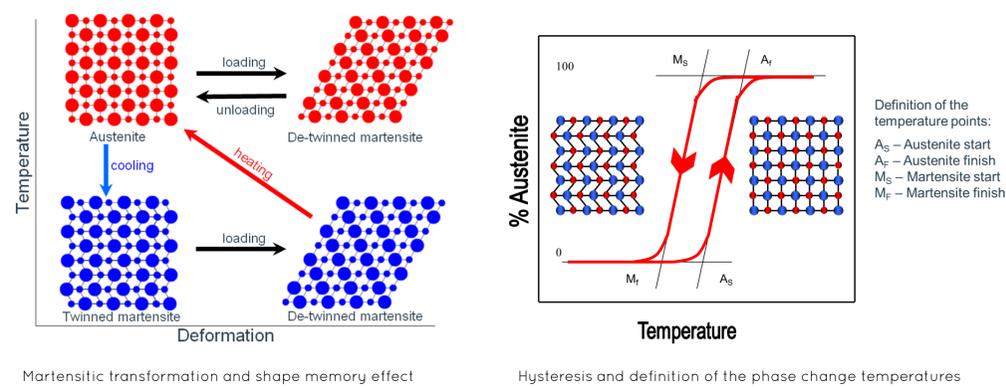


ID 159 - Intelligent Materials In Modern Production - Current Trends For Thermal Shape Memory Alloys

Introduction

A shape memory element is able to memorize and recover its original shape after it has been deformed by heating over its transformation temperature. This unique effect of returning to an original geometry after an inelastic deformation is known as the shape memory effect (SME).

The SME occurs due to a temperature and stress dependent shift in the material's crystalline structure between two different phases, martensite (low temperature phase) and austenite (high temperature phase). The level of the phase change temperatures is mainly dependent on the chemical composition of the SMA and the thermomechanical training.

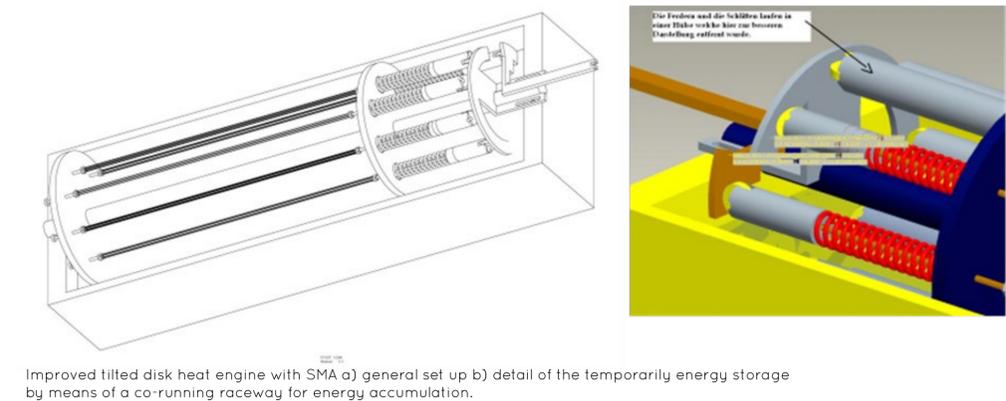


Application

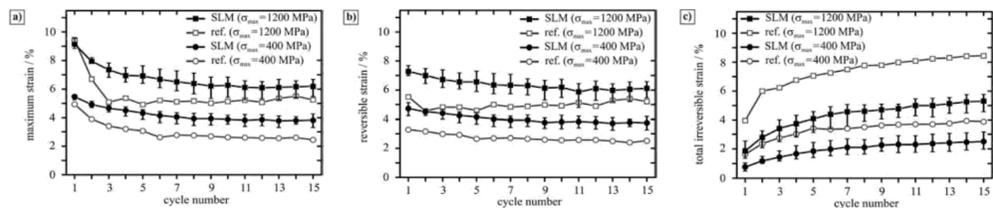
Thermal shape memory alloys show extraordinary material properties and can be used as actuators, dampers and sensors. Since their discovery in the middle of the last century they have been investigated and further developed. The majority of the industrial applications with the highest material sales can still be found in the medical industry, where they are used due to their superelastic and thermal shape memory effect, e.g. as stents or as guidewires and tools in the minimal invasive surgery. Particularly in recent years, more and more applications have been developed for other industrial fields, e.g. for the household goods, civil engineering and automotive sector. In this context it is worth mentioning that for the latter sector, million seller series applications have found their way into some European automobile manufacturers.

The shape memory alloy limb lengthening (SMALL) nail.
 (1) external tube, (2) seals, (3) switch, (4) catches, (5) spring element, (6) thrust, (7) NiTi tube.

Two own applications that are still under development are shown exemplarily on this poster: an active implant for limb lengthening and a solid state heat engine for low energy conversion.



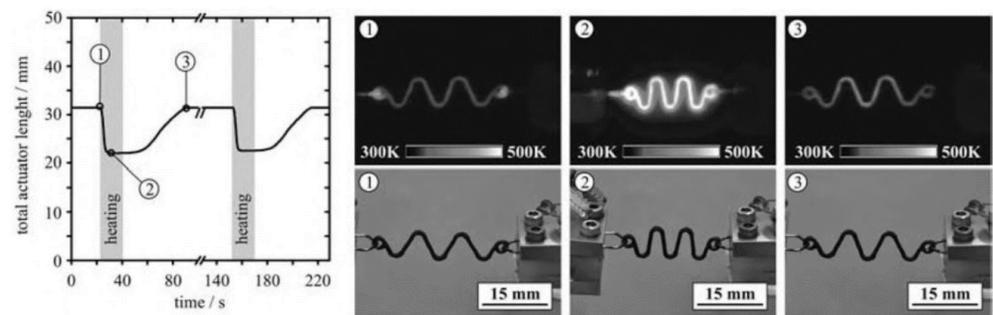
Possibilities of Additive Manufacturing for SMA



Source: H. Meier, C. Haberland, J. Frenzel, Structural and functional properties of NiTi shape memory alloys produced by Selective Laser Melting, Innovative Developments in Virtual and Physical Prototyping – Bartolo et al. (2012) 291-296

Based upon a literature overview it can be stated, that already nowadays it is possible to produce NiTi elements by selective laser melting production technologies (SLM) that have comparable or even better functional characteristics than conventionally produced NiTi. Another additive manufacturing method (AM) that already proved its feasibility to produce NiTi elements is the laser engineered net shaping technology (LENS).

The meandering actuator demonstrates in an impressive way the possibility to create complex functional parts.



Source: H. Meier, C. Haberland, J. Frenzel, Structural and functional properties of NiTi shape memory alloys produced by Selective Laser Melting, Innovative Developments in Virtual and Physical Prototyping – Bartolo et al. (2012) 291-296

Summary and Conclusion

Thermal SMAs show extraordinary material properties and can be used as actuators, dampers and sensors. A short overview of the most important shape memory effects and the most important material properties are given for the SMAs of the NiTi group. In the style of a literature review that does not claim to be complete many examples for industrial applications are given in the paper associated to this poster. Although many of the applications shown here have not yet exceeded the threshold for a successful commercial use on the one side, the number of products already in the market examples demonstrate their industrial application potential. However, the authors of this work are very optimistic that this will change in the near future and much more applications using these intelligent materials will be commercialized. This assessment is mainly based on two new tendencies:

First: the possibilities of the new production technologies, e.g. selective laser melting, will facilitate the manufacturing of shape memory elements for demonstrators, prototypes and even in small commercial series production. It is also to be expected, that in many cases these new production technologies will lead to even better properties, e.g. with regard to the effect size and lifetime.

Second: the German VDI guideline for SMAs introduced in 2017 will give the material a further boost in the industrial implementation of new applications.