Machine Design

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Engineering "Cool" Conditions with Advanced Smart Materials

Five materials developed by the Institute of Advanced Architecture of Catalonia offer cooling methods that use a mixture of the environment and architecture.

Heat is an operational condition that can hinder any mechanic operation. Most sensors use heat as a secondary indicator of failure after noise (i.e., excessive vibration generates heat). Devices are also now designed more compact and with less ventilation. The buildup of excessive heat can create mechanical operation problems and failures.

The Institute of Advanced Architecture of Catalonia (IAAC) crafted advanced materials and systems for passive ventilation and air-conditioning systems to help reduce temperatures in devices and homes. The five highlighted projects are Hydromembrane, Hydroceramic, Morphluid, Breathing Skin, and Soft Robotics.

The students of IAAC's Digital Matter Intelligent Construction developed the materials under the supervision of Areti Markopoulou, IAAC's academic director and project manager. The passive-air condition of spaces is investigated by using a combination of advanced materials, mimicking the organic processes, adaptive strucutres, and robotics that regulate temperature and create sustainable microclimates.

Markopoulou pinpoints the benefits of these advanced materials. According Markopoulou, "the potential of advanced systems and materials to help us have… more sustainable buildings that breathe and behave like living things and interact with their environment." Here is a deeper look into the five materials developed by the IAAC.

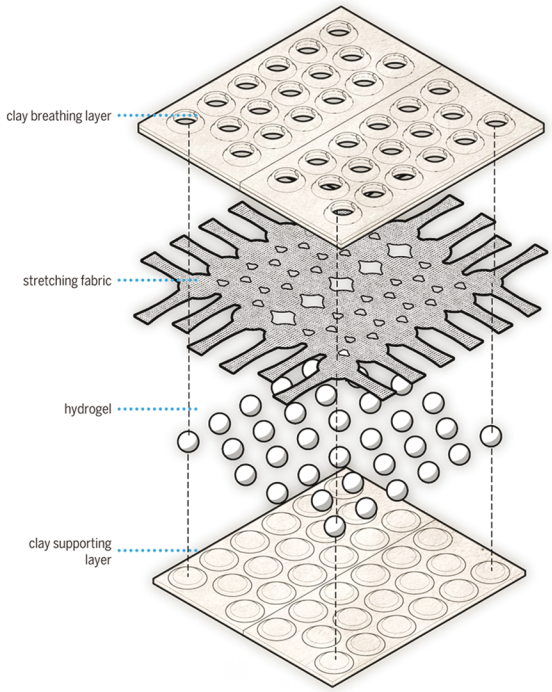
HYDROMEMBRANE

The Hydromembrane is a humidity-sensitive composite system. The membrane consists of six layers and a merge of three materials. Each layer has significantly different physical and chemical features. The Hydromembrane reacts to input moisture and responds with aperture deformations as a primary output. The secondary cooling effect appears because of the materials ability to hydromorph—the ability to change shape due water absorption and evaporation.

Developed as a passive component, the Hydromembrane was developed as a passive composite material that benefits from the membrane's ability to morph as a shape-memorizing actuator. It is highly shape adaptive due to its flexibility and thinness, and the membrane exhibits full shape memory without loss of definition. It can be applied as a second skin to existing buildings or as a smart textile.

Compared to ordinary ventilation and cooling systems, the membrane performs completely passively, which reduces energy consumption. In addition, the material is permanently durable, thus lowering long-term maintenance costs.

HYDROCERAMIC



The Hydroceramic material helps buildings handle heat transfer by using a material called "hydrogel." Hydrogel, a composite material that responds to heat and water, hydrogel is formed into spheres and embedded into ceramic tiles. One of the Hydroceramic's layers is a fabric layer, which acts as a water channel.

Hydroceramic combines the evaporation property of the hydrogels with the thermal mass and humidity-control property of clay ceramic and fabric. The hydrogel absorbs the water or humidity, expands, and as heat is applied, the water vapor is released, which creates the cooling effect. The combination of materials provides a passive evapotranspiration system able to lower the temperature of an interior space by 5°C.

MORPHLUID

Morphluid is a passive shading system—it uses "live roofs" that control the amount of heat and light that enter a space.

Morphluid is based on transition liquids as an activator. It modulates the roof and adjusts the environment by shading. Morphluid uses two tanks of water in a movable structure such as a roof or window. When the water in one tank evaporates, the movable structure tilts, providing shade. Unlike a traditional mechanical system, this natural cooling method uses the natural environment's energy, combined with the architectural design of building components, to dissipate heat.

BREATHING SKIN

Breathing Skin is a water-driven semi-passive material system for outdoor spaces in hot climates. Sodium polyacrylate is superabsorbent polymer of the hydromorph family. Also referred to as waterlock, sodium polyacrylate is a sodium salt of polyacrylic acid.

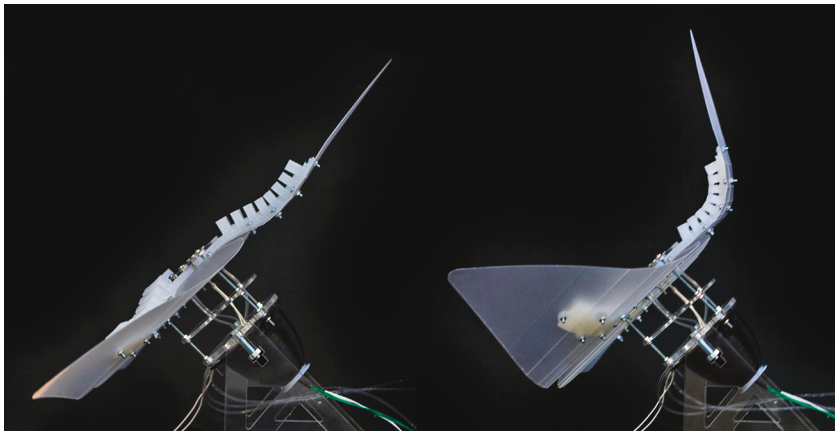
The superabsorbent polymer has the ability to absorb 200 to 300 times its mass in water. It is the major material for the skin system and provides the effect of evaporative cooling as it prolongs the evaporation process. The waterlock is encapsulated in facilitating materials like elastic fabrics (i.e., lycra and silicon), followed by different shapes, patterns, and sizes, in order to optimize the capacitate passive ventilation and cooling in hot and dry summer climates.

SORO

Soft Robotics (SoRo) is a lightweight and sensitive robotic shading device. It attempts to create microclimate by controlling sunlight, ventilation, and temperature to humidify the atmosphere. SoRo adopts different sizes and shapes that can project shade when the integrated liquid evaporates. The shade is known as artificial "sunflowers." The technology is

slowly being integrated into different industries, including medicine and architecture.

The benefits of evaporated movement are obvious when compared to other systems. For example, using pneumatic systems to provide similar shade would require significant engineering and space. Pneumatic systems demand large amounts of active energy that's produced by bulky and noisy machines. Also, it is undetermined at what scale they can perform architecturally.



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