\ [\ m1\ r1^2 + m2\ r2^2 + m3\ r3^2 + m4\ r4^2 + \dots\ ]$$

$$= \alpha\ \Sigma\ m\ r^2$$

$$= I\ \alpha$$

Where α is the angular acceleration and $I = \Sigma\ m\ r^2$. The moment of inertia of the body is equal to the sum of moment of inertias of its particles constituting the body and m is the mass of each particle rotating at a distance r from the rotational axis. The relation between torque and moment of inertia show that if the moment of inertia of a body is very high then high magnitude of torque will be needed to change the state of rotation of such a body. In case of solid sphere $I = 2\ M\ R^2 / 5$ and during rotation of such a body, the axis of rotation goes through the centre of the gravity of the body. The axis also remains perpendicularly situated to the line of force causing rotation. Thus, the body can rotate only about its diameter which goes through the centre of the spherical body [3].

II. THEORY

When a force acts on a body, the force can take the body either in a linear motion or in a rotatory type of motion or in both linear as well as rotatory types of motion. The kind of motion depends upon the line of action of the force from which point it acts on the body. If the line of force acts through the centre of the gravity of the body, then the body goes for a linear motion. In this case, the line of action of the force coincides with the line joining the point with the centre of the gravity of the body. In this case, the angle between the line of force and the line joining the point to the centre of gravity of the body is 0°. The resolved component of force is F Cos0 = F. The total applied force is used to give the linear motion to the body. Hence, such a force is called the linear force. Because, due to its acting through the centre of gravity of the body, the body goes only for a linear motion. But, if the line of action of force does not go through the centre of gravity of the body, the body can go either for purely a rotatory motion or for a dual motion comprised of linear as well as rotatory type of motions. It depends upon the angle between the line of action of force and the line joining with the centre of gravity of the body. If the angle between two aforesaid lines is 90°, the resolved component of the force which acts towards the centre of gravity and responsible for linear motion is F Cos90 = 0. In the absence of any external force acting through centre of gravity, the body can't go for a linear motion. Because, F Sin90 = F, therefore the total applied force is used to develop a torque for the rotation of the body. Such a force which applies a torque to the body is called a rotatory force. But, if the angle between the line of action of force and the line joining the point with the centre of gravity is neither 0° nor 90°, the body will go for both types of motion. The force in this case can be said as throwing force. The line of thrown force and the line joining the point with the centre of gravity of the body makes an angle θ. The resolved component of thrown force F Cosθ acting on the body towards the centre of gravity carries the body for a linear motion while the other resolved component F Sinθ takes the body for a rotatory motion. The body gets torque for rotation as shown in figure 1.

It should be noted that the force applied to a body to provide torque necessary for the rotatory motion is not equal to the force acting on a single particle at the point of application of the force. But, the torque provided to the body is equal to the sum of torques obtained by the various particles for orbitary motion around the axis of rotation. It means to say that as soon as the torque is applied to a body, It's particles from the respective positions also get torques to go in circular motions around a fixed axis.

III. EXPERIMENTAL

DESIGNING AND MULTIPURPOSE DEVICES OF THE APPARATUS

This scientific investigation is primarily related with the theory of electro magnetism. Rotatory motion of a spherical body is obtained with the help of following experimental accessories.

1. A step down transformer of 18 volt kept separately inside a wooden box associated.
2. Two solid cylindrical screwed bolts with nuts which are made of iron metal and are generally used in making bridges over the river. Two nuts are fitted at the top of each screwed bolt. One nut is associated to wind the coil. The other nut remains free to move at the top of the nail. Thus the whole length between the head of the bolt and two nuts fitted at the top is used as crore for electromagnetic coil wound on. Two similar type of crores so made ready for winding electromagnetic coils are needed to set up electromagnetic poles by the passage of alternating current.
3. Thread insulated copper connecting wire available generally in all physics labs. is used as an electromagnetic coil wound on the selected iron made crore in between the head of the crore nail and a nut fixed along the length apart at some distance from the head of the nail. Two similar types of electromagnetic nut poles are clamped at a few distance from each other in such a way that head sides of the bolts remain downward based on a thick wooden block box. The upper side of the nut poles are also clamped by passing through two broad apertures made on the upper edge of the wooden block box in such a way that the electromagnetic coil, the lower side of crore consisting head of the bolt nail and upper sided one nut can keep closed within the box as shown in figure 2. Only movable nuts appear outside for use as the two magnetic poles. This type of arrangement is shown in figure 3.
4. Two weights each of 50 grams having holes at the centre. The weights are those which are generally used in the physical weight box. The weights are made of metallic steel which have high property of retentive magnetism.
5. A metallic tub type of circular disc plate of tin having a hole at the centre. The circumference of the tub is fitted on a plastic case. The plastic case is the place for keeping the two weights one over other.
6. Supporting and carrier rod. The lower end is clamped at the base of the box and the upper end is supported thorough a hole made in between the two nut poles appearing out side. The upper end of the rod goes firstly through the metallic tub plate then to the holes of each weights in such a way that the metallic tub carrying the case and weights can sit on the electromagnetic nut poles appearing outside. The height of the rod is so fixed that it ends before coming out side from the hole of upper most weight. A small tip of hole from the upper most side is left for putting the rotatory body. This design is represented by the figure 4.
7. The solid iron sphere kept over the tip is exhibited in figure 5. This is the body which goes on rotation due to the supply of torque acting on it.

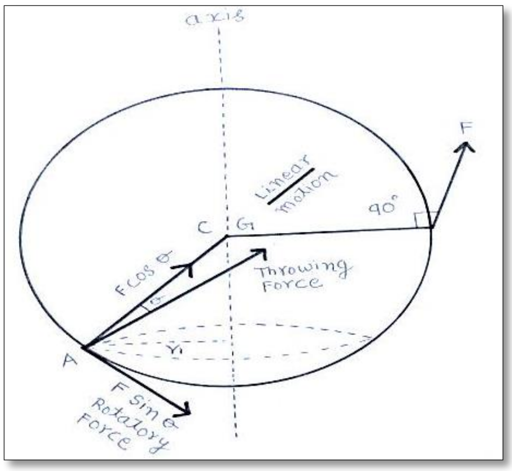

Figure 1. Demonstration of finding a torque for rotatory motion of a spherically solid body due to throwing force.

Figure 2. Inside view of the electromagnetic coils wound on iron screw bolts used as electromagnetic crores.

Figure 3. Out side view of magnetic poles changing its field for magnetization due to electro magnetization by a.c

Figure 4. Demonstration of repulsive force acting on tin based plastic case due to its residual magnetism.

Figure 5. Demonstration of development of rotatory force for the dance of a spherically solid body due to throw.

Bridge making nut bolts are taken about 10 cm in length and 3 cm in diameter approximately for the use of crore needed for winding of the electromagnetic coil. The insulated wire of copper is used as the electromagnetic coil wound on the crore. The length of the coil is 6 cm and the width about 3 cm. Thus, the electromagnetic coil becomes like a transformer coil. But, only the primary winding is done. If we want to study the transformer and generator devices related with the electricity, we can wind the secondary coil over primary also. The system will go to a source of electricity due to the generation of electricity by the law of mutual induction. The electricity will be useful for low voltage lighting devices.

For designing the apparatus, two similar types of electromagnetic coils for magnetizing crore kept in side are joined in series and the electrical connection for the circuit is made by a 18 V step down alternating current transformer. When the a.c circuit is switched on, the source goes to generate magnetism. The nut poles are magnetized due to electromagnetism. Firstly, the coils are electro magnetized. Due to the magnetic set up, the crores placed inside the coils are also magnetized. Crores are used to enhance the net magnetization developed by the electromagnetic coils respectively. The direction of magnetism attained by the electromagnetic nut poles depend upon the direction of current passing through the electromagnetic coils [4]. Due to use of a.c as a source for supplying current passing through the coils, the direction of magnetic field developed in electromagnetic nut poles also changes due to the change of direction of current. Due to this effect of cyclic orientation of magnetic domains of iron made crore, the crore goes on heating to much. Due to cause of this, the nut poles become a source of heat due to generation of thermal energy. The magnetic polarity of nut poles is decided by the estimation of current entering into the coils at both the ends. At one time, both the nut poles are settled to have same magnetic polarity. This can be achieved by viewing the winding of coil at both the ends of each coil and the direction of current passing through it. The polarity of nut poles changes with the same frequency of a.c. source. Now, when the tin based plastic case carrying two weights is put over the nut poles with the help of carrier and supporting rod, the assembly kept over the nut poles starts to vibrate due to acting of compensating force of attraction and repulsion. Due to such vibrations, the source goes to generate the audio sound. The motion of the disc upward and downward is obtained to occur along the axis of supporting rod. The motion of disc container vertically upward and downward is magnified by keeping two weights each of 50 gm over the plate. The carrier should have a fixed height so that a part of hole may be left from the upper side of the weights. This hole behaves as a tip for placing the iron made spherical body on it. The rotatory motion of the spherically solid iron ball is obtained due to thrown force for which the direction of rotational axis and velocity all depend upon the thrown force and the torque achieved as a result of it. The thrown force is magnified by using steel made weights as a media of enhancing residual magnetism. The source goes to derive a mechanical energy responsible for the rotatory motion.

IV. RESULTS AND DISCUSSION

The body of interest which is required to rotate due to moment of a force is selected to be thrown by a force derived from the phenomenon of residual magnetism. However, the primary theory is based upon the development of electromagnetism by a.c. current passing through the electromagnetic coil for the magnetization of nut poles. The nut poles are magnetized by dipole due to electromagnetism. When the ferromagnetic circular disc fitted as a base of plastic case is kept over the nut poles, it is also magnetized by the vectorial sum of magnetic fields generated by the both nut poles in the same direction. Thus, the circular disc made of tin is magnetized in the same direction as the magnetic field is generated and applied by nut poles during first half cycle of a.c passing through the electromagnetic coils for magnetizing nut poles.

Let any time both upper sided nut poles behave as S pole. The magnetic fields near them will be downwards. The iron disc kept over the nut poles is magnetized in the same direction of external magnetic field. The lower side face of the plate becomes N pole while the upper side face as S pole. The lower side situated N pole of the plate is attracted by S poles of both the nut poles. The plate is attracted by a downward force acting on it. This is an usual phenomenon of magnetization, according to which ferromagnetic materials are attracted by the magnet. Thus, during the first half cycle of a.c, the disc is magnetized and it is attracted by the nut poles downward. The force of attraction between the two opposite magnetic poles act downward along the direction of gravitation. Because, a.c changes it's flow of direction of current alternately in the electromagnetic coil. Hence, the nuts polarity changes from S to N during next half cycle. But, the disc plate did not remain attracted. It is repelled vertically upward. This happens due to the retentive property of the disc plate. Due to this property, a magnetic substance like iron when is magnetized once due the presence of magnet nearby, it remains magnetized by the same polarity for some time even after removing the magnetizing field. The remaining magnetism is called residual magnetism. The relative phenomenon is called the retentive property. The circular disc remains in a state of residual magnetism. As soon as, the nut poles get opposite magnetic polarity N due to the magnetization by second negative half cycle due to the change of direction of current passing through electromagnetic coil, the circular disc remain in a state of residual magnetism. Due to the property of magnetic retentivity, the lower face of the disc will behave as N pole as it was during magnetization by the first half cycle. The N pole of plate comes in front of N pole of the nuts. As a result of existence of two opposite magnetic fields association, the circular plate is repelled towards upward direction against the gravitation. The field of residual magnetism remains dominant than the usual magnetism obtained due to gradual increase caused by a.c. Thus, during the cancellation of retentive magnetism, the disc is repelled upward against gravitational force due to repulsive force acting between similar polarity of disc and nuts.

Only a small amplitude of vibrations between nut poles and the circular disc appear due to retentive property of tin iron. The vibrations are the result of attractive and repulsive force acting in between the nut poles and the circular disc. When two weights made of steel are kept over the tin plate carrying case, the amplitude of vibrations increases due to high force of repulsion acting on weights due to higher coercivity of steel metal. Due to this cause, the magnitude of residual magnetism can be cancelled only by applying strong magnetic field in the direction opposite to residual magnetism. Thus, magnetization of steel and residual magnetism on it may be the cause of high amplitude of enhanced force. This enhanced force is used as a source of throwing force. The throwing force is applied on a spherically solid body of iron to go for a movement. The hole left over the upper weight is the place of keeping the spherical body for rotation. The spherical body can be thrown in any direction. The plane of motion of it is adjusted by throwing at various angles. This is accomplished by moving nuts .

If the iron body kept over the weight moves up and down following a linear motion, such a force acting on the body can not rotate it about any axis. In this case the force is being acting through the centre of gravity of the body. But, if the throwing force is applied through one side of the body not through C. G, the body goes for both linear as well as for rotatory motion. The axis of rotation is always perpendicular to the line of force causing torque for rotation.

V. CONCLUSION

Generally, when we throw a body, it is observed that the body goes for a typical type of motion. In this investigation, the motion of a thrown body is resolved. The throwing force is divided into two components. One component of which goes through the centre of gravity becomes responsible to carry the body in a linear motion. The other component of the force which does not act through the centre of gravity carries the body in a rotatory motion due to the establishment of torque. In the other words, the throwing force responsible for such type of typical motion is applied from one side of the body not through C. G. If the force of throw acts totally through the centre of gravity of the body, it will go only for a linear motion.

ACKNOWLEDGEMENT

The author is very grateful to his guide Dr. J. C. Joshi for his keen interest in developing the apparatus designed for a top dance. The author finds very glad to dedicate this achievement in memory of Dr. D. D. Pant for providing

research facilities for luminescence investigations carried out in past as a fellow of council of scientific and industrial research.

REFERENCES

[1] D. Halliday "Fundamentals Of Physics", *Thomsons Publication, **India***, pp. **82 - 84**, **2010**.

[2] J. C. Upadhyaya "Mechanics", *Ram Prasad & Sons Publication*, **India**, pp. **18**, **2002**.

[3] S. Prakash "New Intermediate Physics Part One", *Naveen Publication*, **India**, pp. **431 - 444**, **2011**.

[4] S. Prakash " New Intermediate Physics Part Two", *Nageen Publication*, **India**, pp. **389** - **576** , **2011**.

