German
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Cooling effects for high temperatures

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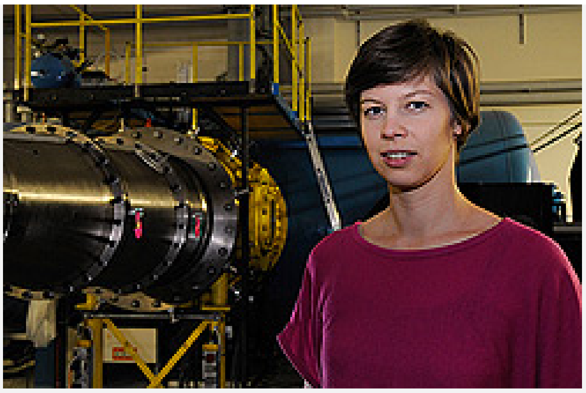
In early 2011, the Australian testing ground at Woomera will become the most exciting place on Earth for Hannah Böhrk. Woomera is the launch site chosen for the SHEFEX II spacecraft which, when it re-enters Earth's atmosphere, will be cooled by means of a system that was conceived and designed for SHEFEX by Dr Böhrk, who works at the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR), in the Institute of Structures and Design. In this interview, she explains how the cooling system for this spacecraft was created.

Question: This cooling system is to be tested on SHEFEX II. How does it actually work?



Hannah Böhrk

Hannah Böhrk: At the point where the cooled section of the heat shield is located, this spacecraft has a porous structure. This shield is of course able, in its own right, to withstand defined thermal loads. Nonetheless, if this material is also permeated by a flow of gas, that gas is then able, as it flows through the pores of the material, to perform a heat exchange function – in other words, the material dissipates heat into the flow of gas. Furthermore, as the gas emerges, it is directed backwards by the velocity of the spacecraft where it creates a film. This film protects the surface from the heat of the air flowing past it. This creates a two-fold cooling effect.

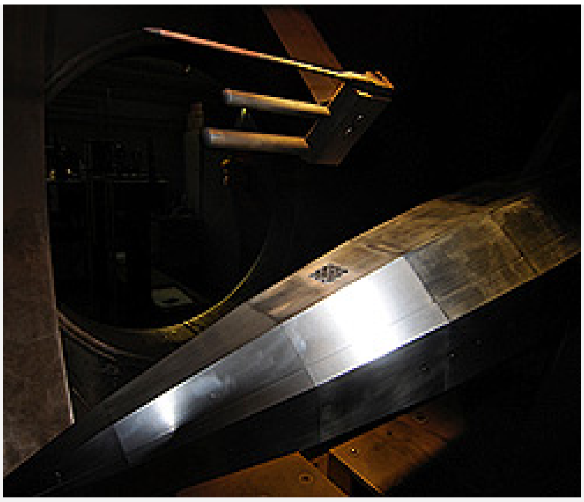
Question: Will this be the first instance of this cooling system being used?

Hannah Böhrk: Theoretically and in ground tests, the principle has been under examination for some time – for example, for the cooling of rocket engine combustion chambers. However, in a flight experiment on board a re-entrant spacecraft during an actual re-entry – that’s certainly going to be a first.

Question: SHEFEX I launched five years ago. How was the projectile cooled back then?

Hannah Böhrk: SHEFEX I also had a ceramic heat shield, but there was no flow of gas through it. The heat shield was radiation-cooled, by which I mean that it was black, giving it a high emissivity level that enabled it to radiate the heat away.

Question: Why then is there a need to develop new cooling methods?



Model of the SHEFEX II flight experiment

Hannah Böhrk: Active cooling is also being devised for other requirements. Of course, the thermal loading depends on the velocity at which you enter the atmosphere. That velocity is in turn dependent on the altitude from which you are returning. A spacecraft like SHEFEX II is being sent up to an altitude of 200 kilometres and is therefore much slower when it re-enters the Earth’s atmosphere than for example a spacecraft returning from the Moon. However, if you are engaged in extremely hot re-entries of this kind, it is entirely feasible to enter temperature ranges with which a radiation-cooled heat shield would simply be unable to cope. In such cases, an active cooling system of this kind may be better able to cool the material, keeping it within an acceptable operational envelope.

Question: What temperatures are encountered by SHEFEX II when it re-enters Earth's atmosphere?

Hannah Böhrk: Well over 1000 degrees Celsius. Mind you, at the hot spots, for example the nose section, that will certainly be more like 1400 degrees C.

Question: What is the objective of your research? Will there come a day when spacecraft are equipped entirely with these porous heat-resistant tiles?

Hannah Böhrk: No, because not all tiles are subjected to the same thermal load. The greatest loading is at the front, that is, on the nosecone. On winged aircraft, extreme temperatures also arise along the leading edges of the wings. Those are the areas where active cooling would be appropriate.

Question: We are already familiar with heat-resistant tiles on the space shuttles – how do the tiles being tested on SHEFEX II differ from these?

Hannah Böhrk: Firstly, SHEFEX has an active cooling system. Secondly, our material is a fibre-reinforced ceramic – we take carbon fibres and embed these in a ceramic matrix. These fibres are highly resistant to damage – they are effectively 'crack stoppers'. If you were to drive a nail into one of these tiles, it would not shatter, because the fibres in the remaining part would continue to hold it together.

Question: What conclusions can you draw from the wind tunnel tests?

Hannah Böhrk: We are now learning how to interpret the data that will be recorded during the flight of SHEFEX II.

This interview was conducted by Manuela Braun.

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