N87-20331

RECENT RESULTS FROM MAUS PAYLOADS

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Abstract

Project MAUS is a part of the German material sciences program and provides autonomous payloads for the Space Shuttle. These payloads are housed in canisters which are identical with those of NASA's Get-Away-Special program. The main components of the hardware are: a standard system consisting of power supply, experiment control, data acquisition and the experiment modules containing experiment specific hardware. Up to now, three MAUS modules with experiments from the area of material sciences have been flown as GAS payloads. Results will be reported from GAS Payload Number G-27 and G-28 flown aboard STS-51G.

MAUS Standard System

A MAUS Payload consists of the experiment mounting structure (EMS), the batteries, the standard electronics for experiment control and data acquisition, the house-keeping systems, and the experiment hardware.

The experiment mounting structure is built on an adapter ring, 6 posts and 2 experiment platforms with brackets. Three different batteries are providing power for experiments and electronics. The total capacity of the experiment battery is 1.8 kWh. The data acquisition system consists of a microprocessor controlled multiplexer unit with digital and analog inputs. The data are stored via an intermediate memory on tape. The capacity is 10 Mbits. To allow long measurement phases a data reduction system is provided. A detailed description of the standard service system can be found in Ref. 1, a photo with integrated experiment G-27 is given in Fig. 1.

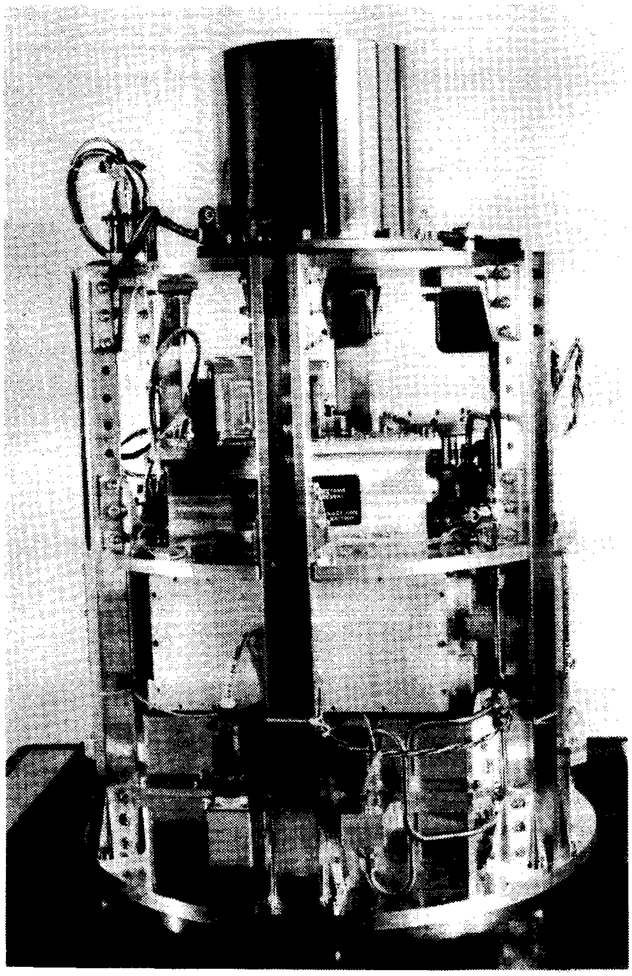

Fig. 1: MAUS standard service system with integrated experiment G-27 on top

Experiment Interface

For experiment accommodation in a MAUS module two platforms are available one of which is adjustable in height by 25 mm-steps. The maximum height for the experiments is 40 mm and the maximum mass about 20 kg. For integration of the experiment dedicated electronics six cards in the standard electronic boxes are available.

Experiments

It is a policy of the project to assign experiments to a MAUS mission rather late in order to maintain a high degree of flexibility. About one year is considered for development of experiment specific flight hardware by the experimenter. Preliminary flight assignments are made from a pool of experiments consisting of microgravity relevant proposals which fit into the limitations set by the MAUS project with regard to powerconsumption, volume, weight etc.. Two GAS Payloads (G-27 and G-28) were flown recently aboard STS-51G as shown in Fig. 2 and a short summary of the results will be given.

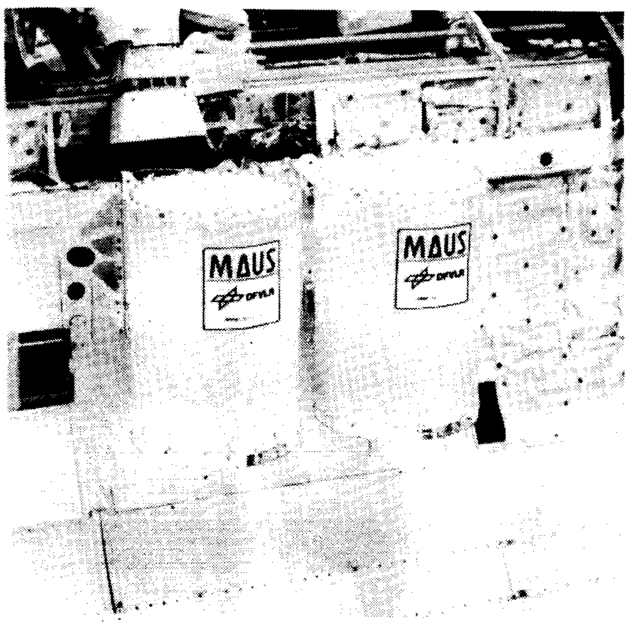

Fig. 2: GAS-payloads G-27 and G-28 in STS-51G cargo bay

"Fundamental Studies in the System Manganese-Bismuth"

Investigator: P. Pant, Krupp Research Institute, Essen

The main objective of this experiment is the synthesis of the intermetallic compound MnBi in an isothermal furnace. The compound forms by a peritectic reaction at 450 ^{o}C involving bismuth and solid manganese. This kind of reaction is diffusion controlled and requires a longer time for completion as if both components were in a liquid state. On Earth, such reactions are incomplete when both components exhibit different densities and become separated by sedimentation and buoyancy. The compound MnBi has promising applications as a magnet material because of its high theoretical coercitive strength which so far could not be achieved with ground based specimens.

First experiments on TEXUS (Technology Experiments and Reduced Gravity, a German program using sounding rockets) showed that during melting and solidification separation of the components did not occur and forces promoting segregation, e.g. tension gradients did not become effective. The MnBi-phase in the flight samples was found in form of micron-sized particles uniformly distributed. The small size is thought to be responsible for the good properties of the flight samples compared with the ground based samples.

During the course of this MAUS experiment six MnBi samples with a stoichiometric composition of 50 at % Mn and 50 at % Bi were processed in a four-chamber isothermal furnace. Sequentially, each furnace chamber containing two samples followed a preprogrammed temperature profile of heating and cooling which was exactly executed including the oscillations around the peritectic temperature. During the critical phase of processing the microgravity levels averaged $\pm$ 5 x 10^{-5} g as indicated by the house keeping sensor. The samples obtained do not show any voids or gas bubbles and were safely contained during all phases within the cartridges. There is no evidence of segregation of the components during processing in contrast to the 1-g reference specimens. The flight-samples were investigated by metallography, electron microprobe analysis, x-ray diffraction and magnetic measurements at room temperature and at 4 K. The lattice constants do not deviate from ground based data. However, the amount of MnBi compound formed in the flight samples increased from 18 to 46 %. MnBi regions with a linear extension of about 200 µm can be found at several locations in the sample as shown in the micrographs of Fig. 3. Here the ground based sample is compared with a representative area of the flight sample. Magnetic measurements reveal that the flight samples exhibit about 50 % of the theoretically predicted value of 75 emu/gram. The essential result of this experiment is that the yield of the peritectic reaction is improved during microgravity processing.

Fig. 3: Micrographs of Mn-Bi samples showing the distribution of Mn, Bi and the compound MnBi. Ground based sample left, flight sample right. MnBi compound is represented with grey color.

"Slip Casting Under Microgravity Conditions"

Investigator: Dr. K. Schweitzer, Motoren und Turbinen Union (MTU), München

The processes of slip casting employs a ceramic slurry to form complicated shapes of hollow bodies. On earth, this process is limited in applications because of gravitational influences on the dispersed particles in the slurry. Sedimentation can only be avioded by the use of materials with equal densities or by the utilization of stabilizing additives. However, the latter may be harmful to the desired properties of the slip cast product. Goal of this experiment is to demonstrate with model materials that slip casting is possible in microgravity even with unstabilized suspensions. Using mixtures of powders with different density, grain-size and concentration. For this reason ceramic and/or metal powders are homogenously mixed in solid paraffin by kneading. Rods of these solid slurries are pressed into cartridges against the ends of porous ceramic disks which are mounted in the lower halves of these cartridges.

During weightlessness thirteen samples of these solid slurries were melted by heating the upper part of the cartridges in a furnace. Then the slip casting process was started by additionally heating the lower part of the cartridge containing the suction bodies made of porous ceramic. These did slowly absorb paraffin but not the dispersed particles. The casting process was stopped by turning off the furnace and cooling the samples. Solidification of the paraffin did preserve the slip cast layers as well as the residual slurries for later examination on earth in respect to their structure and particle distribution.

Due to a temperature excess of the upper heater the programmed temperature profile could not be executed properly during the mission. To analyse the impact of this malfunction on the samples the complete furnace including specimens has been examined by means of computer tomography. The slip castings are still under investigation.

The authors would like to thank Dipl.-Ing. P. Pant, Dr. K. Schweitzer and the German Ministry for Research and Technology (BMFT) for providing the quick-look results.

Housekeeping Data

In addition to the experiment also housekeeping data are monitored and recorded during flight by the MAUS standard system, i.e. acceleration data, battery-voltage gas temperature, gas pressure in the MAUS canister as well as in the batteries. All values except acceleration are set to a certain limit. As an example the acceleration data for payload G-27 are reproduced in Fig. 4. It can be recognized that a high degree of g-jitter is present during the 9.3 hours of experiment operations.

Furthermore, housekeeping data can be correlated with the experiment specific data. In Figure 5 the temperature of the furnace is compared with the temperature in the canister. Heat dissipation from the experiment leads to a slow temperature increase of the standard system.

Up to now 10 MAUS payloads have been flown, three of them in the GAS program. The obtained housekeeping data (some of them are presented in Tab. 1) confirm that verification activities during payload preparation resulted in a predicted behaviour of the system. This shows that the MAUS standard system represents a mature technology capable to conduct a large variety of different experiments.

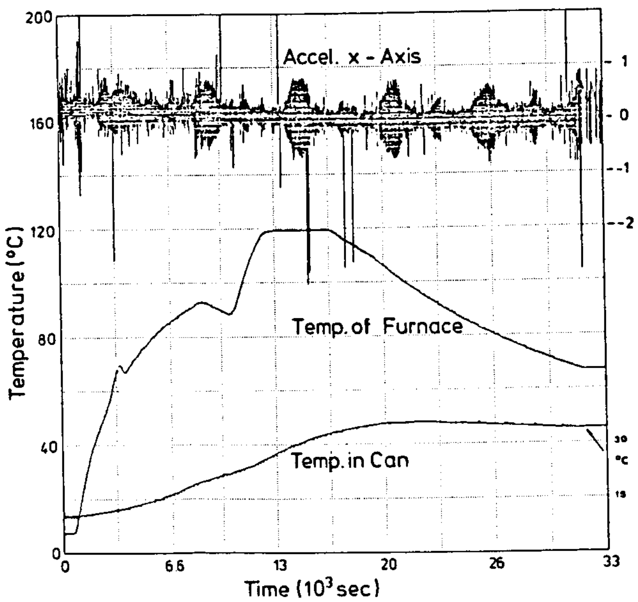

Fig. 5: Correlation of housekeeping data for experiment G-27

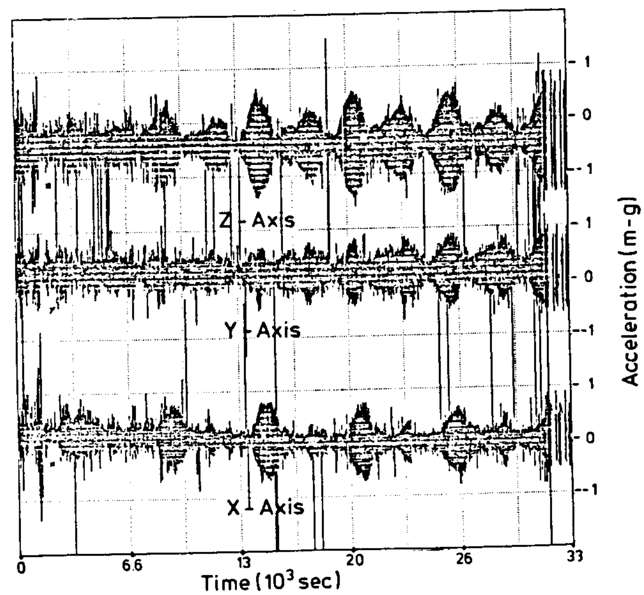

Fig. 4: Accelerations in x, y and z axis for experiment G-27

Housekeeping Data

Experiment	Temperature Exp. Start	Temperature Exp. End	Average Power	Experiment Duration
DG-205I	13.4 °C	22.1 °C	17 W	23.9 h
DG-205II	10.6 °C	23.4 °C	17 W	78.5 h
DG-206A	8.8 °C	12.0 °C	78 W	10.0 h
DG-306	12.8 °C	36.2 °C	125 W	5.6 h
DG-315	17.9 °C	49.3 °C	138 W	1.6 h
DG-318	17.4 °C	42.0 °C	275 W	2.8 h
DG-200	10.3 °C	34.3 °C	43 W	9.3 h
DG-206B	7.0 °C	43.5 °C	100 W	9.0 h

Gas temperature at a post close to position of experiment platform

Future Planning

The German MAUS-program will continue with flights of dual payloads using the remaining 22 GAS options. Launch Service Agreement with NASA have been signed. The MAUS standard system is also available by MBB/ERNO on a commercial basis.

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