Actuator Module of Robot Manipulator for Nuclear Power Plants Inspection, Maintenance and Decommission

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1. Introduction

Because of the high radiation of a nuclear power plant, robotic manipulators have been used for inspection, maintenance and decommission. For example, KAERI has developed an electrically driven manipulator to inspect and repair the steam generator without human workers [1]. For nuclear facility decommissioning, there are many different electrical manipulators to remotely dismantle a nuclear facility [2].

Various manipulators will be necessary for inspection, maintenance and decommission. Only one manipulator cannot response to many required tasks. Therefore, several manipulators are necessary, depending on the payload capacity, their number of axes and their dexterity. Each manipulator was developed for a specific task.

The actuators used at manipulator are varied and many companies sell actuators depending on power, torque and speed. However, the commercial product is not standardized. Therefore, the development of the manipulator is time consuming and expensive.

The essential item of the manipulators is the actuator module. If actuator module is standardized, it is easier to develop manipulator.

In this paper, we developed two electrical actuator modules to standardize the actuator module and easily develop a manipulator using the proposed actuator modules. The electrical actuator module has a motor, gear and rotary sensor, and is also waterproof. The electrically driven manipulator being used in the proposed actuator modules will be shown.

2. Electrical Actuator Module

An actuator module is important to design a manipulator. Generally, the specification of an actuator module comes from the requirement of the manipulator. Most of the manipulators used at a nuclear power plant handle non-destructive inspection equipment having a weight of less than 30kg for inspection. At decommission, the weight of the tool that the decommissioning manipulator handles is mostly less than 30kg.

Most of the manipulators used at a nuclear power plant are working at the underwater or facility with high humidity. Therefore, water-proof manipulators are required. Thus, the developed actuator module must be water-proof.

Therefore, we developed two electrical actuator modules. One has a power of 880W and the other has that of 580W.

The developed electrical actuator module consists of a motor, reducer and rotary sensors. The lightweight torque motor of RoboDrive GmbH is used for the motor of the developed actuator module [3]. To increase the torque, we used a reducer of THK. The two resolvers of Tamagawa Company are used to sensor the angle of the motor and the output of the reducer. To watertight the developed actuator module, an o-rig and oil seal are used.

The drawing of the developed actuator module is shown in Fig 1. and Fig 2.

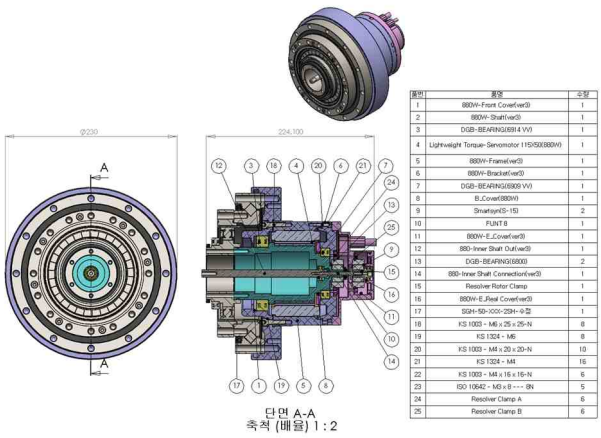


Fig. 1. The drawing of the 880W actuator module

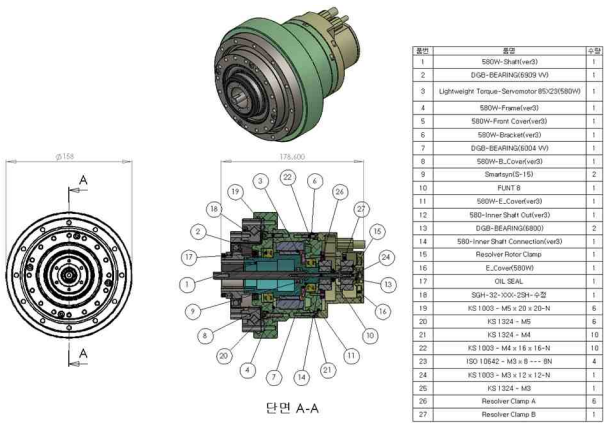


Fig. 2. The drawing of the 580W actuator module

Fig. 3. The pictures of the developed actuator modules

Fig 3 shows a photo of the manufactured actuator modules.

Finally, the specification of the developed actuator modules is shown in Table I.

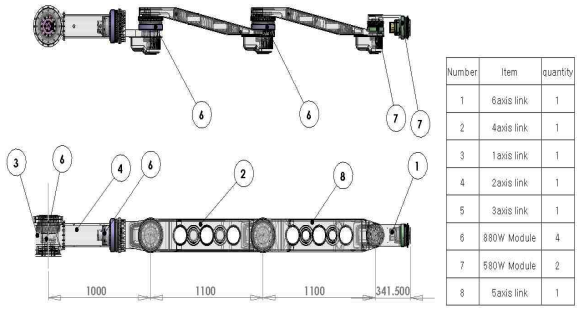
Table I: The specification of actuator module

	880W	580W
Motor	Rated Power: 880 W Rated Torque: 11.2 Nm Rate Speed : 650 rpm	Rated Power : 580 W Rated Torque : 2.3 Nm Rate Speed : 1900 rpm
Reducer ratio	160:1	160:1
Rotary sensor	Resolver	Resolver
Weight	18 kg	7 kg
Size	ϕ 220 mm × 225 mm	ϕ 160 mm × 180 mm
Rated Torque	1800 Nm	370 Nm
Rated Speed	4 rpm	12 rpm

3. The Electrically Driven Manipulator using Developed Actuator Module

In nuclear power plants, the reactor pressure vessel is one of the most important equipment in view of its function and safety. The vessels are usually constructed by welding large rolled plates, forged sections or nozzle pipes together. Therefore, these welds should be periodically inspected using a non-destructive sensor. Using the developed actuator modules, an electrically driven manipulator is developed to inspect the welding area of the pressurized water reactor vessel.

The electrically driven manipulator consists of 4 880W actuator modules and 2 580W actuator modules. The manipulator has a payload of over 30kg. The 880W actuator modules is used at 1, 2, 3 and 4 joints of the manipulator and the 580W actuator module is used at 5 and 6 joints of the manipulator. The standardized actuator module allows us to easily develop a manipulator because the developed actuator module is modularized. Fig. 4 shows the drawing of the manipulator. Fig. 5 shows a photo of the developed manipulator working at the mock-up facility.



Number	Item	quantity
1	6axis link	1
2	4axis link	1
3	1axis link	1
4	2axis link	1
5	3axis link	1
6	880W Module	4
7	580W Module	2
8	5axis link	1

Fig. 4. The drawing of the developed electrically driven manipulator.

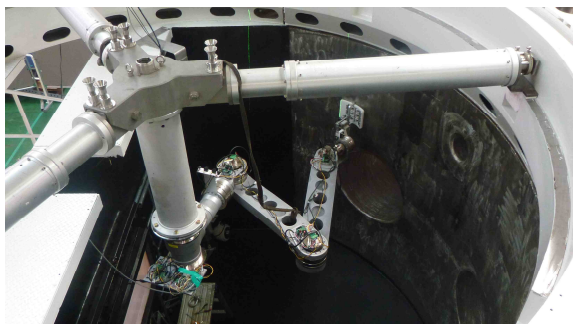


Fig. 5. The picture of the developed electrically driven manipulator which is working at mock-up of reactor pressure vessel.

4. Conclusions

Two modularized electrical actuator modules were developed for inspection, maintenance and decommission. Using the two developed actuator modules, the manipulator inspecting the welding area of reactor vessel is easily developed. Various modularized electrical actuator modules will be developed in terms of size and power. Several manipulators will be developed based on the developed actuator module.

REFERENCES

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