

Metal-reinforced Membranes - Electroplating high-strain membranes into metal shells

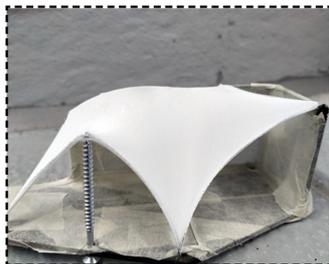
Federico FORESTIERO*, Bruno KNYCHALLA*

*FAUST FabricationArchitectUreStructure
Elektrastrasse 15, 81925, Munich, Germany
info@faust.co

Abstract

The research presented focuses on the development and evaluation of a novel manufacturing strategy for reinforcing high-strain membranes into rigid metal shells. The mean of reinforcement is electroplating, a process that uses electric current for applying thin metal coatings on conductive formworks [1]. In the proposed manufacturing strategy, high-strain membranes serve as stay-in-place formwork for the electrodeposition of metal. Mechanically prestressed high-strain membranes are an advantageous solution for free-form shape exploration and enable double-curved anticlastic geometries without the need of cutting patterns [2]. However, low stiffness membranes are unable to support external loads and they have low weather durability. By metal-reinforcing membranes, it is possible to increase their durability and stiffness expanding their application realm.

The goal is to define the parameters of the fabrication strategy and to evaluate its potentials and limits. Through a series of physical tests, the steps of electroplating membranes are investigated. Firstly the high-strain membrane is shaped into a target geometry by mechanically prestressing it onto a scaffolding. Then the membrane is coated with conductive paint and it is immersed within an electrically conductive solution. Immersion time, solution voltage and metal thickness are measured during the experiments. The membrane geometry is digitized with a 3D laser, scanned before and after electroplating, to verify possible deformations during the manufacturing process. The metal-reinforced membrane, removed from the scaffolding, maintains its geometry, showcasing its shift from a tensile to a shell structure. In fact, the structural typology transforms from form-active to surface-active. Additionally, by varying the fabrication parameters, such as immersion time and position of conductive points, it is possible to achieve differentiated metal coating thicknesses inducing a stiffness gradient pattern. The system's major limitations are a long fabrication time for thick reinforcement and geometrical constraints to achieve uniformed metal layers. The proposed manufacturing strategy, increasing weather durability and stiffness of high-strain membranes, could be a new solution for fabricating free-form facade panels without the necessity of custom formwork. Large manufacturing facilities combined with structural investigations could be conceptually implemented for larger span structures.



High-strain membrane formwork



Electroplating process



Metal-reinforced membrane

References

- [1] J. Edwards, *Electroplating, A guide for designer and engineers*, Committee for Promotion of Electroplating, K&N Press, 1983.
- [2] J. Knippers, J. Cremers, M. Gabler, J. Lienhard, *Construction Manual for Polymers + Membranes*, Birkhäuser, 2011.