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Estimating hydrate formation and decomposition of gases released in a deepwater ocean plume

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Abstract

Oil wells in the deep ocean contain a mixture of oil and gas. If gases are released from such water depths due to an accident, the gases can undergo phase changes as they travel through the water column. Based on previous experiments that were mostly done in the laboratory for gases in pipelines, it is known that under such high-pressure conditions, natural gases will be converted to hydrates. As the hydrates travel upwards, the reduced pressure conditions may change the hydrates to free gas. The impact assessment due to these deepwater releases requires a jet/plume hydrodynamics model with an integrated module to simulate gas hydrate formation and decomposition. In this paper, a model for calculating the rate of the gas hydrate formation and decomposition is developed based on the work of Englezos et al. [Chem. Eng. Sci. 42 (1987) 2647] and Kim et al. [Chem. Eng. Sci. 42(7) (1987)]. The model is then used to calculate the fate of gas bubbles as they travel through the water column. The calculations are useful for understanding the fate of a gas bubble released in the deep ocean and for eventual integration into a jet/plume model. © 2001 Elsevier Science B.V. All rights reserved.

Keywords: Hydrate formation; Ocean; Plume; Deep water; Deepwater plume

1. Introduction

Modern technology allows oil and natural gas to be produced from deepwater wells economically. Exploratory and production wells are in the Gulf of Mexico in water depths of the order of 900 m. Natural gases released below 500 m of water depth can be completely converted to gas-hydrates (Maini and Bishnoi, 1981; Topham, 1984).

The specific gravity of natural gas hydrates varies from 0.91 to 0.95. If gases are converted to hydrates, the overall buoyancy of the plume is altered significantly. As the hydrate particles travel upwards, reduced hydrostatic pressure can lead hydrates to de-

compose into free gas. Therefore, a profound change in the fate of the oil/gas jet/plume in a deepwater blowout can occur depending on whether the gases are converted to hydrates and possibly re-converted to gas. This behavior has not been previously studied but is very important for contingency planning and clean-up efforts in case of an accident.

The percentage of deepwater (wells located around 900 m or below) production in the Gulf of Mexico was 28% in 1997. This production is expected to increase to 47% by 2002 and to 69% by 2007 (Lane and LaBelle, 2000). Regulatory agencies and the industry face an increasing challenge to protect the ocean environment from potential spills. Models are needed that simulate the behavior of oil and gases released from such depths for risk assessment and for analyzing “what if” scenarios. Before developing

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