Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 174 (2017) 11 – 18

Procedia Engineering

www.elsevier.com/locate/procedia

13th Global Congress on Manufacturing and Management, GCMM 2016

Interaction of the gas-vapor mixture and air on the condition drainage system of space launch vehicles when filling cryogenic propellant

V. Trushlyakov[a,*], K. Zharikov[a]

[a]*Aircraft and Rocket Building Department, Omsk State Technical University, Omsk, 644050, Russian Federation*

Abstract

The process of interaction between the chilled drain pipe oxidizer tank with atmospheric air. The conditions when drain- pipes, depending on ambient parameters (temperature, relative humidity). Using modeling package SolidWorks Flow Simulation software processes carried out: a) the expiration of the steam-gas mixture through the drainage and pressure relief valve and drain pipe; b) contacting with chilled air drainage pipe. It is shown that a) during the expiration of the gas mixture the drain pipe cools; b) when closing the safety valve, drainage atmospheric air enters into the drainage pipe, and water vapor condenses and freezes, which can lead to the blockage of the drainage pipe and the explosion of the propellant tank. Recommendations to prevent freezing of the drain pipe.

Peer-review under responsibility of the organizing committee of the 13th Global Congress on Manufacturing and Management

Keywords: Phase transition; vapor-gas mixture; drainage; air.

1. Introduction

Modern problems dictate the reduction of time and the automation prelaunch process of the space launch vehicle (SLV) with the unconditional fulfillment of the requirements of fire and explosion.

Special requirements apply when filling cryogenic propellants (oxygen, hydrogen) [1], which is mainly due to the interaction of the cooled fill of the propellant tank and the gas-vapor mixture to the environment.

* Corresponding author. Tel.: +7-913-624-5014.
E-mail address: vatrushlyakov@yandex.ru

Peer-review under responsibility of the organizing committee of the 13th Global Congress on Manufacturing and Management
doi:10.1016/j.proeng.2017.01.131

In the process of filling the SLV propellant tank with cryogenic it is exposed to temperature extremes, in which a number of transient heat transfer processes are implemented [2,3].

In [4] the processes of heat transfer between the surface of the cryogenic propellant tank and the atmospheric air, followed by the formation of a layer of frost on the wall of the propellant tank.

The numerical model presented in [5,6], describes the final preparation process (filling and pressurization) propellant tank «KSLV» missiles. Thus, the main attention is paid to the flow of the process of cooling the propellant tank, processes and methods of filling and storage of cryogenic components. This is not the pressure relief process of steam and gas products of the cryogenic propellant tank of the SLV.

2. The physical model of the process

When filling the propellant tank with cryogenic liquid component (e.g., liquid oxygen) boiling of the cryogenic component occurs to form a large number of the gas-vapor mixture (GVM) drain which provides the necessary pressure in the propellant tank [7].

During the prelaunch of the SLV, the cryogenic propellant tank needs relief from the pressure, through the automatic opening of the safety valve drainage.

As a result, there is a pressure relief temperature difference between the discharge of the GVM and atmospheric air.

The GVM flowing through the drain pipe (DP) cools it, the DP temperature and drain-safety valve (DSV) is reduced to a temperature value of the GVM, located in the propellant tank.

After closing the DSV it is filled and DP atmospheric air cools and condensation of water vapor (which is present in the air) forms on the surfaces of the DSV and DP.

The condensate in turn resulting from the temperature of the DSV and DP - freezes.

The thermodynamic parameters of the GVM in the propellant tank of the SLV are directly dependent on the fuel component parameters, for example, Figure 1 shows the phase diagram of oxygen [8] in the pressure ***p*** - temperature ***T***.

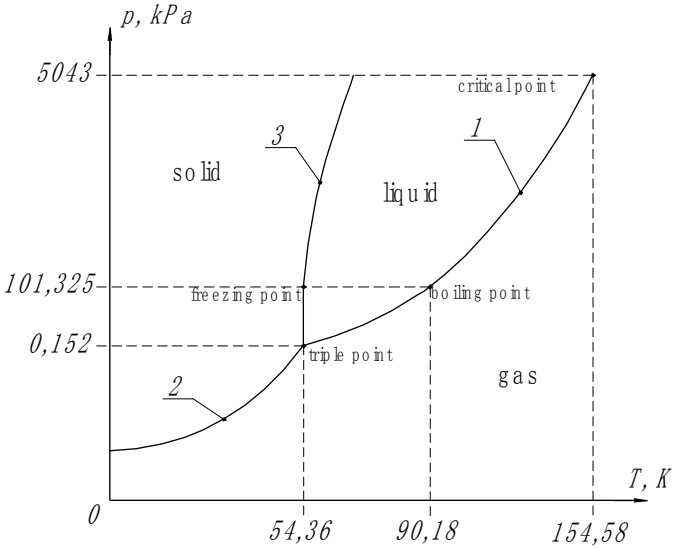

Fig. 1. Phase diagram of oxygen.

As follows from Fig. 1 at pressures and temperatures corresponding to one line below, oxygen is in a gaseous