Study on the plugging inside the riser pipe during the transfer of the low-temperature substances such as methane hydrate

Joji Yamamoto, Yasuharu Nakajima, Satoru Takano, Marcio Yamamoto, Masao Ono, Shigeo Kanada
Ocean Engineering Department, National Maritime Research Institute, Japan
Mitaka, Tokyo, Japan

ABSTRACT

We carried out two preliminary experiments (under the atmospheric pressure and high-pressure conditions) to estimate the inside situation of the riser pipe and the risk due to freezing of the methane hydrate slurry during the transfer process, which are aiming to construct a numerical model to simulate these phenomena. This paper shows some considerations for the construction of an evaluation model, including the formation and dissociation processes of the hydrate in a riser pipe under dynamic conditions during the transfer of low-temperature substances based on the results of these preliminary experiments.

KEY WORDS: Methane hydrate; flow assurance; heat transfer; formation; gas-liquid interface; vortex-induced vibration.

INTRODUCTION

The exclusive economic zone (EEZ) of Japan has a vast area due to a lot of islands in the Japanese Archipelago (Fig. 1) (Chujo et al., 2010). Methane hydrate has been found below the seafloor off the coasts of Japan in large amounts, so that it is expected to be exploited as one of the future energy resources in Japan (Matsumoto, 2009).

In Japan, several methods for the exploitation of methane hydrate from the sediment have been studied in appropriate ways suitable for (i) stratigraphic-type deposits or (ii) shallow hydrate accumulation. First, the stratigraphic-type has fine methane hydrate particles dispersed in the sandy reservoirs. In the second type, the massive methane hydrate accumulation is buried below the seafloor with a mud layer with a thickness of less than 100m.

For the stratigraphic-type deposits, methane hydrate is dissociated to methane gas and water by heating or de-pressurizing the reservoir. After that, only methane gas is recovered subsequently (The Cabinet Office, 2018; AIST, 2019). On the other hand, massive or granular methane hydrate shall be excavated on the seafloor for shallow accumulation. Then, the excavated material is sent up to the platform as a slurry, a mixture of methane hydrate particles soil particles and seawater (Fig. 2) (AIST, 2019). In this second case, the initial two-phase flow (methane hydrate, soil particles and seawater) can be developed into a three-phase flow consisted of methane hydrate, soil particles, methane gas, and seawater by partial dissociation of the hydrate due to a change in temperature-pressure conditions in the risers or flowlines. Moreover, methane hydrate could be re-formed due to changes in pressure and temperature in the pipes (Nicholas et al., 2009; Zerpa et al., 2011; Sum et al., 2021; Creek, 2012; Charlton et al., 2018).

Fig. 1. EEZ of Japan indicated as thickly-colored areas enclosed by bold lines (Chujo et al., 2010).