Novel Direct Fired sCO₂ Power Cycle with Integration of H₂ Combustor

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The decarbonization of the energy industry is a key topic of our time. Deep decarbonization can be achieved via several different ways, e.g., carbon capture, waste heat utilization, or new generation and hybrid power systems. However, with the growing population, the demand for energy will also rise which comes with associated pollution and CO₂ emission. Hence, “zero emission” power systems will be necessary to achieve the overarching goal.

The next generation of power systems may still produce cheap energy or heat for commercial, residential, or industrial sectors, with minimal effect on the operation cost. One of the promising power-conversion cycles is the supercritical carbon dioxide (sCO₂) power cycle. The sCO₂ power cycles have high efficiency for a higher turbine inlet temperature, and have compact size compared to steam or helium power cycles and can be design as indirect or direct fired system. Further, it has the capability to be used with different fuels such as Hydrogen [1]. Hydrogen is another technology that has the capability to enable to production of “zero emission” power [2, 3]. The combination of the sCO₂ power system and the hydrogen technologies will create a very efficient system which has the advantages of no emission of NOx and H₂S and can be operated with very higher turbine inlet temperature. However, the main disadvantage of hydrogen fueled systems is water which is not readily available across the globe [3]. This work is focused on the design and optimization of a novel direct fired sCO₂ power cycle with integration of H₂ combustor and demonstrate feasibility of the proposed hybrid power systems from first and second laws of thermodynamics point of view. The system combines advantages of both systems, very higher cycle efficiency, compactness, low capital cost, high H₂ separation and storage efficiency, and combustion without any emission.

- The system is a closed system with H₂, O₂, sCO₂, and H₂O subsystems
- No emission of the NOx and H₂S
- Very higher maximum operation temperature (TIT) – sCO₂ power cycle
- The power cycle can be integrated with electrolyzer closed water cycle and CFC** storage system
- Integrated load shifting capabilities without excessive water demands through recycling

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**Table:**

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<thead>
<tr>
<th>System</th>
<th>Advantages</th>
<th>Disadvantages</th>
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<tbody>
<tr>
<td>Oxy-combustion direct-fired sCO₂*</td>
<td>No NOx, H₂S, Very Higher TIT</td>
<td>Lower TIT based on heat source (PHX limitation)</td>
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<tr>
<td>H₂/sCO₂ direct-fired</td>
<td>Can be integrated with electrolyzer closed water cycle and CFC** storage system</td>
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</tbody>
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*Fuel is Natural gas – CH4
**CFC is Cryogenic flux capacitor [4]

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