Role of plume dynamics phase in a deepwater oil and gas release model

Lalith K. Dasanayaka, Poojitha D. Yapa*

Dept. of Civil and Envr. Engrg., Clarkson Univ., Potsdam, NY 13699, USA

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Abstract

Offshore exploration and production of oil and gas have increased significantly in the last decade. Computer models are used in emergency response, contingency planning, and impact assessment to simulate the behavior of oil and gas if accidentally released from a well, pipeline, or ship. There are two types of models used for this purpose—models that have both plume dynamics stage and the advection diffusion stage and models that are of simplified nature that has only the advection diffusion stage. This paper compares both types of models and shows what information are similar and what are different and under what conditions. The paper also examines in detail about different criteria that can be used as the transition point (TLPD) from plume dynamics to advection diffusion stage. Key findings of the paper are that except for slow leaks the two types of models give different results for surfcing time and location. This is important because sometimes the two models may show similars that correspond to different times to be similar in shape. The present parametric study suggests that the transition point for TLPD can be based on the buoyant oil droplet velocity corresponding to the median oil droplet size.

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1. Introduction

Worldwide offshore oil production has increased significantly in the last decade. Some of the regions that have active offshore production are Brazil, North Seas, West Africa, and the USA including the Gulf of Mexico. In USA, offshore production accounts for about 30 percent of the total domestic production. In Asia, China and Japan have deepwater exploration programs in progress that have found promising deposits.

Emergency spill response, contingency planning, and impact assessment need an oil and gas spill model as part of their program. In underwater releases, oil and gas initially behave as jets and plumes. For jets and plumes, there have been a number of excellent models developed with the focus mostly on pollutants such as sewage and thermal discharges (e.g. Lee and Cheung, 1990; Frick et al., 1994; Bemporad, 1994). These models were formulated based on robust principles and worked very well in field applications. In this paper jets and plumes are referred to simply as plumes. Model development for simulating underwater releases of oil and gas has taken place mostly during the last 10 years and there are not many available. Two models known to simulate the fate and transport of oil and gas released from underwater were DEEPBLOW (Johansen, 2000) and Comprehensive Deepwater Oil and Gas — CDOG (Zheng et al., 2003). Both models consider plume hydrodynamics and thermodynamics, hydrate formation, rise velocity of oil and gas bubbles, gas dissolution, and the possibility of gas separation from the plume. In the initial stages, the hydrodynamics is governed by the plume mixing, in later stages, passive advection and diffusion are the dominant processes. Many models use both stages. There are some models, however, that are only based on advection—diffusion and the possibility exists that they may be used in critical decision making.

For emergency response and contingency planning, the models are expected to provide answers to key issues such as: 1) time taken for oil to appear first at the surface and its