

## Development of Dynamics Model of Seafloor Mining System and Analysis of Influence Factors in the Deploying Process

Xiaozhou Hu<sup>1,2</sup>, Shaojun Liu<sup>1,2</sup>, Bin Du<sup>1,2</sup>

<sup>1</sup> College of Mechanical and Electrical Engineering, Central South University, Changsha, Hunan, China

<sup>2</sup> The State Key Laboratory of Deep Sea Mineral Resources Development and Utilization Technology,

### ABSTRACT

In this paper, a computational model is developed to simulate the dynamics of a riser system in the process of deployment. From the beginning of deployment process, the riser is considered to be vertically suspended to a deploying frame which is located at the support vessel, and gradually pulled into the sea water by mining tool. Considering the variable length of the immersed riser, a numerical model is presented to capture the dynamics of the riser with a lumped mass approximation. Discretization scheme for riser and pipe geometry and methodology for calculating the internal and external force acting on riser are presented. The riser and the pipe are discretized into an assembly of  $N$  linear elements. The mass of the riser and pipe are lumped at the  $N+1$  node points. A 4<sup>th</sup> order Runge-Kutta approach with proper step size is employed to achieve numerical implementation. Four ocean conditions which are proper for deployment are considered, and the effect of deploying velocity is also researched. The results indicate that the ocean condition and the deploying velocity are playing an important role to determine the kinematic and dynamic condition of the deployment process of deep sea mining systems, and the research results can provide basic information for the design of the heave compensation system and reduction of dynamics effects of riser system on seafloor mining tool during the deploying process.

**KEY WORDS:** Deep sea mining system; lumped mass model; riser system; deployment; dynamic simulation analysis

### INTRODUCTION

Deep sea mining is a field of mining which attracts more and more attention from all over the world, it is considered as an important means to meet the challenge of the gradually exhaustion of land mineral resources. The discussed deep sea mining system typically consists of a mining support vessel, riser and lifting system (including flexible riser, lifting pump and pipe), intermediate station and seafloor mining tool. The COMRA (China Ocean Mineral Resources R & D Association) ocean pilot mining system for 1000m water depth is shown in fig.1.

The mining tool works on the seafloor at 1000m depth, connected by a flexible riser of 400m length to the intermediate station. The intermediate station located at the depth of 900m contains the flexible riser transporting pump and the feeder for lifting pipe. Vessel and

intermediate station are connected by a pipe whose length is 900m. The lifting pump is located at a depth of 400m. Flexible risers and pipes are main elements of the deep sea mining system, and their functions are as following: (a) connecting the mining support vessel and the seafloor mining tool; (b) installing cables to transmit maneuvering commands, data and power; (c) transporting the mud which contains ores from seafloor mining tool to mining support vessel; (d) acting as deploying mean in the process of deployment.

The deployment is an important process of deep sea mining, the purpose of which is the safely and accurately arrangement of the mining tool, flexible riser, pipe, intermediate station and lifting pump onto the appropriate positions. In this paper, the deployment process exclusively covers the process of transferring the mining tool from the vessel to the sea floor, while the configuration of flexible riser is not included.

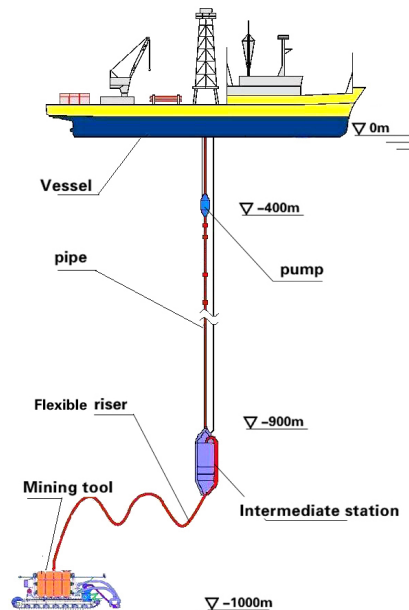


Fig.1 Ocean pilot mining system of COMRA for 1000m water depth

In the deploying process, the heave compensation system which is located at the support vessel is in the state of dead lock, so it cannot compensate any heave motion as expected. As result, the riser system