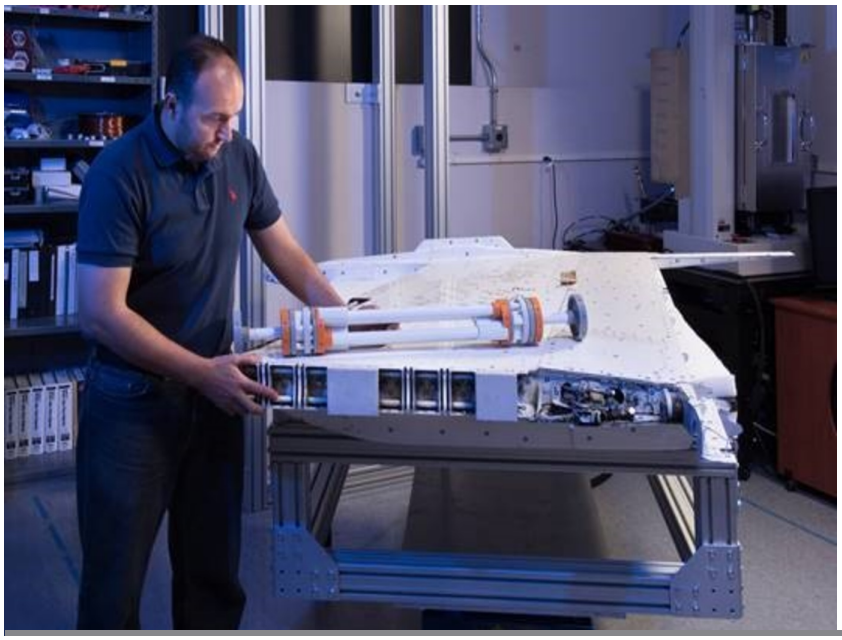


National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Mechanical and Fluid Systems

Shape Memory Alloy (SMA)-Enabled Actuators

SMA tube elements to drive rotary and ring gear motion in compact, powerful actuators

Researchers at NASA Glenn pioneered and matured SMAs to enable future aircraft with morphing airfoil surfaces and adaptive wings that fold to respond to different flight condition demands. SMAs are functional metals with unique properties that can go through solid-state phase transformations—stretched, bent, heated, cooled—and recover their original shape. NASA now has two novel mechanical actuators with SMA transmission elements to move parts with rotational angular twisting, delivering the same power as traditional actuators but in a lightweight, smaller footprint form factor. The new rotary actuator and ring drive actuator move in response to external stimuli, such as heating. The rotary actuator uses nested tubes of SMA to provide torque output or angular displacement; the ring drive actuator uses SMA tubes in a drive gear element to provide continual rotary output in either clockwise or counterclockwise directions. Despite the smaller footprint, the SMA tubes achieve higher power density and similar power output to larger actuators, enabling new designs based on compact actuators.

BENEFITS

- Compact: enables the design of lighter and smaller actuators with increased applications
- Efficient: achieves similar if not higher power output with smaller footprints than state-of-the-art actuators
- Reliable: reduces the risk of mechanical failure and improves the reliability of the rotary actuators
- Simple: does not require the input of a fuel source or pressure-fed fluid, and can provide rotary motion from heating and cooling alone

APPLICATIONS

The technology has several potential applications:

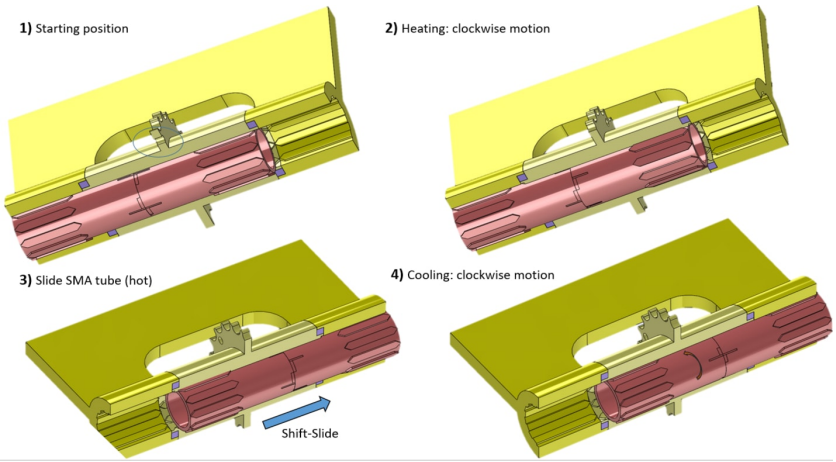
- Aeronautics: smart winglets on sub-sonic air transport to large folding wing sections with reduced rudder configurations
- Space: folding structures such as solar panels, antennas, and booms
- Automotive: door handles and hood lifts
- Marine: doors, compartments, hood lifts
- General: any application utilizing motors, small engines, or any rotary actuation*

*Only applies to the continuous rotation actuator

THE TECHNOLOGY

Actuators typically have large footprints and mass to meet the power output needed for operation, leading to design hurdles for aircraft and space applications. Innovators at NASA Glenn developed two novel actuators with different configurations of tubes of SMA to provide rotary output. The SMA tubes are deformed in their martensitic condition and when exposed to a thermal stimulus, the tubes will revert to their original state while providing rotary motion.

One variation of the innovation nests the SMA tubes within a rotary actuator imparting several technical benefits. Nested SMA tubes can decrease the length of the actuator while achieving the same twist angle. For the same actuator length, a nested configuration of SMA tubes can multiply the twist angle and improve the power output. A second variation utilizes SMA components as transmission elements in a ring drive gear to enable continuous rotation in one direction. Previous similar SMA actuators rotate in one direction while heating and the other while cooling, which can limit the output of the rotary actuator. The innovation developed by NASA allows for continuous rotation in ANY direction, thereby allowing the rotational output capability to be independent from the amount of cyclic angular twist provided by the SMA tubes.



The progression of the Spline Slide configuration of the continuous shape memory alloy tube continuous rotation actuator.

Proposed design of the nested shape memory alloy tubes for use in a rotation actuator

PUBLICATIONS

Patent No: 11,131,294; 11,174,850

technology.nasa.gov

NASA's Technology Transfer Program pursues the widest possible applications of agency technology to benefit US citizens. Through partnerships and licensing agreements with industry, the program ensures that NASA's investments in pioneering research find secondary uses that benefit the economy, create jobs, and improve quality of life.

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