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Modeling Woven Porous Regenerators for Elastocaloric Cooling

Heating and cooling systems in Europe use about 40% of the continent's energy, mostly relying on refrigerants that harm the environment. Elastocaloric cooling offers a greener solution by using shape-memory alloys that heat up or cool down when subjected to compression/tension, eliminating harmful refrigerants. Regenerative elastocaloric systems, employing oscillating fluid flows and active elastocaloric regenerators (AERs), enhance temperature spans 2-4 times beyond material adiabatic limits by recycling heat and improving heat exchange efficiency. Recent designs like tubes, microchannels, or foam structures improve performance but are hard to scale up. This study introduces a new cooling component made from woven meshes (like cloth) that creates tiny pores, offering 4.3 times more heat-transfer area than foam designs. Results show a plain-woven regenerator with 30% porosity achieves the best performance: it delivers 485 W of cooling (11.3 W per gram) and good efficiency (COP 1.48) over a 20°C temperature span, outperforming older designs by 3.3 times. Other weaves, like twilled or dutch patterns, were less effective. These woven designs could enable efficient, eco-friendly cooling systems for large scale cooling and heating applications.

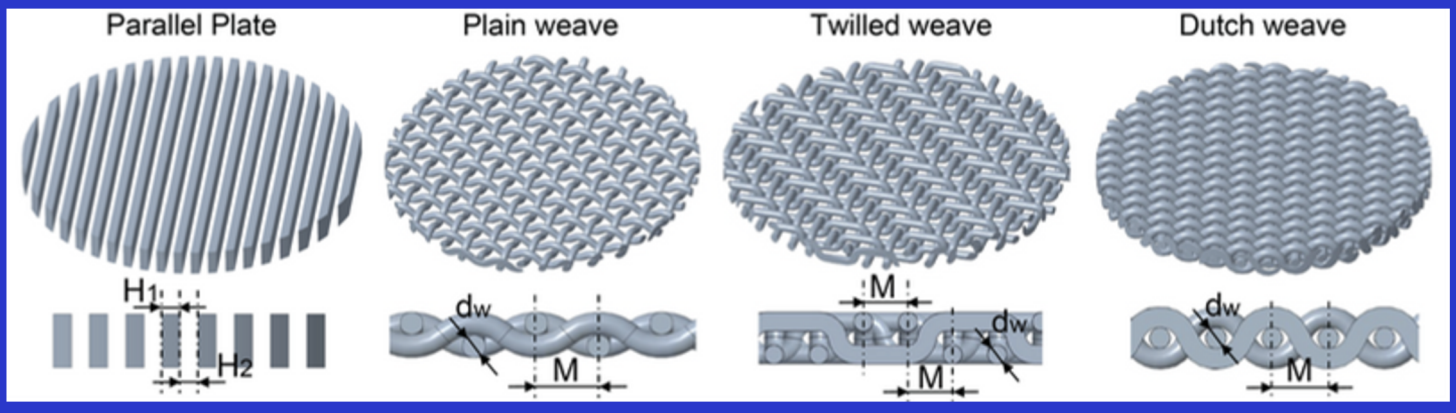

Figure 1. Four different regenerator bed units: parallel plate, plain weave, twilled weave, dutch weave.

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