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The EXTASE thermal probe: Laboratory investigation and modelling of thermal properties.

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Abstract

In recent years space missions including landing devices are getting more important. These missions allow in-situ measurements and lead therefore to information on the structure and behavior of extraterrestrial surface and subsurface layers.

Sensors used for this kind of missions have to be adapted to the non-terrestrial environment conditions. The better the properties of the single elements of each sensor are known, the more precise are the results from the data evaluation of in-situ measurements.

We present the results of thermal conductivity measurements and simulations done for the fiber compound tube used as structural element for the heating segments of the MUPUS-PEN and EXTASE – a spin-off project of *Rosetta*/MUPUS.

1. Introduction

The *Rosetta* mission, which includes an orbiter and a lander, is the first one that will perform a soft landing on a comet nucleus. The MUPUS-probe (MUlti-PUrpose-Sensor for surface and subsurface science [1]) is designed to make *in situ* measurements of the thermal and mechanical surface properties of comet 67P/Churyumov-Gerasimenko. The EXTASE probe has a similar technical design as MUPUS. Although, its functionality is restricted to thermal measurements, its single parts are built from the same materials and mechanically arranged in the same way.

At the German Aerospace Centre in Berlin and the Space Research Institute in Graz several measurements with the MUPUS ground reference model and EXTASE under various pressure conditions were done. One of theses test series includes the comparison of thermal property measurements of the fiber compound tube only and measurements using the same set-up done with the EXTASE probe. The measured values were compared with results obtained from modelling.

3. Measurements and modelling

For the MUPUS-PEN as well as for the EXTASE-probe the thermal sensors are fixed inside a hollow fibre compound tube. The mantle of the hollow tube is made of cyanato-ester with fibreglass. Since there are no data for the specific heat for this tube provided by the manufacturer and the thermal conductivity values differ from those found in the literature, the physical properties of the tube were measured to improve the input values for future models used for the interpretation of MUPUS and EXTASE measurement data .

To determine the thermal conductivity the temperature gradient along the tube was measured under different environment conditions:

- Measurement of the temperature gradient along the tube at atmospheric pressure;
- Measurements in vacuum including radiation shielding;
- Measurements in vacuum allowing for surface-to-ambient radiation;
- Measurement with the same set-up as for the test in vacuum without radiation shielding done with the EXTASE probe.

The temperature values obtained from these measurements are compared with the results of a 2D-axisymetric simulation done with COMSOL. As an example for the results obtained, Figure 1 shows the time dependent temperature profile at specific points at the tube in vacuum with surface-to-ambient radiation.

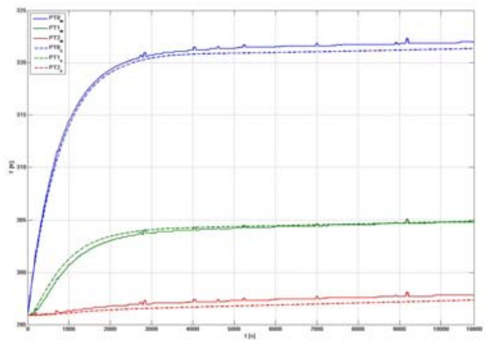

Figure 1: Comparison of the measured temperature of sensor PT0, PT1 and PT2 (solid line) and the results of the 2D-axisymmetric-simulation (dashed line) in case of surface-to-surface radiation.

A comparison of the measured and simulated gradient along the tube after a heating time of 3 h is shown in Figure 2.

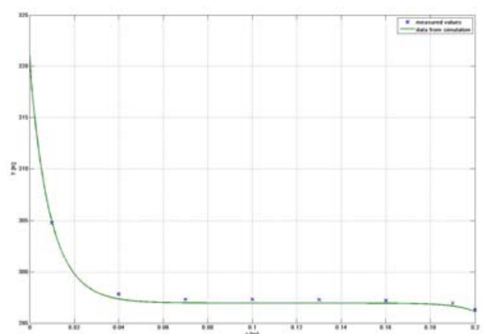

Figure 2: Temperature gradient along the tube after 3 h of heating in case of surface-to-ambient radiation.

4. Summary

These measurements and simulations performed in Graz have lead to, as we think, reasonable results. The thermal conductivity value of the tube is comparable to that found in the literature. Furthermore, the results from the measurements and simulations allows to limit the range of possible specific heat and emissivity values for the tube. Due to the measurements done with the EXTASE probe, a first assessment of the influence of other structural materials like, glue and surface coating on the results of future in-situ measurements can be done.

References

[1] Spohn, T., Seiferlin, K., Hagermann, A., Knollenberg, J., Ball, A.J., Banaszkiewicz, M., Benkhoff, J., Gadomski, S., Grygorczuk, J., Hlond, M., Kargl, G., Kührt, E., Kömle, N., Marczewski, W., Zarnecki, J.C.: MUPUS – a Thermal and Mechanical Properties Probe for the Rosetta Lander Philae, *Space Science Reviews*, **128**, Issue 1-4, 339-362, 2007.