Trading Regenerator Size with Turbine Improved Efficiency in sCO_2 Systems to Enable a More Economical sCO_2 System

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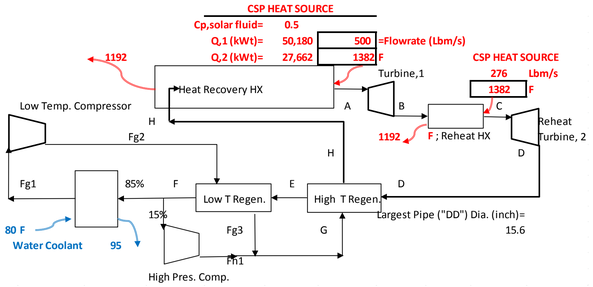
Supercritical CO_2 Power Cycles Symposium

Concepts NREC — The Experts in Turbomachinery

Sandia National Laboratories

QUESTION: IS 2 % IMPROVEMENT IN TURBOMACHINERY EQUIVALENT TO 20% INCREASE IN REGENERATOR SIZE FOR THE SAME CYCLE EFFICIENCY?



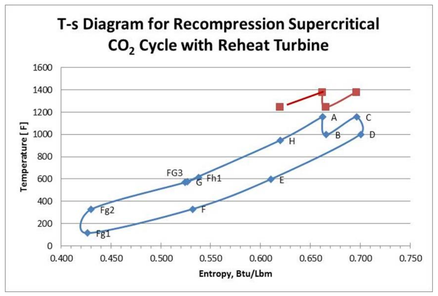


Figure 1a. Recompression SCO_2 Cycle but with a Reheat Turbine Sub-System

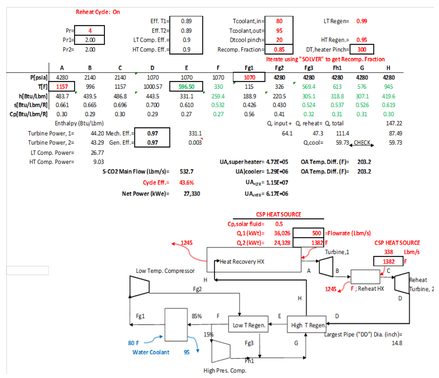


Figure 2. BASELINE Cycle State Points using Concepts NREC's Computer-Validated Cycle Model of Recompression SCO_2 System with Reheat Turbine. Note: 1. Turbine and Compressor Efficiencies: 89% and 90%. 2. High and Low Temp. Regenerator Effectiveness: 99% and 95%, and 3. Cycle Efficiency = 43.6%

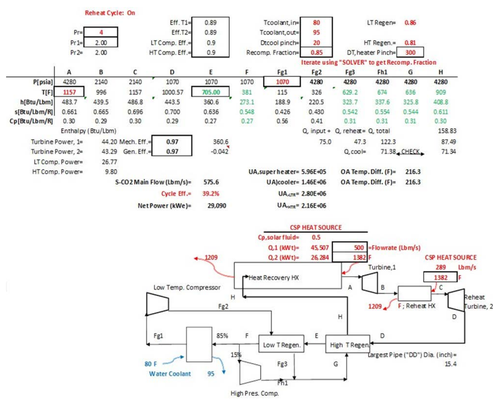


Figure 3a. CASE 1: SCO_2 Cycle with the Same Turbomachinery Efficiencies as shown in Figure 2 BUT with 78% Smaller Regenerator Results in only a 10% drop in Cycle Efficiency to 39.2%

ANSWER: YES!

In summary, comparing regenerator sizes and compressor-turbine efficiencies for Case 1 and 2 in Figures 3a and 3b:
UA, low temp. regen: 2.8 MBtu/hr/R vs. 2.33 MBtu/hr/R
UA, high temp. regen: 2.16 MBtu/hr/R vs. 1.67 MBtu/hr/R

CONCLUSION:

A reduction in regenerator size of 17.3%, by improving turbine and compressor efficiency by only 2.2%.

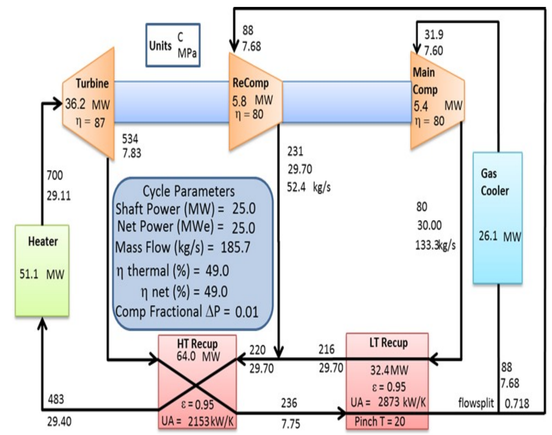


Figure 4. Sandia National Laboratories' Computer Output for Traditional Recompression SCO_2 Cycle.

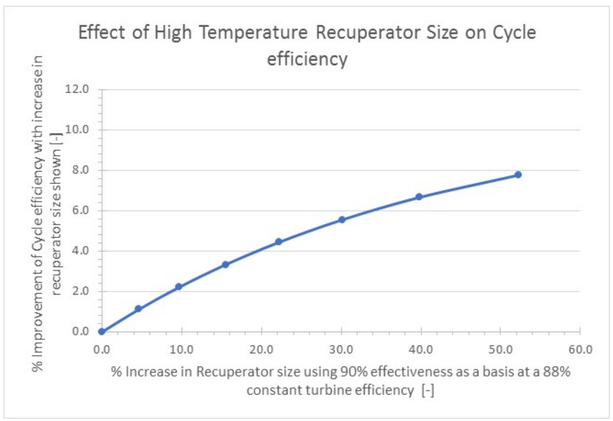


Figure 5a. Effect of HTR Size on Cycle Efficiency

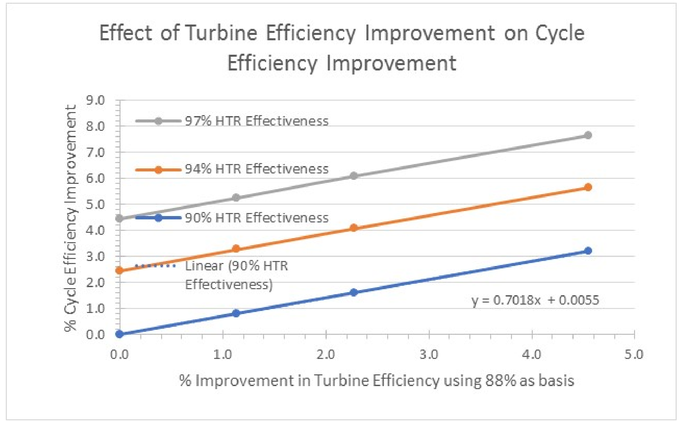


Figure 5b. Effect of Turbine Efficiency Improvement on Cycle Efficiency Improvement

HTR,effect.\tubine eff.	0.75	0.76	0.77	0.78	0.79	0.8	0.81	0.82	0.83	0.84	0.85	0.86	0.87	0.88	0.89	0.9	0.91	0.92	0.93	0.94
0.8	41.5235	41.9858	42.4425	42.8938	43.3364	43.777	44.2057	44.6393	45.0611	45.485	45.897	46.3078	46.7139	47.1155	47.5088	47.9015	48.2897	48.6699	49.05	49.4254
0.81	41.7286	42.1981	42.6556	43.1106	43.5569	43.9977	44.4365	44.8597	45.2917	45.7116	46.1302	46.5402	46.9492	47.3497	47.7456	48.1369	48.5238	48.9101	49.288	49.6661
0.82	41.948	42.4154	42.8768	43.3257	43.7824	44.2267	44.6656	45.0991	45.5201	45.9466	46.3645	46.7774	47.1854	47.5848	47.9871	48.3809	48.7702	49.1549	49.531	49.9073
0.83	42.1695	42.6312	43.1032	43.5593	44.013	44.4574	44.8997	45.3329	45.7643	46.1867	46.6076	47.0196	47.4266	47.8324	48.2334	48.6218	49.0174	49.4004	49.775	50.1571
0.84	42.3932	42.8656	43.3316	43.7915	44.249	44.697	45.1392	45.5757	46.0066	46.432	46.8521	47.263	47.6805	48.0852	48.4808	48.8796	49.2696	49.6549	50.036	50.4117
0.85	42.6258	43.0989	43.5655	44.0328	44.4905	44.9384	45.3841	45.8239	46.2581	46.6827	47.1058	47.5235	47.9319	48.3351	48.7414	49.1386	49.5268	49.9059	50.297	50.6712
0.86	42.8642	43.3415	43.8122	44.2726	44.7378	45.1893	45.6384	46.0739	46.5113	46.939	47.3651	47.7816	48.1928	48.6027	49.0033	49.3988	49.7849	50.179	50.56	50.9357
0.87	43.1051	43.5867	44.0614	44.5295	44.9872	45.4461	45.8949	46.3376	46.7743	47.2011	47.6302	48.0496	48.4592	48.8676	49.2707	49.6686	50.0613	50.4491	50.832	51.21
0.88	43.3559	43.8418	44.3169	44.7889	45.2543	45.7091	46.1535	46.6035	47.0435	47.4732	47.9013	48.3193	48.7316	49.1426	49.5482	49.9441	50.3392	50.7247	51.11	51.4807
0.89	43.6095	44.1035	44.5828	45.0549	45.5202	45.9786	46.4304	46.8758	47.3148	47.7433	48.1786	48.5994	49.0143	49.4236	49.8273	50.2256	50.6184	51.0061	51.384	51.766
0.9	43.8774	44.3643	44.8436	45.3278	45.7968	46.2548	46.7101	47.1588	47.5968	48.0326	48.4623	48.8859	49.2991	49.7109	50.1125	50.5085	50.8989	51.298	51.678	52.0573
0.91	44.1527	44.644	45.1275	45.6035	46.0722	46.5337	46.9881	47.4358	47.8856	48.3245	48.7527	49.1746	49.5949	50.0048	50.4087	50.807	51.2043	51.5915	51.973	52.3547
0.92	44.4316	44.9272	45.4149	45.895	46.3675	46.8327	47.2907	47.7418	48.186	48.6236	49.05	49.4746	49.893	50.3053	50.7116	51.1122	51.507	51.8962	52.275	52.6535
0.93	44.7224	45.2182	45.7102	46.1899	46.6663	47.1307	47.5922	48.042	48.4894	48.9253	49.3592	49.7818	50.2029	50.6128	51.0117	51.4145	51.8114	52.2027	52.588	52.9636
0.94	45.0173	45.5174	46.0137	46.4974	46.9731	47.4411	47.9015	48.3451	48.7957	49.2393	49.6712	50.0965	50.5202	50.9325	51.3387	51.7387	52.1328	52.521	52.893	53.2753
0.95	45.3161	45.8206	46.3165	46.7995	47.2883	47.7504	48.219	48.6754	49.1243	49.5612	49.996	50.4239	50.8402	51.2498	51.6633	52.0603	52.4564	52.8466	53.226	53.6044
0.96	45.6326	46.137	46.6372	47.1241	47.6074	48.0778	48.5401	48.9947	49.4467	49.8864	50.3239	50.7545	51.1731	51.5903	51.9957	52.3947	52.7876	53.1796	53.56	53.9355
0.97	45.9587	46.4675	46.9672	47.458	47.9403	48.4142	48.8749	49.3326	49.7878	50.2251	50.6602	51.0882	51.5091	51.9286	52.3254	52.7372	53.132	53.5095	53.897	54.2741