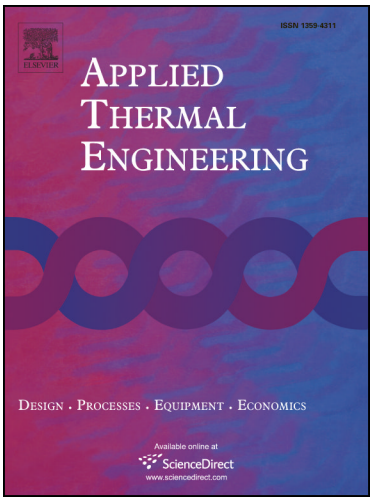

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An Approach to Estimating the Boil-Off Rate of LNG in Type C Independent Tank for Floating Storage and Regasification Unit under Different Filling Ratio

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ABSTRACT

The alternative terminal Floating Storage and Regasification Unit (FSRU) for gas storage and vaporization is rapidly expanding all over the world. FSRU with great storage capacity and long storage time is faced with the continually evaporation of liquefied natural gas (LNG), which result in the decrease of filling ratio. In order to improving the efficiency of electricity generation and utilization of the Boil-off Gas (BOG), accurate and efficient method to estimate the BOR under different filling ratio is in demand. An equivalent conductive model with the combination of adjacent fluid layer and flowing BOG is proposed in this paper to handle the complex convection from the multiphase simulation. Testified by experimental measurement, the highest relative error for BOR estimation is less than 4%, and also the heat transferred by evaporation can be estimated accurately under different filling ratio. With the valid temperature distribution got from this model, the initial condition of transient simulation under specific filling ratio can be given rapidly for further study. Furthermore, the comparison between numerical results and experimental measurement also reveals that the majority of heat is transferred from bulkhead during evaporation under lower filling ratio. Finally, the proposed approach is successfully applied for a case of 30000 m^3 FSRU, and proved to be a valid option to calculate BOR in the engineering field.

Keywords: BOR, LNG, BOG, filling ratio, FSRU

1. Introduction

The demand of natural gas (NG) is growing because of its clean burning and extensive application value, and the scale of NG trade volumes has reached an all-time high again [1-4]. In order to reduce the economic cost and mitigate the demand pressure of land area, an alternative terminal Floating Storage and Regasification Unit (FSRU), similar to a land-based terminal, is more and more widely utilized around the world [5, 6]. It can be treated as an offshore power station with the ability of transporting liquefied natural gas (LNG), vaporizing LNG and delivering NG through specially designed offshore or near-shore receiving facilities. Owing to the great temperature difference between LNG and the ambient as well as the inherent defects of insulation wall [7], the evaporation of LNG is a regular and routine condition during its service period and the corresponding LNG operations. The evaporating gas (boil-off gas, BOG) is the main products in relation to the electricity generation, and the evaporating rate (boil-off rate, BOR) determines the efficiency of regasification and electricity generation. Therefore, estimating the BOR accurately can facilitate the utilization of BOG and improve the economic benefits of FSRU. Nonetheless, the filling level of LNG tank gradually declines during the long storage time, which is even less than 30%, and the BOR under different filling ratio becomes an uncertainty in this condition. As the multiphase flows are complicated and divergent for different filling ratio, accurately estimation of the BOR under different filling ratio becomes an important task [8].