Topology optimization of compliant mechanisms designed with multiple materials

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Abstract

The most widely studied compliant mechanisms by means of topology optimization techniques are Single-Material devices. However, during the last decade, the design of devices with multiple materials gained popularity with the recent development of manufacturing methods. It is the case of the co-extrusion of plastics, the shape deposition manufacturing, or the layered manufacturing with embedded components. As a result, some of the methods applied to Single-Material compliant mechanisms were also applied to the design of Multi-Material compliant mechanisms.

The aim of this paper is to present a generalized formulation for the design of Multi-Material compliant mechanisms with the use of a multiple Sequential Element Rejection and Admission (SERA) method.

The SERA procedure was successfully applied to the design of Single-Material compliant mechanisms (Alonso et al, 2012). The main feature is that the method allows material to flow between different material models. Separate criteria for the rejection and admission of elements allow material to redistribute between the pre-defined material models and efficiently achieve the optimum design (Rozvany and Querin, 2002). These features differentiate it to other bi-directional discrete methods, making the SERA method very suitable for the design of Multi-Material compliant mechanisms.

In the SERA method for Multi-Material compliant mechanisms, the definition of separate criteria for each material model is maintained. The method is extended for M materials so that elements can flow between consecutive levels of material models, including void material (m=0). Elements in material model m "move forward" to material model (m+1) or "move backwards" to material model (m-1). The final topology is made of all the different 'real' materials m= [1, M] present at the end of the optimization.

Numerous examples are presented to show the validity of the multi SERA procedure to design Multi-Material compliant mechanisms. Examples of bi-material inverter and crunching mechanisms and tri-materials gripper mechanisms are presented in this work.

References

Rozvany GIN, Querin OM (2002) Theoretical foundations of Sequential Element Rejections and Admissions (SERA) methods and their computational implementations in topology optimisation, Symposium on Multidisciplinary Analysis and Optimization, Issue 5521.

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