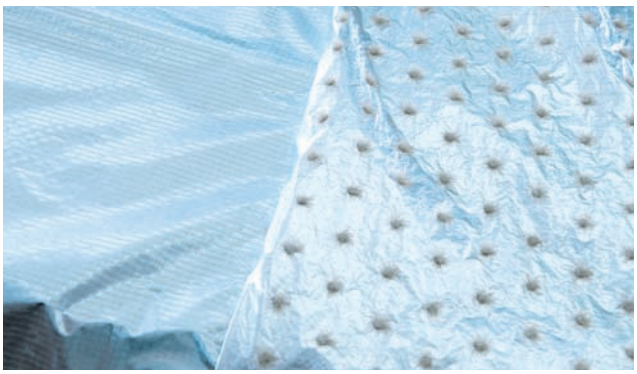
Insulated hot-air balloon

FESTO

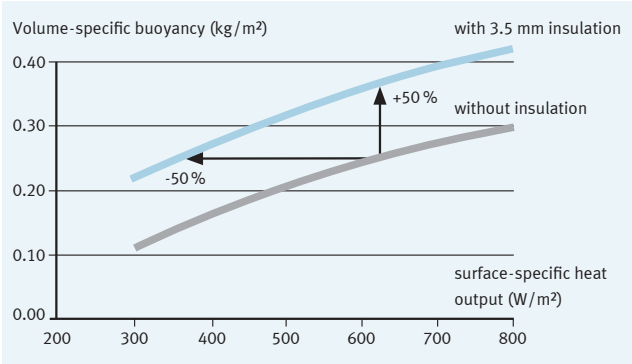
A hot-air balloon with fuel consumption reduced by half

Info

Innovative insulation sets standards in energy efficiency for balloons



Flock insulator



Results of measurements on the model balloon (volume: 30 m³)

Conveying five persons in a hot-air balloon for one hour consumes around the same amount of fuel as an economical passenger car during a drive from Berlin to Barcelona. Thanks to an innovative ultra-light membrane flock insulating material, the fuel consumption of a balloon can be reduced by more than 50 %, or its carrying capacity can be correspondingly increased for the same consumption rate. Insulated hot-air balloon, which was manufactured for Festo, is the world's first balloon to include this new insulating material, which allows the number of fuel cylinders to be reduced and additional passengers to be transported. At the same time, the thermal load on the balloon material is reduced and its service life thereby extended.

In the development project HeiDAS (hot-steam aerostat) by Festo, steam was used instead of hot air to fill the balloon. Steam has twice the load-bearing capacity of air; however, it necessitates insulation to prevent condensation from forming on the interior of the balloon envelope. For this purpose, flock insulation is bonded to a light but sensitive carrier foil that was first produced on commission from Festo in 2003.

The membrane flock insulating material was further developed and applied to the insulated steam balloon. A new ultra-light metallised base fabric transforms the foil into an insulating material suitable for everyday use in balloons. The innovative membrane flock insulating material provides the layer of air required for insulation by means of vertically oriented raised fibres on the base membrane. This membrane with its spacing elements is known as the spacing layer. The gap is closed by a covering layer. The insulting effect is determined by the width of this space, the flock pattern and the surface characteristics of the spacing and covering layers. The outer layer of the balloon envelope itself provides the insulation.

The membrane flock insulating material is extremely light, highly reflective, mildly heat-reflective, temperature-resistant, compressible, readily adaptable to individual requirements and easily optimised by means of adjusting the spacing gap and the number of layers. High compressibility is a fundamental requirement, since balloons are packed and transported after a flight.

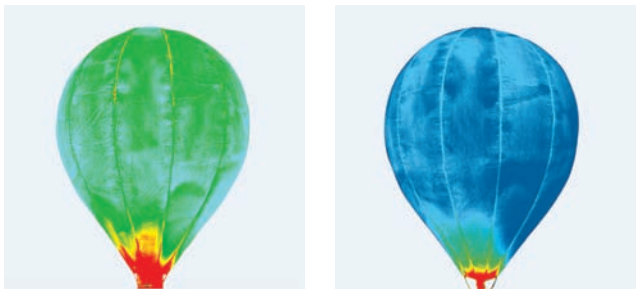
Simulations and measurements carried out with test balloons have provided for initial insulation optimization and savings estimates. Subsequent measurements on the test balloons have confirmed that fuel consumption is reduced by half for a given buoyant force, or carrying capacity is considerably increased for a given quantity of fuel.

Insulated hot-air balloon in the air

The lightweight insulation is situated on the interior of the envelope, where it is protected against the adverse effects of everyday handling; this insulation in turn protects the load-bearing envelope against the effects of high temperatures. Higher temperatures than usual are encountered on the inner surface of the insulating material, while the cooler exterior of the envelope hardly radiates any heat.

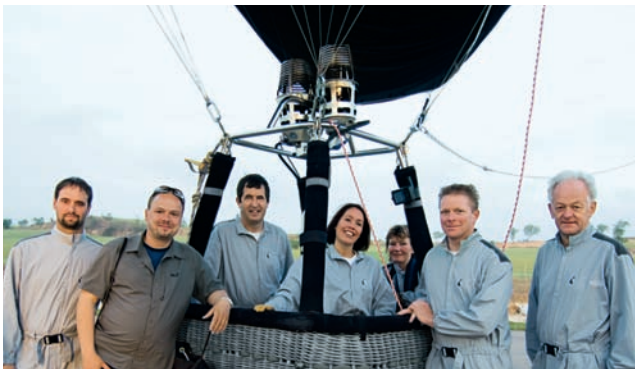
To test this technology in practice, the engineers from UltraMagic and the Technical University of Berlin undertook trials using a first manned and insulated test balloon with a volume of 1.600 m^3, under various conditions for a period of six months. This prototype completed about 100 hours of operation, during which it attained consumption savings of more than 70 % and confirmed the material's durability.

With increasing size, the ratio of a balloon's surface area to its volume decreases. At the same time, the internal pressure on the insulating material increases and reduces the insulating gap between the envelope layers. These effects could impair the function of the insulation. To demonstrate the effectiveness of the aerofabríx® insulation in the new Festo insulated hot-air balloon, a special race was staged: fuel consumption was measured in a direct comparison with an uninsulated balloon of the same volume and with the same load. After 40 minutes of operation, the conventional balloon had used 37.2 kg of propane – the contents of several tank cylinders. The insulated hot-air balloon, by contrast, had consumed less than 11 kg – in other words 30 % of the fuel required by the conventional balloon; this represents a drastic improvement in energy efficiency.



Thermographic images without insulation (left, approx. 55° C) and with insulation (right, approx. 40° C) of model balloons with 30 m^3 volume and identical load-bearing capacity

The insulated hot-air balloon shows what innovations are possible in lighter-than-air aviation. Festo manufactures energy-efficient products and advises its customers as to how energy can be put to even more efficient use in automation. With the insulated hot-air balloon insulated balloon envelope, it will be possible to make balloon travel 50 % more efficient in future.



Technical data

Balloontype:	M-105
Volume:	3000 m^3
Envelope weight:	158 kg
Passengers:	4–5
Fabric insulation:	aerofabrix® [Iso] 45|4.5
Thickness:	6 mm
Specific weight:	45 g/m^2
Thermal conductivity:	0,0265 W/mK
U value (6 mm):	4,5 W/m^2K
Max. operating temperature:	140° C

Brand designation:
aerofabrix® is a brand of Dr.-Ing. Alexander Bormann, Berlin, Germany

Project partners

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