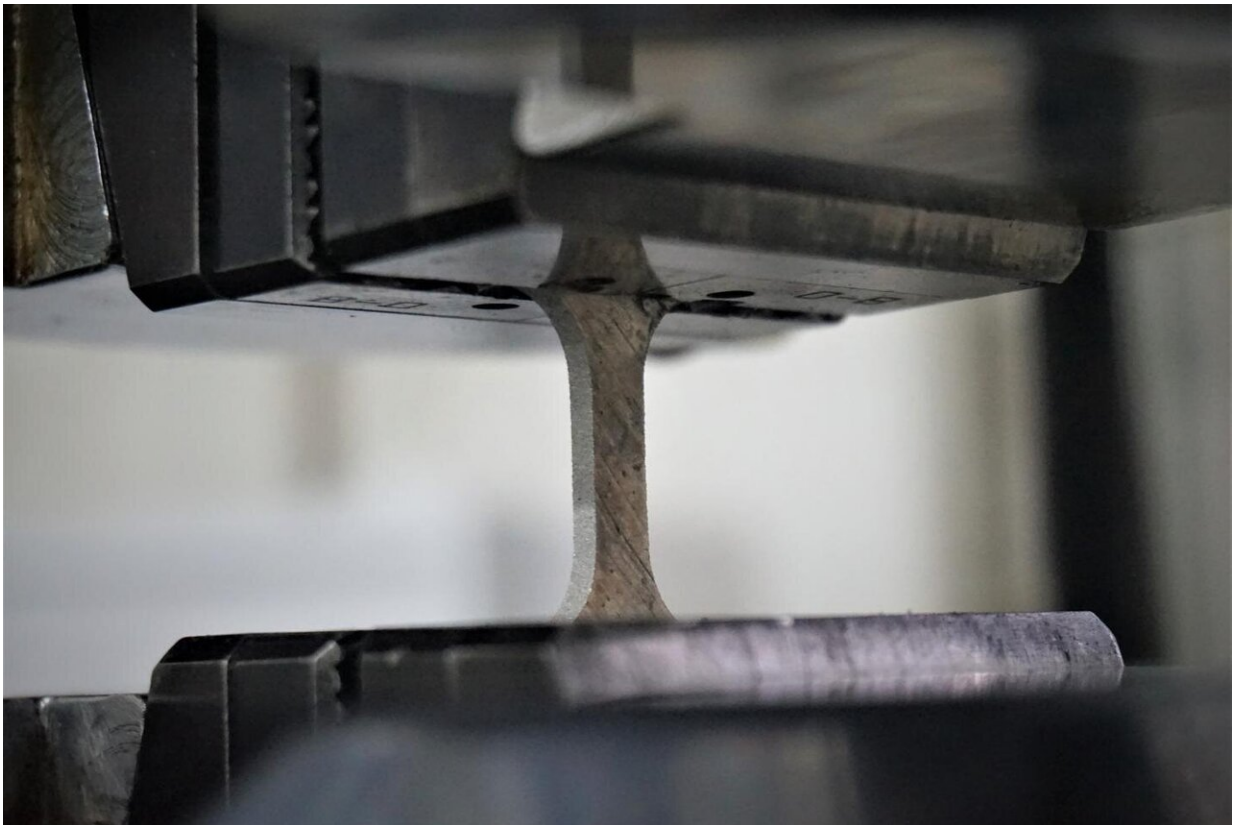


# Findings offer 'recipe' for fine tuning alloys for high-temperature use

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A piece of alloy is stress tested in Levente Vitos' lab at KTH Royal Institute of Technology. Credit: Levente Vitos

Superalloys that withstand extremely high temperatures could soon be tuned even more finely for specific properties such as mechanical

strength, as a result of new findings published today.

A phenomenon related to the invar effect—which enables [magnetic materials](#) such as nickel-iron (Ni-Fe) [alloys](#) to keep from expanding with increasing temperature—was reported to have been discovered in paramagnetic, or weakly magnetized, high-temperature alloys.

Levente Vitos, Professor at KTH Royal Institute of Technology in Stockholm, says the breakthrough research, which includes a general theory explaining the new invar effect, promises to advance the design of high-temperature alloys with exceptional mechanical stability. The article was published in the *Proceedings of the National Academy of Sciences* of the United States of America. Led by Vitos, the research team was comprised of KTH researchers Zhihua Dong, Wei Li and Stephan Schönecker.

Short for 'invariant,' invar plasticity enables magnetically-disordered Ni-Fe alloys to show practically invariant deformation behavior over a wide temperature range—making them ideal for turbines and other mechanical uses in extremely high temperatures.

The invar effect however has never been fully understood, and Vitos says that these new findings help explain the peculiar high-temperature properties of special alloys used in jet engines, such as nickel-based superalloys.

Invar has two known effects: thermal expansion and elasticity (the ability to spring back after bending, for instance). Because both of these effects are linked with the interplay between temperature and magnetic order, they are considered to be specific to magnetically-ordered alloys.

Using first-principles quantum mechanical modeling, the researchers identified how invariant plasticity also occurs in non-magnetic alloys,

when a structural balance exists at the atomic level between cubic and hexagonal close-packed structures.

The new discovery emerges from a long-term collaboration with industry to find alternatives to carcinogenic cobalt in hard metals, such as cutting tools. Vitos says this finding broadens the palette of invar phenomena and material compositions, with clear implications for new applications.

"Our findings create a new platform for tailoring high-[temperature](#) properties of technologically relevant materials towards plastic stability at elevated temperatures," he says.

**More information:** Zhihua Dong et al, Invariant plastic deformation mechanism in paramagnetic nickel–iron alloys, *Proceedings of the National Academy of Sciences* (2021). [DOI: 10.1073/pnas.2023181118](https://doi.org/10.1073/pnas.2023181118)

Provided by KTH Royal Institute of Technology

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