Paraffin Wax Phase Change Actuators

Design Methods of Novel Phase Change Actuators as a Means of Process Control and Stabilization - Phase 1

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Abstract

The first project phase was completed with great success. A completely new, extremely robust actuator concept was developed based on a laser-welded housing consisting of two metal cups enclosing a paraffin wax core. Paraffin is characterized by its volume expansion of more than 20 % when heat is applied and its low compressibility. The resulting actuators with actuating forces of over 60 kN and strokes of up to 0.1 mm are particularly suitable for applications in the regulation of long-term control variables.

Project description

In Industry 4.0, controlled, automatable and robust manufacturing processes are necessary. In addition to stochastic, high-frequency influences, low-frequency system characteristics, e.g. thermal expansion or wear, must also be controlled. This requires high actuating forces with comparatively low actuating travel and reaction speeds. A non-manual industrial solution is still missing.

One solution can be the paraffin-based phase change material actuator in closed housing design. If paraffin is heated, the volume expansion is 20 % and more, and in combination with the very low compressibility, large potentials can be expected.

The objective of the completed project was to develop design methods for an actuator design and a combined forming and joining production. Subsequently, the qualification for the described applications as well as the development of a self-locking wedge gear will follow.

Results

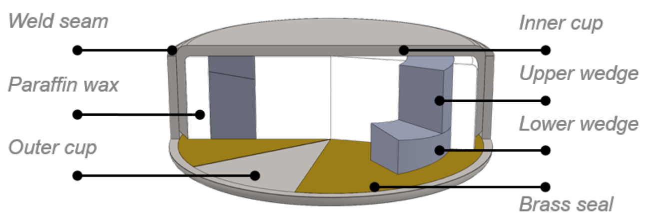
Overall, the project was completed with great success. First, paraffin wax was comprehensively analyzed and a precise simulation model was developed. This allowed an optimal housing design to be derived by means of wide-ranging parameter variations. Furthermore, influences of individual geometric adjustment screws on the actuator behavior were identified.

A production route has been successfully developed for the derived actuator geometry. Laser-cut blanks are first deep-drawn and turned to the required height. After the paraffin assembly and the gluing in of a brass seal, the joining by laser welding takes place. Phase change actuators manufactured in this way were able to achieve maximum forces of over F=60 kN and strokes of over w=0,1 mm with a high degree of reproducibility.

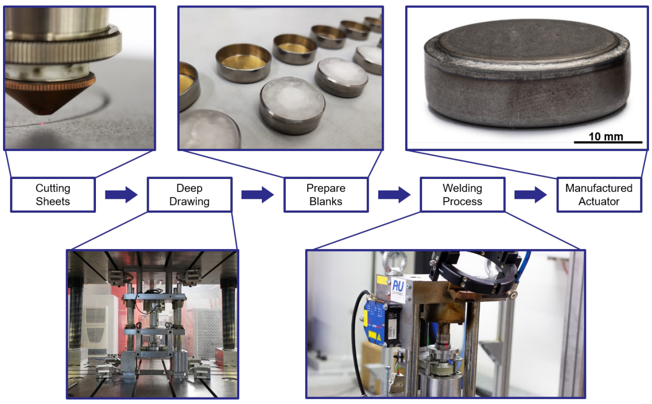
For energy-efficient operation, a self-locking wedge gear was designed, which enables continuous maintenance of the actuating force or stroke when the supply of activation energy is terminated.

Concluding the project, the applicability of phase change actuators could be demonstrated for the targeted influencing of test benches for the validation of machine elements, and additionally for the passive compensation of thermal fluctuations.

Besides a dissertation, three further publications in international journals (e.g. CIRP Annals) have been published in the project.



[1] Structure of the actuator concept



[2] Illustration of the manufacturing route

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