Motion generation of pneumatic artificial muscle

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Abstract

Various commodities that support the senior citizen physically and psychologically appear by the coming of the aged society. A lot of supplementary equipment are installed directly in the user and used. As for such equipment, physical safety and a psychological sense of security are requested. Then, recently, artificial muscle is researched as a wearable actuator that a user can use in comfort. Therefore, we research the support equipment by using the pneumatic artificial muscle. The past research in our laboratory, we made an artificial muscular robot. And, we measured the characteristic of each artificial muscle.
In this research, we generate motion of pneumatic artificial muscular robot.

1.Introduction

Since the advent of aged society, various support instruments that support the senior physically and mentally is created. Many of them are equipped directly by the user.
As for support instruments, physical safety and a mental sense of security are requested. To secure physical safety and a mental sense of security, the following are needed.

(1) Even if controlling becomes impossible, support instruments doesn't become a trouble.
(2) Support instruments are small and light.
(The senior citizen can easily carry possession.)
(3) Support instruments fits flexibly the human body.
(4) No operation sound.

Recently, as a wearable actuator with which a user can equip in comfort, artificial muscles attract attention.
Therefore, we will research the support instrument by using the artificial muscle.
As the first step, in this research, we measure the characteristic of each artificial muscle, and, we make motion generation of artificial muscular robot.

2.Artificial muscle

There are various kinds of artificial muscles. Artificial muscle has following kind.

<Polymer actuator>
(Actuator that used polymeric material.)

<Shape-memory actuator>
(Actuator that used shape-memory material.)

<Electrostatic actuator>
(Actuator using electrostatic power.)

< Pneumatic actuator >
(Actuator that used air pressure.)

In this research, we used the Pneumatic actuator (McKibben artificial muscle) as a suitable actuator for the support instrument that the user equips, because the balance of the generative force and the contraction percentage is good, and, the viscoelasticity characteristic is similar to human's muscle.
The McKibben artificial muscle has structure that wrapped the rubber tube by a plastic fiber mesh. Fig.1 and Fig.2 show pattern diagrams of artificial muscle. When Pneumatic muscle was pressurized, it expands in the radius direction. Power to contract axially is generated. If the artificial muscles is set to 100, the maximum pressurization will be set to 70. The artificial muscle has the expansion and contraction rate of 30%.

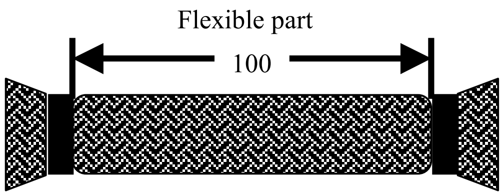


Fig.1 Pattern diagrams before artificial muscle is pressurized

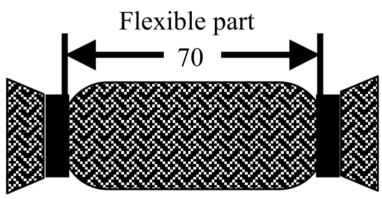


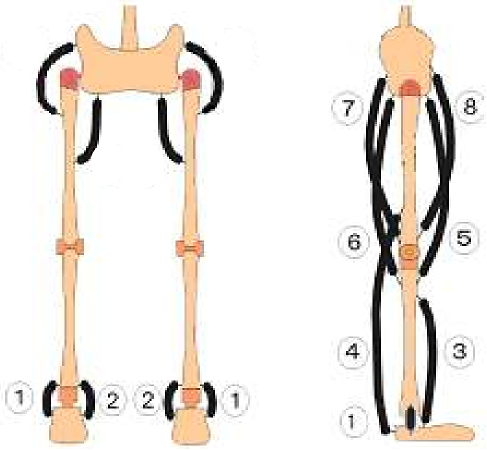
Fig.2 Pattern diagrams after artificial muscle is pressurized

3.Artificial muscular robot

Fig.3 shows pattern diagrams of artificial muscular robot. The frame of the robot is wooden, and it has the hip joint, the knee joint, and the ankle joint. The hip joint and the ankle joint are made from the spheroid joint. The knee joint is made from the hinge joint.

Number of Fig.3 expresses arrangement of artificial muscles.

1: long peroneal muscle, short peroneal muscle (125mm)
2: anterior tibial muscle, posterior tibial muscle (125mm)
3: tibialis anterior (245mm)
4: musculus triceps surae (400mm)
5: musculus quadriceps femoris (330mm)
6: hamstrings (330mm)
7: gluteus maximus (305mm)
8: musculus iliopsoas (305mm)



(1) elevational view (2) left side view

Fig.3 Pattern diagrams of artificial muscular robot

4.Exprerimental apparatus

The outline chart of the apparatus used by this research is shown in Fig.4.

The air tube of the artificial muscle and the air tube of air compressor are connected with the air pressure controller. The control signal from the computer is given to the air pressure controller, and the artificial muscle can be expanded and contracted.

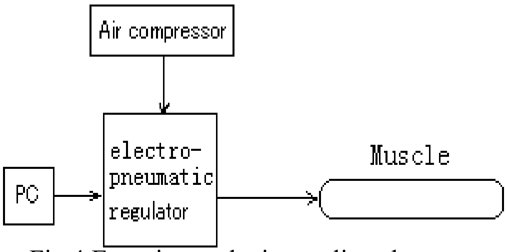


Fig.4 Experiment device outline chart

5.Expansion and contraction characteristic measurement

We used the artificial muscle of different four lengths (160,240,300,400mm) in this experiment.First of all, the load is not put on the artificial muscle. And, constant air pressure is injected. Next, the load is not put on two artificial muscles and constant air pressure is exhausted. The measurement result is shown in Fig.5-6.

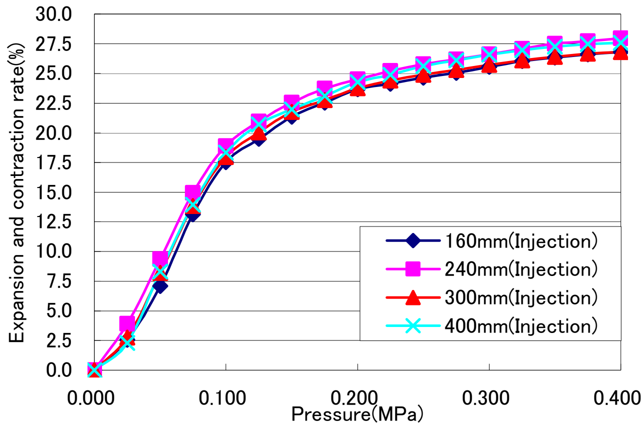


Fig.5 No load characteristic of each length (Injection)

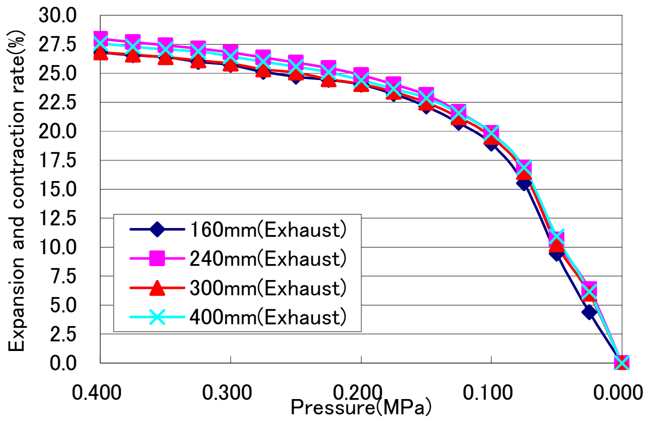


Fig.6 No load characteristic of each length (Exhaust)

These are collectively shown in Fig.7-10.

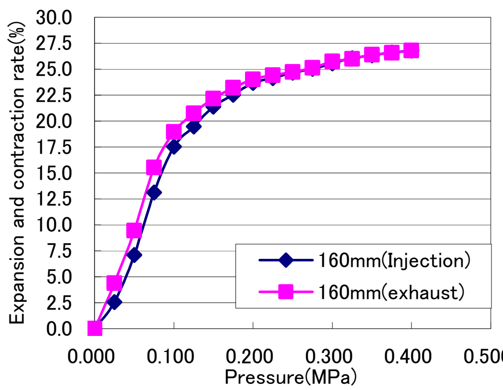


Fig.7 No load characteristic of 160mm in length (Injection-exhaust)

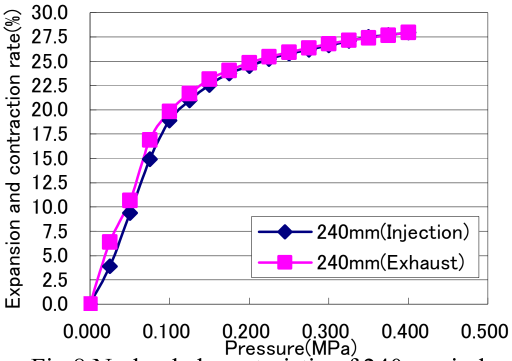


Fig.8 No load characteristic of 240mm in length (Injection-exhaust)

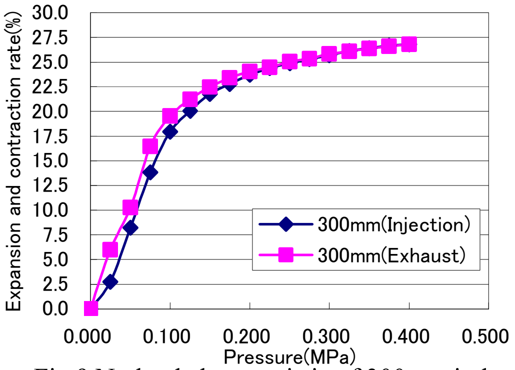


Fig.9 No load characteristic of 300mm in length (Injection-exhaust)

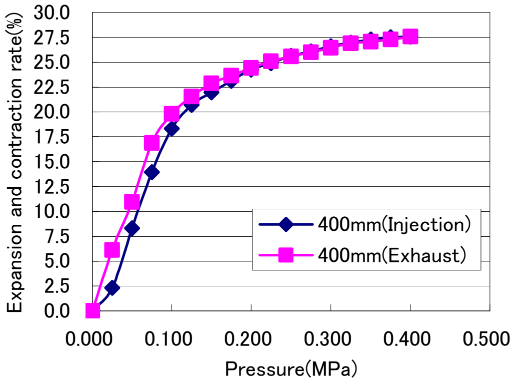


Fig.10 No load characteristic of 400mm in length (Injection-exhaust)

Injection and exhaust in the same length showed the characteristic with a different each curve (Fig.7-10). Cause of hysteresis was thought elastic deformation of rubber tube in the artificial muscle.

6.Load characteristics

Next, we add the loads of certain degree to the artificial muscles, and, we measure the characteristics of expansion and contraction. The measurement result is shown in Fig.11-14. (The measurement result in the artificial muscle of 300mm in length is shown in this paper.)

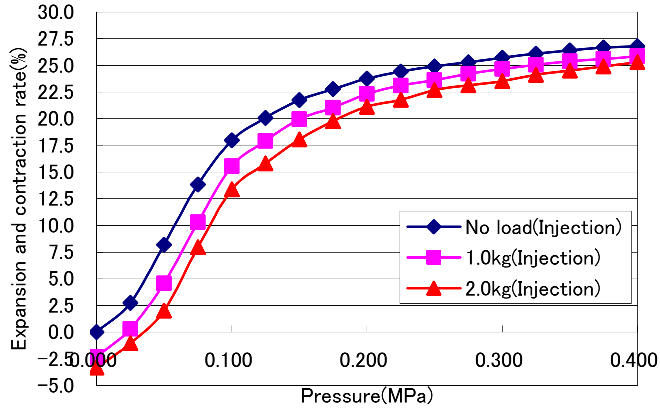


Fig.11 Load characteristic of 300mm in length (Injection)

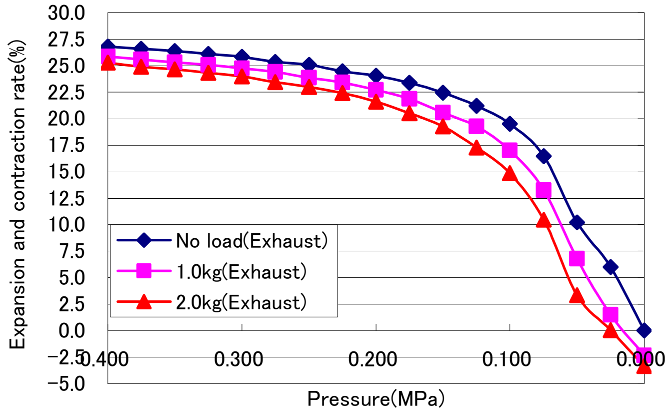


Fig.12 Load characteristic of 300mm in length (Exhaust)

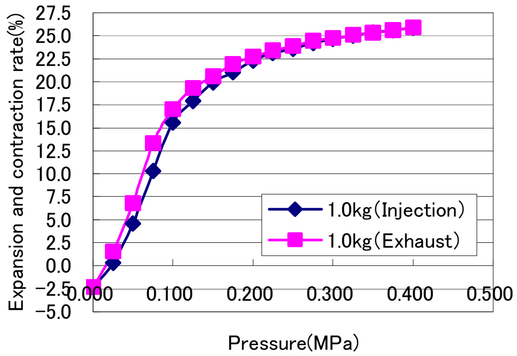


Fig.13 Load characteristic of 300mm in length [Load=1.0kg] (Injection-exhaust)

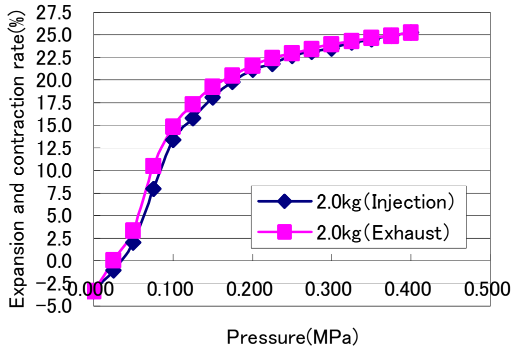


Fig.14 Load characteristic of 300mm in length [Load=2.0kg] (Injection-exhaust)

From the above, the expansion and contraction rate lowers when the load is put regardless of the length of the artificial muscle.

Next、when no-load, the error of injection and exhaust was 3.2% at the maximum. When we put the load of 1.0kg, the error of injection and exhaust was 3.0% at the maximum. When we put the load of 2.0kg, the error of injection and exhaust was 2.5% at the maximum. As a result, artificial muscles can perform a certain amount of hysteresis improvement by applying load.

Moreover, because the error of injection and exhaust is about 3% at the maximum, the expansion and contraction characteristic of using for motion generation of artificial muscles uses the average value of injection and exhaust.

7. Motion generation of bending and stretching

We generated the bending and stretching motion of the robot by using the above-mentioned measurement result. The home position of the robot is shown in Fig.15 (a),(c). The bending position of the robot is shown in Fig.15 (b).

(a) Home position of the robot (b) Bending position of the robot (c) Home position of the robot

Fig.15 Bending and stretching motion of the robot

8.CONCLUSION

In this research, we made Expansion and contraction characteristic measurement of artificial muscles, and the improvement of hysteresis. And, we performed an artificial muscular robot expansion-and-contraction operation generation using the result. However, because the load added to the artificial muscle changes while operating, we cannot accurately control the robot. In the future, we will improve the above issue. In addition, we will generate walk operation of an artificial muscular robot.

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