1. Record Nr. UNINA9910830597203321 Autore Benz Gregory T. Titolo Agitator design for gas-liquid fermenters and bioreactors / / Gregory T. Benz Pubbl/distr/stampa Hoboken, New Jersey:,: Wiley:,: AIChe,, [2021] ©2021 **ISBN** 1-5231-4316-9 1-119-65053-4 1-119-65054-2 1-119-65050-X Descrizione fisica 1 online resource (451 pages) Disciplina 660.28449 Soggetti Bioreactors - Equipment and supplies Lingua di pubblicazione Inglese **Formato** Materiale a stampa Livello bibliografico Monografia Cover -- Title Page -- Copyright Page -- Contents -- Preface --Nota di contenuto Foreword -- Foreword for Greg Benz -- Chapter 1 Purpose of Agitator Design -- References -- Chapter 2 Major Steps in Successful Agitator Design -- Define Process Results -- Define Process Conditions --Choose Tank Geometry -- Calculate Equivalent Power/Airflow Combinations for Equal Mass Transfer Rate -- Choose Minimum Combined Power -- Choose Shaft Speed -- Size Impeller System to Draw Required Gassed Power -- Decision Point: D/T and Gassing Factors OK? -- Mechanical Design -- Decision Point: Is the Mechanical Design Feasible? -- Repeat to Find Lowest Cost -- Repeat for Different Aspect Ratios -- Repeat for Different Process Conditions -- Finish --Summary of Chapter -- List of Symbols -- References -- Chapter 3 Agitator Fundamentals -- Agitated Tank Terminology -- Prime Mover -- Reducer -- Shaft Seal -- Wetted Parts -- Tank Dimensions -- How Agitation Parameters Are Calculated -- Reynolds Number -- Power Number -- Pumping Number -- Dimensionless Blend Time -- Aeration Number -- Gassing Factor -- Nusselt Number -- Froude Number --Prandtl Number -- Geometric Ratios -- Baffle Number --

Dimensionless Hydraulic Force -- Thrust Number -- Typical

Dimensionless Number Curves -- A Primer on Rheology -- Newtonian Model -- Pseudoplastic or Shear Thinning, Model (Aka Power Law Fluid) -- Bingham Plastic -- Herschel-Bulkley -- Impeller Apparent Viscosity -- A Bit of Impeller Physics -- Summary of Chapter -- List of Symbols -- Greek letters -- References -- Chapter 4 Agitator Behavior under Gassed Conditions -- Flooding -- kla Method -- Power Draw Method -- Visual Flow Pattern Method -- Effect on Power Draw -- Holdup -- Example of Holdup Calculation -- Holdup "War Story" -- Variable Gas Flow Operation -- Mechanical Effects -- Summary of Chapter -- List of Symbols -- References.

Chapter 5 Impeller Types Used in Fermenters -- Impeller Flow Patterns -- Axial Flow -- Radial Flow -- Mixed Flow -- Chaos Flow -- Examples of Axial Flow Impellers -- Low Solidity -- High Solidity -- Up-pumping vs. Down Pumping -- Examples of Radial Flow Impellers -- Straight Blade Impeller -- Disc, aka Rushton, Turbines -- Smith Turbines --CD-6 Turbine by Chemineer -- aka Smith Turbine by Many Manufacturers -- Deeply Concave Turbines -- Deep Asymmetric Concave Turbine with Overhang (BT-6) -- Examples of Mixed Flow Impellers -- Examples of Chaos Impellers -- Shear Effects -- Specialty Impellers -- Summary of Chapter -- List of Symbols -- References --Chapter 6 Impeller Systems -- Why Do We Need a System? -- Reaction Engineering -- Fermenter History -- Steps to Impeller System Design -- Choose Number of Impellers -- Choose Placement of Impellers --Choose Type(s) of Impellers -- Choose Power Split or Distribution Among Impellers -- Choose D/T and/or Shaft Speed -- D/T Effects with Variable Gas Flowrates -- Conclusions on D/T Ratio -- Design to Minimize Shear Damage -- Sparger Design -- Ring Sparger -- Predispersion -- Fine Bubble Diffuser -- Summary of Chapter -- List of Symbols -- References -- Chapter 7 Piloting for Mass Transfer -- Why Pilot for Mass Transfer -- Methods for Determining kla -- Sulfite Method -- Dynamic Method -- aka Dynamic Gassing/Degassing Method -- Steady-State Method -- aka Mass Balance Method --Combined Dynamic and Steady-State Method -- Equipment Needed for Scalable Data -- Data Gathering Needs -- Experimental Protocol --Summary of Chapter -- List of Symbols -- References -- Chapter 8 Power and Gas Flow Design and Optimization -- What This Chapter Is about -- Where We Are in Terms of Design -- Design with no Data --Design with Limited Pilot Data -- Design with Full Data -- Choose Minimum Combined Power.

State of Design Completion -- Additional Considerations -- Summary of Chapter -- List of Symbols -- References -- Chapter 9 Optimizing Operation for Minimum Energy Consumption per Batch -- Purpose of This Chapter -- Prerequisite -- Conceptual Overview -- Detailed Procedure -- Minimizing Total Energy Usage -- Practical Design --Additional Considerations -- Summary of Chapter -- List of Symbols --References -- Chapter 10 Heat Transfer Surfaces and Calculations --Purpose of This Chapter -- Design Philosophy -- Overview of the Problem -- Heat Sources -- Cooling Sources -- Heat Exchange Surface Overview -- Principle of Heat Transfer Calculation --Calculations By Type of Surface -- Vessel Jacket, Agitated Side --Simple Unbaffled Jacket, Jacket Side -- Dimple Jacket, Jacket Side --Half-Pipe Coil, Jacket Side -- Helical Coil, Inside -- Helical Coil, Process Side -- Vertical Tube Bundle, Inside -- Vertical Tube Bundle, Process Side -- Plate Coil, Inside -- Plate Coil, Process Side -- Example Problem: Vertical Tube Bundle -- Problem Statement -- Problem Solution -- Additional Consideration: Effect on Power Draw --Additional Consideration: Forces on Heat Exchange Surfaces Used as Baffles -- Additional Consideration: Wall Viscosity -- Additional

Consideration: Effect of Gas -- External Heat Exchange Loops -- Summary of Chapter -- List of Symbols -- References -- Further Readings -- Chapter 11 Gasses Other Than Air and Liquids Other Than Water -- General Principle -- Comments on Some Specific Gasses -- Ammonia -- Carbon Dioxide -- Carbon Monoxide -- Hydrogen -- Methane -- Oxygen -- Economic Factors -- Disposal Factors -- Effects of Different Gasses on Driving Force -- Operating Condition Effects -- Constraints on Outlet Concentration -- Safety -- Liquids Other Than Water -- Summary of Chapter -- List of Symbols.

References -- Chapter 12 Viscous Fermentation -- General Background

-- Sources of Viscosity -- Viscosity Models for Broths -- Effect

of Viscosity on Power Draw -- Example Problem -- Example Problem Answer -- Effect of Viscosity on kla -- Effect of Viscosity on Holdup --Effect of Viscosity on Blend Time -- Effect of Viscosity on Flooding --Caverns -- Estimating Cavern Size -- Xanthan and Gellan Gums --Viscosity Models for Gums -- Installation Survey -- Effect of D/T and No. and Type of Impellers on Results in Xanthan Gum -- Production Curve -- Heat Transfer -- All-Axial Impeller Design -- Invisible Draft Tube vs. Axial/Radial Combination -- Mycelial Broths -- Typical Viscosity Model -- Morphology Effects -- Recommendations --Summary of Chapter -- List of Symbols -- References -- Chapter 13 Three Phase Fermentation -- General Problem -- Effect on Mass Transfer -- Effect on Foam -- Emulsion vs. Suspension -- Complexity: How to Optimize Operation -- Summary of Chapter -- List of Symbols -- References -- Chapter 14 Use of CFD in Fermenter Design --Purpose of This Chapter -- Basic Theory -- Methods of Presenting Data -- Velocity Distribution -- Cavern Formation -- Blending Progress --Flow Around Coils -- Bubble Size, kla, Holdup -- DO Distribution --Summary of Chapter -- List of Symbols -- References -- Chapter 15 Agitator Seal Design Considerations -- Introduction -- Terminology --Main Functions of Fermenter Shaft Seals -- Common Types of Shaft Seals -- Material Considerations -- Methods of Lubricating Seals --Seal Environmental Control and Seal Support System -- Seal Life Expectations -- Special Process Considerations -- Summary of Chapter -- Reference -- Chapter 16 Fermenter Agitator Mounting Methods --Introduction -- Top Entering Methods -- Direct Nozzle Mount -- Beam Gear Drive Mount with Auxiliary Packing or Lip Seal. Beams Tied into Vessel Sidewall -- Beam Gear Drive Mount with Auxiliary Mechanical Seal -- Beams Tied into Vessel Sidewall --Beam Gear Drive Mount with Auxiliary Mechanical Seal -- Beams Tied into Building Structure -- Complete Drive and Seal Mount to Beams Tied into Vessel Sidewall, with Bellows Connector -- Complete Drive and Seal Mount to Beams Tied into Building Structure, with Bellows Connector -- Bottom Entering Methods -- Direct Nozzle Mount --Floor Gear Drive Mount with Auxiliary Packing or Lip Seal -- Floor Gear Drive Mount with Auxiliary Mechanical Seal -- Floor Integrated Drive and Seal Mount with Bellows Connector -- Summary of Chapter --References -- Chapter 17 Mechanical Design of Fermenter Agitators --Introduction -- Impeller Design Philosophy -- Discussion on Hydraulic Force -- Shaft Design Philosophy -- Shaft Design Based on Stress --Simple Example Problem -- Sample Problem with Steady Bearing --Shaft Design Based On Critical Speed -- Cantilevered Designs --Example Problem -- Units with Steady Bearings -- Solid Shaft vs. Hollow Shaft -- Role of FEA in Overall Shaft Design-Simplified Discussion -- Agitator Gear Drive Selection Concepts -- Early History -- Loads Imposed -- Handle or Isolate Loads? -- Handle Loads Option 1: Oversized Commercial Gear Drive -- Handle Loads Option 2:

Purpose-Built Agitator Drive -- Isolate Loads Option 1: Hollow Quill Integrated Drive with Flexibly Coupled Extension Shaft -- Isolate Loads Option 2: Outboard Support Bearing Module -- Bearing Life Considerations -- Noise Considerations -- Torsional Natural Frequency -- Important or Useful Mechanical Design Features -- Summary of Chapter -- List of Symbols -- Greek Letters -- References -- Chapter 18 Sanitary Design -- Introduction -- Definitions -- Construction Principles -- Wetted Parts Construction Methods -- Welded Construction -- In-Tank Couplings. Mounting Flange Area.

## Sommario/riassunto

"As in all kinds of process equipment, agitators must be correctly sized to deliver the process function, while maximizing return on investment and minimizing total energy cost. In a bioreactor, agitators are one of the prime drivers for promoting the development of gas/liquid interfacial area, which has a direct impact on mass transfer and hence production rate. Power consumption is a significant cost, which can be minimized by proper design of the agitation and air delivery systems. Finally, downtime is very expensive, so mechanically reliable agitators are essential. This book is an invaluable guide to the initiation, installation, and maintenance of agitators in fermenters and bioreactors"--