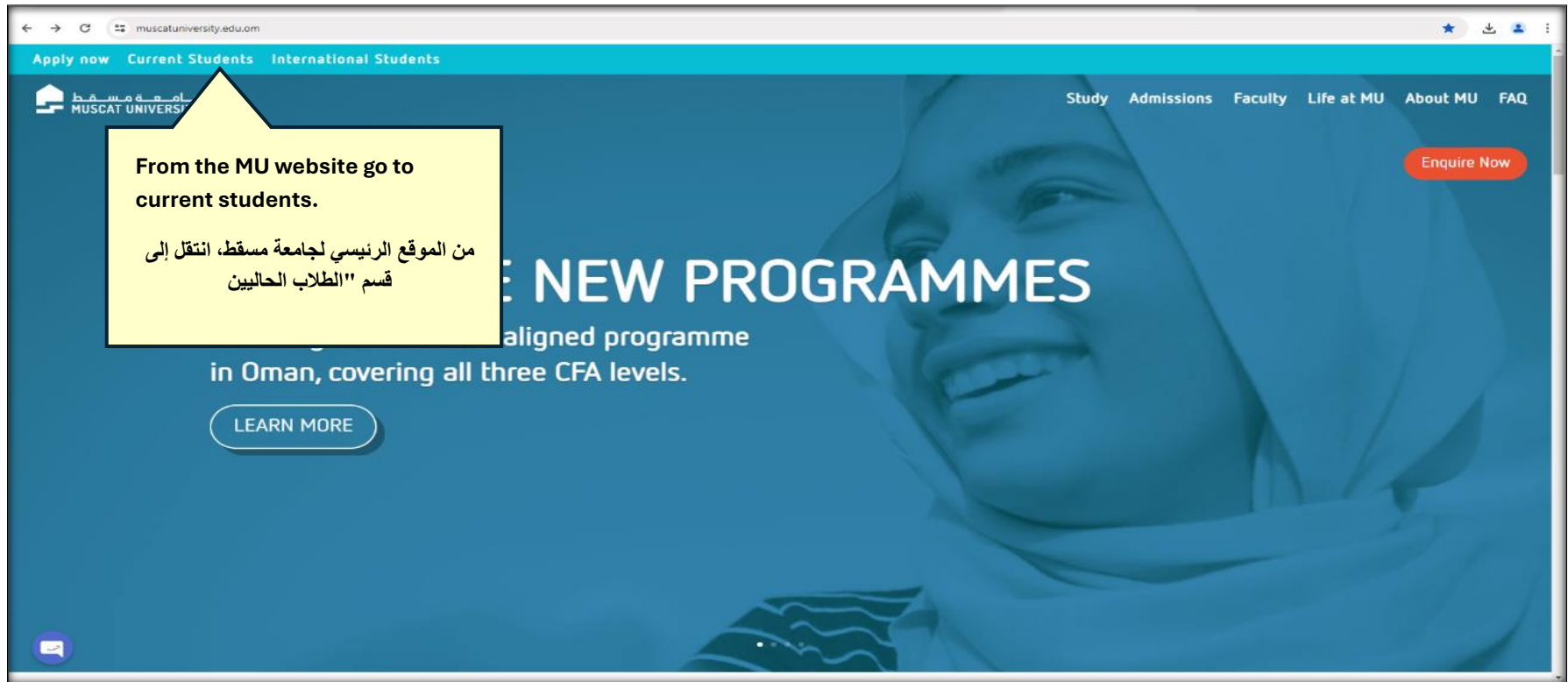




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The screenshot shows the ScienceDirect website interface. At the top, there is a navigation bar with the ScienceDirect logo, a search bar, and links for 'Journals & Books', 'Register', and 'Sign in'. Below the navigation bar, there is a search section with the text 'Search for peer-reviewed journal articles and book chapters (including open access content)'. There are three input fields for 'Find articles with these terms', 'In this journal or book title', and 'Author(s)'. A search button is located to the right of these fields. Below the search section, there is a banner for 'STORIES BEHIND THE FACTS' with a 'Confidence in Research' tag. The banner features two video thumbnails: one of a woman wearing a hijab and another of a woman in a black top. Below the banner, there are navigation tabs for 'Confidence in research', 'Climate change', and 'The Lancet 200'. A callout box with a yellow background and a black border points to the 'Sign in' button. The callout box contains the following text: 'After clicking 'Sign In,' enter your MU email and password. Then, check your email; you'll receive a verification email to confirm that you're MU student and to gain access.' Below this, there is Arabic text: 'بعد النقر على "تسجيل الدخول"، أدخل بريدك الإلكتروني الخاص بجامعة مسقط وكلمة المرور. ثم، تحقق من بريدك الإلكتروني؛ ستتلقى رسالة تحقق لتأكيد أنك طالب في جامعة مسقط.' Below the banner, there is a section titled 'Explore scientific, technical, and medical research on ScienceDirect' with sub-sections for 'Physical Sciences and Engineering', 'Life Sciences', 'Health Sciences', and 'Social Sciences and Humanities'. Under 'Physical Sciences and Engineering', there are links for 'Chemical Engineering', 'Chemistry', and 'Computer Science'. A 'FEEDBACK' button is located in the bottom right corner of the page.

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Confidence in research Climate change The Lancet 200

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The screenshot shows the ScienceDirect homepage. At the top, there is a navigation bar with the ScienceDirect logo, a search bar, and a user profile for Ashwaq AL Mamari. Below the navigation bar, there is a main search area with the text "Search for peer-reviewed journal articles and book chapters (including open access content)". There are three input fields: "Find articles with these terms", "In this journal or book title", and "Author(s)".

Two callout boxes are present:

- Left Callout:** "You can start your search from here" with Arabic text "يمكنك بدء البحث من هنا". It points to the search input fields.
- Right Callout:** "You can browse the journals from here" with Arabic text "يمكنك تصفح المجلات من هنا". It points to the "Journals & Books" link in the top right.


The main content area features a large banner with the text "STORIES BEHIND THE FACTS" and "Confidence in Research". Below the banner, there are three categories: "Confidence in research", "Climate change", and "The Lancet 200".

Below the banner, there is a section titled "Explore scientific, technical, and medical research on ScienceDirect". Underneath, there are links for "Physical Sciences and Engineering", "Life Sciences", "Health Sciences", and "Social Sciences and Humanities".

The "Physical Sciences and Engineering" section is expanded, showing sub-sections like "Chemical Engineering" and "Chemistry". A "FEEDBACK" button is located in the bottom right corner.

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FEEDBACK

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Select the domain:  
**Chemical engineering.**

And subdomain:  
**fluid flow and transfer process**

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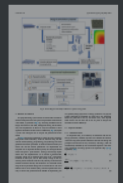
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Applied Thermal Engineering 249 (2024) 123317

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Research Paper

## Novel curled cooler to enhance the efficiency of a photovoltaic panel system

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### ARTICLE INFO

**Keywords:**  
Photovoltaic panel efficiency  
Passive cooling system  
Computational fluid dynamics  
Finned cooler  
Payback time  
Heatsink

### ABSTRACT

The overheating of photovoltaic panels can result in decreased efficiency, potential long-term damage, and reduced energy production. This study proposes a passive cooling system with a new curled aluminum fin profile to mitigate these issues. The thermal response of solar panels with variations in the geometrical parameters of the new curled fin design was studied using computational fluid dynamics (CFD) simulations, where the best-curved fin design option was selected for its implementation. Experimental tests were conducted to determine the thermal-energy response in a PV panel with the new design, compared with a rectangular fin design and without a cooling system as a reference. An economic analysis was also conducted to quantify the payback time based on the energy cost and surplus production rate. The experimental results showed that the new proposed system reduces the panel temperature to 8 °C, knowing that the no-fins system increases the PV panel temperature to 16 °C above ambient. Additionally, the energy production was increased by 4 % with the proposed curled fins, and the payback time varied between 1.1 to 6.4 years, depending on the kWh energy cost per country.

### 1. Introduction

Photovoltaic solar panels constitute a significant component within the scope of global energy generation. They can be found in a wide variety of applications in all areas, including domestic, industrial, and agricultural applications; however, they still have many areas of opportunity that make them remain in the background of energy production compared to conventional energy sources such as fossil fuels. There are many reasons for this, but among the main reasons, the efficiency is only approximately 12 – 18 % for monocrystalline and polycrystalline solar panels [1]. In addition, silicon layers are degraded when exposed to high temperatures [2,3]. Variability in efficiency and energy production is mainly dependent on internal design and external factors such as solar irradiance, wind velocity, soiling, and ambient temperature, which is more notable in the impact of temperature on efficiency performances under hot and arid climates [4,5]. A fraction of the incoming solar irradiance affects the solar cell, which induces a temperature rise, thereby diminishing the efficiency of the photovoltaic (PV) panel owing to the temperature sensitivity of the materials employed in PV cells [6]. This high temperature can lead to structural damage to PV cells if they remain for an extended time [7]. In addition, elevated temperatures

concurrently diminish the output power of the PV system by decreasing the open-circuit voltage and fill factor while escalating internal charge carrier recombination [8]. Hence, dissipating heat from photovoltaic cells poses a challenge that, when effectively met, can lower their temperature and enhance their operational power and efficiency [9,10].

Based on the above, different approaches exist for enhancing the energy efficiency of solar panels (including the implementation of cooling mechanisms). Table 1 provides a comprehensive overview of prominent studies on solar panel cooling systems.

Most of those studies employed water as the cooling medium and achieved temperature reductions between 20–40 °C. However, these water-based cooling systems suffer from intricate infrastructure, substantial expenses, and increased susceptibility to material corrosion [13–16]. Within this group, which uses water as a cooling system, there are spray methods, water immersion, pipe heat exchangers, and nano-fluids, which consist of dispersing nanoparticles in water to increase thermal conductivity and thus improve cooling [17,18]. Additionally, phase-change materials technology stores or releases thermal energy through latent heat during solidification or melting [19–22]. There are hybrid systems PV/T collectors that combine photovoltaic and thermal components to produce electricity and heat simultaneously, where literature shows that they produce more energy per unit surface area

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