

3.240

A piston/cylinder arrangement B is connected to a 1-m³ tank A by a line and valve, shown in Fig. P3.240. Initially both contain water, with A at 100 kPa, saturated vapor and B at 400°C, 300 kPa, 1 m³. The valve is now opened and, the water in both A and B comes to a uniform state.

- Find the initial mass in A and B.
- If the process results in $T_2 = 200^\circ\text{C}$, find the heat transfer and work.

Solution:

C.V.: A + B. This is a control mass.

$$\text{Continuity equation: } m_2 = (m_{A1} + m_{B1}) = 0;$$

$$\text{Energy: } m_2 u_2 = m_{A1} u_{A1} + m_{B1} u_{B1} = {}_1Q_2 + {}_1W_2$$

$$\text{System: if } V_B \geq 0 \text{ piston floats} \Rightarrow P_B = P_{B1} = \text{const.}$$

$$\text{if } V_B = 0 \text{ then } P_2 < P_{B1} \text{ and } v = V_A/m_{\text{tot}} \text{ see P-V diagram}$$

$${}_1W_2 = \int P_B dV_B = P_{B1}(V_2 - V_1)_B = P_{B1}(V_2 - V_1)_{\text{tot}}$$

State A1: Table B.1.1, $x = 1$

$$v_{A1} = 1.694 \text{ m}^3/\text{kg}, \quad u_{A1} = 2506.1 \text{ kJ/kg}$$

$$m_{A1} = V_A/v_{A1} = 0.5903 \text{ kg}$$

State B1: Table B.1.2 sup. vapor

$$v_{B1} = 1.0315 \text{ m}^3/\text{kg}, \quad u_{B1} = 2965.5 \text{ kJ/kg}$$

$$m_{B1} = V_{B1}/v_{B1} = 0.9695 \text{ kg}$$

$$m_2 = m_{\text{TOT}} = 1.56 \text{ kg}$$

$$* \text{ At } (T_2, P_{B1}) \quad v_2 = 0.7163 > v_a = V_A/m_{\text{tot}} = 0.641 \text{ so } V_{B2} > 0$$

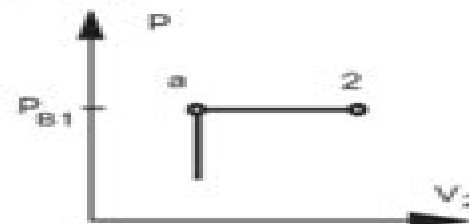
$$\text{so now state 2: } P_2 = P_{B1} = 300 \text{ kPa}, \quad T_2 = 200^\circ\text{C}$$

$$\rightarrow u_2 = 2650.7 \text{ kJ/kg} \quad \text{and} \quad V_2 = m_2 v_2 = 1.56 \times 0.7163 = 1.117 \text{ m}^3$$

$$(\text{we could also have checked } T_a \text{ at: } 300 \text{ kPa}, 0.641 \text{ m}^3/\text{kg} \rightarrow T = 155^\circ\text{C})$$

$${}_1W_2 = P_{B1}(V_2 - V_1) = -264.82 \text{ kJ}$$

$${}_1Q_2 = m_2 u_2 - m_{A1} u_{A1} - m_{B1} u_{B1} + {}_1W_2 = -484.7 \text{ kJ}$$



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Stavros Tavoularis



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Fundamentals of Thermodynamics Claus Borgnakke, 2025-01-09 Discover the Basics of Thermodynamics with the Field's Leading Textbook for over Thirty Years Thermodynamics is the branch of physics concerning the relationship between heat and temperature on the one hand and energy entropy and the properties of matter on the other Its engineering applications are innumerable and include engine design heat transfer air conditioning and refrigeration energy conversion and more For more than three decades *Fundamentals of Thermodynamics* has served as the foundational introduction to this subject for students and interested readers Now fully updated to incorporate the latest research and new pedagogical tools it promises to continue as the field's indispensable survey Readers of the Eleventh Edition of *Fundamentals of Thermodynamics* will find Detailed step by step worked through examples to facilitate learning New material on statistical thermodynamics and other burgeoning subjects An expansive collection of online resources including bonus chapters additional problem sets study problems and more *Fundamentals of Thermodynamics* is ideal for students and instructors in thermodynamics or engineering of thermodynamics at the intermediate or advanced undergraduate level

Fundamental Fluid Mechanics and Magnetohydrodynamics Roger J. Hosking, Robert L. Dewar, 2015-10-19 This book is primarily intended to enable postgraduate research students to enhance their understanding and expertise in Fluid Mechanics and Magnetohydrodynamics MHD subjects no longer treated in isolation The exercises throughout the book often serve to provide additional and quite significant knowledge or to develop selected mathematical skills and may also fill in certain details or enhance readers' understanding of essential concepts A previous background or some preliminary reading in either of the two core subjects would be advantageous and prior knowledge of multivariate calculus and differential equations is expected

Advances in Mechanical Engineering B. B. Biswal, Bikash Kumar Sarkar, P. Mahanta, 2020-01-16 This book comprises select proceedings of the International Conference on Recent Innovations and Developments in Mechanical Engineering IC RIDME 2018 The book contains peer reviewed articles covering thematic areas such as fluid mechanics renewable energy materials and manufacturing thermal engineering vibration and acoustics experimental aerodynamics turbo machinery and robotics and mechatronics Algorithms and methodologies of real time problems are described in this book The contents of this book will be useful for both academics and industry professionals

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research interests include turbulence structure turbulent diffusion vortical flows aerodynamics biofluid dynamics nuclear reactor thermal hydraulics and the development of experimental methods Professor Tavoularis is a Fellow of the Engineering Institute of Canada a Fellow of the Canadian Society for Mechanical Engineering and a recipient of the George S Glinski Award for Excellence in Research Contents Part I General concepts 1 Flow properties and basic principles 2 Measuring systems 3 Measurement uncertainty 4 Signal conditioning discretization and analysis 5 Background for optical experimentation 6 Fluid mechanical apparatus 7 Towards a sound experiment Part II Measurement techniques 8 Measurement of flow pressure 9 Measurement of flow rate 10 Flow visualization techniques 11 Measurement of local flow velocity 12 Measurement of temperature 13 Measurement of composition 14 Measurement of wall shear stress 15 Outlook

Process Plant Equipment Michael D. Holloway, Chikezie Nwaoha, Oliver A. Onyewuenyi, 2012-08-20 Process Plant Equipment Book is another great publication from Wiley as a reference book for final year students as well as those who will work or are working in chemical production plants and refinery Associate Prof Dr Ramli Mat Deputy Dean Academic Faculty of Chemical Engineering Universiti Teknologi Malaysia give s readers access to both fundamental information on process plant equipment and to practical ideas best practices and experiences of highly successful engineers from around the world The book is illustrated throughout with numerous black white photos and diagrams and also contains case studies demonstrating how actual process plants have implemented the tools and techniques discussed in the book An extensive list of references enables readers to explore each individual topic in greater depth Stainless Steel World and Valve World November 2012 Discover how to optimize process plant equipment from selection to operation to troubleshooting From energy to pharmaceuticals to food the world depends on processing plants to manufacture the products that enable people to survive and flourish With this book as their guide readers have the information and practical guidelines needed to select operate maintain control and troubleshoot process plant equipment so that it is efficient cost effective and reliable throughout its lifetime Following the authors careful explanations and instructions readers will find that they are better able to reduce downtime and unscheduled shutdowns streamline operations and maximize the service life of processing equipment Process Plant Equipment Operation Control and Reliability is divided into three sections Section One Process Equipment Operations covers such key equipment as valves pumps cooling towers conveyors and storage tanks Section Two Process Plant Reliability sets forth a variety of tested and proven tools and methods to assess and ensure the reliability and mechanical integrity of process equipment including failure analysis Fitness for Service assessment engineering economics for chemical processes and process component function and performance criteria Section Three Process Measurement Control and Modeling examines flow meters process control and process modeling and simulation Throughout the book numerous photos and diagrams illustrate the operation and control of key process equipment There are also case studies demonstrating how actual process plants have implemented the tools and techniques discussed in the book At the end of

each chapter an extensive list of references enables readers to explore each individual topic in greater depth In summary this text offers students process engineers and plant managers the expertise and technical support needed to streamline and optimize the operation of process plant equipment from its initial selection to operations to troubleshooting

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Metabolism and Medicine Brian Fertig, 2022-01-25 Chronic disease states of aging should be viewed through the prism of metabolism and biophysical processes at all levels of physiological organization present in the human body This book describes the building blocks of understanding from a reasonable but not high level technical language viewpoint employing

the perspective of a clinical physician It brings together concepts from five specific branches of physics relevant to biology and medicine namely biophysics classical electromagnetism thermodynamics systems biology and quantum mechanics Key Features Broad and up to date overview of the field of metabolism especially connecting the spectrum of topics that range from modern physical underpinnings with cell biology to clinical practice Provides a deeper basic science and interdisciplinary understanding of biological systems that broaden the perspectives and therapeutic problem solving Introduces the concept of the Physiological Fitness Landscape which is inspired by the physics of phase transitions This first volume in a two volume set primarily targets an audience of clinical and science students biomedical researchers and physicians who would benefit from understanding each other s language

Aircraft Thermal Management Mark Ahlers,2016-03-02 The simultaneous operation of all systems generating moving or removing heat on an aircraft is simulated using integrated analysis which is called Integrated Energy System Analysis IESA for this book Its purpose is to understand optimize and validate more efficient system architectures for removing or harvesting the increasing amounts of waste heat generated in commercial and military aircraft In the commercial aircraft industry IESA is driven by the desire to minimize airplane operating costs associated with increased system weight power consumption drag and lost revenue as cargo space is devoted to expanded cooling systems In military aircraft thermal IESA is also considered to be a key enabler for the successful implementation of the next generation jet fighter weapons systems and countermeasures This book contains a selection of papers relevant to aircraft thermal management IESA published by SAE International They cover both recently developed government and industry funded thermal management IESA such as the Integrated Vehicle Energy Technology INVENT program and older published papers still relevant today which address modeling approaches

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Mass and Energy Balances Seyed Ali Ashrafizadeh,Zhongchao Tan,2018-01-10 This textbook introduces students to mass and energy balances and focuses on basic principles for calculation design and optimization as they are applied in industrial processes and equipment While written primarily for undergraduate programs in chemical energy mechanical and environmental engineering the book can also be used as a reference by technical staff and design engineers interested who are in and or need to have basic knowledge of process engineering calculation Concepts and techniques presented in this volume are highly relevant within many industrial sectors including manufacturing oil gas green and sustainable energy and power plant design Drawing on 15 years of teaching experiences and with a clear understanding of students interests the authors have adopted a very accessible writing style that includes many examples and additional citations to research resources from the literature referenced at the ends of chapters

Steady State and Time Dependent Compressed Air Energy Storage Model Validated with Huntorf Operational Data and Investigation of Hydrogen Options for a Sustainable Energy Supply Friederike Kaiser,2020-12-17 Wind power and photovoltaic energy play a significant role in sustainable energy systems However these two renewable energy sources do not generate electrical energy on demand and are subject to natural fluctuations Thus the need for compensatory measures arises Compressed air energy storage power plants CAES are a possible solution to providing negative and positive control energy in the electric grid However in contrast to other energy storage devices such as pumped hydro energy storage or batteries the storage medium compressed air hardly contains any energy or more precisely enthalpy Yet compressed air storage allows the operation of highly efficient gas turbines which are not only particularly fast available but also achieve better efficiency than combined cycle power plants used today as illustrated by the example of the modern gas and steam power plant Irsching with η_{tc} 60% from 2011 compared to the 20 years older McIntosh CAES with η_{tc} 82.4 % In this thesis the calculation methods for the thermodynamics of the CAES process are presented and validated by measured data from the operations of the CAES power plant Huntorf Both the steady state and the dynamic time dependent analyses of the process take place The characteristic value efficiency is discussed in detail since numerous different interpretations for CAES exist in the literature A new calculation method for the electric energy storage efficiency is presented and a method for the calculation of an economically equivalent electricity storage efficiency is developed Consideration is given to the transformation of the CAES process into a hydrogen driven and thus

greenhouse gas free process Finally a model CAES system is tested in a 100 % renewable model environment Consequently it can be stated that in the steady state thermodynamic calculation in particular the consideration of realistic isentropic efficiencies of compressors and turbines is essential to correctly estimate the characteristic values of the process Furthermore a steady state view should always be accompanied by dynamic considerations since some process characteristics are always time dependent The simulation shows that by mapping transient operating conditions the overall efficiency of the system must be corrected downwards Nevertheless in the model environment of a 100 % renewable energy system it has been shown that a CAES is a useful addition that can provide long term energy storage

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