Qualification tests on Underwater Mining System with Manganese Nodule Collection and Crushing Devices

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ABSTRACT
A tracked under water mining system with a polymetallic nodule collector, crusher and positive displacement pump has been developed and tested at 500 m water depth. This system is a continuation of the developmental work done using flexible riser concept for mining fine seafloor materials like sand and silt in 2006. The collector device of the machine has three modules of mechanical pick up devices and cleated belt conveyors. The collected nodules are fed in to two crushers for size reduction and lateral transport. The crushed nodules are then pumped to the mother vessel by a twin cylinder positive displacement pump through a flexible riser. The system was tested near Angria Bank off Malvan coast in Arabian Sea at 512 m depth during October 2010. This paper describes in detail the various systems and devices in the mining machine and the results of the mining tests carried out at the site.

KEY WORDS: Underwater mining machine; Polymetallic Nodules; Artificial nodule laying machine; Manganese Nodule Collector.

INTRODUCTION
Integrated Mining System proposed for mining polymetallic nodules from the deep ocean floor in Central Indian Ocean Basin (CIOB) is based on Flexible Riser Concept and multiple mining machines (Grebe et al, 1996). The mining system will consist of three to four crawler based underwater mining machines connected to a single small floating semisubmersible platform (Handschuh et al, 2001) as shown in Fig. 1. The mining machine has polymetallic nodule collector with mechanical pick up devices, cleated belt conveyor, crushing system and solid-water transportation system with a single positive displacement pump. The polymetallic nodule mining system has been proposed to be developed in four phases. The initial phase of development of the mining system was started with the aim to prove the flexible riser mining concept. An underwater mining machine capable of mining fine seafloor material like sand or silt was developed which had a manipulator with a cutter mechanism and a positive displacement sand pump. The flexible riser concept was tested during 1998-2000 (Deepak et al, 2001). Demonstration of the concept for long term operations required dynamic positioning in the mother ship Sagar Kanya for launching and recovery operations. This facility was incorporated and the mining system was tested again for mining fine sea floor material for long term operations in 2006 in the second phase (Deepak et al, 2007). Based on the results from the tests and the confidence gained the manipulator and cutter were replaced with a mechanical nodule collector. Qualifying the mining machine at 500 m water depth called for creating a nodule site similar to that of the actual at CIOB, as no nodules are available at the test site (Angria bank) in Arabian Sea. Artificial nodules having similar crushing properties as that of polymetallic nodules were developed. A remotely operable artificial nodule laying system was developed to lay these nodules and the system qualified off Chennai coast in 2007 (Amudha et al 2009). The same system was used to create a nodule carpeted track to facilitate testing of the underwater mining system with collector and crusher in October 2010.

Fig.1. Integrated Mining System using Flexible Riser Concept

ARTIFICIAL NODULE LAYING SYSTEM
The Artificial Nodule laying system consists of a hopper with positioning thruster, rotary vane feeder, hydraulic power pack, servo valve pack, sonar, cameras, depth sensor, altimeter, motion reference unit (MRU), data acquisition system, fibre optic multiplexing and