THEORETICAL QUESTIONS OF THE APPLICATION OF THE LIGHT AND LONG LIFE GAS BALLOONS IN MARTIAN AND PLANETARY ATMOSPHERES.

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Summary: According to our theory diffusion of gas from gas balloons can be prevented by active separation of gases in the multiple layer spaces of balloon envelopes of several layers. Balloons created this way are of long life allowing their application for research or storage gases in Martian or in other atmospheric planetary environment. Martian space programs give actuality of the atmospheric balloon technology and research [1,2].

The main questions of the application of gas balloons:

- Sealing (and insulating in respect of molecular gas transport) ability of the envelope material of the balloon against gas diffusion, which consists of two elements:
- Partial diffusion resulting from the difference of the gas composition of the outer-inner space
- Mechanical diffusion resulting from the difference of inner-outer pressure
- Composition and characteristics of the surrounding environment (atmosphere)
- Temperature, fluctuations
- Radiation properties, UV radiation
- Gravitation factor
- Mechanical, stability issues
- Flexibility, resilience
- Light envelope material of good gas sealing capacity

Issues regarding gas sealing capacity and gas diffusion of the envelope material: Gases can easily be absorbed into and through the material of the gas separating envelope of the balloon from both directions. The rate of penetration depends on the material of the envelope. The gas permeability is interpreted on the basis of the liquid model by Graham resulting from Fick law.

Mechanical diffusion: It is a gas penetration due to the difference of the pressure of outer-inner spaces. It depends on the material characteristics of the separating envelope, the rate of pressure difference, gas concentration and temperature.

Partial diffusion: Partial diffusion results from the difference of composition of the outer-inner gases separated from each other. The rate of partial diffusion depends on the solubility of the gases in the envelope, but it does not depend on the pressure difference of gases, even in given case it works in opposite direction with the mechanical pressure gradient.

Summary of the effects of mechanical and partial diffusion:

The partial diffusion primarily depends on the solubility and practically it is independent from the pressure difference. The mechanical diffusion mainly depends on the direction and rate of pressure gradient. In our case the inner pressure is bigger than the outer one, therfore their effects are added and gas outflow can be even significantly bigger than the partial diffusion gas penetration.

The total weight of the envelope can be decreased by the appropriate choice of the material properties, but the diffusion can not be decreased below a given limit in connection with the properties of envelope materials.

In case of conventional gas space isolation, which can be called passive as well, gas sealing is only based on the presence of the isolation membrane as well as material properties deteriorating as time goes by. Every gas balloon with passive envelope is continuously losing lifting gas and parallel lifting power. At the same time, this gas balloon is gradually being filled with the surrounding gas and it becomes heavy as well (Fig. 1.).

Additional general issues of gas balloons:

Filling gas: The filling gas applied is generally hydrogen and helium. The thermal capacity and diffusibility of both filling gases is big, so radiation increases the temperature of the filling gas, resulting in the increase of temperature or pressure of the filling gas. The risk of increase of diffusion as well as breaking of the envelope increase accordingly.

Envelope: Passive envelope of one or more layers (composite), loses its sealing ability in proportion with the deterioration of the envelope. Envelope diffusion is not manageable, it can not be put under control.

Martian parameters to be taken into consideration when designing gas balloons

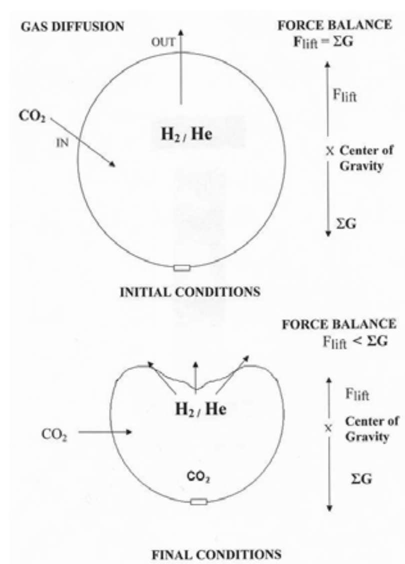

Fig. 1 Passive balloon envelope in the Martian atmosphere

The main characteristics of the Martial atmosphere (gas composition, pressure, density, temperature and its changes, static charge, dust of micro particle size, UV radiation flux, physical loads) are different to that of the Earth. Surface gravity on Mars is 3.74 m/sec^2. Due to the self weight of the balloon, due to the self weight of the filling gas, useful load, mooring rope – mass/length, stability, self-load bearing ability of balloons on Mars is smaller than in Earth

It is possible to optimize, (respectively manage) the mechanical, thermal, radiation, UV resistance parameters of the material of the envelope if appropriate materials are chosen for envelopes. Recently, in case of the light balloon structures gas diffusion can not be managed by choosing the proper materials, if the problem of the diffusion is not solved. Most of the above issues can be sorted out by the solution suggested by us: Multiple layer *nil-diffusion* balloon envelope with active isolation.

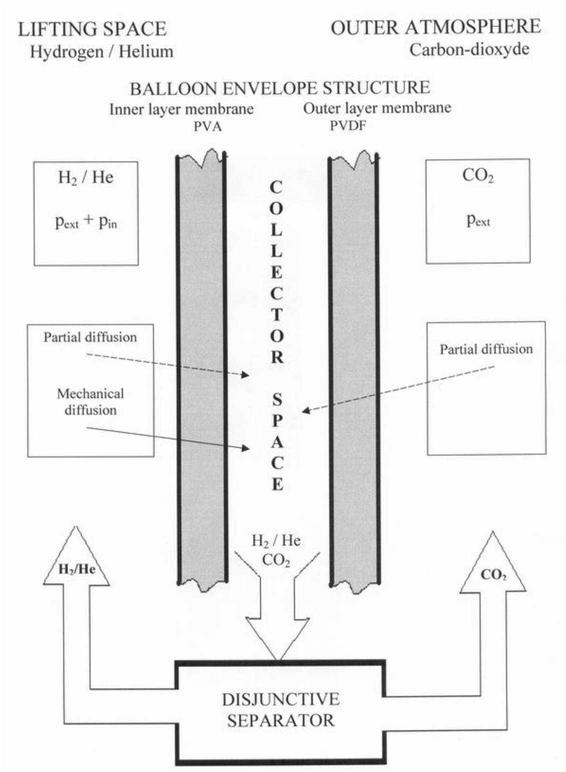

Fig. 2. Multiple layer balloon envelope with active gas isolation for the Martian atmosphere

The balloon envelope at least consists of the following material layers: The inner layer membrane closing the lifting/inner space e.g a PVA polymer film; Separating space – collector space joining to the active isolation; The outer membrane bordering the surrounding / outer space e.g. PVDF polymer film. The active isolation collector space of perm selectivity, which can be directed is according to the know-how relating to WO 2005/090154 A1 PCT description.

The process of the the envelope managing method: The filling gas of the inner lifting space, - characteristically hydrogen and/or helium, - absorbs into the closing membrane. Then, due to the inner bigger pressure + partial diffusion effect, the filling gas diffuses towards the outer environment. Meanwhile it penetrates into the active isolation intelligent membrane collector layer, the filling gas does not escape but from this collector space, by a properly guided separating process it is removed and sent back to the lifting space by the „disjunctive separator" unit (Fig. 2.). This way the lifting power of the active isolation balloon does not decrease, because the lifting gas can not diffuse to the outer surface of the protecting membrane, where otherwise it would be lost in the surrounding air during evaporation, but it is continuously guided back to the lifting space.

Possible realizations of gas balloons under Martian conditions: The envelope structure: minimum two-layer, with one separating space, preferably three-layer, with two separating spaces The number of layers applied is related to the total mass of the envelope, because the mass of the layers alone (in itself) increases the total mass of the envelope. However, the material of the certain single envelope layers (the inner membrane and the outer membrane layers) can be of smaller mass, because their specific functions (UV resistance, increased gas-stopping ability) can occur separately from each other, they do not have to appear in a single envelope layer.

The way of separation from the interval gas compound:

After liquification the hydrogen or helium gas left is sent back to the lifting space. CO_2 gets back to the atmosphere in liquid or solid state. Separation of hydrogen – glowing palladium membrane: hydrogen penetrates, CO_2 remains.

Advantages: With the application of our process and envelope structure the life expectancy of balloons is multiplied compared to those with passive envelopes.

Multiple aims can be achieved by the envelope structure and relating active gas treating processes suggested by us.

- Envelope diffusion can be managed, minimized, in given case eliminated.
- Lifting capacity of balloon can be maintained on the long run – it can be retained
- Protection of the inner, actual lifting gas space can be increased by the multiple envelope (against outer UV and other radiations).
- Mechanical protection of the inner gas space is ensured to a greater extent (in case of a possible damage of the outer envelope the inner envelope can still provide the necessary protection).

Perspectives: Active separation (and guiding back gases to their source spaces) ensure lifting capacity of the balloon on the long term. In case of a balloon intended for storing, the purity of the gas stored can be granted. This gives a possibility for storing oxygen in big volume for a manned Mars mission. If water is found on Mars, it can be used (with electrolysis in a simple way) for gaining oxygen for ensuring conditions for human existence as well as for gaining hydrogen to fill and operate observation balloon sondas as lifting gas.

References: [1] Kerzhanovich, V.V. et al. (2004): Break through in Mars balloon technology. *Advances in Space Research,* **33**, no. 10, p. 1836-1841. Mahaffy, P.R. et al. (2003): Astrobiology Exploration Strategies for the Mars Polar Regions Using Balloon Platforms. Third Internat. Conf. on Mars Polar Sci. Exploration. #8038.