COMBINED SENSOR PACKAGE COMARS+ FOR MEASURING AEROTHERMAL AND RADIATION LOADS ON THE EXOMARS EDM CAPSULE BACK COVER

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The European Space Agency (ESA) is preparing the ExoMars EDM (Entry, Descent and Landing Demonstrator Module) for a flight in 2016. The design of the back cover TPS has been carried out with relatively high safety margins, since the prediction of the aerothermal and radiative loads using existing experimental and numerical tools still has large uncertainties. During entry into the Martian atmosphere the convective heating of the capsule base region is significantly lower than the front cover heating but has a transient behaviour. Therefore numerical simulation of the base region flow using CFD codes is challenging and expensive. Hypersonic wind tunnels allow measuring this transient process at flight relevant Mach and Reynolds numbers, but the specific enthalpy of the flow is significantly lower compared to the flight case. Short duration high enthalpy facilities like shock tunnels with testing times of a few milliseconds are not suitable to capture this time dependent phenomena. The second driving factor for the TPS design margins is the radiative heating created by the hot and excited carbon-dioxide molecules in the vehicle shoulder region behind the bow shock. For most of the critical trajectory points the predicted radiative heat flux is significantly higher than the convective heating. But both numerical and experimental tools have big shortcomings in simulating the correct radiation environment during Mars entry. Based on the former flight instrumentation experience combined aerothermal sensor package COMARS+ has been developed to perform radiative and convective heat flux measurements on the EDM back cover TPS during the flight in 2016. The combined sensors are able to measure static pressure, total heat flux and radiative heat flux. The electronic box is used for sensor signal conditioning and multiplexing for data acquisition by the EDM. For the pressure measurement a Pirani pressure sensor is used. The total heat flux is measured by a heat flux microsensor of the Vatell Company and the radiative heat flux at two different spectral bands is measured by two sensors from CNES called ICOTOM. The DLR radiometer measures the total (broadband) radiative heat flux.

Figure 1 shows measured total heat flux rates at two different flow conditions during calibration tests performed in the arc heated facility L2K. The flat plate test model with integrated sensors was placed outside the free jet and swept into the flow after achieving steady state flow conditions. The peaks at time points 172 s and 185 s are caused by heating due to the side shock of the free stream when the model is injected or removed from the flow. The constant heat flux rate between these transition points shows the quality of the flow and reliability of the sensor. The model is re-injected into the flow at time point 216 s after adjusting the flow parameters for the second test condition. Since the total heat flux is proportional to enthalpy and square root of stagnation pressure it decreases at low enthalpy flow conditions.

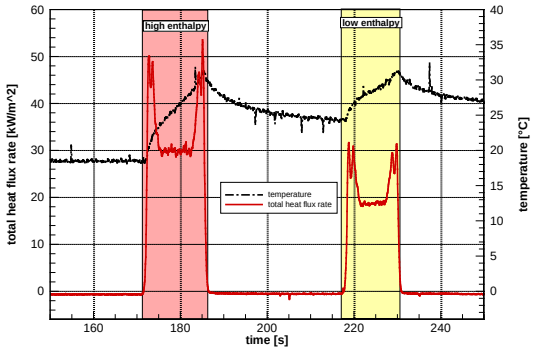

Figure 1: Measured total heat fluxes with a COMARS sensor integrated into a flat plate model at two different flow conditions

All components of the COMARS+ payload for the ExoMars mission in 2016 have been designed and characterized by means of numerical simulations. Aerothermal tests at two different flow conditions using Martian Atmosphere composition demonstrated the sensitivity of the COMARS sensor to different low level radiative and total heat fluxes. Complementary spectroscopic measurements show that the main contributor of the radiative heat loads in the Martian atmosphere is the CO2 molecule. The qualification campaign for the COMARS+ payload including vibration, shock, thermal-vacuum, EMC and bioburden reduction tests is completed. The delivery of the flight models will take place in August 2014.