Development and Testing of Underwater Mining Systems for Long Term Operations using Flexible Riser Concept

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ABSTRACT

An underwater mining system using flexible riser concept was demonstrated for operations in the Indian seas at 410 metres water depth in 2000 for short duration. Based on the tests, enhancements were done on the mining system for long term operations in areas pertaining to distribution of buoyancy packs, sealing and heat dissipation arrangements. The mother ship was also equipped with Launch and Recovery System and Dynamic Positioning System. The modified system was tested for long term maneuverability and pumping operations at 451 m depth in 2006. The paper discusses the enhancements carried on the mining system and the mother vessel and the results from the sea tests.

KEY WORDS: Underwater mining vehicle; crawler; flexible riser; manganese nodules; deep sea mining.

INTRODUCTION

India has been allotted a mining site in the Central Indian Ocean Basin (CIOB) by the International Sea-bed Authority and is keen on developing technologies to mine manganese nodules. Deep sea mining of manganese nodules from soft ocean floor at 5000 to 6000 metres depth is a major technological challenge. India has been working on developing this complex technology in a phase wise manner. To minimize development costs and associated risks, initial efforts are focused on realization and qualification of machinery for long term operations in shallow waters, followed by further development of machinery for deep waters. An initial study was done on the various deep sea mining concepts and the flexible riser concept (Grebe, 1997) was chosen for development. An underwater mining system was developed for operations and the flexible riser concept was validated in the Indian seas at 410 metres water depth in 2000. (Deepak et al, 2001) jointly by National Institute of Ocean Technology (NIOT) and Institut für Konstruktion (IKS) of University of Siegen, Germany. The tests gave confidence for carrying out further studies that lead to enhancements in the mining system and the mother vessel, which were cost intensive. The modified system was tested for long term operations at 451 m depth off Goa coast during March 2006.

FLEXIBLE RISER SYSTEM

Most of the existing deep sea mining concepts are based on the tests carried out by various consortia active in the seventies (Chung, Whitney and Loden 1980; Brink and Chung, 1981; Chung, 1996). The systems had either a self propelled nodule collector (Chung 1996) or a towed collector (Heine and Sung, 1978) which collects and pumps nodules from the ocean floor to the lifting system, either directly or through an intermediate storage buffer unit. The lifting system has been either hydraulic or air-lift. Hydraulic lift systems had multistage centrifugal pumps installed at three different depths (Kuntz, 1978; Chung and Tsurusaki, 1994). In the case of airlift systems, compressed air was injected at intermediate depths and the solids were lifted up as a three phase mixture.

The flexible riser system is one of the novel deep sea mining systems being developed after the Law of the Sea treaty (UNCLOS -III) became effective as of 1994. A crawler based underwater mining machine collects the nodules as it moves along the ocean floor. The underwater mining machine is self propelled and remotely controlled. The presence of multiple mining machines (Fig. 1) a flexible riser system instead of a rigid riser system and a single positive displacement pump instead of multiple centrifugal pumps are the main differences of this system when compared to pipelift systems. The complete system has been discussed in detail in Handschuh et al (2001).

The flexible riser system has been proposed to be realized in four phases :
- First phase of validation of the flexible riser concept at 400-500 metres water depth for underwater mining operations.
- Second phase of evaluation of the performance of the system developed in the first phase for long term operations by equipping the mother vessel with a Dynamic Positioning System.
- Third Phase of realization of manganese nodule collection and crusher systems and their addition to the underwater mining machine developed in the second phase.
- Fourth phase of validation of the flexible riser concept for manganese nodule mining operations in the Central Indian Ocean Basin using one underwater mining system.