bradscholars

Greening Chemical Engineering laboratory at Bradford University

Item Type	Article
Authors	Mujtaba, Iqbal;Patel, Rajnikant;Karodia, Nazira
Citation	Mujtaba IM, Patel R and Karodia N (2015) Greening Chemical Engineering laboratory at Bradford University. QScience Proceedings - Engineering Leaders Conference 2014. 2015: 74.
DOI	https://doi.org/10.5339/qproc.2015.elc2014.74
Rights	(c) 2015 The Authors. This is an Open Access article distributed under the terms of the Creative Commons CC-BY license, which permits unrestricted use, distribution and reproduction in any medium, provided the original work is properly cited.
Download date	2025-05-28 03:36:39
Link to Item	http://hdl.handle.net/10454/9201

UNIVERSITY of BRADFORD

Library

The University of Bradford Institutional Repository

http://bradscholars.brad.ac.uk

This work is made available online in accordance with publisher policies. Please refer to the repository record for this item and our Policy Document available from the repository home page for further information.

To see the final version of this work please visit the publisher's website. Access to the published online version may require a subscription.

Link to publisher version: *http://www.qscience.com/doi/pdf/10.5339/qproc.2015.elc2014.74*

Citation: Mujtaba IM, Patel R and Karodia N (2015) Greening Chemical Engineering laboratory at Bradford University. QScience Proceedings - Engineering Leaders Conference 2014. 2015: 74.

Copyright statement: © 2015 The Authors. This is an Open Access article distributed under the terms of the Creative Commons CC-BY license, which permits unrestricted use, distribution and reproduction in any medium, provided the original work is properly cited.

QSCIENCE PROCEEDINGS

OPEN ACCESS

Engineering Leaders Conference 2014

Greening chemical engineering laboratory at Bradford University

I.M. Mujtaba[1,*], R. Patel[1], N. Karodia[2]

[1]School of Engineering, University of Bradford, Bradford BD7 1DP, UK
[2]School of Life Science, University of Bradford, Bradford BD7 1DP, UK
*Email: I.M.Mujtaba@bradford.ac.uk

ABSTRACT

This paper highlights the work undertaken to assess the current state of the art of the Chemical Engineering Laboratory at the University of Bradford (UK) in terms of total energy and water usage and sound pollution and to propose an action plan to 'greening' the laboratory so that future students are trained in a laboratory where sustainability is the key feature of all learning activities. The project was funded by National Higher Education STEM (Science Technology Engineering and Mathematics) Programme. This review and assessment was carried out by two academic staff and one technical staff member with chemical engineering background.

http://dx.doi.org/10.5339/qproc.2015.elc2014.74

© 2015 Mujtaba, Patel, Karodia, licensee Bloomsbury Qatar Foundation Journals. This is an open access article distributed under the terms of the Creative Commons Attribution license CC BY 4.0, which permits unrestricted use, distribution and reproduction in any medium, provided the original work is properly cited.

QSCIENCE.com
An Initiative of Qatar Foundation

Cite this article as: Mujtaba IM, Patel R, Karodia N. Greening chemical engineering laboratory at Bradford University, QScience Proceedings (Engineering Leaders Conference 2014) 2015:74 http://dx.doi.org/10.5339/qproc.2015.elc2014.74

1. INTRODUCTION

Water and energy contribute immensely to the quality life and go hand in hand. Our health and wellbeing (food, accommodation, medicine, and transports) determine our quality of life and require sustainable and steady water and energy supplies. The world's population is predicted to increase exponentially and the desire to have improved standards of living, together with increased water pollution due to industrial use of water, is increasing the water and energy demand. These factors are putting severe strain on the quantity of available freshwater and energy sources.

In addition, global warming is one of the most serious challenges facing us today. To protect the health and economic well-being of current and future generations, we must reduce our emissions (carbon footprint), make use of alternative sources (renewable) of energy, reclaim and reuse water.

Science and engineering plays a vital and increasing role in meeting the current and future needs of both Society and the planet Earth: from carbon capture to sustainable energy generation and from water supply to waste management by developing new technology, know-how, and practical solutions. Meeting the exponentially growing water and energy demands and securing sustainable energy and water supplies are important challenges for scientists and engineers today.

Experimenting with a number of unit operations is a fundamental part of the chemical engineering curriculum at Bradford where the students get hands on experience with many pieces of equipment such as distillation, reactor, absorption, water treatment, desalination, cooling tower, etc. Although ethics and sustainability concepts are built in the curriculum and are part of almost every module of the course, the unit operation labs provide great opportunities to embed and extend the concept of sustainability, especially in terms of energy and water usage, environmental pollution, etc.

Most recently, The University of Bradford (UK) has been resourced by Science, Technology, Engineering and Mathematics (STEM) funding to undertake a technical audit of the chemical engineering laboratory, within the School of Engineering with an ultimate objective of ***greening the laboratory*** so that energy and water usages and environmental pollution (carbon foot print) are reduced. This paper highlights the unit operations where there are opportunities for such reduction. From last academic year the students, during laboratory experiments, were motivated to consider/think of possible reduction in water, energy and pollution in each experiment. The ultimate idea is to develop a Green Matrix for Chemical engineering laboratory and to share that with IChemE and other UK HEIs (those providing chemical engineering courses) as well as designers of these laboratory equipment.

2. CHEMICAL ENGINEERING CURRICULUM AT BRADFORD

The distinctive feature of the course at Bradford is a traditional chemical engineering (oil, gas and petrochemical) but with a particular focus in advanced materials engineering (based on our excellent research in polymer processing and technology). The Bradford curriculum is aimed at developing a deep understanding of fundamental and advanced technical principles, analytical tools, and competence in their application together with a wide range of management, personal and professional skills. The course provides our graduates with essential tools based on the concept of sustainability and low carbon footprint for changing raw materials into useful products in a safe and cost effective way, and that is reflected in the final year design project. At MEng level our graduates have further choice of specialisation in Food and Pharmaceutical Engineering, Desalination Technology and Sustainable Energy Systems.

Table 1 shows the current 4 years MEng programme specification for Chemical Engineering at Bradford.

The IChemE has published a *Technical Roadmap for 21st century chemical engineering* (www.icheme.org/TechnicalRoadmap). This broad ranging publication highlights six issue areas of critical global importance where chemical engineers will have enormous influence: (a) health, safety, environment, (b) sustainable technology (c) energy (d) food and drink (e) water (f) biosystems. Table 2 shows the relevant modules addressing some of the above issues identified in the Technical Roadmap.

3. ENERGY, WATER AND ENVIRONMENTAL POLLUTION

Year 2 and Year 3 students attend two laboratory modules named Chemical Engineering Practice-1 and Chemical Engineering Practice-2 where they experiment with a number of unit operations (Table 3).

Table 1. Chemical Engineering Curriculum at Bradford.

Year 1 Modules	Year 2 Modules
Introduction to Chemical Engineering	Further Engineering Analysis
Engineering Analysis	Thermodynamics
Materials Technology	Fluid Mechanics 2
Essentials of Chemical Structure, Bonding and Reactivity	Technology Operations Management
Introduction to Chemical Thermodynamics	Chemical Engineering Practice - 1
Cell and Microbiology for Engineers	Structure and Solid Modelling
Fluid Mechanics 1	Separation Processes Engineering
Laboratory Practice and Professional Skills 2	Introductory Control
Introduction to CAD and Flow Sheeting	Computer Modelling Techniques
Health and Safety Management	Process Design
	Engineering Statistics
	Petroleum Product Engineering-1
Year 3 Modules*	**Year 4 Modules***
Chemical Engineering Practice - 2	Transport Process Modelling
Design Project (Chemical Engineering)	Advanced Research Project
Design Project (Petroleum Engineering)	Polymer Engineering
Design Project (Pharmaceutical Engineering)	Upstream Production Operation
Materials Failure Analysis	Desalination Technology
Reaction Engineering	Sustainable Energy
Petroleum Product Engineeing-2	Food and Pharmaceutical Process Engineering
Six Sigma for Business Excellence	Refinery Operation
Advanced Control	Finite Element Methods
Robotics Systems	Risk Management
Reliability Engineering	

* Students studying up to Year 3 obtain BEng degree. Students studying up to Year 4 obtain MEng degree.

Table 2. Core Modules Addressing IChemE's Technical Roadmap.

Sustainable Technology - Materials	Energy
Chemistry + Mathematics	Chemistry + Mathematics
Materials Technology	Thermodynamics
Structure and Solid Modelling	Sustainable Energy
Materials Failure Analysis	Health and Safety Management
Control	Control
Process Design	Reaction Engineering
Petroleum Product Engineering	Transport Process Modelling
Transport Process Modelling	Upstream Production Operation
Health and Safety Management	Refinery Operation
Water (Pollution, Treatment, Freshwater)	**Food and Pharmaceutical**
Chemistry + Mathematics	Chemistry + Mathematics
Transport Process Modelling	Transport Process Modelling
Fluid Mechanics	Separation Process Engineering
Engineering Thermodynamics	Food and Pharmaceutical Engineering
Health and Safety Management	Control
Separation Process Engineering	Process Design
Desalination Technology	Reaction Engineering
Cell and Microbiology for Engineers	Engineering Thermodynamics
Reaction Engineering	Fluid Mechanics
Control	Health and Safety Management
Process Design	Cell and Microbiology for Engineers

Introducing the scope of Energy and Water minimisation and carbon capture are often the top level objective in each of the experiments.

Note, most (except distillation and absorption) of these equipment are table top small scale equipment (Figure 1) suitable for university teaching (www.armfield.co.uk). However, these equipment do not necessarily provide the scope for energy, water and pollution minimisation. Therefore a technical audit of the lab was carried out with the funding from the National HE STEM Programme to assess the energy and water usages and sound pollution level so that further actions can be taken to minimise energy and water consumptions and sound pollution wherever possible. The ultimate goal is to make the

Table 3. Weekly Water and Energy Usage in the Lab.

Equipment	Water Usage, L	Energy Usage, kWh	Sound Pollution dB
Corrosion Kit	3.6	99.36	Negligible
Absorption (CO2 Capture)	900	0.86 (Water Pump) 1.73 (Air Pump	74 (Air Pump)
Distillation	750.0	7.36	Negligible
Cooling Tower	3.0	2.56	Negligible
Batch Reactor	5.0	0.69	Negligible
CSTR	5.0	0.69	Negligible
Tubular Reactor	7.5	0.69	Negligible
Shell & Tube Heat Exchanger	225.0	0.20	Negligible
Plate Heat Exchanger	225.0	0.20	Negligible
Process Control	150.0	3.0	Negligible
Fluidised Bed	10.0	0.65	Negligible
Sedimentation Tank	240.0	0.67	Negligible
Aeration Unit	20.0	0.02	Negligible
Desalination (Reverse Osmosis)	2400.0	9.3	75 (low flow) 85 (high flow)
Water Distiller	4.0	4.64	Negligible
Total Per Session ~	**4900**	**135**	
Total for 2 sessions	**9800**	**270**	

Figure 1. Chemical Engineering Unit Operation Lab at Bradford.

laboratory green and to impart this knowledge to our students working in the laboratory. Table 3 shows the weekly energy and water usage together with sound pollution level for each of the equipment.

3.1. Observations

a) Corrosion Kit

High power consumption of about 100 kWh is noted. We suggest using small air pump (run intermittently).

b) Gas Absorption Unit

(i) Currently for each experiment about 900 L of water is used. We suggest a bigger storage tank to reuse the water. An inverter drive could also be used to control the water flow rate. This would reduce the power consumption.

(ii) Air pump noise is about 74 dB. We suggest the use of an inverter drive to control air flow which would reduce noise and power consumption

c) Distillation Column
Currently for each experiment about 750 L of water is used. We suggest using a re-circulating chiller unit to conserve water

d) Heat Exchanger
Currently for each experiment about 450 L of water is used which is currently wasted. There is an opportunity for water saving by using a small storage tank and natural cooling in between experimental sessions.

e) Process Control Unit
Currently for each experiment about 150 L of water is used. There is an opportunity for water saving by using a small storage tank.

f) Sedimentation Tank
Currently for each experiment about 240 L of water is used. There is an opportunity for water saving by using a large storage tank.

g) Reverse Osmosis
   (i) Currently for each experiment about 2400 L of water is used. There is an opportunity for huge water saving by recirculation and by installing a chiller unit. Concentrated brine is currently disposed of after each experiment session. Instead of wasting this huge amount of water, make up water can be added just to match the salinity of feed water before each run.
   (ii) Water pump noise is about 85 dB. We suggest the use of acoustic sound proofing for the unit.

4. CONCLUSIONS

Carrying out this initial study, in a relatively small laboratory, has shown just how much water and power is consumed on a weekly basis and it has also given us an indication as to where significant savings can be made. Often, the focus is on delivering the curriculum and so these types of laboratories are operated without thinking about or looking at the consumption of the utilities. All Chemical Engineering laboratories throughout the UK universities and globally should look at their water and power usage in order to make them more sustainable and hence greener. The degree of sound pollution should also be addressed because often pumps, motors, compressors etc. are found running simultaneously in teaching laboratories, creating a substantial amount of noise.

This project has opened up our eyes and shown that even in a relatively small University laboratory environment, savings in water and power usage can be massive. Since carrying out this project we have been sharing our findings with our students and focussing their minds in the area of energy, water and pollution minimisation. This type of review offers valuable understanding into how undergraduate students identify and process significant issues such as green principles and the adoption of more sustainable practices within the context of chemical engineering.

Acknowledgement

The funding from National HE STEM Programme is gratefully acknowledged by the authors.