Servo Technology for Protecting People

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1. Introduction

Advances in servo systems have mainly done through contribution to *monozukuri* (manufacturing) such as for machine tools, injection molding machines, and semiconductor manufacturing equipment. Moreover, these systems are increasingly being used in medical and welfare equipment to maintain people's health. Servo systems are now expected to contribute toward manufacturing, maintaining people's health, and preserving the environment.(1)

In this article, we'll introduce our Servo Systems products used in medical devices to protect people's health. We'll then introduce our technology that protects people's safety, using our production line where this servo product is manufactured as an example.

First, we introduce a Servo Systems product used with medical analysis equipment. Next, we introduce an example of using a Servo Systems product with a cutting-edge remote pipette operation system for cell culturing. Finally, we introduce our servo technology that protects the safety of factory workers taking an example of a motor assembly process in which people work together with robots.

2. Use with Medical Analysis Equipment

The medical field is supported by a wide variety of medical devices. One example of such a device is medical analysis equipment, which is crucial in diagnosing illness and determining an individual's state of health.

There are various types of analysis equipment, such as genetic testing equipment, automatic biochemical analyzers, blood testing equipment, and urine testing equipment. Many stepping motors are used in these kinds of medical analysis equipment. This chapter introduces some of our products used in medical devices, taking an automatic biochemical analyzer as an example.

2.1 Equipment overview

Figure 1 shows the appearance of an automatic biochemical analyzer. An automatic biochemical analyzer uses blood or urine to induce a reaction with a reagent, to analyze the components of the sample such as sugars, proteins, and lipids.

Fig. 1 Automatic biochemical analyzer

2.2 Example of usage in equipment

With an automatic biochemical analyzer, the specimen sample and reagents are placed on a turntable. A pipette is used to dispense the specimen sample and reagents. This equipment uses many motors so that these processes are all performed automatically.

Figure 2 shows an example where stepping motors are used in an automatic biochemical analyzer. Stepping motors can be easily installed inside the equipment and are capable of performing highly accurate positioning control. This makes them very suitable for use in controlling the shaft of the turntable and the pivot shaft of the pipette.

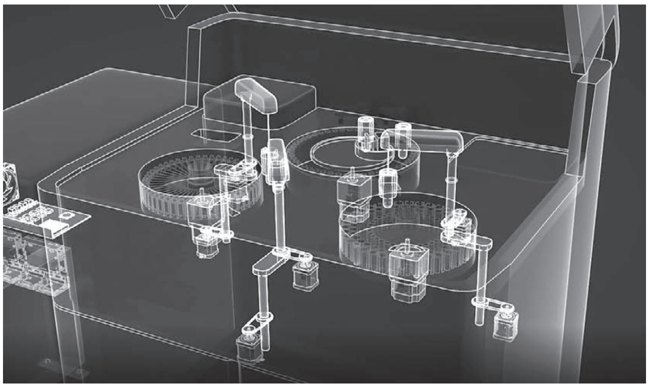

Fig. 2 Illustration of stepping motors in use

2.3 Product specifications (Stepping motors)

The *SANMOTION F* series 42 mm sq. 2-Phase 1.8° stepping motor[2] achieves low noise, high torque, and low energy consumption. It is often used in medical analysis equipment. Its increased torque improves the testing speed, and lower noise reduces the burden on the medical technician, and increased efficiency results in reduced heat generation and better energy savings, contributing to the medical field.

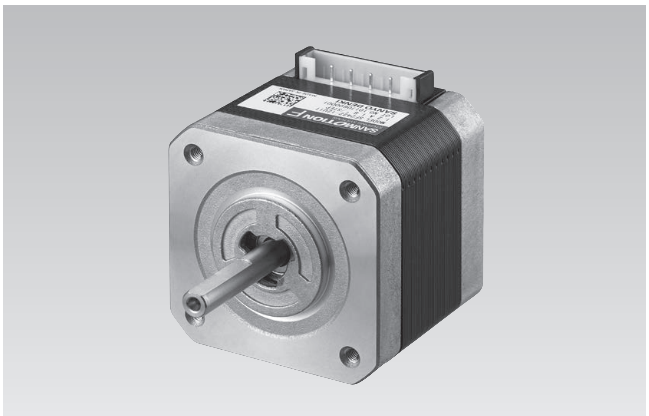

Fig. 3 Appearance of SF2422 type

3. Use with Remote Pipette Operation System for Cell Culturing

The field of regenerative medicine has made rapid advances in Japan, and this has significantly increased the demand for cell culturing. On the other hand, insufficient workplace safety and staffing shortages are two issues faced by individuals involved in cell culturing, and there is a pressing need to develop technology to resolve these issues.

In response, products are now being developed to allow pipette operation to be performed remotely that use a 5G mobile communications system and robot arms. This chapter introduces the *SANMOTION* compact cylinder linear servo motor[4] that is installed in the end effector of a remote robot arm of an advanced remote pipette operation system for cell culturing.

3.1 Equipment overview

Remote pipette operation using a 5G mobile communications system and robot arms is illustrated in Figure 4 (operator side) and Figure 5 (remote robot arm side).[3] A remote pipette operation system for cell culturing has two basic requirements. First, the operator must feel no delay. Second, the remote robot arm must accurately mimic the movement of the operator. The following two technologies are required to achieve these.

1) Technology to eliminate delay when transferring operator movement data
2) Pipette operation system that accurately mimics operator movements

The *SANMOTION* compact cylinder linear servo motor is used in the remote pipette operation system for cell culturing to operate the pipette in the remote robot arm's end effector. It is capable of accurately mimicking the movement of an expert operator as they move the pipette.

Fig. 4 Pipette operation (operator side)

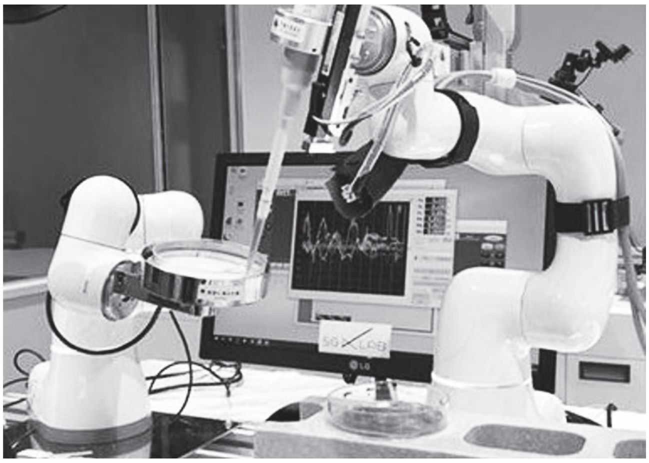

Fig. 5 Pipette operation (remote robot arm side)

3.2 Compact cylinder linear servo motor specifications and features

Figure 6 shows the appearance and structure of the *SANMOTION* compact cylinder linear servo motor. This compact linear servo motor has an all-in-one structure with a built-in linear encoder and linear guide, with a width of only 12 mm. The inside of the stainless steel pipe is composed of a mover with a built-in magnet and a stator with a stationary power supply cable, downsizing the motor and achieving ease of use.

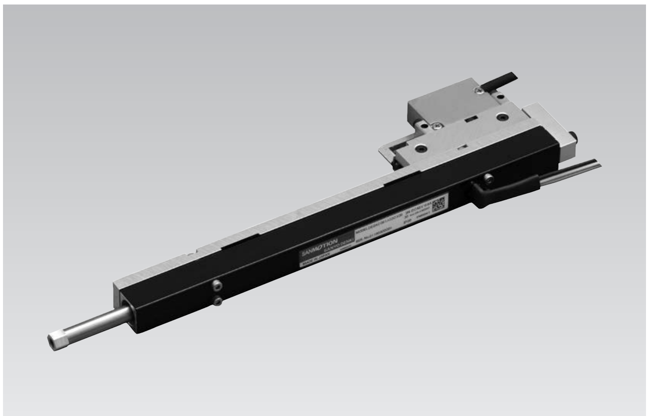

Fig. 6 *SANMOTION* compact cylinder linear motor

The motor has a maximum thrust of 16.5 N and a rated thrust of 5.1 N, achieving both increased thrust and downsizing. The maximum acceleration with no load is 37.4 G. This motor is expected to play an important role in a wide variety of fields thanks to its high-acceleration/deceleration operation and high-speed positioning.

The built-in linear encoder has a resolution of 1 μm, making it suitable for precision positioning operations. This allows for fine control when suctioning, dispensing, and measuring small amounts of liquids when using a pipette during the cell culturing process, without damaging cells.

The compact cylinder linear servo motor has a coreless linear structure with a back yoke. There is no fluctuation in thrust caused by magnetic fluctuation, and its operation is smooth and responsive. This allows an expert operator to control the pipette in real time with the robot arm end effector accurately mimicking their movements, making this motor ideal for driving the end effector of a robot arm.

The *SANMOTION* compact cylinder linear servo motor contributes toward the development of remote pipette operation systems for cell culturing that allow for fine operations to be performed remotely, as a technology for protecting people.

4. Motor Assembly Process Technology for People to Work Together with Robots

We use collaborative robots in processes for manufacturing the stepping motors used in medical devices so that workers can safely and reliably perform complicated tasks in limited spaces.

In this chapter, we introduce our specialty technology that protects the safety of workers that is used in a motor assembly process in which people work together with robots.

4.1 Assembly process in which people work together with robots

Figure 7 shows a stepping motor assembly line. This manufacturing line performs all tasks from assembly to checking for 56 mm sq. size[5] motors.

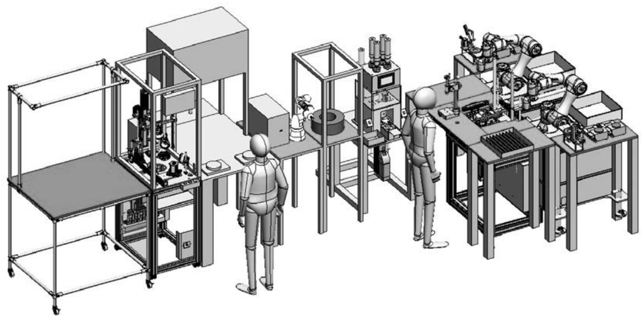

Fig. 7 56 mm sq. stepping motor assembly line

There are two collaborative robots placed at the head of the line. These supply parts to workers. Once a robot supplies a part, it then searches and picks next part while the worker is busy with assembly work. In this way, people and robots work together to establish a seamless assembly line. Figure 8 shows the collaborative robots installed when building the line.

Image recognition cameras are mounted on the end effector of robots. These are used to capture images of the parts being picked. This image data is used to recognize differences in height between parts as well as their locations, and to control the operation of the robots. This allows 3D gripping technology to be used, which means that randomly placed parts can be gripped.

Controlling the trajectory of movement at which the robot grips parts based on image data is our specialty technology.

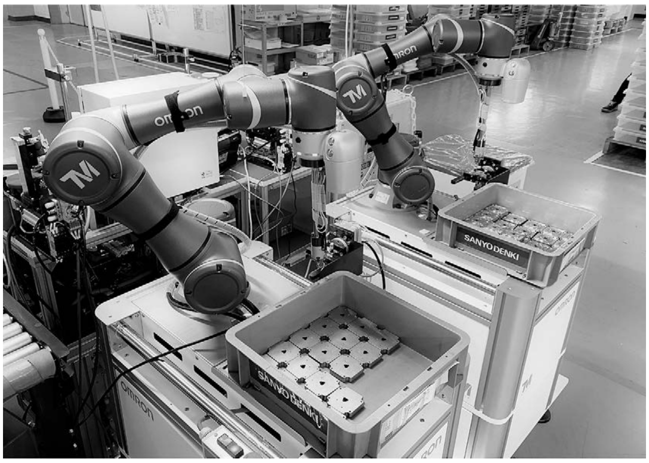

Fig. 8 Collaborative robot

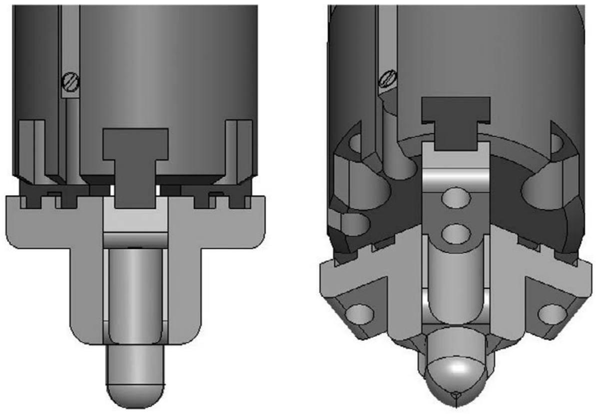

Fig. 9 Robot gripper finger
(Example of inherently safer design)

4.2 Safe manufacturing with robots

When building a production line that includes collaborative robots, it is important to ensure the safety of workers. We repeatedly conducted risk assessments and implemented countermeasures to assess and respond to possible risks that could occur at the manufacturing site, based on various safety standards including ISO/TS 15066 (an international safety standard for collaborative robots) and ISO 12100 (a basic safety standard). In this way, we were able to install collaborative robots, while ensuring worker safety.

We implemented several safety measures. Contact between robots and people is classified into two categories as defined in ISO/TS 15066: transient contact and quasi-static contact. These categories define how robots and people come into contact. Momentary contact (such as impact) is classified as transient contact, while clamping is classified as quasi-static contact.

The collaborative robots used here were configured to stop immediately if any transient contact is made. This is done by lowering the torque limit (tolerance) on any axes that experience a high external reactive force when impact occurs.

Quasi-static contact (clamping) would mainly occur with the worker's hands or fingers during parts gripping. We set a torque limit during the downward motion of axes to ensure safety when the robot is operating. When designing the robot gripper finger, we gave it a rounded shape and made use of an inherently safer design to reduce the risk of injury to workers.

Figure 9 shows the robot gripper finger we designed, as an example of an inherently safer design.

Through making use of collaborative robots and carefully designing the robot gripper, we ensured the safety of the stepping motor assembly line when workers and robots make contact.

5. Conclusion

In this article, we introduced some examples of using servo technology in medical analysis equipment and a remote pipette operation system for cell culturing. These examples show how our Servo Systems products can be used in medical devices that protect people's health. We also introduced an example of technology for safely manufacturing these servo products.

The motor technology used in medical analysis equipment achieves lower noise, higher torque, and lower energy consumption. This helps improve testing speed and reduce equipment noise. Reducing the noise of medical devices can help reduce the burden on medical technicians and patients.

We used a compact cylinder linear servo motor with large thrust and high response in the remote pipette operation system for cell culturing. This allows an expert operator to control a remote pipette in real time, with the robot arm accurately mimicking their movements.

We also introduced our specialty technology that protects people's safety using an example of a motor assembly process in which people work together with robots, where contact between people and robots was carefully designed for safety.

Expectations for our Servo Systems technology will continue to grow for use as technology for protecting people's health and safety, and as technology for protecting the global environment. We are committed to developing servo systems that will continue to meet these expectations and provide new value.

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