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Mini Review

Self-Organizing Hydraulic Textiles for Multiple Room Use

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Abstract

Modern building applications strive for new materials and solutions to address future problems. Especially with regard to resource efficiency, customizability and sustainability, a great pressure arises. The novel textile class of hydraulic textile actuators (HTA) presented in this article serves these tasks and provides solutions for the issues of thermal management, lighting technology and sound insulation.

Keywords: Construction; Hydraulic textiles; OPW technology; Lamination; Thermal management; Lighting technology; Sound insulation

Review

Modern working environments are more mobile and flexible today than they were years ago. Also, new working environments with changed requirement profiles are constantly emerging, which we do not yet know today and for which solutions available today are accordingly not applicable. In addition, the Corona crisis has recently shown us how important it is to be able to effectively use the increasingly small, coveted, and expensive space available to us, for example when a kitchen has to become a home office.

This idea is not new. As early as the fashion exhibition, CAFE SAMT UND SEIDE, in 1927, Ludwig Mies and Lilly Reich created a temporary installation dedicated to this theme. Colored textiles were hung over bent metal tubes and spread across the space. By moving the curtains in relation to each other, small and large spaces were created as needed for appropriate audiences with specific tasks. These were referred to as flowing space [1].

This concept can be taken up and improved using hydraulic textile actuators (HTA). Here, too, the outer shell forms the space, which can be designed variably. The aim is now to create a flexible and temporary space that adapts to the user and not vice versa. In addition, such constructions are reusable and future-proof. In this way, walls can be created that are more than just walls. In the following, we will discuss how this can be realized by means of HTA and what potential this technology offers.

The aforementioned HTAs are a new class of textiles that are related to the already familiar pneumatic actuators. They are also manufactured using the one-piece woven (OPW) technique, in the form of multilayer fabrics, close to the final contour with many degrees of freedom. The resulting flexurally limp, lightweight and large-area actuators are laminated in a roll-to-roll process in the interests of economical production and cut to final contour by laser. In contrast to PTA, where, as the name suggests, compressed air is used, the flooding medium in HTA is a liquid medium, in the simplest case water.

An important difference between pneumatics and hydraulics is that the gases used in pneumatics are compressible, whereas the fluids used in hydraulics are incompressible.

Returning to civil engineering applications, the following illustrates how HTA can be used for this purpose in the future. HTAs have a self-organizing behavior when flooded. The structure of the HTA is created by means of a weaving process through the defined insertion of chamber structures for pressure conversion and for pressure conduction. This allows defined flooding processes inside the system, which sets up sections of the textile sequentially and can execute motion sequences. In this way, compact folded fabric panels can be quickly turned into mobile walls. These obtain their stability from the water-filled double-layer fabric sections, between which single-layer fabric sections are automatically braced, best compared to a bat wing. This consists of a finger (corresponding to a double-layered and water-filled tissue section) and a flight skin (single-layered tissue section). The OPW technique allows for any dimension of textile design starting with table partition units over coworking space applications up to walls in the room. Simple deflation allows the structures to be re-collapsed after use and stowed accordingly. Successful tests on this are being carried out at the DITF Denkendorf. A tree leaf was chosen as the form-giving object, with corresponding leaf veins for water transport and stability, as well as leaf blade, which provides form and layer protection as an inlay fabric.

HTAs require the presence of a hydraulic flooding medium, such as water, to function. This allows the textiles to influence the physical properties of the building, such as heat, light and acoustics.

This can be easily demonstrated using the example of such a possible, novel, heating approach. Warm water, ideally heated free of charge and effectively by the sun, is chosen here as a medium for heating and as a storage medium for heat. Fine double-layered vein structures in the fabric thus distribute the available energy over a large surface application in the room. In the case of the table partition unit already presented, the heat can even be brought close to a person, which means greater utilization of the energy, since the entire room does not have to be heated here. In addition, the specific heat capacity can be used in general. In addition to heating, buffering and cooling, especially with the possibility of spatial and temporal change, open up completely new applications.

Likewise, structural applications built up by HTAs are suitable for the use of various lighting scenarios. Such fields of application can be opened up by incorporating light-effective yarns. The yarns described couple light, from an external light source, into the system, which is then transported through the fluid and coupled out at defined points. In this way, diffuse lighting modules can be created if the right light source is selected. These can illuminate an entire room over a large area. HTAs used as table separation units bring light to a workstation in this way and can thus ensure a glare-free working environment. HTA applications realized by OPW technology are geometrically very versatile and subject to only a few limitations. For example, walls can be created with woven-in letters, characters, or entire words. These then serve for orientation in the room or indicate safety-relevant aspects such as the word “EXIT”. For all textiles, a lamination must be found that is sufficiently pressure-tight while at the same time permeable to light. In addition, the effect can be optimized by laminating the HTAs with one side dark and one side transparent, which allows light to pass through to only one side.

Due to their field of application in room design, HTAs also address demands for sound insulation. Especially in the training of coworking space applications, quiet working environments are mandatory. Responsible for this is an absence of noise as much as possible. HTAs can contribute to this in order to avoid an undesirable, disturbing or health-endangering manifestation of sound. In general, sound is the mechanical vibration in an elastic medium that forms pressure and density fluctuations, which propagate as sound waves and are perceived as sound. Various noise sources, such as voices or traffic, transmit sound energy with the help of the medium air. An effective countermeasure to this situation is the presence of mass, which reduces the transmission of energy into a neighboring room. The more mass present in a component, the better the airborne sound insulation. HTAs have by their structural design, in the form of water, stored and systematically bring sound insulation directly at installation.

The last point is to show the combinatorics of all the properties, thermal management, lighting technology and sound insulation, which makes an HTA interesting for the building application. This can result in solutions that allow rooms to be used in a new, individual, and flexible way in both the commercial and private sectors. This is of particular importance when building in existing structures or when converting real estate. Thus, the presented technology can make an important contribution to a qualitative and social redensification. HTAs can also make an important contribution to decarbonization by upgrading existing real estate for new tasks and by exploiting the energy potential.

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Conflict of Interest

No conflict of interest.

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