

10-90 A combined gas-steam power plant is considered. The topping cycle is a gas-turbine cycle and the bottoming cycle is a nonideal reheat Rankine cycle. The moisture percentage at the exit of the low-pressure turbine, the steam temperature at the inlet of the high-pressure turbine, and the thermal efficiency of the combined cycle are to be determined.

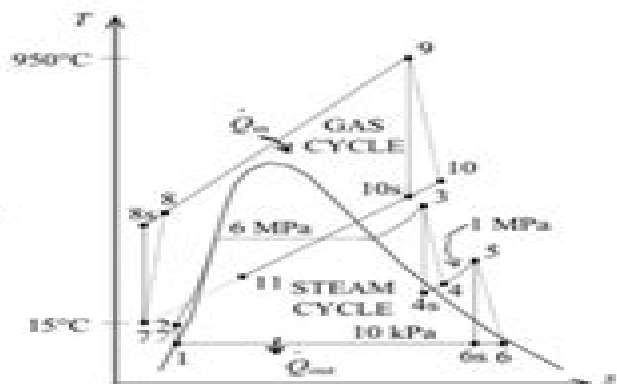
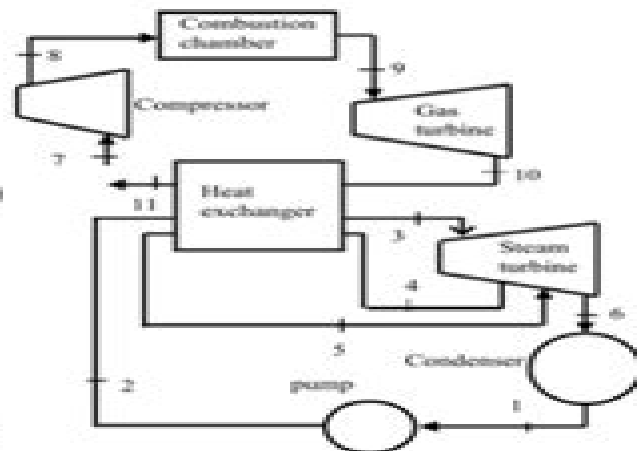
Assumptions 1 Steady operating conditions exist. 2 Kinetic and potential energy changes are negligible. 3 Air is an ideal gas with variable specific heats.

Analysis (a) We obtain the air properties from EES. The analysis of gas cycle is as follows.

$$\begin{aligned}
 T_7 = 15^\circ\text{C} &\longrightarrow h_7 = 288.50 \text{ kJ/kg} \\
 \left. \begin{aligned} T_7 = 15^\circ\text{C} \\ P_7 = 100 \text{ kPa} \end{aligned} \right\} & s_7 = 5.6648 \text{ kJ/kg} \\
 \left. \begin{aligned} P_8 = 700 \text{ kPa} \\ s_8 = s_7 \end{aligned} \right\} & h_{8s} = 503.47 \text{ kJ/kg} \\
 \eta_C = \frac{h_{8s} - h_7}{h_8 - h_7} &\longrightarrow h_8 = h_7 + (h_{8s} - h_7)/\eta_C \\
 &= 290.16 + (503.47 - 290.16)/(0.80) \\
 &= 557.21 \text{ kJ/kg} \\
 T_9 = 950^\circ\text{C} &\longrightarrow h_9 = 1304.8 \text{ kJ/kg} \\
 \left. \begin{aligned} T_9 = 950^\circ\text{C} \\ P_9 = 700 \text{ kPa} \end{aligned} \right\} & s_9 = 6.6456 \text{ kJ/kg} \\
 \left. \begin{aligned} P_{10} = 100 \text{ kPa} \\ s_{10} = s_9 \end{aligned} \right\} & h_{10s} = 763.79 \text{ kJ/kg} \\
 \eta_T = \frac{h_9 - h_{10s}}{h_9 - h_{10}} &\longrightarrow h_{10} = h_9 - \eta_T (h_9 - h_{10s}) \\
 &= 1304.8 - (0.80)(1304.8 - 763.79) \\
 &= 871.98 \text{ kJ/kg} \\
 T_{11} = 200^\circ\text{C} &\longrightarrow h_{11} = 475.62 \text{ kJ/kg}
 \end{aligned}$$

From the steam tables (Tables A-4, A-5, and A-6 or from EES),

$$\begin{aligned}
 h_f @ 10 \text{ kPa} &= 191.81 \text{ kJ/kg} \\
 v_f @ 10 \text{ kPa} &= 0.00101 \text{ m}^3/\text{kg} \\
 w_{\text{pump}} = w_f (P_2 - P_1)/\eta_P &= (0.00101 \text{ m}^3/\text{kg})(6000 - 10 \text{ kPa}) \left(\frac{1 \text{ kJ}}{1 \text{ kPa} \cdot \text{m}^3} \right) / 0.80 \\
 &= 7.56 \text{ kJ/kg} \\
 h_2 = h_1 + w_{\text{pump}} &= 191.81 + 7.65 = 199.37 \text{ kJ/kg} \\
 \left. \begin{aligned} P_3 = 1 \text{ MPa} \\ T_3 = 400^\circ\text{C} \end{aligned} \right\} & h_3 = 3264.5 \text{ kJ/kg} \\
 & s_3 = 7.4670 \text{ kJ/kg} \cdot \text{K} \\
 \left. \begin{aligned} P_6 = 10 \text{ kPa} \\ s_{6s} = s_3 \end{aligned} \right\} & x_{6s} = \frac{s_{6s} - s_f}{s_{fg}} = \frac{7.4670 - 0.6492}{7.4996} = 0.9091 \\
 & h_{6s} = h_f + x_{6s} h_{fg} = 191.81 + (0.9091)(2392.1) = 2366.4 \text{ kJ/kg}
 \end{aligned}$$



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F. Carl Knopf



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Supplementary Material and Solutions Manual for Mathematical Modeling in the Environment Charles R. Hadlock, 2020-05-05 This manual is meant to provide supplementary material and solutions to the exercises used in Charles Hadlock's textbook *Mathematical Modeling in the Environment*. The manual is invaluable to users of the textbook as it contains complete solutions and often further discussion of essentially every exercise the author presents in his book. This includes both the mathematical/computational exercises as well as the research questions and investigations. Since the exercises in the textbook are very rich in content rather than simple mechanical problems and cover a wide range, most readers will not have the time to work out every one on their own. Readers can thus still benefit greatly from perusing solutions to problems they have at least thought about briefly. Students using this manual still need to work out solutions to research questions using their own sources and adapting them to their own geographic locations or to numerical problems using their own computational schemes, so this manual will be a useful guide to students in many course contexts. Enrichment material is included on the topics of some of the exercises. Advice for teachers who lack previous environmental experience but who want to teach this material is also provided and makes it practical for such persons to offer a course based on these volumes. This book is the essential companion to *Mathematical Modeling in the Environment*. **Modeling, Analysis and Optimization of Process and Energy Systems** F. Carl Knopf, 2011-12-14 Energy costs impact the profitability of virtually all industrial processes. Stressing how plants use power and how that power is actually generated, this book provides a clear and simple way to understand the energy usage in various processes as well as methods for optimizing these processes using practical hands-on simulations and a unique approach that details solved problems utilizing actual plant data. Invaluable information offers a complete energy saving approach essential for both the chemical and mechanical engineering curricula as well as for practicing engineers. **Pilots' Powerplant Manual** United States. Civil Aeronautics Administration, Lawrence Ellsworth Shedenhelm, 1940 **Application of Expert Systems in the Power Generation Industry** PEP (Professional Engineering Publishers), 1993-04-15 A collection of papers presented at a seminar organized by the steam plant committee on the application of expert systems in the power generation industry. Topics covered include computerized knowledge-based systems for fossil plant productivity and cost and performance modelling system for power generators. **War Department Education Manual** United States Armed Forces Institute, *Scientific and Technical Books in Print*, 1972 [Introduction to Energy, Renewable Energy and Electrical Engineering](#) Ewald F. Fuchs, Heidi A. Fuchs, 2020-12-15 A great resource for beginner students and professionals alike. *Introduction to Energy, Renewable Energy and Electrical Engineering Essentials for Engineering Science*. STEM Professionals and Students brings together the fundamentals of Carnot's laws of thermodynamics, Coulomb's law, electric circuit theory and semiconductor technology. The book is the perfect introduction to energy-related fields for undergraduates and non-electrical engineering students and

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