MICROMO
MICRO MOTION SOLUTIONS

APPLICATION SPACE TECHNOLOGY

Flight into the Unknown

MINIATURE MOTORS JOURNEY WITH COMET SPACE PROBE THROUGH OUTER SPACE

Exotic operating conditions often reveal the true qualities of a product. On the other hand, niche applications frequently lead to interesting developments in commercial fields of industrial application. The combination between special requirements and general know-how for widespread application can also be found in the Rosetta comet mission. The probe will take 10 years to travel approximately 300 million miles through outer space to reach the Churyumov-Gerasimenko comet.

Standard miniature drives are being employed with only minor modifications in the anchor system to ensure the safe landing of the probe. As in more expensive space travel projects, maximum reliability of all installed components was also required here. Both motor and gearbox are subject to extremely tough environmental conditions and after years of traveling through space they have to function "at the push of a button". Standard drives fulfilling such space project requirements can carry out terrestrial functions in extreme areas of application such as, for example, in the high-vacuum environment of electron microscopes or in chip production without any problems.

FAULHABER GROUP
We create motion

During a comet mission with a planned landing the low gravity of the orb makes it hard to get a hold on the surface and to keep it there reliably during the entire duration of the mission. A solution had to be found for this problem on the Rosetta mission. Under the aegis of the DLR, the German Max Planck Institute for Extraterrestrial Physics (MPE) developed a special anchor system for the probe. A harpoon will be launched which penetrates the comet's surface and an EC miniature drive will then lash down the probe on the surface with a rope. Each kilogram of mass which needs to be launched into space requires energy, i.e. propellant, and therefore costs extra money. Therefore small, lightweight solutions are required. Engineers and technicians at the MPE are cooperating with the miniature drive specialists of FAULHABER to develop a drive solution. In this manner a solution for demanding drive functions was developed which is exotic yet easily transferrable to terrestrial fields of application.

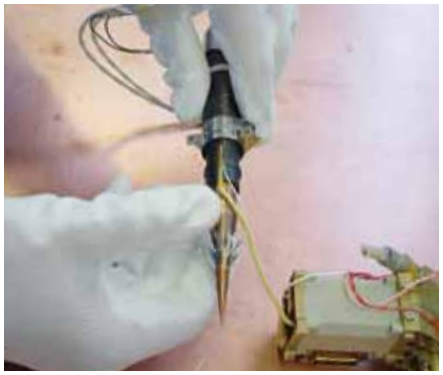
Outer space, the demanding "void"

All components of the probe are subject to considerable stress until its landing on the comet. In addition to the enormous vibration and acceleration forces at liftoff, the lowest temperatures and vacuum must be tolerated constantly for years without causing any damages. Immediately after the landing the harpoon head is launched by an explosive charge towards the surface of the comet and penetrates into it. Barbed hooks prevent the "plug" from breaking loose again. The harpoon trails a rope from a magazine. Following the shot the rope is wound up by miniature motor power onto a reel, anchoring the probe on the comet's surface in the process. Once the end of the rope is reached, the motor tightens a spiral spring on the reel shaft. The spring ensures that the anchor rope is slightly biased to cushion minor settling motions of the harpoon or the landing legs of the probe.

"Know how" saves huge costs

"In the past innovative drive systems would have probably been developed specifically for this kind of mission. Nowadays the cost factor is an essential element of all considerations, also in space", says Markus Thiel, Business Unit Manager Mechanics at the MPE. The probe developers were thus looking for off-the-shelf products which already conformed to most of the required technical specifications. In the extensive small motor range of the FAULHABER specialists they finally struck it rich. A standard drive solution consisting of motor and suitable gearbox fulfilled all mechanical requirements. The special conditions in space could be taken into account by some comparatively minor modifications at reasonable costs.

All mechanical motion generates friction which has to be reduced by lubricants. Grease or oil cannot be employed in outer space, they either solidify at the low temperatures or vaporize in the vacuum in outer space. Here solid lubricants are the remedy. But here also the devil is in the details. Graphite, for example, only lubricates properly if it is possible to take up gases like water vapor or nitrogen between the graphite layers. However, these gases are absent in the vacuum. Here the terrestrial lubricant graphite behaves rather like chalk. If you rely instead on molybdenum disulfide(MoS_2) with a layered structure like graphite, lubrication will also work in a vacuum, at the low temperatures in space and up to several hundred °C. The solid lubricant was applied on the surfaces of the special bearings to be lubricated and the standard cogs.



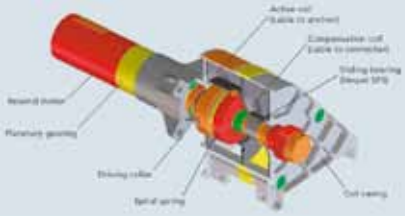
Harpoon unit for safe anchor fixture on the comet's surface

Low temperatures of less than –100 °C and different materials can promptly cause blockages of precisison components due to thermal expansion. For this reason the nickel-plated standard brass gearbox casing had to be replaced by a steel casing adapted to the thermal expansion of the steel cogs. Thanks to the accommodation of FAULHABER the required steel casings could be included in the standard production process. In this way their precisely fitting interchangeability was ensured. Due to the perfect fit of the individual transmission components the "reinforced" fit-for-space components could be reassembled easily. This is another property of standard components which saves both time and money.

A driving mechanism with attached transmission served as the original motor for this space tuning. Motor and transmission together only have a diameter of 16 mm with a length of 45 to 65 mm depending on the chosen gear reduction. With a motor output of 11 W a torque of 300 to 450 mNm can be provided at the output shaft in both directions of rotation. In addition, the low transmission clearance of less than 1° allows sensitive positioning.

Nowadays, state-of-the-art small drives can be utilized for a multitude of applications "off the rack" thanks to the latest construction techniques. Notwithstanding, they can often be used with slight modifications in more exotic applications. Customized drives to suit the special needs of customers fulfill even higher demands. The sooner the drive specialists' know-how is involved during the development, the better the implementation of the customers' specifications. Users can focus on their core competencies in this context. As a result, both time and money will be saved and the time to market is reduced.

Design configuration of the "harpoon anchor"



Rewind system with miniature motor and spiral spring as flexible energy storage

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