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Bio-inspired heat dissipation system integrated in buildings: development and applications

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Abstract

The advances in building technology and the development of more efficient solutions in the building services field show no signs of abating. The ongoing research presented in this paper seeks to reduce the energy consumption for cooling in buildings through the alternative approach of biomimetics. The solution deals with the design of heat dissipation surfaces integrated in architecture, specifically in building façades. The surfaces would reject the heat generated in cooling cycles. The prior research path, the early development and the current state analysis are explained as well as the potential applications.

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Keywords: Building integration; energy dissipation; biomimetics; cooling.

1. Introduction

The world is moving towards an increase of energy demand in every field. In this context the demand for cooling purposes in buildings is not an exception and is expected to rise throughout the following years [1]. Furthermore, the market for air-conditioning is growing considerably in residential use and in the tertiary sector the installed stock of air conditioning chillers might increase from around 180GW in 2010 to around 240GW in 2020 and 270GW in 2025. Besides, 75% of the 2025 stock will be composed of products installed before 2020 due to the long lifespan of chillers [2].

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Cooling represents an important use of energy globally and a significant driver of peak electricity demand. Hence, the future of cooling demand and efficiency depends on the necessity of developing good guidance on the best type of cooling systems for different applications [3].

In this instance, several advances have been made to reduce both the cooling demand and consumption. Some of the strategies developed to replace partially the active cooling consumption can be based on passive or very low energy consumption solutions [4]. Among building typologies, data centers stand out regarding cooling consumption requirements. Thus, it must be highlighted that over the last years this buildings are being the subject of study to test passive strategies or alternative cooling systems [5].

However, the majority of those investigations do not consider the integration in the building as such, but the characteristics of the building are assessed on the one hand and the cooling system on the other. The solution presented in this paper seeks to be integrated in the construction systems itself, like previous works and theories from author could demonstrate in [6] and [7].

The object of study in this paper is an alternative solution for cooling systems emerged from an alternative approach. It is a result of the project 'Redesign of the Integration of building energy from Metabolisms of Animals' (RiMA), which sought animal thermoregulation strategies predisposed to implement in the design of HVAC&R systems [8]. This project had nature-inspiration as a trigger for multiple solutions, in fact, this methodology has led to results related to thermoelectric façade optimization based on beehives strategies [9] or office buildings thermal performance improvements inspired by tunas' thermal regulation [10].

The solution seeks to improve the performance and aims to decrease the energy consumption peak points of chilled water production systems or air conditioning systems. Besides, most of the drawback caused by cooling towers could be reduced. To that end, the applied strategy involves a bio-inspired cooling panel integrated in buildings which dissipates the heat generated in cooling systems. The solution assembles an active system optimization integrated in building construction.

Therefore, this is an on-going investigation which has already achieve favorable results. On the one hand, this paper presents the research with the obtained preliminary analysis of the results. On the other hand, the applicability of the technology in architecture is proposed.

Nomenclature

amb	ambient
c_e	specific heat, kJ/kg·K
ε	*emissivity*
h	heater
in	inlet
$\dot{m}$	mass flow rate, kg/s
out	outlet
q	volumetric flow rate, l/min
Q_{tot}	total heat transfer, W
Q/A	total heat transfer per unit area, W/m^2
Q_{rad}/A	radiation heat transfer per unit area, W/m^2
ρ	density, kg/m^3
σ	*Stefan-Boltzmann* constant, $W/m^2 \cdot K^4$
T	temperature, °C

2. Background: biomimicry as trigger

Biomimetics or biomimicry is an approach to innovation that seeks sustainable solutions to human challenges by emulating nature's strategies [11]. The rising interest around this discipline has already provide successful solutions and innovative fields of research [12, 13, 14].