

Simulation of oil spills from underwater accidents 1: Model development

Simulation de deversements de petrole dus a accidents sous-marins 1: Elaboration du modele

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ABSTRACT

A three-dimensional comprehensive numerical model is developed to simulate the behaviour of buoyant oil jets that result from underwater accidents. The numerical model is developed based on a Lagrangian integral technique. The model can simulate the behaviour of oil in stratified or unstratified ocean environments. Both the shear induced entrainment and the forced entrainment are considered in the model. The presence of a multi-directional ambient current is considered. The fluid in the buoyant jet can be a liquid, gas or liquid/gas mixture, which is typical of many underwater oil-related accidents. The model formulation includes the diffusion and dissolution of oil from the jet to the ambient environment. This paper presents the model development including the governing equations and the numerical discretization. A companion paper presents the verification of the model and applications to several cases.

RESUME

Un modele numerique tridimensionnel a ete developpe pour simuler ie comportement de jets flottants de petrole provenant d'accidents sous-marins. Le modele numerique a ete developpe a partir d'une methode integree lagrangienne. Le modele peut simuler le comportement du petrole dans un environnement marin stratifie. Le modele prend en compte a la fois l'entrainement du au cisaillement et l'entramement force. La presence d'un courant multidirectionnel dans le milieu ambiant est prise en compte. Le fluide a l'interieur du jet flottant peut etre un liquide, un gaz ou un melange liquide/gaz , ce qui est la caracteristique de nombreuses observations de rejets sous-marins. La formulation du modele prend en compte la diffusion et la dissolution du petrole issu du jet dans le milieu ambiant. L' article presentant l'elaboration du modele comprend les equations regissant les phenomenes, puis la discretisation numerique. Un second article presente la verification du modele et son application a plusieurs cas.

Introduction

Over the past two decades, public awareness of the damaging effect of oil spills on the environment has increased. Over 50 oil spill models have been developed to predict the trajectory and fate of spilled oil (Huang & Monastero,1982; Spaulding, 1988; ASCE, 1996). Almost all of these models, however, have been concerned with surface or near surface spills such as that from a tanker (ASCE, 1996). In oil spills due to underwater accidents, such as a broken oil pipeline or an oil well blowout at the sea bed, oil usually behaves as a submerged buoyant jet. Underwater blowouts often contain a mix of oil and gas (e.g., Methane). The advection/diffusion equation is not valid for simulating the oil trajectory and dispersal pattern until oil reaches the far field. Therefore, developing an oil spill model capable of simulating both surface and underwater spills is necessary. Studies on submerged buoyant jets of oil are scarce. McDougall (1978), Fannelop & Sjoen (1980), Milgram (1983), and Fannelop et al. (1991) developed models to simulate the underwater blowout

Revision received May 29, 1997. Open for discussion till April 30, 1998