Foreword

Application of Fluid Power to Robot Systems

KAWASHIMA Kenji*

Nowadays, many people are probably under the impression that fluid power systems are being replaced by electric systems. However, the robot industry, which is regaining attention due to aspects such as a decreasing birthrate and aging population, is experiencing a phenomenon that we can call the “revival hit” of fluid power.

The U.S. venture company Boston Dynamics’ quadrupedal robot “Big Dog”, the video of which was released in 2008, is a famous robot that surprised robot researchers. The robot is controlled by a hydraulic servo and moves like a real animal. Its movements feel almost eerie. It is known that we experience such feelings when robot movements become too close to organisms. This is a fine example that fully demonstrates the attractions of hydraulic servo control, such as its great output. I think the streamlining and miniaturization of factors, such as valves and pumps, have also greatly contributed to this trend.

In recent years, the “Tough Robotics Challenge” program has been implemented in the Impulsing Paradigm Change through Disruptive Technologies Program (ImPACT), which is a large-scale national project [Note 1]. Its objective is to develop robots that can undertake difficult work in disaster-affected areas. The Robotics and Mechatronics Conference 2016 (sponsored by the Robotics and Mechatronics Division, The Japan Society of Mechanical Engineers), which is the largest academic conference in the field of robots, was held in Yokohama in June. An ImPACT session was held, and a number of presentations were given on hydraulic drive robot research and development cases.

Furthermore, research and development in the field of “soft robotics”, which has softness that is highly compatible with humans, is becoming more popular than robots that consist of conventional rigid bodies. In this field, the roles of fluid power – especially pneumatic drive – are growing. The aforementioned academic conference also held a session on fluid power robotics, and a number of robot research cases using pneumatic actuators were presented. Research using pneumatic rubber artificial muscles is especially increasing.

Research and development of technologies that are applied to robots, which support human movements, are especially active. One of the famous domestic examples is the muscle suit, which Professor Hiroshi Kobayashi and others at Tokyo University of Science have commercialized through a venture company [Note 2]. This robot assists the lower back area of people make lifting movements, and its practical use is being promoted in the field of nursing care, etc.

Overseas, researchers at Harvard University and other organizations have established the “Soft Robotics Toolkit” website to build soft robots [Note 3]. I expect that this is largely influenced by the fact that 3D printers have become more popular, enabling users to easily produce molds. Active research, such as the results of Harvard University [Note 4] that were featured in the scientific magazine “Science”, is being promoted

The authors promote research and development to apply robots, which utilize pneumatic drives, to medical fields. They have commercialized a robot arm to maintain and operate endoscopes in minimally invasive surgery [Note 5]. This system uses a gyro sensor, which is attached to the operator’s head, and the arm moves in conjunction with the head movements. It controls four degrees of freedom through direct drive without a gear reducer, due to the soft pneumatic actuator and relatively large force.

This direct drive is quite attractive as an actuator for robots. Possessing back-drivability to directly project the external force information to the pressure on the drive is critical when collaborating with humans or in terms of robot safety, which is connected to humans. Not having the risk of damaging the gear reducer due to spontaneous shock, etc., is a great advantage for robots in extreme environments.

We hope that application and deployment of fluid power systems will accelerate in the robot industry in the future.

Note 1) http://www.jst.go.jp/impact/program/07.html
Note 2) http://innophys.jp/
Note 3) http://softroboticstoolkit.com/
Note 4) Stephen A. et.al., Camouflage and Display for Soft Machines, Science, (Aug. 2012).
Note 5) HARAGUCHI Daisuke et.al., Robot arm for endoscope, Hydraulics & Pneumatics, Vol. 55, No. 3, pp. 18-22 (2016)

* Professor, Institute of Biomaterials and Bioengineering, Tokyo Medical and Dental University