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The new type actuator by applying the EHD phenomenon
— Development of the EGD Motor —

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ABSTRACT

The purpose of this study was to develop the new type actuator which has flexibility by using an EHD phenomenon for the application to the small machine or welfare system. The EHD phenomenon is a phenomenon that generates the flow in the insulating fluid by applying a high voltage electric field. Especially, rotation type actuator using an EGD phenomenon was developed by this study. And, EGD (Electro Gas Dynamics) phenomenon is a kind of the EHD phenomenon which occurs in the gas. Then, this actuator was called EGD motor. The EGD motor has one pair of electrode, one of these is a cylindrical electrode for a stator and another is L shaped electrode for a rotor. We changed the shape of electrode and measured the torque and rotation speed, to evaluate the rotational performance of the EGD motor

KEY WORDS

EHD phenomenon, EGD phenomenon, motor, actuator, compliance

INTRODUCTION

Various equipments are developed for the medical and welfare system. Especially, in the equipment for the welfare system, flexibility to the over-load is more necessary than a positioning accuracy. Then, compliance is necessary in the actuator to use for these equipments. However, because there are few things which have compliance in the existing electric actuator, advanced control technology is necessary in making these equipments have compliance. Moreover, a fluid power actuator which uses pneumatics has compliance, but a peripheral device such as a pump and a compressor is necessary to use this actuator. Because of that, when this actuator is used, the whole of the system becomes large, and has the problem of the occurrence of the noise.
Therefore, if an actuator for the small system which has compliance can be developed, not only a welfare system but also application in many industry fields can be expected.

EHD PHENOMENON

The EHD phenomenon is a phenomenon that generates the flow in the insulating fluid by applying a high

voltage electric field. For example, the insulating liquid climbs toward the line electrode from the board electrode when the high voltage electric field was applied at that electrode arrangement in the liquid as shown in figure 1. And the gas which is evaporated insulating liquid, contrary to the EHD phenomenon in the liquid, flows from the line electrode to the board electrode when the line electrode is pulled up in the gas from the liquid. This flow of gas was called EGD (electro gas dynamics) phenomenon, and we developed prototype of actuator by applying this EGD phenomenon which flowed from the line electrode to the board electrode.

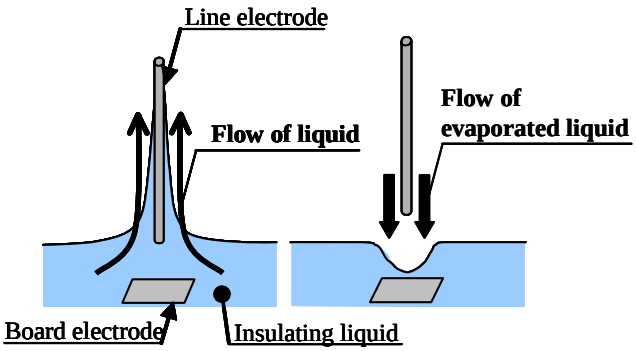


Figure 1 EHD phenomenon which liquid level rises, and EGD phenomenon which liquid level becomes dent

TYPE OF THE DEVELOPED ACTUATOR

In this study, we developed a rotation type of motor as a kind of actuator using the EGD phenomenon, because the motor is general actuator. Then we called that developed motor the EGD motor.

EGD MOTOR

Figure 2 shows the movement principle of the developed EGD motor. Parts which drive the EGD motor are composed of the cylindrical electrode and L shaped electrode. If the insulating gas is filled here, the voltage of the plus is applied to the cylindrical electrode, and L shaped electrode is connected with Gnd, the current of air by the EGD phenomenon is generated from the L shaped electrode toward the cylindrical electrode. L shaped electrode installed in the axis rotates by the reactive force of the EHD flow. It is thought that the number of parts is little and the miniaturization is easy because this EGD motor works only by a simple electrode structure and the gas. Moreover, it is thought that Moreover, it is thought that there are features with flexibility because driving source is a gas in the EGD motor.

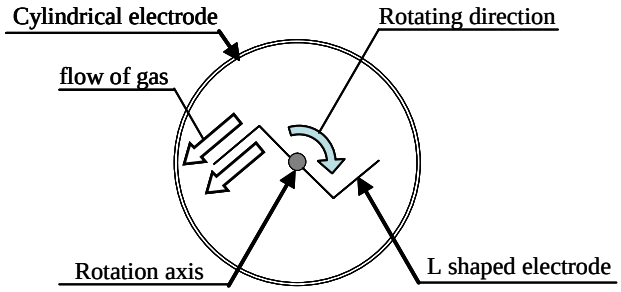


Figure 2 Movement principle of EGD Motor

PURPOSE

In this research, we aimed at the development of actuator which applied the EHD phenomenon. In evaluating the EGD motor from both sides of the miniaturization of the height of the cylindrical electrode and the miniaturization of the diameter of the cylindrical electrode, characteristic concerning the miniaturization of the EGD motor which used EGD phenomenon known as EHD phenomenon generated in the state of the gas was examined.

DEVELOPED EGD MOTOR

The appearance of the developed EGD motor is shown in figure 3 and the size of this motor is shown in figure 4. In this motor, the diameter is 96 mm, the height of bottom part is 20 mm and the height of lid is 10 mm. The size of the cylindrical electrode is 74 mm in the outside diameter, 60 mm in the inside diameter, and 13mm in height. Moreover, L shaped electrode is 20 mm in length, and 10 mm in width. The EGD motor was manufactured by the structure that the cylindrical electrode of various diameters and height was able to be exchanged easily.

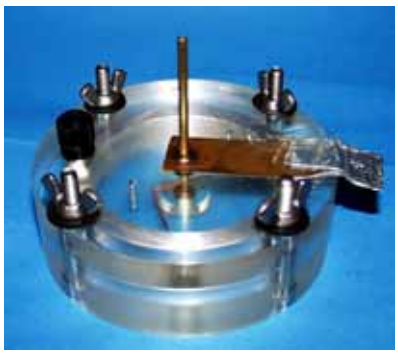


Figure 3 Developed EGD motor

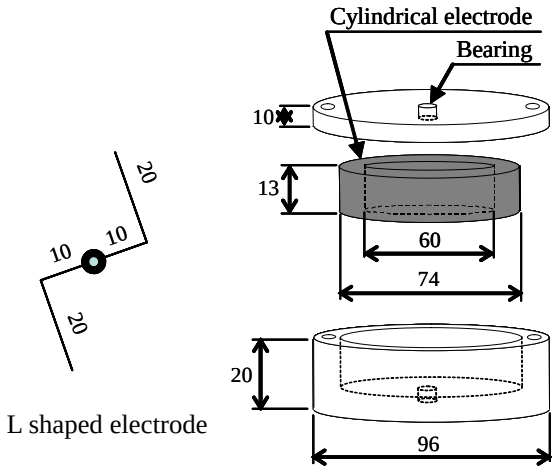


Figure 4 Size of EGD motor

EXAMINATION OF MAKING THIN TYPE

The EGD motor which changed only the height of the cylindrical electrode was manufactured, and the performance of the EGD motor was evaluated from the value of the starting torque and the no load rotational speed of the EGD motor which manufactured.

EXPERIMENT DEVICE

The rotating speed is measured with a reflecting plate and an optical speed indicator, and the torque is measured with the load cell which measures force by which the rotation axis winds up the string as shown figure 5.

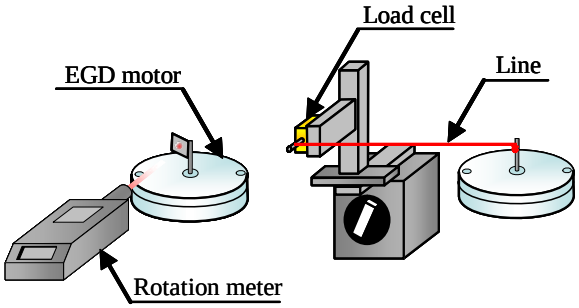


Figure 5 Experiment device

EXPERIMENT CONDITION

The experiment condition is shown below.
Applied voltage: 18 kV (Voltage not discharged)
Cylindrical electrode: Height 13 mm, 10 mm, and 8 mm
The gas: The insulating fluid was put in the EGD motor, and the liquid was evaporated enough.
Measurement frequency: Average five times

RESULT

Figure 6 shows the relation among the rotating speed, the torque, and height of the cylindrical electrode. The rotating speed showed the tendency to increase when the cylindrical electrode thinned. The maximum rotating speed of the EGD motor became 4741 rpm in 4 mm height. On the other hand, the torque became constant, and was about 20 μNm in each height.

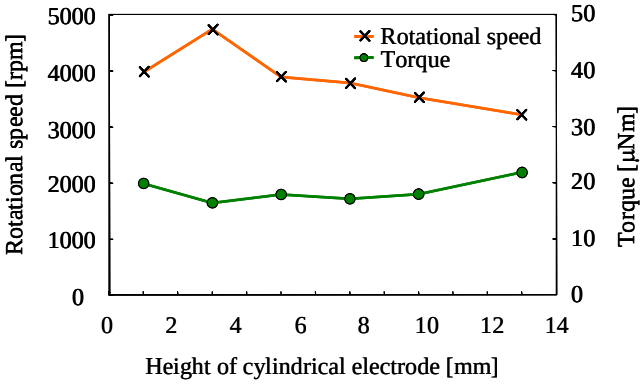
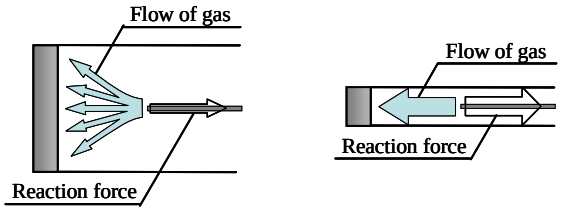


Figure 6 The relation among the rotating speed, the torque and the height of the cylindrical electrode

DISCUSSION

The rotating speed had increased by making the cylindrical electrode thin as shown by "Results". The force which is effective in the rotating direction weakens, because in a high cylindrical electrode, the gas which flows from the line electrode to the board electrode diffuses as shown figure 7(a). However, the flow of gas is bunched by low cylindrical electrode, and a bigger reactive force was able to be obtained as shown in Figure 7(b). Therefore, it can be said that EGD motor is suitable for making to the thin type because the rotating speed increase in changing height. The change in the value of torque did not appear so much. As shown in Figure 8, flow of the gas which generates the rotational force disturbs the rotational movement by hitting against other electrode on the other hand.



(a) Flow of gas in a high electrode

(b) Flow of gas in a low electrode

Figure 7 Influence by thickness of electrode

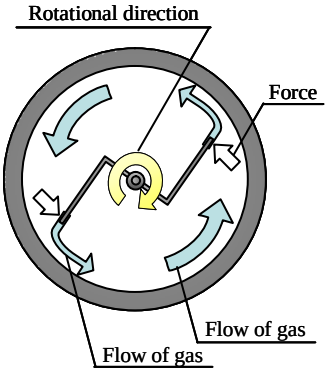


Figure 8 Influence which flow of gas in EGD motor exerts on performance

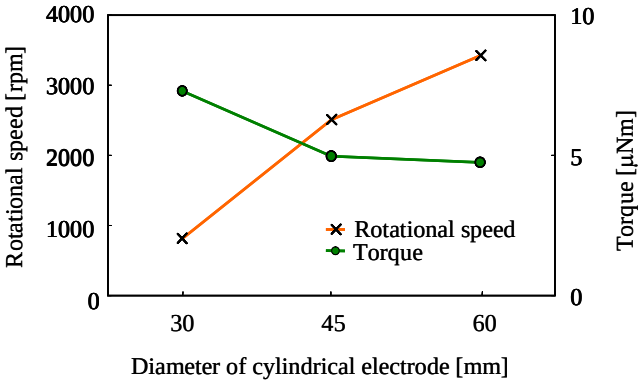


Figure 9 The relation among the rotating speed, the torque and the diameter of the cylindrical electrode

EXAMINATION OF MAKING SLIM TYPE

The inside diameter of the cylindrical electrode which be developed EGD motor was changed, to slim type was evaluated from idling speed and the starting torque.

EXPERIMENT CONDITION AND EXPERIMENT DEVICE

The experiment condition and the experiment device are shown below.
Applied voltage: 16 kV (Voltage not discharged).
Electrode: Inside diameter 45 mm, and 30 mm.
L shaped electrode was changed according to the ratio of inside diameters of the cylindrical electrode (Table 1).
Additionally, the experiment is a condition same as the examination of making thin type.

Table 1 Inside diameter of cylindrical electrode and relation of L type electrode

[mm]

Inside diameter of cylinder electrode	L shaped electrode	
	I	_
90	10	20
60	7.5	15
45	5	10

RESULT

Figure 9 shows the relation among the rotating speed, the torque, and inside diameter of the cylindrical electrode in the slim type of motor. The rotating speed increases as the inside diameter of the cylindrical electrode becomes small, and the torque has decreased. Rotating speed became 2918 rpm at 30 mm in the inside diameter and torque became 8.5 Nm maximum at 60 mm in the inside diameter.

DISCUSSION

The rotating speed increases when the inside diameter of the cylindrical electrode becomes small and the torque has decreased. As these factors, the rotating radius of the line electrode becomes small by reducing the inside diameter of the cylindrical electrode, and moment of inertia decreases. And, it is thought that the rotating speed increases and the torque decreased as well as a general rotor. Therefore, it is thought that EGD motor can obtain the high revolution by making to a slim type as well as a usual electromagnetic motor.

SUMMARY

In this study, we developed the EGD motor using the EGD phenomenon which is a kind of the EHD phenomenon occurred in the gas. And, to investigate a change in the performance of the miniaturized EGD motor, we made a thin type of motor and slim type of motor. In the slim type of EGD motor, the rotating speed was increased compared with the original type of EGD motor, as well as a usual electric motor. In addition, in the thin type of EGD motor, the rotating speed was increased compared with the original type of EGD motor, as well as the slim type of EGD motor. As for the electric motor, increase of rotational speed in this thin type of motor was not seen.

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