Mechanical behavior of balloon's enveloppe materials in stratospheric environment

Laure Gevaux*†[1], Hugo Le Meitour[1], Anne-Sophie Lectez[1], Stéphanie Venel[1], Erwan Quevarec[1], David Lévêque[2], and Simon Lewandowski[2]

[1]Centre National d'Études Spatiales [Toulouse] – French Aerospace Agency, 18 avenue Edouard Belin F31401 Toulouse Cedex 9 (France) – France

[2]ONERA / DPHY, Université de Toulouse [Toulouse] – PRES Université de Toulouse, ONERA – France

Abstract

The CNES's balloon department gathers around sixty people specialized in balloon design, gondola architecture, flight chain assembly, integration & testing, flight physics and ground & flight operations.
The CNES currently uses 3 types of stratospheric balloons for scientific missions: ZPB (Zero Pressure Balloon), SPB (SuperPressure Balloon) and SSB (Steerable Stratospheric Balloon). The enveloppe materials are usually made of thin polymer films which are chosen according to the balloons missions constraints (16 to 40 km altitude, overpressure from 0 to 25 hPa, temparatures from –110 to +30∘C). The materials technical requirements are mostly low mass, thermo-mechanical resistance, creep resistance, UV/ozone ageing resistance and gas tightness.

Common balloon issues are caused by the polymer films as it may show low mechanical properties and/or undesirable fracture profiles (premature failure, delamination, cold brittleness) during the stratosphere mission.

SPB film envelope are made of different polymer films such as polyester and polyamide films which are assembled with polyester adhesive tapes. Although combining different polymer films is useful to achieve better mechanical, thermal and tightness envelope properties, it can lead to a very complex material showing negative synergies within its layers.

1D tensile test at low temperature is usually a good and easy way to characterize envelope films but may not be enough to fully understand the envelope behavior on the balloon structure. This is why a bulge test with stereo digital image correlation (DIC) is necessary to help better simulate the balloons mechanical stresses.

Effect of simulated stratospheric aging on the material will also be discussed to show the impact of UV aging on the envelope material and thus on the mission duration.
Compromise to find the best suitable material is an ongoing work and already new solutions are being investigated to minimize risks of envelope failures (new adhesive tape natures, new assembly geometries).

*Speaker

†Corresponding author: laure.gevaux@cnes.fr

Keywords: balloon, stratospheric environment, UV aging, mechanical stresses, enveloppe failures