Cold & black environment design in large space simulator

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Background

To verify the thermal design of spacecraft and the performance of thermal control system in-orbit, ground test must be fully conducted during the manufacture of spacecraft, which is accomplished in space environment simulator. The function of space environment simulator is to provide vacuum, cold &black, and infrared environment.

Objectives

- The effective test space: ϕ8500mm×9000mm.
- shroud surface temperature is below 100K, heat load :100Kw.

Conclusion

- The effective test space: ϕ8500mm×9000mm..
- Average temperature of shroud is 90K and temperature uniformity is ±3K with heat load.
- It takes 6 hours to warm up shroud from -120℃ to 30℃.
- Inside surface of shroud facing test specimen is coated with black paint, absorbtivity to sunshine $\alpha_S \geq 0.95$, hemisphere emissivity $\varepsilon_H \geq 0.90$； .

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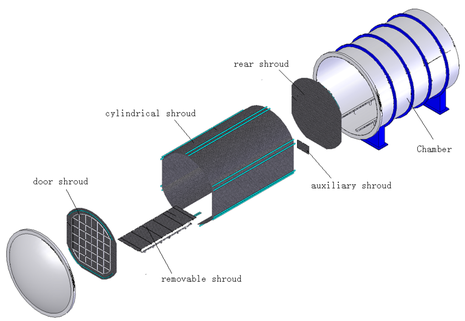
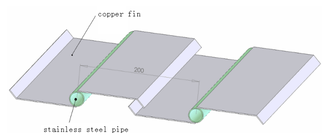
Methods

To realize cold & black environment, it depends on shroud and nitrogen system which provide with sub-cooled liquid nitrogen for shroud. The inside surface of shroud is coated with black paint with high emissivity to simulate black environment. During thermal test, liquid nitrogen in single phase flows through shroud by convection. Since shroud is installed in the vacuum chamber of which vacuum degree is lower than 1.3×10^{-3}Pa, dominant heat exchange between shroud and test specimen is radiation..

shroud

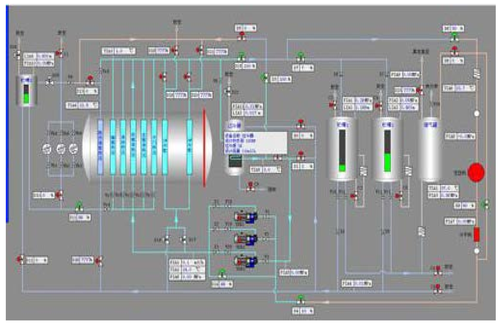


Shroud is divided into 5 parts, which create enclosed space.

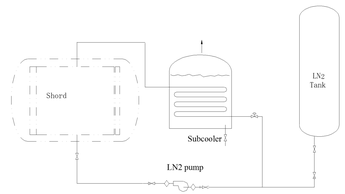


Shroud chooses the structure of stainless steel pipe welded with copper fin .

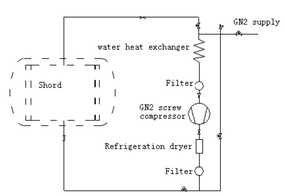
Nitrogen system



Nitrogen system consists of liquid nitrogen system, gaseous nitrogen system, liquid nitrogen storage system.



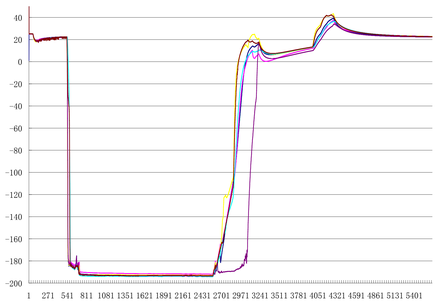
Schematic of LN2 subsystem



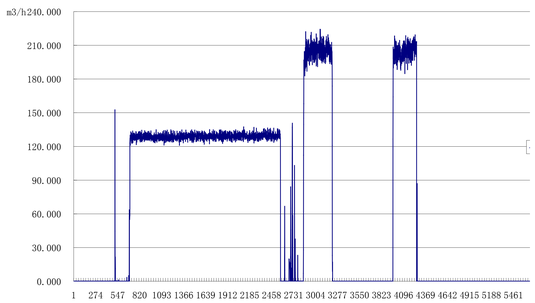
Working principle of GN2 subsystem

Test verification

Test verification



Graph of Shroud temperature.



Graph of Nitrogen flux

After installation completion of space simulator, commissioning test was conducted with the start of chamber, vacuum pump system, measurement and control system, shroud, and nitrogen system. Before start the thermal cycling, vacuum degree maintains at 10^{-4}Pa and shroud temperature keeps 90K±3K all the time. The average flux of liquid nitrogen is 127 m^3/h.

Photos

Photos after facility completion are shown

GN2 subsystem

Test chamber

pipeline

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