Bench Scale Carbon Dioxide Capture Educational Unit Operations Pilot Plant

Item Number: LPK-CEBJ

Introduction

This bench-scale educational pilot plant simulates industrial CO_2 separation using a multi-tower adsorption system for hands-on engineering training. Students achieve ≥90% CO_2 purity while studying pressure swing adsorption, desorption kinetics, and process control in gas purification experiments.

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Parameter	Description / Capability
Feed Gas Composition	Nitrogen and Carbon Dioxide mixture (typically 15:85 ratio or customizable)
CO_2 Product Concentration	≥ 90% after separation
Regeneration Temperature Range	100°C to 300°C via electric heating jacket control
Regeneration Methods	Vacuum desorption and thermal inert gas purging
Control Interface	Modular PLC with 32-channel signal monitoring and open-source programming capacity
Sensors and Analytical Tools	Inline thermal mass flowmeters, electronic pressure transmitters, and dual-gas (N_2/CO_2) analyzers
Structural Materials	Corrosion-resistant stainless steel (SUS304/316) piping and an aluminum alloy mounting frame

Experimental Module	Student Learning Outcomes	Relevant Textbook Terminology
Adsorption Kinetics & Breakthrough Analysis	Measuring concentration profiles over time; determining breakthrough capacity and mass transfer zones within packed beds.	Gas Adsorption, Breakthrough Curves, Mass Transfer Coefficient
Desorption & Adsorbent Regeneration	Comparing vacuum thermal regeneration with inert gas purge; calculating energy efficiency and desorption rates.	Sorbent Regeneration, Thermal Desorption, Vacuum Swing Adsorption
Cyclic Process Design & Control	Configuring valve-switching sequences to establish continuous separation cycles; adjusting cycle times to optimize recovery.	Cyclic Process Design, Pressure Swing Adsorption (PSA), Process Control
Mass Balance & Yield Evaluation	Performing overall material balances; determining gas separation recovery rates and purity factors.	Material Balances, Gas Separation Unit Operations, Separation Factors