A New Deep Ocean Electrical Driven Manipulator: Working system

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ABSTRACT:

As the development of mine, oil and gas resources exploitation in the ocean, the underwater equipments work more and more deeply. With the support of the Chinese high technology develop program (the 863 program), we study and design a new underwater 3500m electrical driven manipulator. The manipulator features modular integration joints, open architecture and simple centralized control system. The working system design is discussed in detail. Experiments results demonstrated the manipulator work ability. It can be mounted on working class remotely operated vehicles (ROVs) or Autonomous underwater vehicle (AUVs).

KEY WORDS: electrical manipulator; deep ocean; integration joints; working system.

INTRODUCTION

Ocean is paid more and more attention today, so the underwater vehicle with manipulator is regarded as one of the most important tools in ocean exploring. Manipulators are often used in underwater tasks such as salvage, maintenance and so on. In terms of driving types, there are two kinds of underwater manipulators. One is hydraulic, these manipulators feature large power, high ratio of lift force to weigh and relatively easy to implement hydraulic pressure compensation. The Work System Package (WSP) of Naval Ocean Systems Center is a famous and typical remote underwater manipulation system (Wernli, 1979). The system can exchange tools in the field without being brought back to surface of water. There are common drawbacks in hydraulic manipulator. The hydraulic system must contain large hydraulic power unit and complex valves, easy contamination environment and high price. Another kind of underwater manipulator is electric manipulator. Small output power, high precision, clean and low price is characteristic of these manipulators. A United Kingdom company CSIP, part of the ECA Group, has launched a new five-function electric underwater 3000m manipulator arm( ARM-5E);Powered with 24V DC and 3A, It has a lift capacity of 25kg. The manipulator can be used to do such missions: underwater intervention, underwater manipulation, object retrieval. It is suitable for work-class electric remote operate vehicles (ROVs). Because limit of energy, power and space in autonomous underwater vehicles (AUVs). Underwater electric manipulator is almost a necessity for autonomous underwater vehicle manipulator system. High pressure in deep sea is the main difficulty. Except compression resistance and pressure compensation, insulation is another technical problem in electric manipulator design. These difficulties belong to mechanical design problem.

Besides that, there is a control difficulty in the design of a deep ocean manipulator. In most of commercial ROVs today, the manipulator is operated by an operator. The work performance depends on operator's skill. Remote operation is tedious and hard work. It is lack of vision telepresence. Lots of study has been done in order to reduce the burden of operator. Supervisory control (Yoerger and Slotine, 1987) is often used. A vision servo system (Yann and Nose, 2005) was studied in Twin-Burger 2. The manipulator can sample jelly fish with the help of stereo vision servo. A new working space control system(Jun and Shim, 2009) was developed in the Korea Ocean Research & Development Institute (KORDI) ROV Hemire in order to assist operator during coring, drilling and underwater connector mating. Semi autonomous underwater vehicle for intervention mission (SAUVM) (Marani and Choi, 2009) has been developed in Hawaii University. Today, it is one of the first underwater vehicles (if not the only one) capable of autonomous manipulation. It can retrieve hazardous objects. It is one of the few examples worldwide of applications using autonomous manipulation for underwater intervention technology.

The aim of this paper is to study above problems. A deep ocean electric manipulator (named huahai-4E, stands for four functions deep ocean electric manipulator in china) is designed. It is of open frame architecture, integrated joints which is oil filled to compensate high water pressure. The manipulator has telecontrol, program control and auto manipulation (three control modes). The structure of the paper is given as following. First part is overview of the whole system, then mechanical structure, integrated joints, the control system and some experiments about the system.

DESIGN CONCEPT AND SYSTEM OVERVIEW

The underwater manipulator is designed to catch some objects in deep ocean. Fig. 1 shows the application concept. The deep ocean electric manipulator system (DOEMS) is mounted in the bottom of the underwater vehicle (ROV or AUV). DOEMS is mainly consisted of an