Process Design Project for Final Year MEng Chemical Engineering Students in Partnership with Industry

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This case study describes how the Chemical Engineering department at Loughborough worked in partnership with GlaxoSmithKline on a process design project for five final year MEng students. Links to CS8 and CS18.

Reasons for engagement

Chris is keen to involve industrialists with teaching and asked Greg Simmonds at GlaxoSmithKline (GSK) if he and his colleagues would be interested in working with a group of five final year MEng students on a project which ran throughout the second semester at Loughborough University. The final year Process Design module generally tackles a different project each year and often involves industry partners. This adds some reality to the project, since the design is based on an existing chemical process and it also brings the students into contact with experienced engineers who have designed or operated the plant. Greg was one such engineer, who had been previously a chemical engineering student in the department and now works for GSK at their manufacturing plant in Dartford, Kent (see Kellett – CS8 and Simmonds – CS18).

GSK insisted on a confidentiality agreement before they could become involved as the design project involved a commercial process to manufacture an active pharmaceutical ingredient (API) that was later formulated into an antiretroviral drug for the treatment of Human Immunodeficiency Virus (HIV). The project focused on the manufacture of an intermediate molecule from which the API would be eventually manufactured– to consider the whole of the production chain from raw materials to finished API would have been far too complex for a single design group. Although the intermediate molecules are no longer produced at Dartford, it was useful to have a site visit, where the students could see at first hand the types of equipment that they were busy designing.

The students had to take into account safety issues, good manufacturing practice and product quality, as well as to produce a complete technical design of the process. The project allowed the students to practise and develop a wide range of skills and knowledge obtained throughout their University education. Passing the final year MEng design project is an important requirement to achieve Corporate Membership of the IChemE and CEng status.

The engagement

GSK provided basic information about the process, which was based on the manufacture of an antiretroviral drug which is now out of patent. The project group started the project by doing a thorough literature search, looking

at patents and scientific papers, which described the process and chemical synthesis routes. From this they developed an outline process flow sheet, which they then slowly populated by selecting appropriate equipment to achieve each unit operation. By the time that Greg made his first visit to the department, about 5 weeks into the project, an initial flow sheet, mass and energy balance had been established. The students presented their work to Greg and prepared a long list of questions for him to answer. This certainly helped correct some misapprehensions about the way the process operated and suggested a number of improvements to the flow sheet.

Around ten weeks into the project Chris organised for the students to visit the site, where they delivered a presentation to some of the GSK staff and were questioned on some of the design choices that they had made. The students were given a tour of the site, and had the opportunity to visit two plants that were conceptually similar to the one they were designing. One was a more modern than the other, so the students could contrast the ways in which the design philosophy of pharmaceutical plants had changed over the years. The visit also allowed the students to meet the plant operators and engineers who run the equipment, much of which is specific to the pharmaceutical industry. The presentation at GSK was good practice for the assessments which were later held back in the department. Each design group had to deliver a 30 minute presentation to the academic staff and prepare a major written report which gave full details of all aspects of their design: review of the process science, process plant description, process flow diagram including material and energy balances, piping and instrumentation diagram or engineering line diagrams, equipment list and specification of all major equipment including materials of construction, plant layout, start-up, normal shut-down, emergency shut-down procedures, operating instructions for the major item of equipment, process safety and hazard assessment, environmental impact, capital and operating costs, market survey and business plan.

Issues

It took much longer that expected to have the confidentiality agreement signed by all parties, which meant that the project actually started before all the information had been supplied by GSK. When the information did arrive, there were some parts that were incomplete, poorly specified or difficult to interpret. But in fact this was a really useful lesson for the students in how to deal with data that may contain errors or inconsistencies; it made them question the sources of all the information they obtained and to think about consistency checks to validate their data.

Benefits

The students found the project challenging and interesting mainly because it was a real industrial project and they had to make decisions as a group throughout the project. Team working and management was an important component of the project. With a realistic project, the students could clearly identify the requirements of the product and the benefits that pharmaceuticals provide to society in general and HIV victims in particular. There was also a great sense of achievement at the conclusion of the project, to come so far, from almost no knowledge of the process, to the point where they could have detailed technical discussions with GSK engineers.

By carrying out a fairly extensive paper-based design before the site visit, the students had already thought about some of the technical issues that were faced by the GSK engineers. The students were sometimes surprised to find that they had selected the same equipment and methods that were actually used in the GSK process.

For Greg Simmonds and GSK it was an opportunity to showcase their industry sector to the final year MEng students. As a result of this interaction, at least two of the students made an application to GSK for graduate employment.

The students gained experience in dealing with people in industry; about half had already had some industrial training on a sandwich placement, but for the other half this was their first experience of being on site and dealing with practical engineering issues. As a module tutor, Chris felt there was slightly less pressure on him, as there was always some additional support from the industrial partner.

Unintended outcomes

The lack of information quickly forced the students to think about approximate methods of calculation and it made them realise how much of the knowledge about a process is gained during start-up and commissioning of the plant. They also comprehended how difficult it is to gain reliable and detailed data on complex reaction schemes, particularly when the materials have a very high value and are hazardous to handle.

Reflections

Chris would like to involve more companies with group design projects such as the one described above. The problems of confidentiality and access to information are ones of commercial reality and can be overcome, making these types of projects a valuable learning experience for staff and students. He felt the students gained much from this partnership with GSK and it gave the company a good amount of exposure within the graduating class of chemical engineers.

Context

Chris Rielly graduated with BSc (Eng) and PhD degrees in Chemical Engineering from Imperial College, University of London. He held a post-doctoral research position within the Fluid Mechanics Group at Cambridge University Engineering Department, before becoming a lecturer in the Department of Chemical Engineering at the University of Cambridge. During his time there he obtained a year's leave to work for a chemical contracting company, John Brown Engineers and Contractors, where he gained first hand experience of plant design. In 1999, Chris came to Loughborough University to take up a new chair in Chemical Engineering, where he is currently Head of Department. His research interests are in experimental and computational fluid dynamics of multi-phase mixing processes, model-based and direct nucleation control of pharmaceutical crystallisation processes, spray freeze drying and spray drying of foods and pharmaceuticals and de-agglomeration and dispersion of formulated nano-particle products.