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Supercritical carbon dioxide cycles for power generation: A review

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HIGHLIGHTS

- Over one hundred and fifty references, one third of which from the last three years.
- Cycles are classified into categories according to common features.
- Forty-two categories for stand-alone cycles and thirty-eight for combined layouts.
- Stand-alone (simple) cycles in literature show dispersion of up to 30%.
- Stand-alone (simple) cycles in literature show dispersion of up to 50%.

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ABSTRACT

Power cycles running on carbon dioxide at supercritical pressure and temperature were introduced in the late ninety-sixties but, after a warm welcome to the theoretical performance announced, they were later abandoned in favour of standard combustion gas turbines. Nevertheless, the technology was brought forward about a decade ago and has since captured significant attention from the scientific and industrial community. The number of publications has risen exponentially and there are several experimental projects under development today. The performances of these cycles have been deeply analysed in literature, proving to be theoretically competitive.

This paper reviews all the works published in the topic to date. Different cycle concepts (stand-alone and in combination with other cycles using the same or different technologies), layouts, fuels, applications (power only or combined heat and power) and operating conditions are reviewed and categorised according to the configuration of the cycle. This latter feature is thought to be an interesting added value of this paper since, rather than just listing the past work in the area of sCO_2 power cycles, it also organises the numerous cycles in different categories and provides a comparison of the claimed performance of each one of them.

This comparison between the performances of the various configurations is based on the values declared in the original papers and thus applies to very different boundary conditions. Obviously, this great heterogeneity of the available data (in particular the temperatures and pressures considered) makes it impossible to establish a fair comparison between the configurations reviewed. Therefore, a future study seems to be mandatory where the performances of all cycles should be compared for the same set of operating conditions.

Contents

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Nomenclature

η_{th}	thermal efficiency
ASME	American Society of Mechanical Engineers
Bott.	Bottoming
CSP	Concentrated Solar Power
GT	Gas Turbine
IC	Intercooled Compression process
KAERI	Korea Atomic Energy Research Institute
KAIST	Korea Advanced Institute of Science and Technology
LNG	Liquified natural gas
MCFC	Molten Carbonate Fuel Cell
n.d.	not declared
Nes.	Nested
ORC	Organic Rankine Cycle
Preh.	Preheating
R	Regeneration process
R134-a	Haloalkane Refrigerant, Norflurane
Recompr.	Recompression
RH	Reheated Expansion process
sCO_2	Supercritical Carbon Dioxide
SFC	Split-flow before Compression process
SFE	Split-flow before Expansion process
SFH	Split-flow before Heating process
SFHE	Split-flow before Heating and Expansion process
ST	Steam Turbine
SwRI	Southwest Research Institute
TEES	Thermo-Electric Energy Storage
TES	Thermal Energy Storage
TIT	Turbine Inlet Temperature
Topp.	Topping
w/	with
WHR	Waste Heat Recovery