System Preparations for Deep Water Locomotion Trials of Deep Sea Mining Crawler

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ABSTRACT

India has been developing technology for deep sea mining to harvest polymetallic nodules from the Central Indian Ocean Basin (CIOB). The seabed mining system is a crawler type mining machine. The mining machine collects the nodules from the seabed, crushes them into smaller sizes and pumps it as seawater slurry to an intermediate pumping station. The mining machine in static and dynamic state is to be supported on the very soft sea bed of shear strength, in some places being less than 2 kPa. The maneuverability of the mining machine is thus a challenge while operating on the soft seabed. Predicting the traction of the mining machine and other associated parameters are very important for developing the locomotion system of the mining machine. An Experimental Undercarriage (EUC) system was equipped with a latching system in order to estimate the riser loads on the machine during locomotion. The EUC system will also measure the static and dynamic sinkage, vehicle slip, power required and drive motor pressure. This paper presents the design, analysis, configurations and functional testing of an Experimental under-carriage (EUC) system. The stability analysis was carried out using numerical and analytical methods to arrive at an optimum configuration of EUC system. After the configuration is finalized the whole main frame and super structure system has been analyzed using a finite element analysis software by considering the launching and retrieval loading conditions. The weakest positions were identified and reinforced adequately such that the stress and deformations are within the permissible limits. The load test experiments were also carried out with various loading conditions to qualify the design and FEA analysis. This paper also discusses the qualifications of various underwater sensors, design and development of sensor’s enclosures at hyperbaric conditions for 6000 m depth for measuring the traction parameters of an Experimental Under-Carriage system.

KEY WORDS: Experimental Undercarriage, Polymetallic Nodules, deep sea mining, crawler, Locomotion, soft soil.

INTRODUCTION

India is developing a Mining System for harvesting the polymetallic nodules from the deep ocean floor in the Central Indian Ocean Basin (CIOB) which is based on Flexible Riser Concept as shown in Fig. 1. Initially the flexible riser concept was demonstrated in the shallow water in Indian seas at 410 m water depth (Deepak et al, 2001) which had a manipulator with a cutter mechanism and a positive displacement sand pump for pumping operations.

Subsequently, the mining machine was enhanced with three modules collector and pick up device and S-transfer positive displacement pump for the operation. The system was tested near Angria Bank in Arabian Sea at 512 m depth using artificial nodules, which were specially developed and laid on the sea bed to qualify the collection, crushing, pumping systems and flexible riser concept of the mining system (Rajesh et al).

The maneuverability of the tracked vehicle in soft clay soil is difficult and it is very important to know the soil properties to develop a mining system. The Remotely operable Sub-sea In-situ Soil tester (ROSIS) was developed and tested at 5462 m water depth at the mining site in the Central Indian Ocean Basin. The actual bearing strength and the shear strength of the undisturbed soil was measured. The bearing strength varied between 5 kPa at the surface of the soil to 20.6 kPa at 492 mm below the soil surface. This data is being used for the design and development of the mining system (Muthukrishna Babu et al).

Based on the field trial results and in-house studies an Experimental Undercarriage (EUC) system was configured with necessary measuring devices to estimate the traction and resistance parameters of the mining machine. The EUC system was functionally qualified in Bay of Bengal.