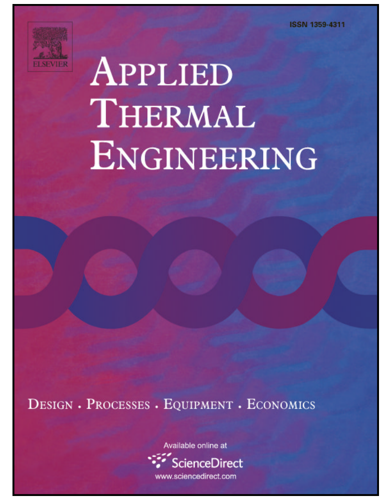
Accepted Manuscript



Research Paper

Experimental study on pressure control of liquid nitrogen tank by thermodynamic vent system

Bin Wang, Yonghua Huang, Jingyi Wu, Tianxiang Wang, Gang Lei

PII: S1359-4311(17)31549-1
DOI: http://dx.doi.org/10.1016/j.applthermaleng.2017.07.067
Reference: ATE 10735

To appear in: *Applied Thermal Engineering*

Received Date: 6 March 2017
Revised Date: 22 May 2017
Accepted Date: 9 July 2017

Please cite this article as: B. Wang, Y. Huang, J. Wu, T. Wang, G. Lei, Experimental study on pressure control of liquid nitrogen tank by thermodynamic vent system, *Applied Thermal Engineering* (2017), doi: http://dx.doi.org/10.1016/j.applthermaleng.2017.07.067

Experimental study on pressure control of liquid nitrogen tank by thermodynamic vent system

Bin Wang[1], Yonghua Huang[1*], Jingyi Wu[1], Tianxiang Wang[2], Gang Lei[2]

[1] Institute of Refrigeration and Cryogenics, Shanghai Jiao Tong University, Shanghai 200240, China

[2] State Key Laboratory of Technologies in Space Cryogenic Propellants, Beijing 100028, China

[*]Corresponding author e-mail: huangyh@sjtu.edu.cn

Abstract: Long-term storage of cryogenic propellants on orbit as the replenishing fuel for spacecraft and energy supply source for space station is a crucial part of future space exploration. Thermodynamic vent system (TVS) was proposed as an effective technology to maintain the propellant tank pressure and reduce the mass loss of liquid propellant. This study presents an experimental investigation on the pressure control effect of a TVS installed in a 1.36 m^3 liquid nitrogen (LN_2) tank of the testing facility named Efficient Cryogenic Fluid Storage Test Platform (ECFSTP). Two operation modes, namely the mixing-only mode and the mixing-venting mode of TVS were compared and analyzed. The degree of superheat of the ullage dropped more rapidly and significantly under the mixing-venting mode, which produces the cooling effect by the venting stream from the throttling valve in addition to venting itself. The effects of different pressure control bands on the performance of the TVS have also been comparatively investigated. The results confirmed the feasibility and effectiveness of the TVS to control the tank pressure within the range of 220~260 kPa for long time running, with 50% fill level and 9.31 $W \cdot m^{-2}$ leaking heat flux.

Keywords: Thermodynamic vent system; Pressure control; Experimental study; Liquid nitrogen

1. Introduction

Cryogenic propellants pair LH_2–LO_2 is widely used in space missions due to their high fuel performance and nontoxicity. Deep space exploration calls for long-term storage technologies of cryogenic propellants on orbit. The inevitable space heat leakage causes evaporation or boiling-off of the cryogens that will definitely lead to increase of the interior pressure. Besides, thermal stratification at zero-g is much more severe than that in the 1-g environment as commonly experienced, which results in excessive tank pressure rise [1]. Therefore, pressure control is one of the enabling technologies for storing two-phase cryogens in low-gravity environments. A conventional solution for propellant venting on orbit is to employ auxiliary systems to separate the liquid and vapor by accelerating or rotating the tank. However, it must incur weight load penalties and increase mission complexity. A thermodynamic vent system (TVS) was proposed as an effective technology for such pressure control tasks by venting vapor propellant only without resettling. The first generation TVS [2] played a limited role in eliminating the fluid thermal stratification due to its structural constraint. The second generation TVS [3] proposed by Marshall Space Flight Center (MSFC) and Rockwell® replaced the compact heat exchanger with a spray bar and introduced a mixing pump to accomplish better destratification effect. The thermal energy was extracted from the