Numerical Model of No-Vent-Fill (NVF)

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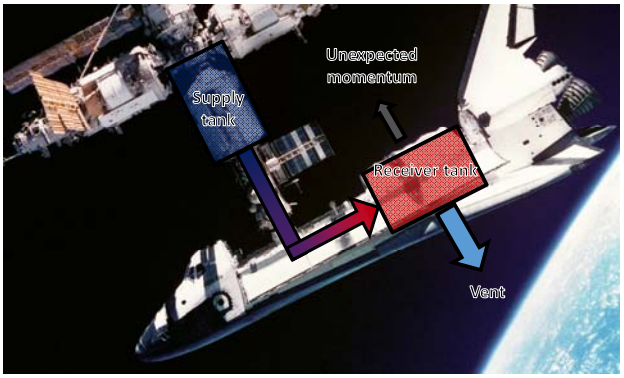
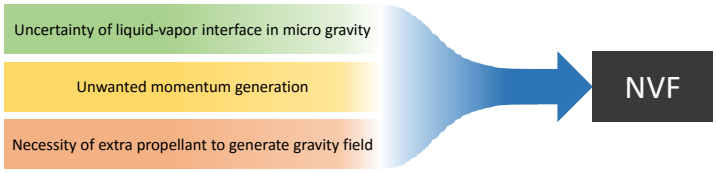
Introduction of NVF



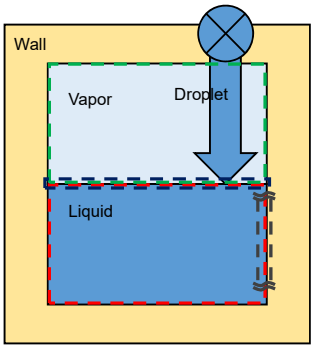
- **Definition**
  - No-Vent-Fill: Cryogenic propellant transfer and filling under micro gravity without venting process
- **Problems of Vent-Fill**



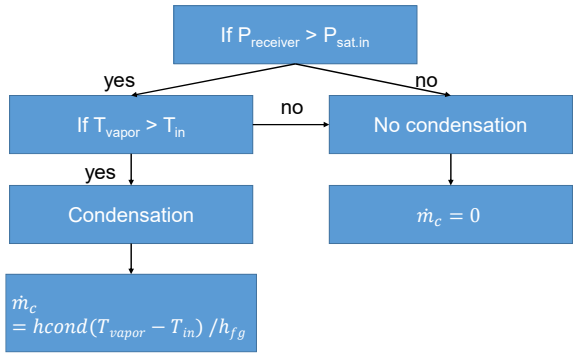
- **Advantages**
  - Reduction of the spacecraft weight at launching
  - Increase of the available fuel to explore space

System modeling

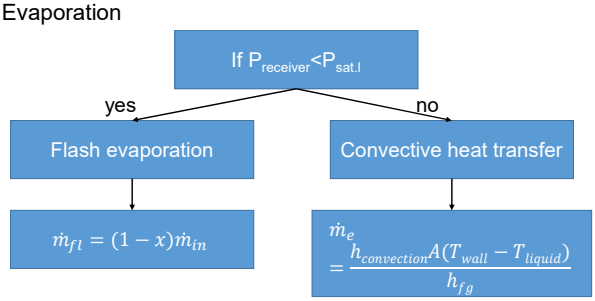
- **Assumptions**
  - Condensation at gas-droplet interface only
  - Negligible heat transfer at vapor-wall interface
  - Uniform temperature of liquid
  - Empirical heat transfer coefficient from previous experimental data
- **Control volumes**
  - Vapor control volume
  - Liquid control volume
  - Liquid-vapor interface control volume
  - Liquid-wall interface control volume



- **Process logics**
  - Condensation



  - Evaporation



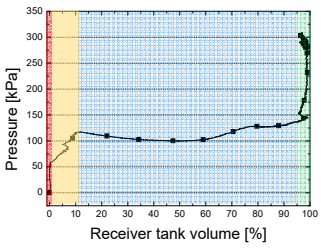
- **Processes**

0. Pressurization due to flash evaporation

1. Pressurization due to the tank cool down

2. Pressure decrease due to condensation

3.Pressurization due to compression of vapor

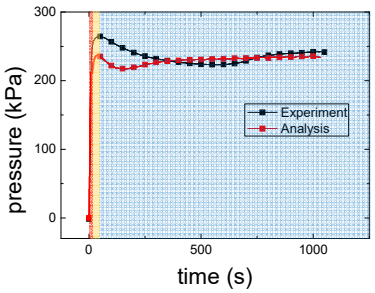


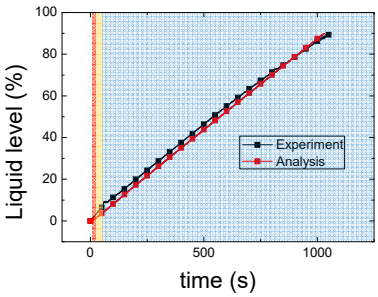
Problem & Objective

- **Problem**
  - Difficulty of predicting the experimental results
- **Objective: Development of a reliable numerical model for NVF**
  - Developing an analytic model by using previous experimental data
  - Reducing experiment costs
  - Considering of flash evaporation process at the beginning of the NVF

Result and discussion

- **Propellant selection: R14 (CF_4)**
  - Non flammable
  - Similar structure with methane: CH_4
- **Initial conditions**
  - Wall temperature: 180 K
  - Supply tank pressure: 400 kPa
- **Boundary conditions**
  - Average mass flow rate: 7 g/s (by using valve coefficient C_v in analysis)
  - Liquid temperature: 155 K





0. Pressurization due to flash evaporation

1. Pressurization due to the tank cool down

2. Pressure decrease due to condensation

- **Discussions**
  - The numerical model quite well predicts the real situation; especially for the pressure tendency, the process time and the liquid level.
  - Compensation of liquid level by using mass balance correlation due to uncertainty of the level meter.

Objectives

- **Conclusions**
  - The first numerical model of NVF with considering the flash evaporation process is constructed.
  - More accurate heat transfer correlations are needed.