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THERMAL SYSTEM DESIGN FOR A LARGE SPACE SIMULATOR(Φ8 m $\times$ L10 m)

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ABSTRACT

According to the National Space Program of Korea, KARI (Korea Aerospace Research Institute) has been developing a large space simulator (working dimension; Φ8 m $\times$ L10 m) to verify the performance of future large satellites under the space environment conditions. Especially, a very low temperature condition of space will be simulated by shrouds covering the inside surface of the vessel. The surface of shrouds will be cooled down to 77K by liquid nitrogen (LN2) from ambient temperature and hence, an optimal LN2 circulation system design is necessary to remove gaseous nitrogen (GN2) sufficiently and maintain the shrouds at the LN2 temperature.

Keywords: space simulator, thermal vacuum chamber, shroud, phase separator

1. INTRODUCTION

According to the National Space Program of Korea, 7 multi-purpose Satellites (KOMPSAT), 4 Geo-stationary Orbit Satellites (COMS) will be launched to observe the earth, ocean, environment and weather, and to offer stable services of communication & broadcasting until 2015 (Larson & Wertz 1992). Due to the large size of future Satellites, KARI (Korea Aerospace Research Institute) decided to equip a large thermal vacuum chamber (working dimension; Φ8 m $\times$ L10 m), which simulates the orbit environment in space.

The space environment can be characterized as very harsh conditions; ultra-high vacuum and extremely cold (-270°C) or hot temperature conditions depending on whether a satellite is exposed to solar beam or not. Once the spacecraft is launched and enters its orbit, the satellite is exposed to this space environment. The continuous exposure to such space environment could cause malfunction of major parts of the spacecraft, which could lead to the failure of the entire mission. Due to the fact that space environment is completely different from that of the ground, the satellite that functioned normally on the ground could show some unexpected malfunction in space environment. For this reason, the performance of the spacecraft must be confirmed under the simulated conditions of the space environment.

Basically, the large thermal vacuum chamber consists of a vacuum vessel and thermal shrouds simulating ultra-high vacuum ($< 10^{-5}$ torr) and extremely cold temperature (< -180°C), respectively. The surface of shrouds will be cooled down to 77K by liquid nitrogen (LN2) from ambient

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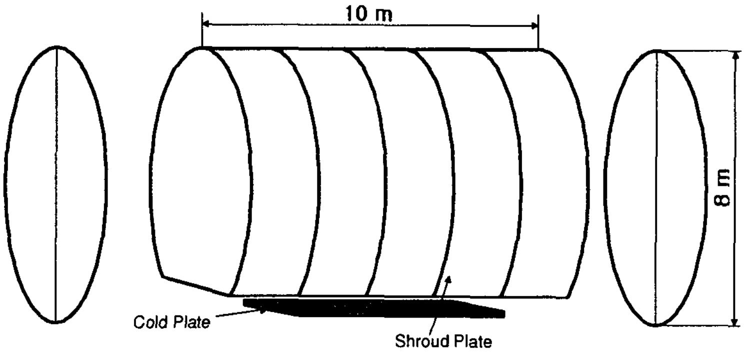

Figure 1. Thermal shrouds description.

Table 1. The size of LN2 or GN2 pipes.

Locations of LN2 or GN2 Pipes	Inner Dia.(mm)
Shroud Inlet	25.4
Shroud Outlet	50.8
Exhaust Header Pipe inside Chamber	152.4
Exhaust Header Pipe outside Chamber	203.2
Exhaust Header Pipe inside Chamber from Door Shroud	101.6
Exhaust Pipe from Phase Separator	304.8

temperature and hence, an optimal LN2 circulation system design is necessary to remove gaseous nitrogen (GN2) sufficiently and maintain the shrouds at the LN2 temperature. Also, an optical payload like space telescope will be thermally tested inside the chamber. Additional dedicated shrouds with specific thermal generators will be used to realize the local thermal cycling of the optical specimen.

2. THERMAL SHROUDS

A very low temperature condition of space will be simulated by shrouds (Figure 1) covering the inside surface of the vessel. The surface of shrouds will be cooled down to 77K by LN2 and hence, made of stainless steel (SUS 304L) to stand such cryogenic temperatures. The internal face of the shrouds in view of the specimen will be black-painted to have the highest emissivity possible, but the external emissivity of the shrouds will be lower than 0.2.

The shrouds are divided into sixteen areas; eleven for the cylindrical part, two for fixed permanent convex end, two for the door, one for cold plate.

3. LN2 CIRCULATION SYSTEM

Initially, the shrouds with ambient temperature will be cooled by LN2, which is available directly from outside tank at 3 bars. To chill down around 12tons of shrouds from ambient to cryogenic temperature, 8,486 liters of LN2 would be consumed and result in the production of 5,482,000 liters

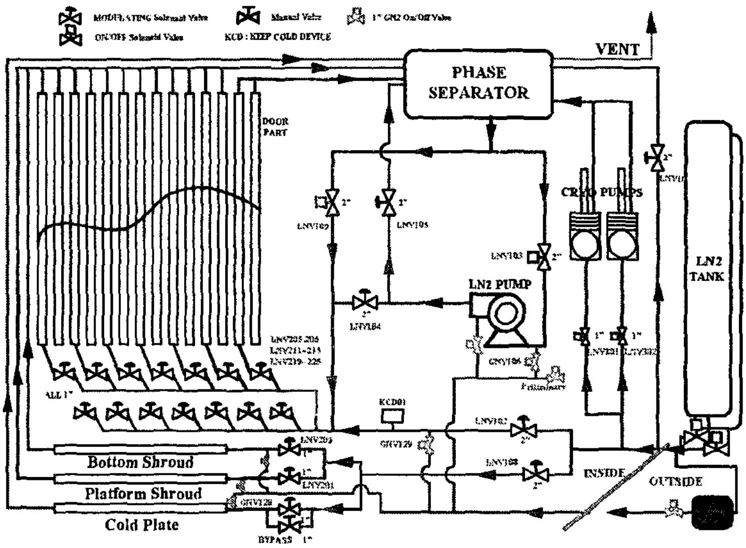

Figure 2. LN2 circulation system.

of gaseous nitrogen (GN2). Accordingly, an optimal LN2 circulation system was designed to remove GN2 sufficiently and maintain the shrouds at the LN2 temperature. Table 1 shows the optimal size of LN2 or GN2 pipes.

The nitrogen from shroud area flows into the phase separator, in which GN2 streams out to the exterior and surplus LN2 is preserved. In this case, it will take much time and LN2 for the shroud temperature to reach a certain value. Once, the shrouds are maintained at cryogenic temperature, LN2 is not supplied directly from outside tank but LN2 pump.

LN2 from the outside tank is supplied to the phase separator at which the pressure is maintained around 1 bar. The inlet and outlet of the LN2 pump are opened to prepare the pump. When the pump and lines become cold enough, the pump is started and LN2 is circulated. The pump speed is proportionally changed according to the LN2 level of the phase separator, but homogeneous temperature distribution of shroud area and low consumption of LN2 can be expected at the steady state. Figure 2 shows the schematics of LN2 circulation system.

4. CONCLUSIONS

Cryogenic shrouds and LN2 circulation systems for the large thermal vacuum chamber with working dimensions of $\Phi 8$ m × L10 m were discussed. Deep space simulation shrouds covering the whole inside surface of the vessel are cooled down to 77K by liquid nitrogen (LN2), which is supplied by open loop control from outside tank in the beginning, but close loop control using LN2 pump at the steady state to secure a homogeneous temperature distribution of shrouds.

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