More Complex Brayton Cycles

TABLE 6.9
Results of Brayton Cycle Cases of Examples 6.7 through 6.14

Parameter	Ex. 6.7	Ex. 6.8	Ex. 6.9	Ex. 6.10A	Ex. 6.10B	Ex. 6.11	Ex. 6.12	Ex. 6.13	Ex. 6.14
$\beta = \left(\frac{p_2 p_4}{p_3 p_1}\right)^{\gamma-1/\gamma}$	1.0	1.0	1.05	1.0	1.0	1.0	1.0	1.0	1.0
Component isentropic efficiency (η_s)	1.0	0.9	0.9	1.0	0.9	1.0	1.0	1.0	1.0
Regenerator effectiveness (ξ)	—	—	—	0.95	0.95	0.95	—	—	—
Pressure ratio (r_p)	4	4	4	4	4	8	4	4	4
Intercooling	—	—	—	—	—	—	$\frac{p_1'}{p_1} = \frac{1}{2}\frac{p_2}{p_1}$ $T_1'' = T_1$	—	$\frac{p_1'}{p_1} = \frac{1}{2}\frac{p_2}{p_1}$ $T_1'' = T$
Reheat	—	—	—	—	—	—	—	$\frac{p_3'}{p_4} = \frac{1}{2}\frac{p_3}{p_4}$ $T_3'' = T_3$	$\frac{p_3'}{p_4} = \frac{1}{2}\frac{p_3}{p_4}$ $T_3'' = T_3$
Turbine work ($\dot{W}_T/\dot{m}$) Btu/lb MJ/kg	925.9	833.3	776.5	925.9	833.3	1229.4	925.9	1052.5	1052.5
	2.150	1.935	1.803	2.150	1.935	2.855	2.150	2.444	2.444
Compressor work ($\dot{W}_c/\dot{m}$) Btu/lb MJ/kg	458.7	509.7	509.7	458.7	509.7	801.9	395.96	458.7	395.96
	1.066	1.184	1.184	1.066	1.184	1.862	0.920	1.066	0.920
Net work ($\dot{W}_{NET}/\dot{m}$ Btu/lb MJ/kg	467.2	323.6	266.9	467.2	323.6	427.5	529.9	593.8	656.5
	1.084	0.752	0.620	1.084	0.752	0.993	1.23	1.378	1.524
Heat in ($\dot{Q}_R/\dot{m}$) Btu/lb MJ/kg	1103.0	1052.9	1052.9	934.9	844.4	1205.7	1364.5	1630.1	1890.8
	2.560	2.45	2.45	2.172	1.961	2.800	3.169	3.786	4.391
Cycle thermal efficiency (η_{th})(%)	42.3	30.7	25.3	50.0	38.3	35.46	38.8	36.4	34.7

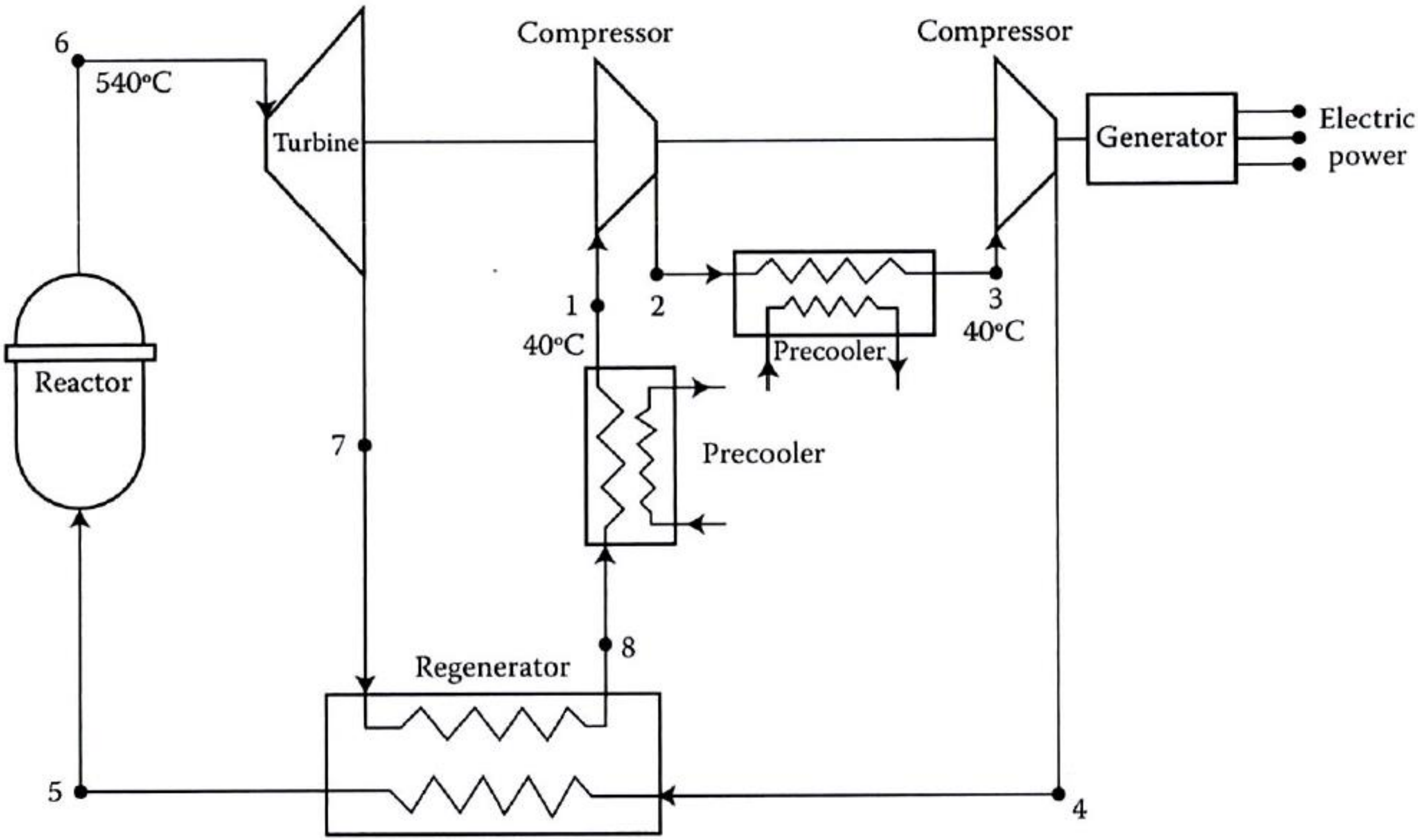
A gas-cooled reactor is designed to heat helium gas to a maximum temperature of 540°C. The helium flows through a gas turbine, generating work to run the compressors and an electric generator, and then through a regenerative heat exchanger and two stages of compression with pre-cooling to 40°C before entering each compressor. Each compressor and the turbine have an isentropic efficiency of 85%, and the exchanger drop factor β is equal to 1.05. Each compression stage has a pressure ratio (r_p) of 1.27. The heat exchanger effectiveness (ξ) is 0.90.

Determine the cycle thermal efficiency. The Brayton cycle system is illustrated in Figure 6.42. The pressure drop factor β is defined as

$$\beta \equiv \left(\frac{p_4}{p_6} \cdot \frac{p_7}{p_1} \cdot \frac{p_2}{p_3} \right)^{\gamma-1/\gamma} = 1.05$$

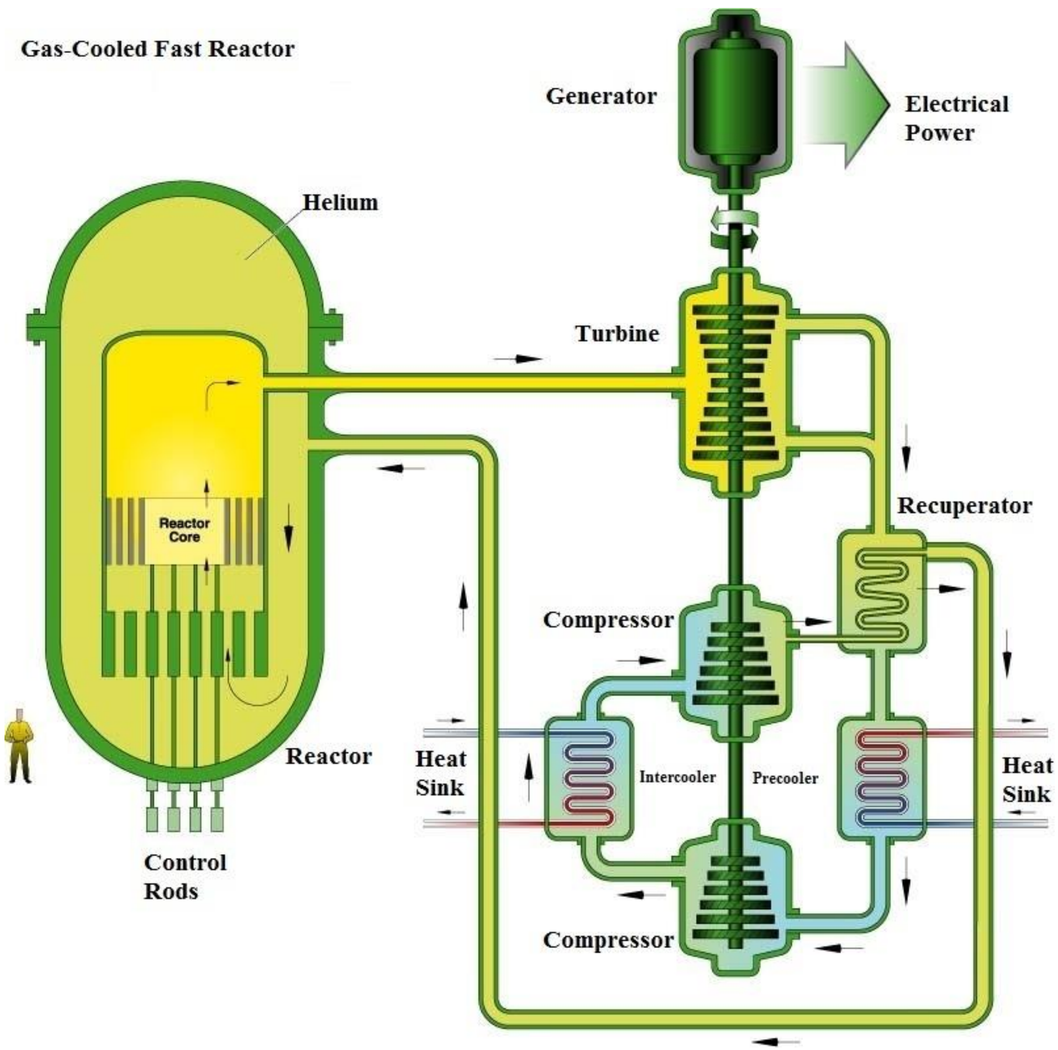
Answer: $\eta_{th} = 13.8\%$

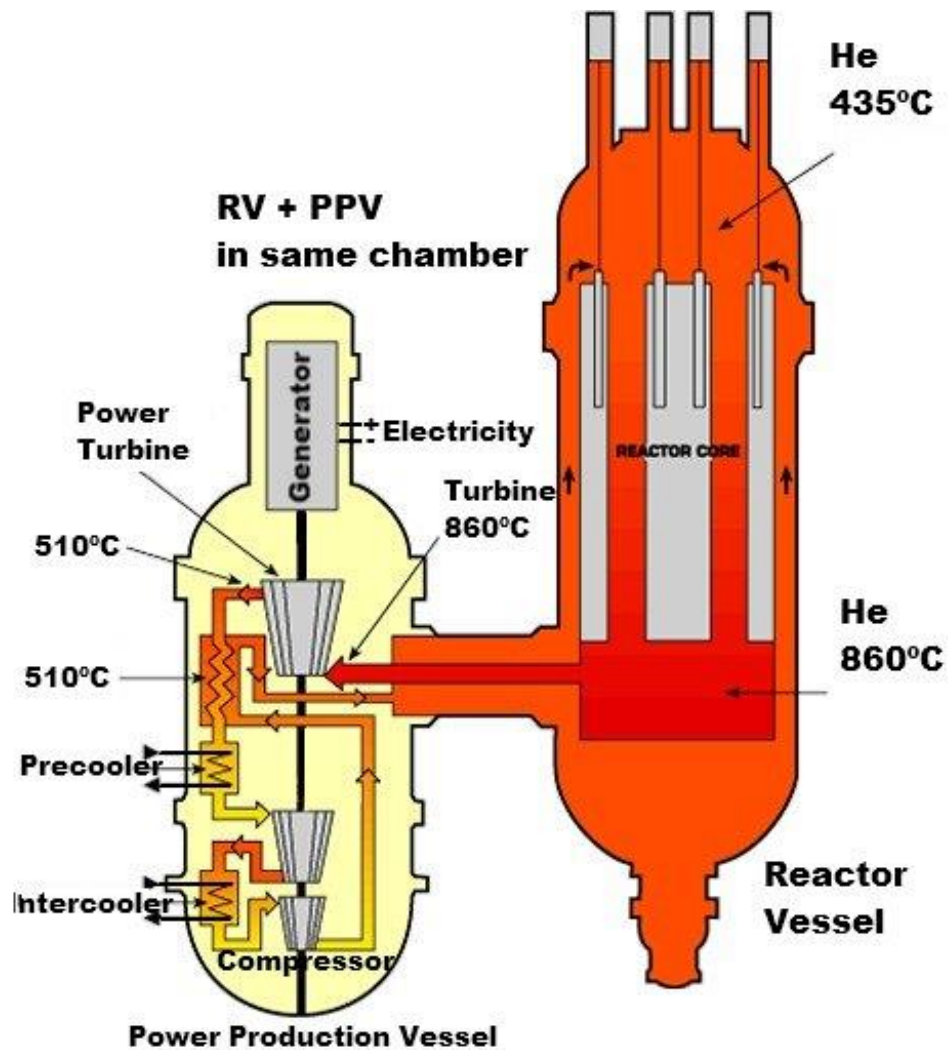
More Complex Brayton Cycles



Simple Brayton Cycle

- Brayton Cycle

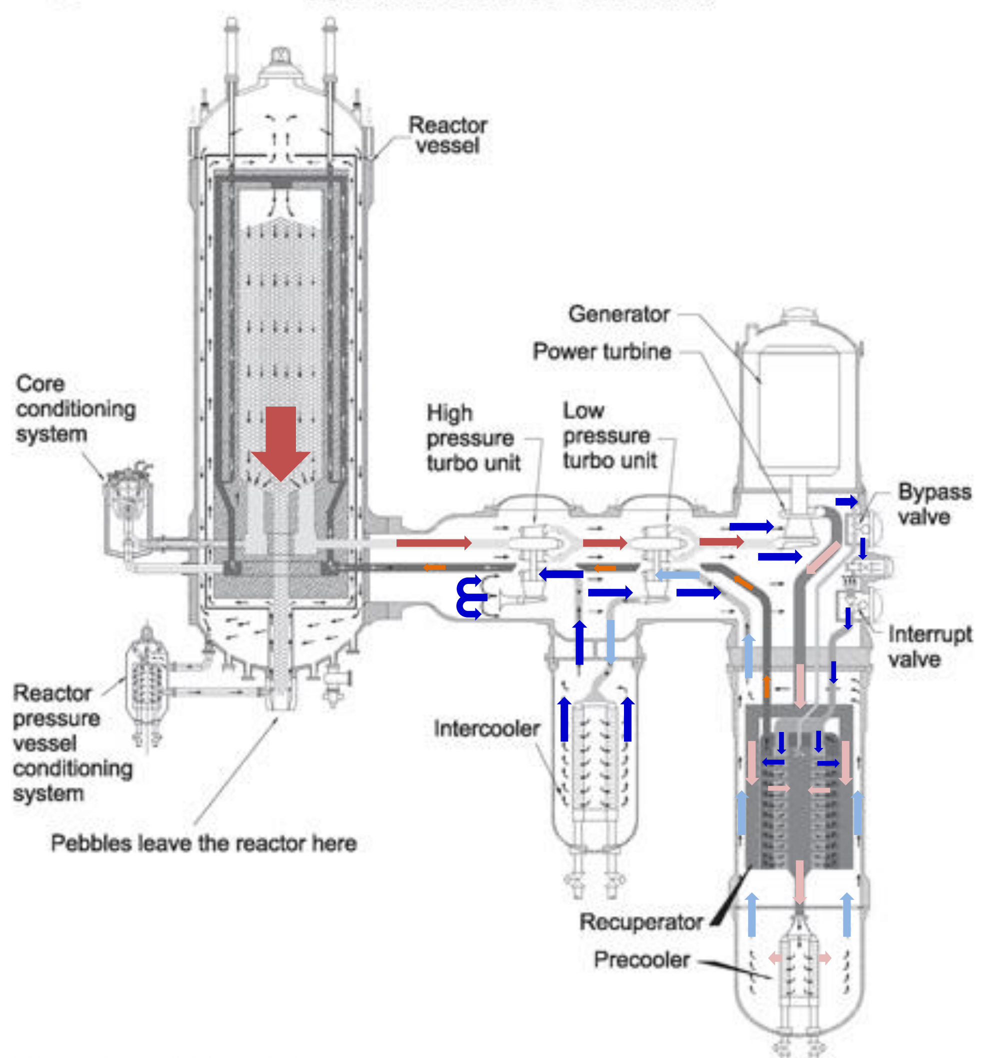




Simple Brayton Cycle

- Brayton Cycle

Figure 2



Source: Courtesy of Eskom

Contents of Lecture

- Contents of lecture
  - Chapter 1 Principal Characteristics of Power Reactors
    - Will be replaced by the lecture note
    - Introduction to Nuclear Systems
  - Chapter 4 Transport Equations for Single-Phase Flow (up to energy equation)
  - Chapter 6 Thermodynamics of Nuclear Energy Conversion Systems: Nonflow and Steady Flow : First- and Second-Law Applications
  - Chapter 7 Thermodynamics of Nuclear Energy Conversion Systems : Nonsteady Flow First Law Analysis
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  - Chapter 8 Thermal Analysis of Fuel Elements

Nuclear system

Thermodynamics

Heat transport
Conduction
heat transfer