

Experimental Study of Water Jet System for Hybrid Pick-up Device

Jae-Yong Shim, Keh-Sik Min, In-Kyu Park, Kyung-Sik Ham and Jin-Woog Cho
Hyundai Maritime Research Institute, Hyundai Heavy Industries Co., Ltd.
Ulsan, Korea

Sup Hong and Jong-Su Choi
Korea Research Institute of Ships and Ocean Engineering
Taejon, Korea

ABSTRACT

A pick-up device, which is collecting nodules on the seabed, is one of the most important components of the collector (or miner). In this paper, the design and model test of water jet system of a hybrid pick-up device have been described. The water jet system was composed of pipes, nozzles, pump and motor. For the design of water jet system, determination of pump and motor was preceded and then the piping design was accomplished. The design was verified by a model test. Deep sea sediments were simulated by bentonite which was mixed with water. Nodules were being imitated by hand made concrete shapes. The model tests were carried out by varying the values of design factors to get a maximum pick-up rate of nodules. The maximum pick-up efficiency was acquired when the distance between nozzles and sediments was 100 mm. The effects of advance speed and size of nodules were also checked during the model test.

KEY WORDS : hybrid pick-up device, conceptual design, water jet system, model manufacturing, natural conditions, model test

INTRODUCTION

A collector (or miner) for deep sea mining is traveling on the seabed, collecting manganese nodules and transporting the nodules to a lifting system. The collector, which consists of pick-up device and vehicle (or carrier), should have high reliability because it is operated at the deep seabed of 5000 m depth. The pick-up device is mounted in front of the collector and its main function is to gather the nodules at the seabed. The pick-up efficiency of the pick-up system has an important effect on the total efficiency of the whole mining system. Three types of pick-up system have been suggested so far. They are mechanical, hydraulic and hybrid pick-up system. Among the subsystems of hybrid pick-up device, the water jet system loosens the deep sea sediments and lifts the nodules from the seabed. Therefore, this one is the most sensitive system to determine the pick-up efficiency and requires the experimental study in order to design the optimum system.

Reviewing the research and development of deep ocean mining

technology including collector, the pilot mining tests on manganese nodules of mechanical and hydraulic pick-up device were carried out by many consortiums in the 1970's. Ocean Management Inc. (OMI) tested both hydraulic and mechanical pick-up device (Brockett III, 1977) and Kennecott Exploration Inc. (KEI) used hydraulic pick-up device only (Heine, 1978). Ocean Minerals Company (OMCO) announced that they had a relatively large scale test in 1978 by mechanical pick-up collector (Welling, 1981). The hybrid collector was developed during the 1980's in some countries (Herrouin, 1989). This type of collector has not yet been performed the pilot mining test in the Clarion Clipperton Zone (CCZ).

This study was concentrated on the conceptual design of hybrid pick-up device and the model test of water jet system. From the study, this paper describes the developing process of water jet system which is composed of pipes, nozzles, pump and motor. The model design and manufacturing were carried out based on the conceptual design of hybrid pick-up device and the model test was performed to verify the design concept and to obtain more information for future studies on the collector.

DESIGN OF PICK-UP DEVICE

The design of a collector including pick-up device should be placed into the context of the long term development for an eventually commercial production of metals from the deep seafloor in the Clarion Clipperton Zone (CCZ). The initial design is performed considering the natural conditions, mining possibility and environmental protection of mining areas. Suggestions of mining concepts and economical and technical systems of those suggestions are outlined at the initial stage.

Consideration Factors for Design

For design of a pick-up device, some factors should be considered. They are environmental conditions, annual production capacity and pick-up mechanism. The principal dimensions and advance speed of collector are determined when the average nodule abundance, shear strength of sediments and annual production capacity are decided. The choice of pick-up mechanism also is important in the aspect of