

BENCH-SCALE AUTOMATED BIOREACTOR

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PROJECT SPONSOR: DEV SHRESTHA, (UI BE)



OBJECTIVE AND VALUE PROPOSITION

This small-scale bioreactor system will help students learn practical applications of core principles like heat transfer, mass/energy balance, and instrumentation.

BACKGROUND

Continuous Stirred Tank Reactor (CSTR):

- Substrates and microorganisms (e.g., yeast) are continuously fed and products (e.g., ethanol) are steadily removed
- Constant agitation maintains optimal growth conditions

Microbial Growth Kinetics

Monod Model: Shows relationship between substrate concentration and growth rate at steady state to calculate dilution rate

$$\mu = \frac{\mu_{max} * S}{K_s + S}$$

Logistic Model: Describes growth limited by system constraints (carrying capacity), adjusting for biomass limitation

$$\mu = k * (1 - \frac{X}{X_{\infty}})$$

Flow Rate: Growth rate equals dilution rate (D), and $\mu = D = \frac{F}{V}$

Control System

Programmable Logic Controller (PLC): Top level logic and modular field I/O used in many process control applications

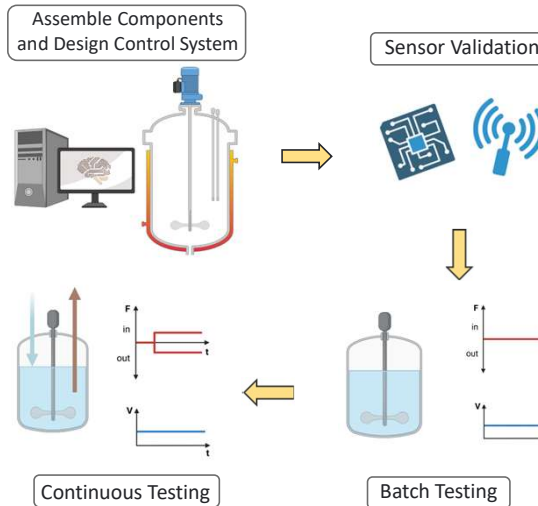
Ladder Logic: Instruction based programming used in PLC applications

Feedback Control System: Takes information from the system and uses it to execute controls.

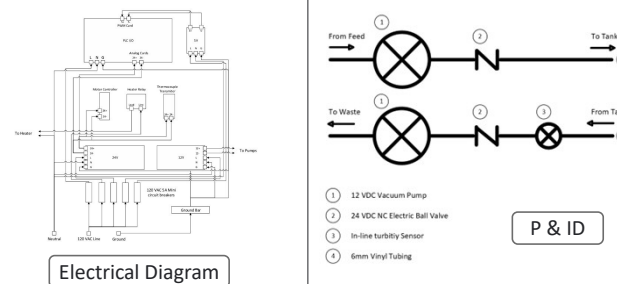
KEY REQUIREMENTS

- Capacity:** 2 Gallon Minimum
- Uniformity:** Maintain concentration, pH, and temperature within 5% of the desired value at any point
- Continuous Monitoring:** Measure and monitor the level, temperature, pH, dissolved oxygen, and pressure
- Control System:** Management of monitoring components
- Inoculation Ports:** To introduce culture or activated sludge, media, and preconditioned water
- Gas Sensing:** Sensors to measure methane, oxygen (O2), and carbon dioxide (CO2) concentration
- Maintenance:** Design allows for easy cleaning and disassembly

CONCEPT DEVELOPMENT

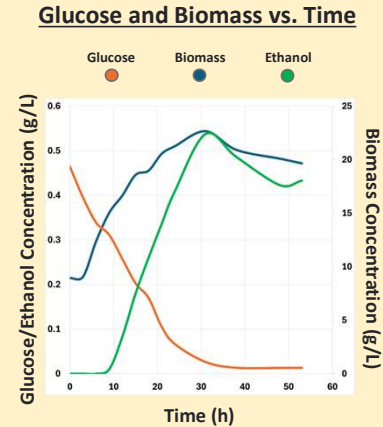


FINAL DESIGN



VALIDATION

Logistic Growth Rate Constant (K)	0.136 h ⁻¹
Maximum Specific Growth Rate (μ _{max})	0.852 h ⁻¹
Half Saturation Constant (K _s)	6.810 g/L
Maximum Flow Rate (F)	6.440 L/h
Biomass Yield (Y _{X/s})	0.018 g/g glucose
Product Yield (Y _{P/s})	1.227 g/g glucose



CONCLUSION AND RECOMMENDATIONS

Conclusion:

- Successful design and manufacturing of a functional control system for a small-scale bioreactor, demonstrating its potential for use in educational settings

Recommendations for Improvement:

- Implement a more robust pumping system to prevent backflow and reduce the risk of contamination
- Integrate a pressure sensor to enhance system monitoring and control accuracy

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