Abstract

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0ptProject Overview

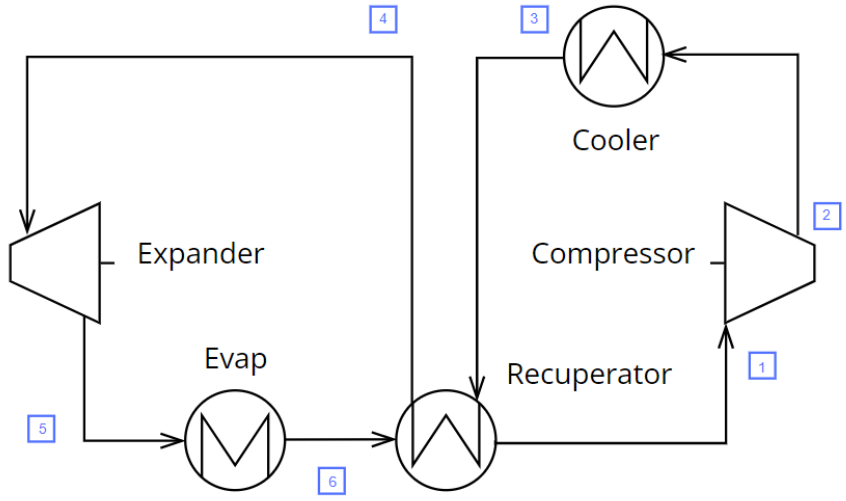
In this program, Echogen Power Systems (Echogen), and partners will design, build and demonstrate a new CO_2-based heat pump steam generator (HPSG) that offers world-class performance at high temperature lift in a vitally-important class of industrial heating that is presently difficult and expensive to decarbonize.

One of the most important industrial processes is the production of steam, which is used in a broad range of industries, including food and beverage processing, and pulp/paper and chemical production. Today, the vast majority of steam is produced by fossil-fired boilers, which, besides emitting large quantities of CO_2, are also significant emitters of air pollutants such as particulate matter, nitrogen oxides, carbon monoxide and unburned hydrocarbons, leading to adverse health effects among the local population, which is frequently among those identified by the Justice40 initiative as being disadvantaged due to environmentally or health reasons. By converting these fossil-fired boilers to renewable electrically-heated systems, a significant portion of global industrial processes can be fully decarbonized. While direct electrical heating (DEH) boilers (e-boilers) are commercially available, the Coefficient of Performance (COP), defined as the ratio of heat produced to electrical energy input, cannot exceed a value of 1.0 for DEH systems.

Conversely, heat pumps achieve COP values in excess of 1.0 by extracting heat from a lower-temperature heat source and using a thermodynamic cycle to raise the temperature of the extracted heat. However, today's steam-generating heat pumps are limited to low pressure ($<$ 2 barg) steam generation and require a waste heat source to operate. An efficient means to generate higher pressure steam, especially using an ambient temperature heat source (either water or air), will represent a key advancement towards industrial decarbonization.

High-temperature heat pumps are presently under development by several groups, but they are limited to hot water or low-pressure ($<$2 barg) steam generation. Direct Mechanical Vapor Compression (MVC) of steam is limited to applications where a significant quantity of waste heat at elevated temperature is available as the heat source.

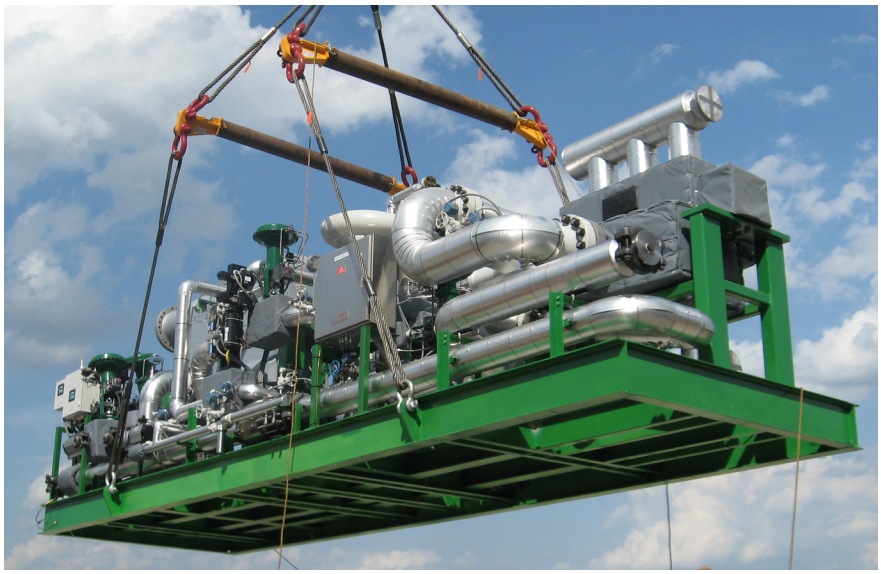
Echogen, a leader in the development of CO_2-based thermodynamic systems, has recently invented (USPTO Application 63/392,646) a new heat pump cycle that overcomes the limitations of other heat pump technologies (Figure), utilizing CO_2, a low-cost, ultra-low GWP refrigerant. This heat pump steam generator (HPSG) can generate high-temperature (over 200 ℃), medium-pressure (up to at least 20 barg) steam from heat sources at typical ambient temperature ranges (40 ℃ down to as low as -20 ℃) at COP values ranging from 1.4 to 2.0. In comparison to an e-boiler, Echogen's CO_2 HPSG can reduce system operating costs by 30 to 50%. In addition, for applications where chilled water is a concurrent need with steam production, further operational cost savings of 5-10% can be realized while attaining combined COP values ranging from 1.8 to over 3.0. [h!]



Transcritical CO_2 heat pump

0ptBackground

Echogen is a private, for-profit company that has established itself as a leader in the field of supercritical carbon dioxide (sCO_2) power cycles. Echogen is the first (and only) company to have developed a commercially-available sCO_2 power system, the EPS100 (Figure). This system was the first multi-megawatt sCO_2 system in operation (Held and Avadhanula, 2017)(Held, 2014)–having successfully completed factory testing, it was then introduced as a commercial offering through a licensing partnership with Siemens Energy (TransCanada, 2019). [h!]



Echogen EPS100 sCO_2 power generation system

0ptReferences

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