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CARBON DIOXIDE CAPTURE AND SEQUESTRATION BY INTEGRATING PRESSURE SWING ADSORPTION WITH AN OPEN CYCLE SUPERCRITICAL CO_2 BRAYTON POWER GENERATION SYSTEM

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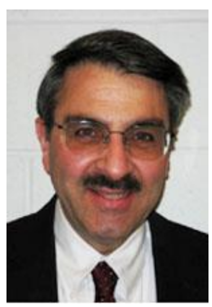
BIOGRAPY

Frank Di Bella, P.E. is a former Program Manager at Concepts NREC LLC working on Large Product Development within the Engineering Services Group. Of particular professional interest is the development of novel energy efficient systems using waste heat recovery as well as renewable energy, including ocean kinetic and potential energy. Mr. Di Bella has written several papers on energy storage, waste heat recovery using Organic Rankine Cycle Systems, the development of thermo-mechanical energy storage, and the efficient refueling of hydrogen fueled vehicles to maximize range. Current interests detailed in the current paper involve the use of ocean energy to produce hydrogen for pipeline delivery to the user or at pressures suitable for effective energy storage.



ABSTRACT

Reduction of carbon dioxide (CO_2) through sequestration is an energy-intensive process, requiring as much as 10-15% of a utility's power generation. Concepts NREC (*CN*) has developed a hybrid cycle that combines a Supercritical CO_2 Brayton cycle (SCO_2) with a Pressure Swing Adsorption (PSA) process.

The goal of this hybrid cycle is to significantly reduce the external power required for carbon sequestration, by utilizing the highly efficient SCO_2 cycle. The hybrid cycle is particularly attractive to use on a coal-fired power plant in order to reduce the release of CO_2 into the environment. As such, the proposed cycle may be thought of as a "cross-over" system to enable the continued use of coal in utility power generation systems even as natural gas and/or renewable energy continue to be developed, along with the necessary infrastructure of pipelines and large surface area and, thus, can be phased in to completely replace the coal powered systems. The "Cross-over" concept can be used for countries that continue to plan new coal-fired facilities until natural gas

infrastructure is in place but who are also cognizant of the need to reduce CO_2 emissions. This hybrid cycle also uses a PSA process to recover CO_2 from the exhaust gas stream, and then utilizes the recovered CO_2 as the working fluid in an SCO_2 cycle. The discharge of the SCO_2 cycle is sequestered into an underground geophysical vault, but only after the SCO_2 is first passed through a let-down turbine that recovers a significant portion of the energy of compression until the ground vault is pressurized, thus providing additional power generation.

CN estimates that this new hybrid cycle will reduce the required power for CO_2 sequestration by at least 30-40%. The power for compressing the sequestered CO_2 can be reduced by 80% if a CO_2 pressure let-down turbine is also used. Of course, the cost per kw ($/kw) of such a combined system is also important to the acceptance of the concept. However, the cost must also be balanced against the increasing costs of not reducing the release of CO_2 into the atmosphere. Such cost comparison is left to another study while the goal of this study: the analysis of the thermodynamic viability of the proposed concept is presented and found to be acceptable.

Current independent studies indicate that the new cycle could utilize K-promoted hydrotalcite in a high-pressure, high-temperature PSA system to recover CO_2 from utility power plant exhaust gas. The cycle is thought to satisfy the need to reduce the atmospheric release of CO_2 from, in particular, coal-fueled power plants, until such time as the coal plants can be replaced by renewable energy sources and/or power plants that use cleaner-burning fuels. To be clear, the thermodynamic analysis offered in this paper is focused on the successful recovery of CO_2 from the exhaust gases of a power plant, ostensibly a coal-fired plant where it has the most benefit but also a natural gas fired plant. The recovery of the CO_2 by a PSA system has shown some merit, but the use of a PSA system should not be considered to be at the sacrifice of other methods for recovering CO_2 from exhaust gases.

It is generally agreed that this reduction is necessary for the sake of future generations; but it is also understood that the deployment of current CO_2 reduction techniques is costly. Thus, the technical objective of several research programs sponsored by the DOE has been to reduce the initial cost and power consumption of systems that effectively capture, reduce, or sequester carbon dioxide.

Thus, the proposed hybrid SCO_2/PSA cycle provides a technical solution, albeit a futuristic one that requires the further development of the basic SCO_2 system as well as the selection of the most viable CO_2 recovery methodology. This is seen as at least honoring the spirit, if not the immediate intent of the climate change initiatives agreed upon at the COP21 Conference, as essential for the health of the populations of all nations of the world.

INTRODUCTION

There has been continuous and increasing concern expressed by the environmental community of the need to reduce fossil fuel-generated carbon emissions that are entering the atmosphere. The 2015 Paris Climate Talks (COP21) were successful in achieving consensus from 196 countries that climate change must be given significant attention and that the release of carbon, in the form of carbon dioxide and carbon monoxide, must be curtailed.

Climate scientists have shown that the carbon emissions from the combustion of fossil fuels for the generation of electric power can most significantly be controlled by conservation and innovation through three strategies:

- *Conservation efforts, which curtail the amount of power required*

- *A shift in power generation from fossil fuels to renewable energy sources*
- *Efficient capture and sequestration of carbon dioxide, the byproduct gas resulting from fossil fuel combustion, particularly coal combustion*

The first two strategies are being implemented, but fossil fuels are readily available and will still be needed as a power source for many years to come. This leaves the third strategy to help resolve the CO_2 dilemma, while providing reliable power generation. The U.S. Department of Energy (DOE) has been at the forefront of supporting innovative approaches to use coal combustion at high cycle efficiencies, while also capturing the CO_2 generated by power plants. Once captured, these emissions can be sequestered, thus reducing the environmental impact of gases known to contribute to climate change. For example, the Allam Cycle is under development, with support by the DOE. This cycle utilizes an oxygen separation process to remove nitrogen from the air, and then uses the oxygen to burn with gasified coal. The oxygen is pressurized to 4,000 psia and then burned with syngas to temperatures of 1,200°C to 1,400°C. Without the presence of nitrogen, the product of combustion is CO_2 and water. The high-pressure CO_2 – steam fluid stream is expanded through a turbine before it is sequestered into the ground at pressures of 1,100 psia. This system is thus not truly a cycle, but rather an open-flow, SCO_2 power system. The Allam Cycle will serve to utilize the still abundant supply of coal as the primary fuel for the lifetime of the plant.

RESULTS AND DISCUSSION

Background of Concept

An alternative to the Allam Cycle is one that has been conceptualized by *CN* that combines a Supercritical CO_2 Brayton cycle with a Pressure Swing Adsorption. The Pressure Swing Adsorption system can be replaced with an equivalent process that can capture CO_2 from the products of combustion of an existing power plant. Emphasis is focused on the SCO_2 cycle, once the carbon dioxide has been scrubbed from the exhaust gas and then the sequestration process. The *CN* system also utilizes the recovered CO_2 as the working fluid in an open-flow SCO_2 cycle, but there is one important distinction between the *CN* system and the Allam Cycle; the proposed cycle is intended to be added to existing coal-fired power plants as a thermodynamic **topping cycle**. As such, the proposed system can be properly labeled a "crossover" system, in that it can be retrofitted onto existing coal-fired, power generation plants until renewable energy power generation systems become the dominant source of utility power. *CN* has labeled this system **(SCO_2)^2**, because it is intended to use the highest combustion temperatures that an existing power plant can generate, while minimally impacting the continuous power generation of the existing steam boilers-turbine power generating units, and while producing power at a SCO_2 cycle efficiency of 40-50%. The need for the highest temperature heat energy from the combustion system of the primary power plant can be accomplished several ways. It is the intent of this paper to focus on how much energy and at what temperature is needed to provide a viable combined PSA-SCO2 system and not the selection of a precise means of accomplishing the heat input. However, one such viable means of providing the heat energy to the SCO_2 system is to provide an additional 1-2% of the exhaust mass flow rate used in the coal-fired combustion system and produce exhaust temperatures of 2,000F (1,100C) using coal or natural gas as the fuel.

All the exhaust from the power plant is directed to the Pressure Swing Adsorption (or equivalent) system where the CO_2 gas is removed from the products of combustion. The **(SCO_2)^2** system utilizes the recovered CO_2 gas to serve as the working fluid in the **(SCO_2)^2** system. The suggestion here that a CO_2 capture could be accomplished by using a PSA process is based on current, independent studies that indicate that the new cycle could utilize K-promoted hydrotalcite in a high-pressure, high-temperature PSA system, to recover CO_2 from utility power plant exhaust gas. However, this is not to exclude other means of recovering the CO_2 from the exhaust gas.

The recovered CO_2 stream is then directed to the sequestration compressors, that are intercooled, reciprocating compressors. The compression of the CO_2 from the atmosphere to 1,000 psia is most effectively accomplished using positive displacement (reciprocating) compressors, due to the relatively low volume flow rate and high-pressure ratio requirements for compression.

The primary goal of this hybrid cycle is to significantly reduce the external power required for carbon sequestration, by utilizing the highly efficient SCO_2 cycle to provide approximately 30-40% of the power required by the sequestration compressor. The discharge of the **(SCO_2)^2** cycle is sequestered into an underground geophysical vault, but only after the SCO_2 is first passed through a let-down turbine that recovers a significant portion of the energy of compression, until the ground vault is pressurized, thus providing additional power generation.

Engineering and Technical Details

To achieve this goal, *CN* has developed a new hybrid, thermodynamic cycle. The cycle is shown using a PSA technology to capture CO_2, in combination with pressurization for sequestration by means of an open SCO_2 cycle. It is important to note however, that the choice of a PSA cycle to separate CO_2 from the exhaust products is only one of several CO_2 removal systems that could be coupled with the proposed SCO_2 cycle.

The proposed **(SCO_2)^2** cycle is shown in Figures 1a, 1b, and 2a, 2b, along with performance parameters associated with its integration into a 235 MWe coal-fired power plant. The choice of a coal-fired plant is not arbitrary but is intended to strongly imply that the proposed integration is a means of keeping the coal fired systems operational until natural gas and renewable energy power generation can replace the less desirable coal systems. Figures 1a and 1b illustrate the proposed **(SCO_2)^2** cycle, using a reheat SCO_2 turbine. Figure 2 provides a preliminary specification for the speed and diameter of the single stage SCO_2 turbines. Figure 3 illustrates the same system with a turbine inlet temperature changed from 700°C to 900°C with the same exhaust heat temperature from the power plant's coal fired steam boilers.

It is proposed that the **(SCO_2)^2** cycle functions as a topping cycle. The highest combustion temperatures that a power plant can generate, while minimally impacting the continuous power generation of existing steam boilers, would be used by the hybrid system. The SCO_2 cycle efficiency is 40-45%, and is thus higher than the typical, older, coal-fired power plant. Therefore, the power conversion efficiency of the power plant can be increased, as some of the coal's combustion is used to generate power to offset the CO_2 compression power. As shown in Figure 1a, approximately 40-45% of the 1-2% of the mass flowrate of combustion gases used in the primary power plant are diverted to the reheat heat exchanger to increase the inlet temperature of the reheat turbine, and the balance is directed to the primary SCO_2 turbine. For conservative analysis purposes it was assumed that temperature of the combustion exhaust gases that are returned to the power plant is reduced by 50-100°F, in order to avoid adversely affecting the existing steam boilers in the power plant, which are downstream from the planned, primary SCO_2 heater. This combustion heat stream is then utilized, as required, by the power plant, to generate electric power in a typical Rankine cycle or in a modified Rankine cycle, that includes feed water heaters and reheat turbines.

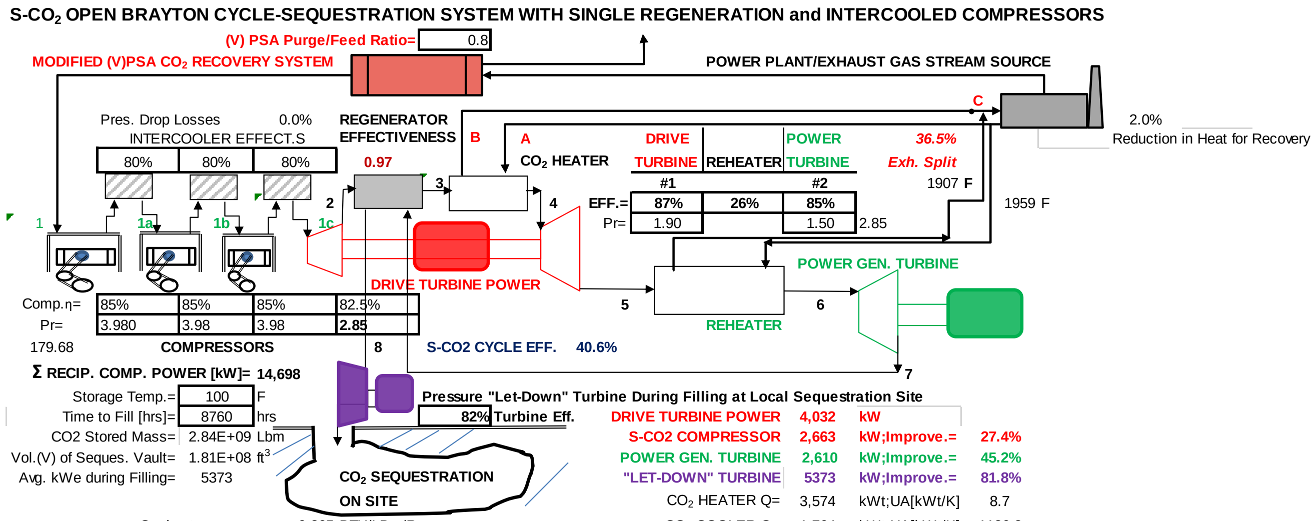
The cycle starts with the removal of the CO_2 from the exhaust products of combustion from the coal fired combustion system. The PSA is one such means of recovering the CO_2. The flow stream of CO_2 proceeds to be compressed using positive displacement, intercooled compressors to approximately 1,100 psia, just above supercritical pressure for CO_2. The CO_2 fluid stream is then compressed to a pressure ratio of 2.85 and continues along a regenerative Brayton Cycle, with reheat turbines as shown. The discharge of the second reheat turbine is used for regeneration of the compressor discharge and a third turbine stage is used as a "pressure let-down" turbine in order to recover the 1,000 psia CO_2 as it is released into the CO_2 sequester vault. The sequestration is assumed to be relatively close to the coal-fired power plant.

The CO_2 stream that is recovered from the PSA process is then directed to the sequestration compressors, shown in Figure 1 as multistage, intercooled reciprocating compressors. The compression of the CO_2 from the atmosphere to 1,000 psia is most effectively accomplished using positive displacement (reciprocating) compressors, due to the relatively low volume flow rate and high-pressure ratio requirements for compression. CO_2 compressors are available from the many commercial vendors who provide such equipment, without any additional research and development required.

The intercooling of the CO_2 between stages is also typical, although not universally done, unless there is adequate ambient water or air cooling. The intercooling improves the compression efficiency, and thus reduces the work of compression. Intercooling also helps to increase the effectiveness of storing the compressed CO_2 gas in a fixed-volume sequestration vault. However, in the proposed hybrid SCO_2/PSA cycle, the compressed CO_2 proceeds to the SCO_2 axial or radial compressor, where its pressure can be boosted to supercritical pressures, thus beginning the SCO_2 power generation cycle.

The net power generated by the SCO_2 process is 10 MWe, when the reheat turbine is used in the cycle. This translates to a 35% improvement in power needed for the work of compression for sequestration of the CO_2. The power improvement is still as high as 30% if the reheat turbine is not used in order to save in the initial capital cost and the O&M of the system. There is an option to recover the let-down pressure from the sequestered CO_2 stream as it fills the underground vault, and this results in a power improvement that can be as high as 80%. If higher turbine inlet temperatures similar to oxy-combustion temperatures are available, the power improvement, with respect to the work of compression for CO_2 sequestration, can be as much as 55%.

CN's hybrid **(SCO_2)^2** cycle is an innovation that reduces the operation and maintenance costs of post-combustion, carbon dioxide capture and sequestration. It can be shown that as much as 10% of the net electric power output of a utility power plant that captures and sequesters the CO_2 generated from its fossil fuel combustion process is consumed by the CO_2 compressors for sequestering the CO_2 at 1,400 psig. The proposed open **(SCO_2)^2** cycle reduces sequestration power consumption by as much as 50-57% of that required by CO_2 compressors; an improvement can be increased to 80% or more if a pressure let-down turbine is used during the sequestering (underground vault) filling process. For a 500 MWe power plant, this amounts to an operational cost savings of $80M over a 20-year period. If the sequestration into the ground is to be done directly into the ground substrate, then the pressure let-down turbine cannot be used.



Cp, heat source= 0.265 BTU/LBm/R
Cv, heat source= 0.188 BTU/LBm/R
K= 1.41

FLUID: carbon dioxide
MOLE. WT. 44.01
Critical Pressure [psia]= 1070 **73.8 Bar,a**
Critical Temp. [F]= 87 **30.5 C**

Heat Balance Check= 100%

CO_2 COOLER Q= 1,764 kWt;UA[kWt/K] 1126.2
REGENERATOR Q= 23,698 kWt;UA[kWt/K] 4405.1
INTERCOOLER ΣQ= 18,758 kWt; 36.8
REHEATER Q= 6230 kWt;
THERMAL STORAGE Q= 1764 kWt;

Twater, in [F] = 82.4 Water Mass Flow= 15,549 GPM
Twater, out [F]= 91.4

Air-Fuel Mass Ratio= (Lbm,air/Lbm,coal) 25.3

	1	1a	1b	1c	2	3	4	5	6	7	8	9	A	B	C
Pres. [psia]	17.4	69	276	1097	3126	3126	3126	1645	1645	1097	1097		14.9	14.7	14.7
Temp. [F]	200	154.4	143.7	142.5	319	1134	1259	1109	1330	1235	341		1959	1907	1907
Enthalpy [Btu/lbm]	243.5	232.6	225.6	200.8	228.8	478.4	516.0	473.5	539.1	511.6	262.1		519.1	505.3	505.3
Density [Lbm/ft^3]	0.11	0.47	2.01	10.78	21.07	7.71	7.12	4.22	3.68	2.62	6.15		0.017	0.017	0.017
Flow rate [Lbm/s]	90.03	90.03	90.03	90.03	90.03	90.03	90.03	90.03	90.03	90.03	90.03		245	245	672
Entropy [Btu/Lbm/R]	0.6899	0.6109	0.5391	0.4451	0.4515	0.6731	0.6958	0.6999	0.7390	0.7419	0.5339				
CO_2 Cp	0.22	0.22	0.23	0.42	0.39	0.30	0.30	0.29	0.30	0.30	0.27				
Pres. bar,a	1.2	4.8	19.0	75.7	215.6	215.6	215.6	113.4	113.4	75.6	75.6		1	1	1
Temp. [K]	366.3	341.0	335.0	334.4	432.3	885.3	954.6	871.2	994.0	941.3	444.8		1343.5	1314.5	1314.5
Enthalpy [KJ/kG]	565	540	524	466	531	1111	1198	1100	1252	1188	609		1205	1173	1173
Temp. [C]	93	68	62	61	159	612	682	598	721	668	172				
Density [kG/m^3]	2	8	32	173	338	124	114	68	59	42	99		0	0	0
Mass Flow [Kg/s]	40.92	40.92	40.92	40.92	40.92	40.92	40.92	40.92	40.92	40.92	40.92		111.33	111.33	305.37
Vol. Flow [Nm^3/hr]	79820	79820	79820	79820	79820	79820	79820	79820	79820	79820	79820		331745	331745	909933

Figure 1a. Proposed Hybrid Open (SCO_2)^2 Cycle at 700°C inlet Turbine Temperature With Reheat Turbine for Sequestration of CO_2 from Coal Fired Utility Power Plants

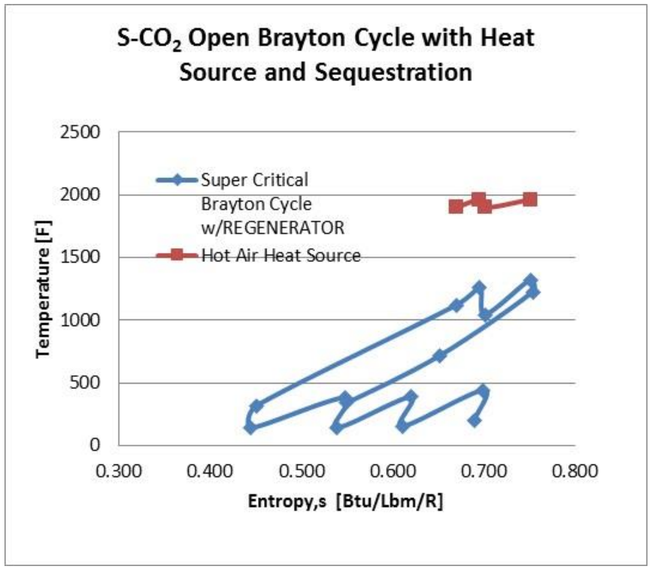


Figure 1b. T-S Diagram For (SCO₂)^2 Cycle In Figure 1a

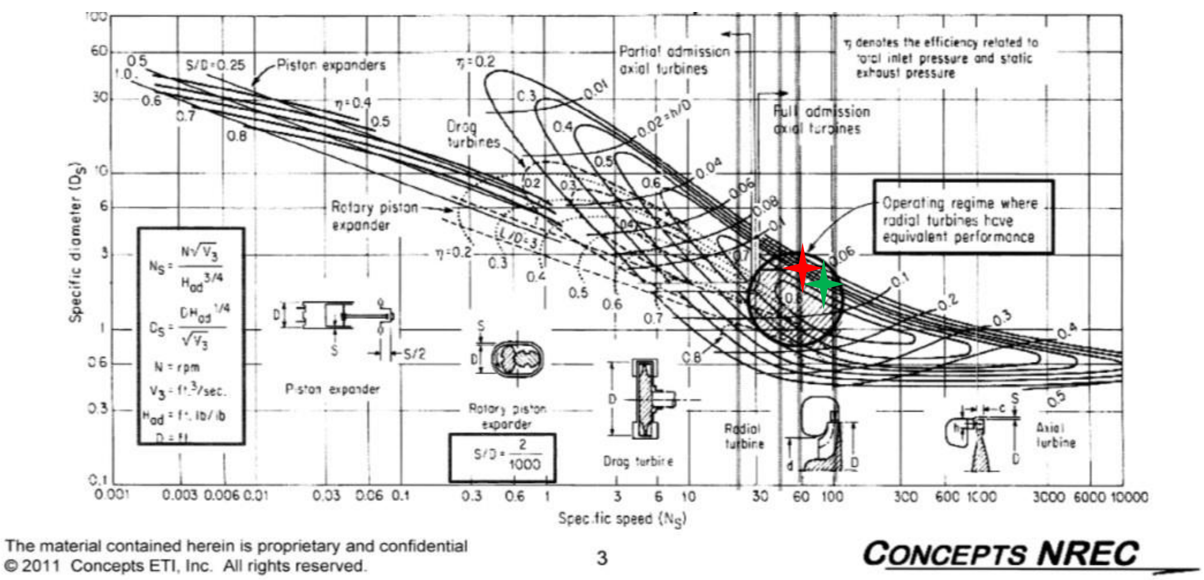


Figure 2a. Turbine Balje Diagram For (SCO₂)^2 Cycle In Figure 1a

TURBINE No. 2

V3 [cft/s]=	24.461	Flow Rate	3.24E+05	lbm/hr	40.92 kg/s
Had [ft-lbf/lbm]=	25158	P,in	1645	psia	11.34 Mpa
Had [kJ/kg]=	75	T,in	1330	F	994.0 K
D [ft]=	0.492	P,out	1096.67	psia	7.563 MPa
N [rpm]=	30,000	P,stage,out	1097	psia	7.563 MPa
No. of Stages=	1		85%	Turbine Eff.	
Ns=	74.3	Δh,issen.=	75.2	KJ/Kg	
Ds=	1.25				2614 kW
Tip Speed [m/s]=	236	**Ns=**	**16.51**		
Tip Speed [ft/s]=	773	**Ds=**	**2.41**		

V/Us= 0.61

0.150	**Dia (m)**	**773**	ft/s
30000	**RPM**		
1	**No. of Stg.s**		

TURBINE No. 1

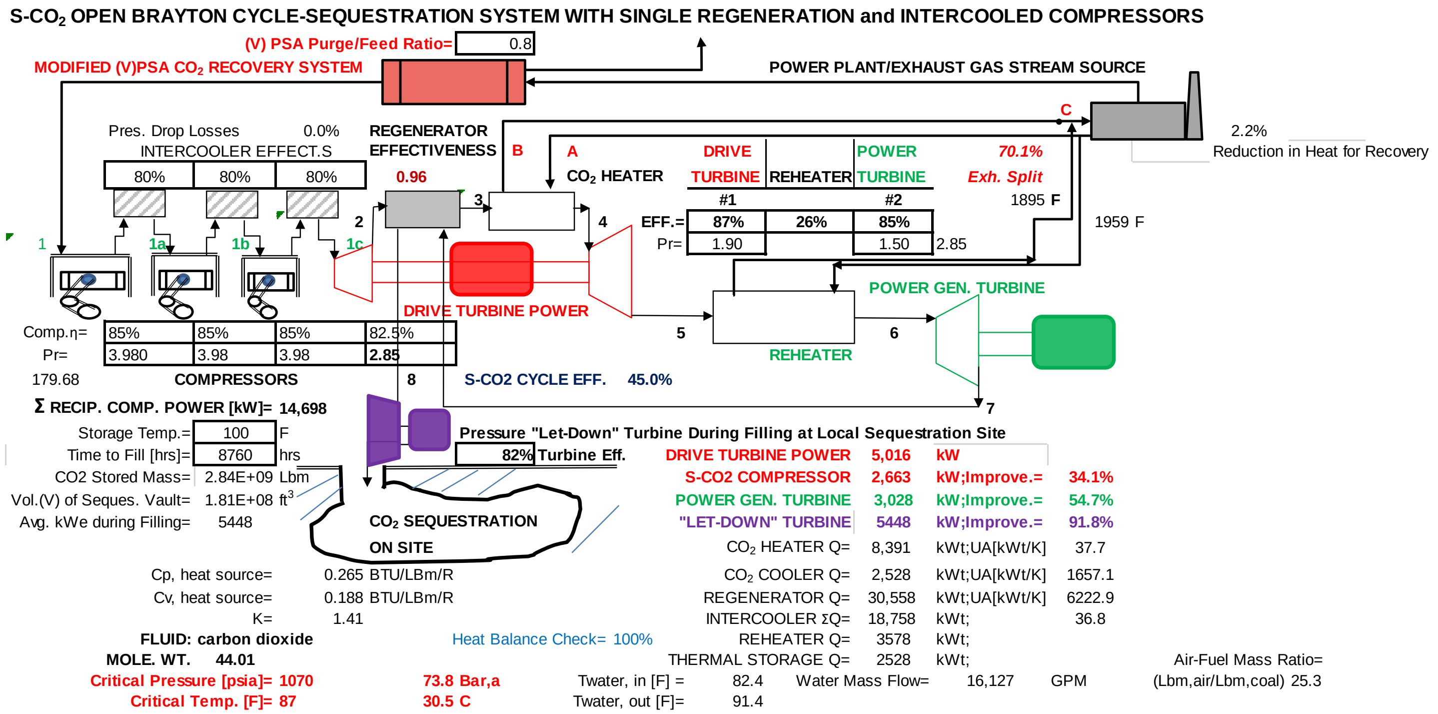
V3 [cft/s]=	21.341	Flow Rate	3.24E+05	lbm/hr	40.92 kg/s
Had [ft-lbf/lbm]=	37970	P,in	3126	psia	21.56 Mpa
Had [kJ/kg]=	113	T,in	1259	F	954.6 K
D [ft]=	0.492	P,out	1645	psia	11.345 MPa
N [rpm]=	40,000	P,stage,out	1645	psia	11.345 MPa
No. of Stages=	1		87%	Turbine Eff.	
Ns=	67.9	Δh,issen.=	113.4	KJ/Kg	
Ds=	1.49				4038 kW
Tip Speed [m/s]=	314	**Ns=**	**14.10**		
Tip Speed [ft/s]=	1030	**Ds=**	**3.69**		

V/Us= 0.66

1564

0.150	**Dia (m)**	**1030**	ft/s
40000	**RPM**		
1	**No. of Stg.s**		

Figure 2b. Turbine Design Specifications for 700°C Cycle shown in Figure 1



	1	1a	1b	1c	2	3	4	5	6	7	8	9	A	B	C
Pres. [psia]	17.4	69	276	1097	3126	3126	3126	1645	1645	1097	1097		14.9	14.7	14.7
Temp. [F]	200	154.4	143.7	142.5	319	1373	1659	1485	1608	1503	371		1959	1895	1895
Enthalpy [Btu/lbm]	243.5	232.6	225.6	200.8	228.8	550.6	638.9	586.1	623.8	591.9	270.1		519.1	502.2	502.2
Density [Lbm/ft^3]	0.11	0.47	2.01	10.78	21.07	6.66	5.75	3.38	3.18	2.25	5.85		0.017	0.017	0.017
Flow rate [Lbm/s]	90.03	90.03	90.03	90.03	90.03	90.03	90.03	90.03	90.03	90.03	90.03		471	471	672
Entropy [Btu/Lbm/R]	0.6899	0.6109	0.5391	0.4451	0.4515	0.7153	0.7601	0.7642	0.7830	0.7859	0.5438				
CO_2 Cp	0.22	0.22	0.23	0.42	0.39	0.31	0.31	0.30	0.31	0.30	0.27				
Pres. bar,a	1.2	4.8	19.0	75.7	215.6	215.6	215.6	113.4	113.4	75.6	75.6		1	1	1
Temp. [K]	366.3	341.0	335.0	334.4	432.3	1017.8	1176.8	1080.4	1148.8	1090.2	461.2		1343.5	1308.1	1308.1
Enthalpy [KJ/kG]	565	540	524	466	531	1279	1484	1361	1449	1375	627		1205	1166	1166
Temp. [C]	93	68	62	61	159	745	904	807	876	817	188				
Density [kG/m^3]	2	8	32	173	338	107	92	54	51	36	94		0	0	0
Mass Flow [Kg/s]	40.92	40.92	40.92	40.92	40.92	40.92	40.92	40.92	40.92	40.92	40.92		214.09	214.09	305.37
Vol. Flow [Nm^3/hr]	79820	79820	79820	79820	79820	79820	79820	79820	79820	79820	79820		637929	637929	909933

Figure 3. (SCO_2)^2 System With 900°C Turbine Inlet Temperature

The unique characteristics of the **(SCO_2)^2** cycle include:

- An SCO_2 cycle that uses, as a working fluid, the same CO_2 that is recovered from the utility waste heat source.
- A PSA system that removes CO_2 gas from the exhaust gas waste stream. The best choice for CO_2 adsorbents that can operate at the temperatures anticipated in the integrated supercritical cycle have been researched by several contemporary and independent chemical engineering researchers [references 1, 2, and 3]. There is consensus that K-promoted hydrotalcite, in a high-pressure, high-temperature PSA system, can effectively recover CO_2 from utility power plant exhaust gas at higher-than-typical operating temperatures. In addition, a novel application of a pressure reduction turbine can be integrated into the proposed hybrid system. If a pressure reduction turbine is used as part of the PSA process, a savings of 10% of the power typically used in the vacuum pumping of the PSA sequence can be shown.

- A reheat turbine, which is added to the cycle to improve the SCO_2 cycle efficiency to 57%.
- Recovery of pressure energy from the local sequestration process, which occurs as the pressurized CO_2 leaves the open SCO_2 cycle and begins to fill the underground sequestration vaults. (A remote sequestration ground vault may require the same pressure let-down CO_2 turbine for some power recovery, but it would not be integrated into the SCO_2 turbine-compressor-generator proposed for facilities that can have local sequestration of recovered CO_2 gases.)

The use of the compressed CO_2 as the working fluid in an open SCO_2 cycle is unique and is among the innovations that are proposed for the **(SCO_2)^2** cycle. This open cycle design eliminates a very large SCO_2 cooler that otherwise is used in a typically closed SCO_2 cycle. Also, any CO_2 working fluid that leaks past shaft seals can be easily recovered, depressurized, and returned to the inlet of the PSA process for continued service. This design feature eliminates the need for very expensive dry gas seals and replaces their service with appropriately designed labyrinth seals or an equivalent, less-expensive seal.

There is considerable consensus [6] that future sequestration of CO_2 will need to be done at a great distance from the source of the CO_2, if the sequestration is to use limited geophysical (naturally occurring) vaults in the ground. For this to be successful, the CO_2 would need to be compressed at the source of the CO_2 and then transported in pipelines, much like natural gas is transported from its source in oil fields, or from liquid natural gas ports, to the site of demand.

This transportation approach requires that the pipes carrying CO_2 be small in diameter, which makes them inexpensive. The CO_2 is then transported at very high pressures; in fact, it has been suggested that these should be supercritical pressures. Once the CO_2 arrives at the empty and/or partially pressured geophysical vault, the pressure is reduced, “let-down”, until the vault is filled.

This pressure let-down is similar to what happens now when natural gas is transported between states, across long distances, at 700 psia, for example, and then is reduced to the local (end-of-the-line) pipeline pressures of 40 psig. In the case of the CO_2 sequestration, there is, basically, an empty hole in the ground that needs to be filled. The filling continues until the pressure in the vault increases to the acceptable storage level, or until the gas is absorbed into the ground substrate, or both. It can be shown that a pressure let-down turbine can recover approximately another 30% of power during this filling process.

Summary

The proposed SCO_2/PSA hybrid system will enable the cost-effective use of a CO_2 sequestration system in a fossil fuel power plant. The **(SCO_2)^2** cycle operates as a “topping cycle,” enabling the recovery of heat from the power plant’s highest heat source, and providing sufficient power to drive commercially-available sequestration CO_2 compressors. Concepts NREC has conducted a feasibility study that has demonstrated that a 10 MWe SCO_2/PSA system can service a 235 MWe coal-fired power plant. The proposed hybrid system enables CO_2 sequestration at 1,000 psig and provides almost all (80%) of the necessary CO_2 compression power.

Nomenclature

DS- Specific Diameter of turbine or compressor
NS- Specific Speed of turbine or compressor
PSA- Pressure Swing Absorption System for Carbon Dioxide capture
(SCO_2)^2- Sequestered Super critical CO_2 cycle with PSA carbon capture technology
SCO_2- Supercritical CO_2 Cycle

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