Development of a New Underwater Manipulator Actuated by BLDC Motor

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ABSTRACT.
A new type of 6 d.o.f. underwater manipulator appropriate for a small ROV has been designed. Analyses on the kinematics of the manipulator and on the joint torque of the joint actuators are performed. The manipulator has been designed to be compact and light to handle 20kg payloads compared with its 25Kg weight. For this, a new joint actuator has been developed based on the BLDC motor combined with the harmonic driver. The joint actuator weighs less than 2.5kg but generates more than 300Nm stall torque, and its torque performance is presented through load tests.

KEY WORDS: underwater manipulator; BLDC motor; joint actuator.

1. INTRODUCTION

Underwater resources are essential for building improved economical society in 21st century and for continuous economical growth. Maritime industry is expected to contribute for these. One of the most crucial devices for the maritime industry is the underwater manipulator. Most of the developed manipulators are hydraulic ones for deep sea operation. These manipulators have heavy weight and are usually applied at heavy ROVs. Also, some lighter manipulators composed of 2 or 3 axes have been developed for simple tasks.

Research papers related with developing or applying underwater manipulators are not many, but some early experimental studies have been undertaken by McLain (1966) and Leabourne (1999). Also, Yamada and Sagara (2002) have showed that the motion of the manipulator and the AUV are close to the simulation results through experiments. An AUV system and manipulator using module method was developed. The manipulator has been developed using the magnetic coupling mechanism for waterproofness by Ishitsuka (2004). Also, the task-oriented manipulability of tele-operated robotic arms mounted on a remotely operated vehicle (ROV) and its application to task-oriented joint configurations have been described by Ishitsuka(2005).

This paper focuses on researching a new underwater manipulator actuated by BLDC motors with less than 70W capacity. In order to solve waterproofness problem of the actuating motors, a new twin oil-jacket waterproof motor cylinder was developed. A smaller and lighter underwater manipulator than hydraulic based manipulators was developed applying the joint actuator for UUVs. In this paper, the design of the joint actuator and its performance through experiments are introduced.

2. Structural Design of the Manipulator

2.1 Mechanical Design

Most of the industrial manipulators have structure of the yaw-pitch-pitch joints from the lowest in lower three joints. Since lower joints are pitch joints, high torques are applied on them due to the gravitational force. Therefore, for the manipulator in this paper, roll joints are applied at lower two joints to avoid the gravitational force so that lighter and smaller joint actuators of the manipulator can be designed. The manipulator was designed as shown in Fig. 1 and Fig. 2. Overall structure of the manipulator was designed as yaw-yaw-pitch-pitch-roll.

Fig. 1. Degree of freedom of the manipulator