

## Torque enhancement of dry lubricated downsized Harmonic Drive® gears (HARMADES)

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Driven by advantages such as e.g. high stiffness, zero backlash and compactness Harmonic Drive® gears have become standard for various space applications and are used as reducers in space mechanisms like SADMs, robotic joints or FPM.

Today, the common approach is to apply liquid lubrication (grease or oil) to ensure proper function of the gear over the demanded lifetime. However, the use of liquid lubricants significantly limits the operational temperature of the gear. To overcome this drawback, the introduction of dry lubrication for Harmonic Drive® gears was subject of former development, which lead to design of specifically adapted gear components. Prototypes were successfully tested between 2011 and 2014 in the frame of the HarmLES – Project.

The current project HARMADES aims for further improvement of the state-of-the-art of dry lubricated strain wave gears. This shall be achieved by introduction of an additional heat treatment (nitriding) to enhance wear resistance of the gear teeth, which turned out to be the major challenge within the project. To additionally follow the increasing need for smaller gears with higher ratio, a prototype of a gear size 14 (pitch circle diameter 35.6mm), ratio 160 was designed.

The presentation will report on the achievements attained within the project. In the course of several iterations, the nitriding process could be more and more optimized for the use within Harmonic Drive® gears. Following basic running trials with different nitriding versions, finally a prototype of a dry lubricated, nitrided gear was manufactured. The gear was subjected to characterisation, thermal vacuum testing and visual inspection. Furthermore, especially the structure of the nitriding layer was metallographically analysed. Results of tests and analysis will be subject of the presentation.

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