Multi-objective Design Optimization for Manganese Nodule Pilot Miner Considering Collecting Performance and Maneuver of Vehicle

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ABSTRACT

A pilot miner, which is designed to collect manganese nodules on the deep seabed, intends to collect manganese nodules while traveling on cohesive soft soil. When operating a pilot miner, one needs to maintain traffic-ability at low traction speed for maneuver operation as well as operates the vehicle straight in order to increase collecting efficiency by keeping high traction speed. Thus, if a pilot miner is designed in one property, it will become superfluous design due to conflict of incompatible properties. In this paper, multi-objective design optimization considering both collecting and maneuver operation is proposed for optimization of a pilot miner.

KEY WORDS: Manganese nodule pilot miner; deep-sea mining tracked vehicle; multi-objective design optimization; Tchebycheff method; kriging metamodel.

INTRODUCTION

Recently, a deep-ocean mining system has received growing recognition for the development of plentiful marine mineral resources. It consists of mining vehicle system, transportation system, and mother station. The deep-sea mining system is illustrated in Fig. 1. In this research, we adopt a self-propelled crawler equipped mining vehicle system equipped with many devices. It collects mineral resources, especially manganese nodules, while traveling on cohesive soil of about 5000 meters depth. Transportation system conveys the manganese nodule to the mother station through a flexible hose, a buffer, and riser pipes. The mother station stores the collected mineral resources and controls each subsystem with utility equipment.

Among these systems, the pilot miner system is a core component because it actually undertakes to pick up manganese nodules. As an experimental research, the test miner has been developed to verify the design concepts of pilot miner in the scale of 1/20 of the commercial capacity for inshore tests as shown in Fig. 2 (Hong, Kim and Choi, 2010). In this paper, we mainly consider the optimum design of a commercial pilot miner system which is a further study of the test miner. Core components of the pilot miner are a crawler with four tracks and four collectors. Crawlers should travel stably on the extremely soft soil of the deep sea while consuming the smallest amount of power if possible. The collectors are required to efficiently pick up the manganese nodules.