

On the generation of the torque in a ball bearing motor

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We examined the generation of torque in a ball bearing motor from the electromagnetic viewpoint, i.e., the possibility that the torque was generated by current in the metal spheres. We noticed that a repulsive force between the conductors was generated by the magnetizing currents, if the conductors were close to each other. Based on this fact, we examined the current route in the motor. As a result, we noticed that the current direction into the spheres and out of the spheres is in the opposite direction as each contact between the outer ring and the metal sphere, and the metal sphere and the inner ring of the bearing was passed, i.e., the contact is made at a boundary, and the current direction in the inner ring is opposite to that in the outer ring. From this fact, a repulsive force due to the magnetizing current occurs between the conductors which form each contact, and we took this force as the origin of the torque in this motor. The factor which determines the direction of rotation coincides with the non-directional rotational characteristic of this motor, because it is not included in the generation of this repulsive force. Simply put, the motor rotates in either direction.

Key words: ball bearing motor, repulsive force, torque.

1. Ball bearing motor

A ball bearing motor is an unusual electric motor that consists of two ball-bearing-type bearings, with the inner races mounted on a common conductive shaft, and the outer races connected to a high current, low voltage power supply. An alternative construction fits the outer races inside a metal tube, while the inner races are mounted on a shaft with a non-conductive section. This method has the advantage that the tube will act as a flywheel. The direction of rotation is determined by the initial spin which is usually required to get it going. This motor has the following properties.

- (1) It rotates with DC and AC voltage.
- (2) The direction of rotation is dependent only on the direction turned regardless of the type and polarity of power supplied.
- (3) The operation for many hours is difficult because of Joule heating.

This phenomenon is very interesting as a physical phenomenon. As to the mechanism of the motion, we are proposing that both heat and electromagnetic action are

involved, though this has not been established.¹⁻⁴⁾

H.Gruenberg has given a thorough theoretical explanation based on pure electromagnetism (and neglecting the thermal effects completely).³⁾ Also, P. Hatzikonstantinou and P. G. Moyssides claim to have found an excellent agreement between the results from the electromagnetic theory and the experiments measuring the total power and efficiency the motor.⁴⁾

2. Purpose of this study

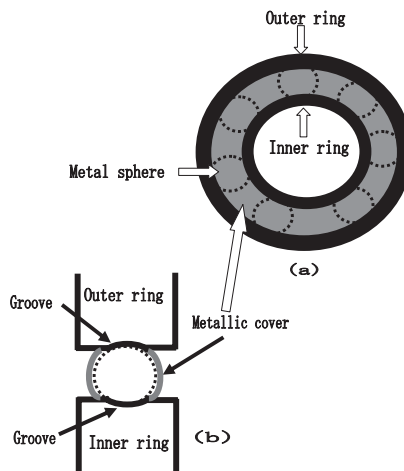


Fig. 1 A schematic illustration of the bearing. (a) Front view. Seven iron balls are protected by two sheet metal covers. (b) Sectional view.

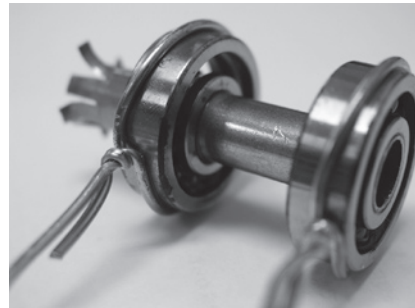
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In this study, the possibility of rotational motion generated by the torque through the electromagnetic effect of the metal sphere bearing was examined in order to gain insight into the motion mechanism. It is easy to imagine that the metal spheres rotate, because rotary motion in the bearing is generated by rotary motion of the inside metal ring. However, confirmation of coincidence of the application of current and the rotation of the bearing spheres is part of our study.

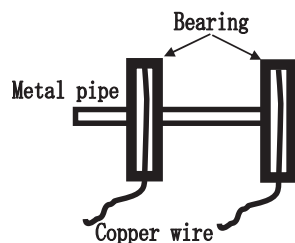
3. Preparation

The bearing has a sealed metallic cover. Since there is a cover, the metal spheres are not visible from the outside. Therefore, the cover must be removed in order to examine the action of the metal spheres. We tested the exposed metal spheres held in place by the two bearing conformers. We found that it was easy to expose the metal sphere by removing the cover (see Fig.1). However, the stability of the contact condition between both wheels and metal spheres is lower in comparison to the case in which there is a cover. Stability is especially affected by distortion of the bearing with respect to the metal pipe. Therefore, it is necessary that the correct orientation be maintained between the bearing position and metal pipe.

Figure 2 shows a motor and the bearings with the metal cover removed. The observation of the metal sphere is carried out with a fiber-scope and TV monitor (see Fig.3). The output switch of the DC power source is instantaneously switched to ON, supplying current. The output of the DC power source is set for a current that is higher than the lowest current necessary for slight rotation. We observed the movement of the metal sphere at the moment when the output switch of the DC power source was turned ON. The whole bearing is filled with the sewing machine oil including the metal spheres in order to improve lubrication. The contact condition between the metal spheres and both wheels greatly affects the action of the metal spheres. The observation is carried out in order to observe changes in the contact condition between metal sphere and both wheels as the metal pipe is rotating.



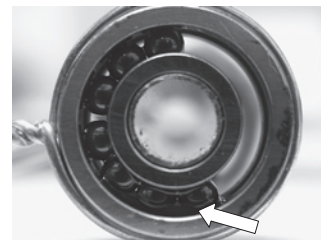
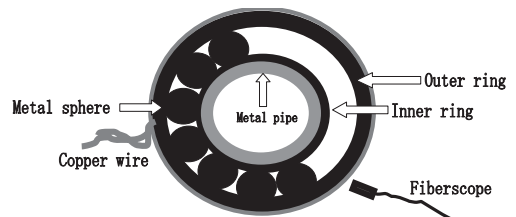
(a)



Connection to the power supply (direct current and alternating current) through the ammeter

(b)

Fig. 2 A schematic illustration of motor with the metallic cover removed. (a) Experimental model. (b) Schematic diagram.



Observation direction

The front view of the bearing with the metal covers removed

Fig. 3 The experiment to observe the movement of the metal sphere.

4. Result of examination

The movement of the metal sphere at the moment when the DC power source was turned on was observed, after the preparation described above. At the beginning there is no movement of the metal spheres, but movement of both wheels. We observed that there was a short interval between when the current flowed and both wheels started to move. We observed motion when the metal spheres emitted a frictional sound. There was one case in which the current flow and metal pipe rotation was coincident. Generally, some externally applied rotary motion is necessary in order for this motor to rotate, because it generally does not rotate solely by the application of voltage. In some instances the metal pipe did rotate when the current flowed. This was an unexpected result.

The above observation clarified that the torque was generated in the metal sphere. Generally, the movement of the metal spheres can not be observed, because generally the metal spheres in the bearing are not exposed. In this study, it was important to observe the instantaneous movement of the metal spheres in the bearing in order to clarify the motion mechanism.

5. On the possibility of the torque generation by electromagnetic factors

There are various views on the motion mechanism of this motor. The torque being generated by the contact with the metal spheres needs to be clarified. Therefore we examined the mechanism of the torque which arises in this contact. The torque in a typical electric motor is generated by current producing a magnetic field. In these motors there is a permanent magnet and/or current coil for forming a magnetic field. However, such arrangements have not been added near the metal sphere of this motor. The component that generates the magnetic field must exist and originate from the electromagnetic factor in the contact of the metal spheres. The generation of the magnetic field is not only a magnetic coil but also the current itself. A force arises between the conductors where the current is flowing. Based on these facts, we examined the current route in this motor.

We noticed that the current flow is in the opposite direction for the inner and outer rings. Figure 4(a) show the current route. A repulsive force acts between conductors, when the

current direction in the two conductors is opposite (see Fig. 4(b)). Though this repulsive force is proportional to the product of the currents, it is inversely proportional to the distance between the conductors. The possibility that the motive force arises because of this electromagnetic action is a consideration we explored.

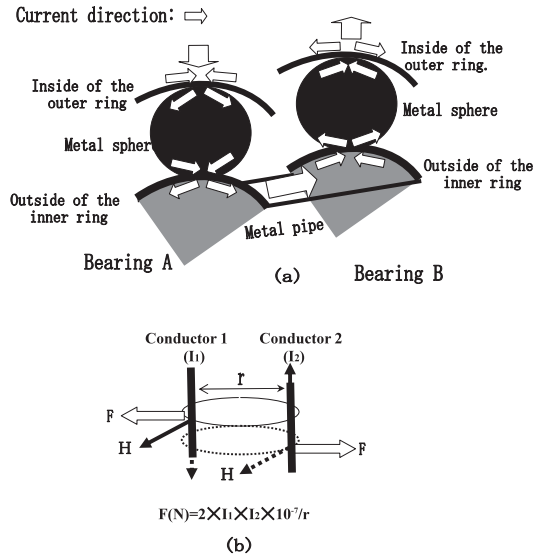


Fig. 4 The current flow between bearings. (a) The outline of the current flow approaching bearing B from bearing A. (b) A repulsive force acts between conductors and current direction in the conductors is opposite.

In the following, this hypothesis is examined. For each contact, the repulsive force is 0.02N, if the current is 10 A, and the separation 1 mm. There are two different combinations for the conductors in which the current can be flowing in opposite directions. Therefore, each metal sphere has four places where the force can exist. Each bearing has 28 places for sites where the force exists because the bearings being used contain seven metal spheres. Therefore there are 56 places total for the individual force, because there are two bearings in this motor. The total of all these individual forces is about 1N. This force exceeds the (0.05~0.1N) force necessary to rotate the metal pipe; that is, make the motor rotate. And the direction is not dictated by the repulsive force which arises due to the opposite current direction in each contact. This agrees with the non-directional rotation direction of this

motor. Based on these observations it appears that the torque of this motor originates from electromagnetic action, and that it arises in the part in contact with the metal sphere.

Finally, we looked at defects of this motor. The largest defect in this motor is the large amount of Joule heating. This makes it difficult to carry out long-term operation. To overcome this problem we tested cooling methods using oil, water and air. As a result of trial and error, long-term operation was possible if the motor was soaked in low viscosity oil.

6. Conclusion

The action of the metal spheres in the bearings as related to current flow indicated that an electromagnetic factor was involved in the generation mechanism for the torque

of this motor. As a result, we were able to confirm that the metal spheres moved coincident with instantaneous current flow. And, it was possible to determine that there is a high probability that the repulsive force produced by the interaction of currents in the contact position and magnetic field of the metal spheres is intimately involved in the generation of the torque.

References

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