

Prestressed shells with tailored multistable behavior.

KEYWORDS

- MULTISTABLE SHELLS
- BISTABILITY
- AERODYNAMIC SURFACES
- MORPHING STRUCTURES
- ADAPTIVE SURFACES

AREA

- CIVIL, CONSTRUCTION & MECHANICAL ENGINEERING

CONTACTS

- PHONE NUMBERS
+39.06.49910888
+39.06.49910855

- EMAIL
u_brevetti@uniroma1.it

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Patent Type

Patent for invention.

Ownership

Sapienza University of Rome 100%.

Inventors

Stefano Vidoli, Matteo Brunetti.

Industrial & Commercial Reference

Automotive and aeronautical engineering, some branches of mechanical engineering (e.g. aerodynamic surfaces in turbines).

Time to Market

Working prototypes have been already produced, but must be tailored and optimized for specific applications (e.g. aeroelastic interaction in fluids).

Availability

Cession, Licensing, Research, Development and Experimentation.

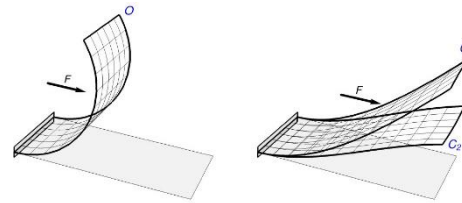


Fig. 1 Target clamped shell stable shapes.

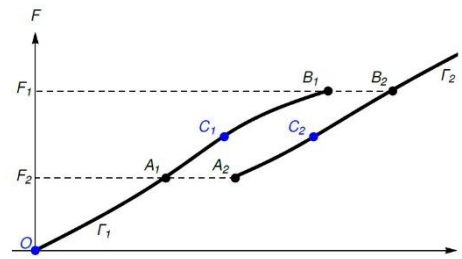


Fig. 2 Equilibrium path as the load increases.



Fig. 3 Prototype: initial shape made in collaboration with italian company.

Abstract

The technology proposed in this patent allows to design, and then to realize, shells structures with controlled bistable behavior. This kind of structures can drastically change their configuration depending on the applied load without the need of actuation. An example could be an aerodynamic surface capable of changing its shape if the flux velocity exceeds a given threshold, and then returning to its initial shape once the velocity vanishes.

The threshold velocities, along with the stable equilibrium configurations and their shapes, can be designed to fulfil the specific application requirements.

Publications

- ❖ Brunetti M., Vincenti A., Vidoli S., Bistability of orthotropic shells with clamped boundary conditions: an analysis by the polar method, Compos. Struct., 194 pp. 388-397, 2018.
- ❖ Brunetti M., Vincenti A., Vidoli S., A class of morphing shells structures satisfying clamped boundary conditions, Int. J. Solids Struct. 82 pp. 47-55, 2016.



Prestressed shells with tailored multistable behavior.

Technical Description

We propose a method for realizing a shell having more stable equilibrium configurations, the shapes of which are established on the basis of the operational conditions, in correspondence with a specific range of values of the applied load.

As the external conditions change, the shell changes its shape autonomously, so as to maximize the aerodynamic performance. This behavior is obtained by imposing a prestress field, induced by flattening and clamping a part of the shell boundary;

for shells of rectangular planform, one of the short sides.

The prestress depends on a set of parameters which describe the shell initial shape and the material. The method allows to choose such parameters so as to obtain the prestress that guarantees the desired multistable behavior.

Technologies & Advantages

The shell changes its shape in order to fulfil pre-established performance requirements, so maximizing the structural efficiency.

For example, it can be used as a mobile aerodynamic appendage to improve the performance of a vehicle.

It can be designed to have a shape at low load speeds and a radically different shape at large load speeds.

The change in shape occurs spontaneously as the load changes.



Fig. 4 Prototype: clamped stable shape without applied loads, point O on Fig. 2



Fig. 5 Prototype: first clamped stable configuration at fixed load, point C1 on Fig. 2.



Fig. 6 Prototype: second clamped stable configuration at fixed load, point C2 on Fig. 2

This guarantees several advantages:

- the actuation energy is provided by the load acting on the shell and it is not necessary to use actuators;
- unlike traditional bistable structures, when the load is removed the shell recovers its initial shape without external intervention: the reversibility of the transformation is always assured;
- it is possible to design all the parameters defining the equilibrium path: both the stable shapes and the critical transition loads;
- by modifying the curvature of the clamp it is possible to adapt shapes and critical loads even in operation.

Applications

Making possible to design structures capable of being efficient in radically different operating conditions, the patent invention has excellent possibilities of use, in both civil (e.g. building adaptive skins or ventilation systems) and industrial engineering (e.g. morphing aerodynamic appendages).

In this last field, in particular, the invention turns out to be a reliable and economical solution. Indeed, for the device to work, it is not necessary to supply energy to the system or to use gear systems, since:

- the transition between the different equilibrium configurations is triggered by load itself;
- the maintenance of each configuration is assured by its stability.

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➤ EMAIL
u_brevetti@uniroma1.it



SAPIENZA
UNIVERSITÀ DI ROMA

ASuRTT _ UFFICIO VALORIZZAZIONE E TRASFERIMENTO TECNOLOGICO
SETTORE BREVETTI E TRASFERIMENTO TECNOLOGICO

➤ <http://uniroma1.it/ricerca/brevetti>