Investigation of the evaporation process of liquefied natural gas injected in front of a compressor

Sebastian Schuster, Chair of Turbomachinery, University of Duisburg-Essen, Germany,
Dieter Brillert, Chair of Turbomachinery, University of Duisburg-Essen, Germany
Friedrich-Karl Benra, Chair of Turbomachinery, University of Duisburg-Essen, Germany
Uwe Martens, Siemens AG, Dresser-Rand Business, Duisburg, Germany

Long Abstract

Introduction

Liquefied Natural Gas (LNG) is stored and transported in tanks as a cryogenic liquid, i.e. liquid at a temperature below its boiling point at about 100 K. Due to heat ingress into LNG and its cryogenic nature, during storage, shipping and loading/unloading modes LNG continuously evaporates (boil off gas – BOG). The increase of BOG in storage and ship's tanks increases the LNG operating tank pressure. In order to maintain the operating tank pressure within the safe range, BOG should be continuously removed. Since BOG reduces the quantity of cargo delivered by LNG tankers and increases the heat value of LNG in storage and ship's tanks, the quantity of BOG is a key factor for the technical and economic evaluation of the LNG supply chain. The pressure of BOG is boosted by compressors in receiving terminals, and sent along with LNG gasified by LNG vaporizers to city gas companies and the fuel systems of power plants [1, 2]. To reduce the compressor energy demand the compressor inlet temperature should be low. This can be achieved by injecting LNG into the suction line of the compressor. Doing this, it has to be ensured that all injected LNG is evaporated before entering the compressor inlet avoiding damage at the impeller blades. So, it is important to know the evaporation process of the LNG in a free stream.

Methods

The evaporation process of injected LNG droplets is investigated under realistic boundary conditions in order to make sure that no remaining droplets will reach the comprssor impeller. Using the conservation laws of mass and energy a 1D numerical model is determined which allows to calculate the evaporation of liquid hydrocarbon droplets in a free stream. The fluid properties are taken from NIST [3]. A comparison between the 1D model and a 3D Navier-Stokes solution shows a good agreement regarding the decrease of the droplet diameter during the evaporation process with respect to the amount of injected mass of liquid fluid and gives a good indication of the requested distance for complete evaporation. In addition, the derived 1D model predicts the temperature decrease of the BOG during evaporation in a very good accordance to the 3D Navier-Stokes solver (Fig. 1). Using the 1D model it is possible to quickly evaluate the thermodynamic inlet parameters of a compressor for given boundary conditions. In addition, in can be stated if all injected liquid is evaporated at the compressor inlet or if there will be formed liquid films at the walls.

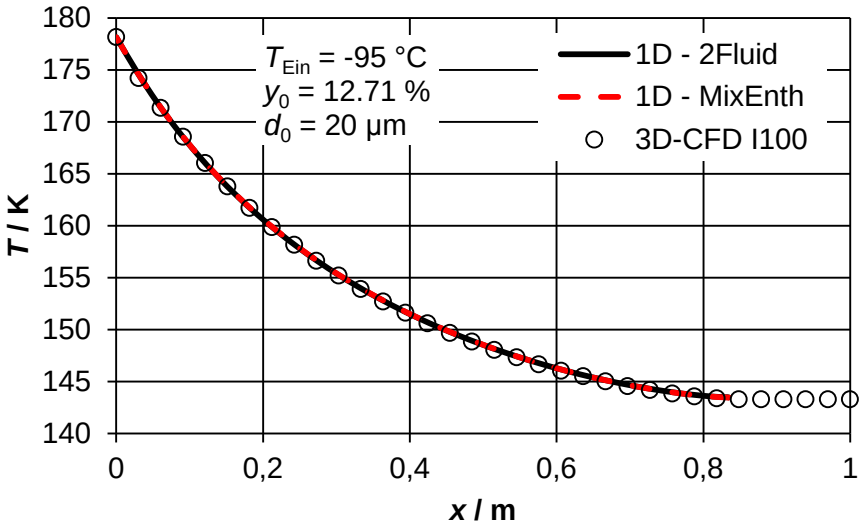

Figure 1: Temperature decrease of BOG during the evaporation distance

References

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