UNIVERSITY OF LOUISIANA AT LAFAYETTE

STEP Committee

Technology Fee Application

Inclusion of Gas-Gas and Liquid-Liquid Separation Systems to Unit Operations Laboratory

Title

Prashanth Buchireddy

Name of Submitter
(Faculty or Staff Only)

College of Engineering

Organization

Title: **Inclusion of Gas-Gas and Liquid-Liquid Separation Systems to Unit Operations Laboratory** Date: 7-15-19

Name (Contact Person): Dr. Prashanth Buchireddy
Address: Department of Chemical Engineering, P.O. Box 43675, Lafayette, LA 70504
Name: Dr. Prashanth Buchireddy Email: pxb5173@louisiana.edu
Name: Dr. Dhan Fortela Email: dbf3150@louisiana.edu
Name: Dr. Emmanuel Revellame Email: exr7867@louisiana.edu
Department/College/Org: Department of Chemical Engineering (CHEM) and Department of Industrial Technology (ITEC)/ College of Engineering

ABSTRACT (250 words or less):

The goal of this proposal is to introduce two key unit operations (separations) systems used in a wide spectrum of industries to the CHEE unit operations laboratory curriculum, which will allow enhancement of undergraduate students learning experience through hands-on engagement. Both the proposed systems will complement the existing unit operation units in the laboratory, while focusing on gas-gas and liquid-liquid separations concepts and safety principles, which are widely employed in chemical, pharmaceutical, food, petroleum, biotech, and environmental industries. Hands on experience will allow enhanced learning of theoretical separation concepts and principles taught in a class room environment and result in producing highly qualified graduates who are well trained and ready to cater to the existing and fast growing chemical process industry in Louisiana and beyond (Over $117 billion investments are in various phases of planning/construction/implementation in Louisiana, with a majority being contributed through petrochemical, chemical, and liquefied natural gas industries). Introduction of these systems will cater to over 130 students per year from chemical engineering and industrial technology departments. Moreover, there is a high potential for the civil engineering students to use these systems. Furthermore, these could also serve as demonstration units to showcase how separation process works and their applications during recruiting events, such as Annual Engineering and Technology Week.

A. Purpose of Grant

The purpose of this grant is to introduce two key unit operations (separations) systems used in a wide spectrum of industries to the CHEE and ITEC unit operations laboratory curriculum, which will allow enhancement of undergraduate students learning experience through hands-on engagement. Students in general tend to perceive and understand concepts and principles better through hands on exposure to equipment, instruments, and tools compared to learning through lectures and simulations. Thus, inclusion of the proposed equipment to the laboratory will allow students gain an improved understanding of the concepts taught in the class room environment. Procurement of the proposed systems will complement the existing unit operations laboratory, which is the only laboratory based course in chemical engineering curriculum that allows students access to hands on engagement. This unit operations is also currently used by ITEC students for an elective course in chemical technology. Both the proposed systems will complement the existing unit operation systems in the laboratory, while focusing on gas-gas and liquid-liquid separations concepts and associated safety principles, which are widely employed in chemical, pharmaceutical, food, petroleum, biotech, and environmental industries.

Proposed systems for inclusion to the unit operations laboratory include Cinc centrifuge and membrane separation unit. Cinc centrifuge is a mechanical separation unit operation widely employed by a wide range of industries for separation, extraction, washing and reaction operations. This unit has a unique patented rotor and weir design, which allows efficient flow and phase separation. This unit can accommodate variation of both rotor RPM and the heavy phase weir diameter, which will result in 100 – 1,400 “G’s” and allow varying flow rates (residence time), thus can be employed for rapid, efficient separation of any two immiscible fluids. Membrane air separation unit, designed solely for teaching purposes was designed in partnership with Air Products, LLC who specialize in PRISM membrane separators for gas separation applications. Since, this unit was designed for teaching purposes, several parameters including the feed air pressure, orientation of membrane modules, and flowrates could be varied, as well as the membrane could be changed. These units were chosen based on their technology and option to vary a wide range of parameters that can accommodate several learning objectives on the mechanical and gas separation principles.

The goal of this proposed project will be accomplished through purchasing, installation, maintenance and developing learning modules for the above listed systems. In addition to the CINC V02 (liquid-liquid) centrifugal separator and membrane air separation unit, an online gas analyzer (NOVA) will be procured to continuously monitor the separation of individual gas components from gas mixtures. Acquiring these systems will allow development of several new experiments focused on separations principles to the unit operations laboratory. This will allow students to gain hands on experience by employing the principles/concepts learnt from various classes.

Enhancement of the unit operations laboratory aligns perfectly well with the chemical engineering department’s vision, which is to provide highly qualified graduates who are well trained for industry**,** graduate school, or professional schools and its emphasis on graduating students with strong fundamental theory, intensive problem solving and hands-on laboratory experience. It will provide ITEC students with an opportunity to get familiar and enhance their exposure to various systems used in the industry. Also, enhancement of the laboratory would address the University’s mission through one of the stated strategic imperatives which targets creation of stimulating academic environment supported by the latest innovations in technology. The proposed project would impact existing curriculum, student

experience, and work force development by producing quality chemical engineering and industrial technology graduates ready to transition to work force catering to employer's demands and expectations. Graduates will be ready to enter chemical process industries with the knowledge and skill set desired by the vastly growing chemical process industries in Louisiana. Site selection magazine states that industrial investments to the tune of $117 billion are in various phases of planning/construction/implementation in Louisiana, with a majority being contributed through petrochemical, chemical, and liquefied natural gas industries. Graduating chemical and industrial technology students from UL Lafayette will cater to the current demands and future needs and demands of the growing chemical industry.

Specifically, this initiative will **impact the student body** in the following ways;

1) Enhancement of the chemical engineering laboratory, which will allow the class to offer additional experiments using separations principles that used in a wide range of industries.
2) Enhancement of undergraduate students learning experience through hands-on engagement.
3) Allow improved understanding of the gas-gas and liquid-liquid separations concepts that are critical to the growing chemical industry and safety principles and practices associated with the same.
4) Impact over 130 students per year in chemical and industrial technology majors and has a high potential for use in civil engineering courses.

B. The Projected Lifetime of Enhancement

10 - 15 years

C. Person(s) Responsible for Project

a. Implementation: Dr. Prashanth Buchireddy, Dr. Dhan Fortela, and Dr. Emmanuel Revellame
b. Operation: Chemical Engineering and Industrial Technology Students, Faculty, & Staff
c. Installation & Maintenance: Mr. Jim Dooley
d. Training: Prashanth Buchireddy and Jim Dooley, Chemical Engineering

Qualifications:

Dr. Prashanth Buchireddy is an Assistant Professor in the Department of Chemical Engineering. He has been teaching unit operations I and II for over 3 years. He served as a PI and Co-PI on several state, federal, and industry grants and successfully implemented the same and managed projects with expenditures over $4 Million dollars. Dr. Buchireddy played a key role in the design and implementation of two pilot scale systems; 3 tons/day bubbling fluidized bed gasification system and 0.25 tons/day torrefaction system, both of which incorporate industrial grade equipment (unit operations) and process instrumentation and controls. His experience and expertise with real industrial units and management of projects to the tune of several million dollars will allow him to implement this project effectively.

Dr. Dhan Fortela is an instructor in the Department of Chemical Engineering and teaches unit operations laboratory. He also teaches chemical reactor design, chemical engineering thermodynamics, stage operations, and introductory chemical engineering. He holds a Ph.D. from University of Louisiana at Lafayette in Systems Engineering. His research interests include computational modeling and analysis of biochemical and chemical systems, and development of processes and systems for waste-to-materials and waste-to-energy conversion. For the past 3 years, he has been working on bioenergy (biogas) production using pilot scale digestors, which involve industrial-grade instrumentation and control

systems similar to those in the unit operations laboratory.

Dr. Emmanuel Revelamme is an Assistant Professor in the Industrial Technology Department. He has been teaching a class (ITEC 380) that utilizes the chemical engineering laboratory. He received his Ph.D. from Mississippi State University in Chemical Engineering. His research interests include chemical and biochemical conversion of biomass/waste to fuels.

Mr. Jim Dooley is a computer and laboratory technician in the Department of Chemical Engineering. He has been maintaining the unit operations lab for over 20 years. He holds a B. S. in Electrical Engineering from the University of Louisiana.

D. Previously Funded STEP Grants

a. None

E. Product Images

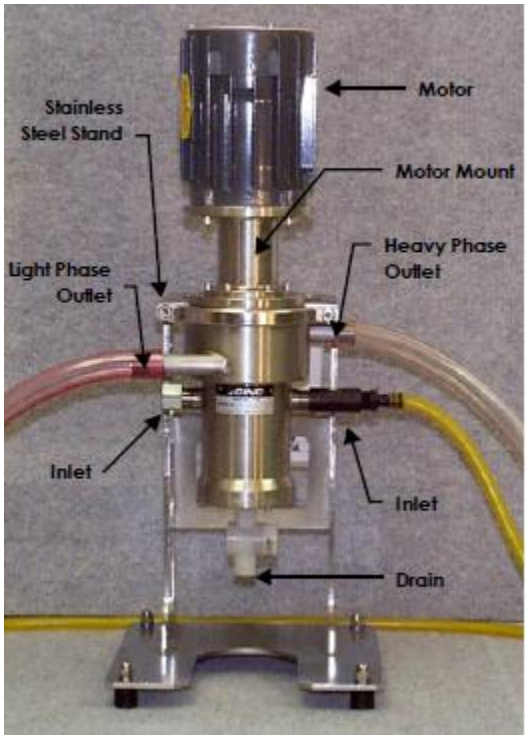

Figure 1: CINC Centrifuge

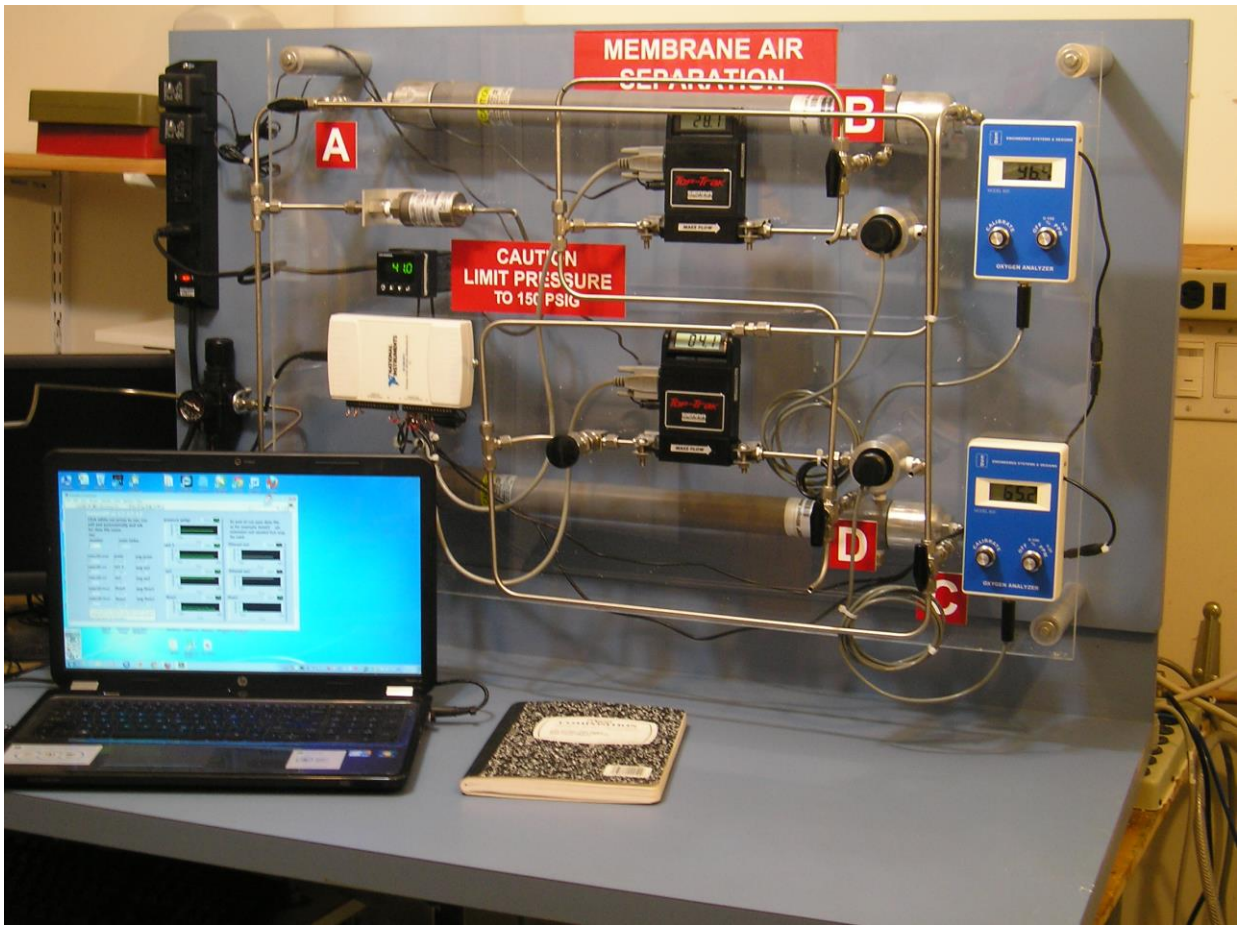

Figure 2: Membrane Air Separation Unit

Figure 3: Nova Portable Gas Analyzer

F. Budget Proposal, Timeline, & Quote

Timeline:
Year 1:
During year 1, CINC liquid-liquid centrifuge, membrane air separation unit, and NOVA portable gas analyzer will be ordered. Both the unit operations will be installed and tested for further incorporation into the courses. During year 1, Dr. Buchireddy will develop learning modules that will incorporate numerous objectives targeting mechanical separations, such as evaluating varying degree of separation based on theoretical calculations and comparing the same with experimental results for various immiscible liquid mixtures. Example objectives for one such experiment are the following: a) To become familiar with mechanical separation operations using centrifugal separation technique b) Design experiments based on theoretical correlations to achieve maximum separation of milk and cream from milk, which is common in the dairy industry.

The membrane air separation unit produces relatively pure oxygen and nitrogen, using high pressure air as a feed, will be integrated with portable gas analyzer to monitor gas variations over time. Several parameters can be varied including the orientation of the permea separation modules, which can be configured in either series or parallel and operated at varying pressures and flowrates. This set up will allow the instructors design several learning modules with different objectives, which will be developed in year 1. Sample objectives for this system that targets gas separations and mass transfer include; calculation of the overall transfer coefficients K_{O2} and K_{N2}, and plot these as functions of operating pressure, with tube side gas flow rate as a parameter. Discuss the constancy or lack of constancy of these transfer coefficients. Can significant lack of constancy (i.e. effect of pressure) be demonstrated?

Both the systems will be set up and tested during year 1 and the designed experiments will be performed by Dr.Buchireddy and Dr. Fortella and the laboratory technician (Mr.Dooley) will be trained accordingly.

Year 2 - 15
After testing and training, these experiments will be included into the laboratory syllabus during year 2 for students to gain valuable hands on experience with this system. Also, potential for inclusion of these units into civil engineering courses will be evaluated and implemented. Maintenance of the systems will be performed on a regular basis from year 2 onwards.

Budget:

Quantity	Item	Cost/Unit	Cost*
1	Membrane Air Separation Teaching Unit • System • Computer and Software • Shipping	$18,000	$18,000
1	CINC Centrifuge • V02 - Rotor Size 2 in., Throughput up to .5 gpm, Footprint 9 in.. x 9 in., Height 25 in., Approximate Weight 25 lbs. • Materials of Construction - 316L SS • Finish – Standard • Mix Mode - High, Low and Direct Feed • Installed Mix Option – Low • Base and Stand - Electro-Polished Stainless Steel • O-Ring Material - Teflon Encapsulated Silicone • Inlet/Outlet Fittings - Male 3/8" NPT • Drain Fitting - Teflon Ball Valve	$5,617	$5,617
1	Auxiliary Components for CINC Centrifuge • 1/8 HP Brook Compton XP Group C&D Class 1 Div II D63C 3450 Rpm • Controller (VFD) - 110 VAC / YASKAWA • Spare Parts Kit - Stainless with Lo Mix Seal • Power Cord Length - 15 Feet • VFD to Motor Cord Length - 50 Feet • Weirs - Stainless Steel - Set of 15 • Installed Weir - 0.925 • Shipping	$1,500	$1,500
1	NOVA Portable Gas Analyzer • CO_2, N_2, O_2, CH_4 • Shipping	$12,500	$12,500
Total		$37,617	$37,617

Budget Proposal

1.	**Equipment**	**$ 37,617**
2.	**Software**	**$**
3.	**Supplies**	**$**
4.	**Maintenance**	**$**
5.	**Personnel**	**$**
6.	**Other**	**$**
TOTAL:		**$37,617**