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Chemical Engineering- for Operation and Design of Chemical Plants

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ABSTRACT: Chemical engineers develop economical commercial processes to convert raw materials into useful products. Chemical engineering uses principles of chemistry, physics, mathematics, biology, and economics to efficiently use, produce, design, transport and transform energy and materials. The work of chemical engineers can range from the utilization of nanotechnology and nanomaterials in the laboratory to large-scale industrial processes that convert chemicals, raw materials, living cells, microorganisms, and energy into useful forms and products. Chemical engineers are involved in many aspects of plant design and operation, including safety and hazard assessments, process design and analysis, modeling, control engineering, chemical reaction engineering, nuclear engineering, biological engineering, construction specification, and operating instructions.

KEYWORDS: commercial, engineers, nanomaterials, plant design, modeling, hazard, industrial, specification

I.INTRODUCTION

Chemical engineers typically hold a degree in Chemical Engineering or Process Engineering. Practicing engineers may have professional certification and be accredited members of a professional body. Such bodies include the Institution of Chemical Engineers (IChemE) or the American Institute of Chemical Engineers (AIChE). In India the equivalent body is the Indian Institute of Chemical Engineers (IIChE) which also conducts collaborative events with AIChE and ICheE. A degree in chemical engineering is directly linked with all of the other engineering disciplines, to various extents. A 1996 article cites James F. Donnelly for mentioning an 1839 reference to chemical engineering in relation to the production of sulfuric acid.[1] In the same paper, however, George E. Davis, an English consultant, was credited with having coined the term.[2] Davis also tried to found a Society of Chemical Engineering, but instead, it was named the Society of Chemical Industry (1881), with Davis as its first secretary.[3][4] The History of Science in United States: An Encyclopedia puts the use of the term around 1890.[5] "Chemical engineering", describing the use of mechanical equipment in the chemical industry, became common vocabulary in England after 1850.[6] By 1910, the profession, "chemical engineer," was already in common use in Britain and the United States.[7] In the 1940s, it became clear that unit operations alone were insufficient in developing chemical reactors. While the predominance of unit operations in chemical engineering courses in Britain and the United States continued until the 1960s, transport phenomena started to receive greater focus.[8] Along with other novel concepts, such as process systems engineering (PSE), a "second paradigm" was defined.[9][10] Transport phenomena gave an analytical approach to chemical engineering[11] while PSE focused on its synthetic elements, such as those of a control system and process design.[12] Developments in chemical engineering before and after World War II were mainly incited by the petrochemical industry;[13] however, advances in other fields were made as well. Advancements in biochemical engineering in the 1940s, for example, found application in the pharmaceutical industry, and allowed for the mass production of various antibiotics, including penicillin and streptomycin.[14] Meanwhile, progress in polymer science in the 1950s paved way for the "age of plastics".[15] Concerns regarding the safety and environmental impact of large-scale chemical manufacturing facilities were also raised during this period. Silent Spring, published in 1962, alerted its readers to the harmful effects of DDT, a potent insecticide.[16] The 1974 Flixborough disaster in the United Kingdom resulted in 28 deaths, as well as damage to a chemical plant and three nearby villages.[17] The 1984 Bhopal disaster in India resulted in almost 4,000 deaths. These incidents, along with other incidents, affected the reputation of the trade as industrial safety and environmental protection were given more focus.[18] In response, the IChemE required safety to be part of

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every degree course that it accredited after 1982. By the 1970s, legislation and monitoring agencies were instituted in various countries, such as France, Germany, and the United States.[19] Advancements in computer science found applications designing and managing plants, simplifying calculations and drawings that previously had to be done manually. The completion of the Human Genome Project is also seen as a major development, not only advancing chemical engineering but genetic engineering and genomics as well.[20] Chemical engineering principles were used to produce DNA sequences in large quantities. Chemical engineering design concerns the creation of plans, specifications, and economic analyses for pilot plants, new plants, or plant modifications. Design engineers often work in a consulting role, designing plants to meet clients' needs. Design is limited by several factors, including funding, government regulations, and safety standards. These constraints dictate a plant's choice of process, materials, and equipment.[22]

Plant construction is coordinated by project engineers and project managers,[23] depending on the size of the investment. A chemical engineer may do the job of project engineer full-time or part of the time, which requires additional training and job skills or act as a consultant to the project group. In the USA the education of chemical engineering graduates from the Baccalaureate programs accredited by ABET do not usually stress project engineering education, which can be obtained by specialized training, as electives, or from graduate programs. Project engineering jobs are some of the largest employers for chemical engineers.[24]

A unit operation is a physical step in an individual chemical engineering process. Unit operations (such as crystallization, filtration, drying and evaporation) are used to prepare reactants, purifying and separating its products, recycling unspent reactants, and controlling energy transfer in reactors.[25] On the other hand, a unit process is the chemical equivalent of a unit operation. Along with unit operations, unit processes constitute a process operation. Unit processes (such as nitration, hydrogenation, and oxidation involve the conversion of materials by biochemical, thermochemical and other means. Chemical engineers responsible for these are called process engineers.[26]

Process design requires the definition of equipment types and sizes as well as how they are connected and the materials of construction. Details are often printed on a Process Flow Diagram which is used to control the capacity and reliability of a new or existing chemical factory.

Education for chemical engineers in the first college degree 3 or 4 years of study stresses the principles and practices of process design. The same skills are used in existing chemical plants to evaluate the efficiency and make recommendations for improvements.

Modeling and analysis of transport phenomena is essential for many industrial applications. Transport phenomena involve fluid dynamics, heat transfer and mass transfer, which are governed mainly by momentum transfer, energy transfer and transport of chemical species, respectively. Models often involve separate considerations for macroscopic, microscopic and molecular level phenomena. Modeling of transport phenomena, therefore, requires an understanding of applied mathematics.[27] Chemical engineers "develop economic ways of using materials and energy".[29] Chemical engineers use chemistry and engineering to turn raw materials into usable products, such as medicine, petrochemicals, and plastics on a large-scale, industrial setting. They are also involved in waste management and research.[30][31] Both applied and research facets could make extensive use of computers.[28]

Chemical engineers may be involved in industry or university research where they are tasked with designing and performing experiments, by scaling up theoretical chemical reactions, to create better and safer methods for production, pollution control, and resource conservation. They may be involved in designing and constructing plants as a project engineer. Chemical engineers serving as project engineers use their knowledge in selecting optimal production methods and plant equipment to minimize costs and maximize safety and profitability. After plant construction, chemical engineering project managers may be involved in equipment upgrades, troubleshooting, and daily operations in either full-time or consulting roles. [32]

II.DISCUSSION

The Institution of Chemical Engineers (IChemE) is a global professional engineering institution with over 33,000 members worldwide.[2] It was founded in 1922 and awarded a Royal Charter in 1957.

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It has offices in Rugby, London, Melbourne, Wellington, New Zealand, Kuala Lumpur, and Singapore.[2]

In 1881, George E. Davis proposed the formation of a Society of Chemical Engineers, but instead the Society of Chemical Industry (SCI) was formed.[4][5]

The First World War required a huge increase in chemical production to meet the needs of the munitions and its supply industries, including a twenty-fold increase in explosives.[6] This brought a number of chemical engineers into high positions within the Ministry of Munitions, notably K. B. Quinan,[7][8] Frederic Nathan[7] and Arthur Duckham.[9]

The increased public perception of chemical engineers renewed the interest in a society, and in 1918 John Hinchley, who was a Council Member of the SCI, petitioned it to form a Chemical Engineers Group (CEG), which was done, with him as chairman and 510 members.[8] In 1920 this group voted to form a separate Institution of Chemical Engineers,which was achieved in 1922 with Hinchley as the Secretary, a role he held until his death.[10] The inaugural meeting was held on 2 May 1922, at the Hotel Cecil, London.[11]

Despite opposition from the Institute of Chemistry and the Institution of Civil Engineers,[12][13] it was formally incorporated with the Board of Trade on 21 December 1922 as a company not for profit and limited by guarantee.[14] The first Corporate meeting was held 14 March 1923 and the first Annual General Meeting on 8 June 1923: Arthur Duckham was confirmed as President, Hinchley as Secretary and Quinan as Vice-President.[13][14] At this time it had about 200 members.[14] Nathan was the second President in 1925.[15]

The American Institute of Chemical Engineers, which had been founded in 1908, served as a useful model. While suggestions of amalgamation were made and there was friendly but limited contact, the two organisations developed independently.[16]

In 1926 an official Seal of the Institution was produced by Edith Mary Hinchley, wife of John Hinchley.[17][18]

The same year the Institution set the first examinations for Associate (i.e. professionally qualified) membership, bringing it into line with the Civil and Mechanical Institutions.[19] In addition to four set examinations of three hours each, there was a 'Home Paper' requiring the candidate to gather information and data and design a chemical plant, accompanied by drawings and a written design proposal within a time limit of a month.[20]

In 1938 the membership passed 1000.[21]

In 1939 the first courses were recognised as granting exemption from the examinations for Associate Membership, being Manchester College of Technology and of the South Wales and Monmouthshire School of Mines.[21] Others followed in subsequent years.

In 1942 Mrs Hilda Derrick (née Stroud) was the first female member, in the category Student, taking a correspondence course in chemical engineering during the war. She was active in promoting the Institution and profession to women.[22]

In 1955 Canterbury University College, New Zealand, and University of Cape Town, South Africa, were the first overseas institutions to have their qualifications recognised.[23]

On 8 April 1957 the IChemE was granted a Royal Charter, changing it from a limited company to a body incorporated by Royal Charter, a professional institution like the Civil and Mechanical ones,[24][25] with HRH Prince Philip, Duke of Edinburgh as patron,[26] a role he continued for over 63 years.[27]

In 1971, the membership grades were changed: Associate became Member and Member became Fellow.[28]

In 1976 the Institution moved its Headquarters from London to Rugby.[28]

The IChemE is licensed by the Engineering Council UK to assess candidates for inclusion on ECUK's Register of professional Engineers, giving the status of Chartered Engineer, Incorporated Engineer and Engineering Technician. It is licensed by the Science Council to grant the status of Chartered Scientist and Registered Science Technician. It is licensed by the Society for the Environment to grant the status of Chartered Environmentalist. It is a member of the European Federation of Chemical Engineering.[29] It accredits chemical engineering degree courses in 25 countries worldwide. "Promoting and advancing the science of chemical engineering in all its branches, promoting competence

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and a commitment to sustainable development, advancing the discipline for the benefit of society and supporting the professional development of members."[30] IChemE has two main types of membership, qualified and non-qualified, with the technician member grade being available in both categories.[31]

Qualified membership grades.

Fellow – A chemical engineering professional in a very senior position in industry and/or academia. Entitling the holder to the post-nominal FIChemE and is a chartered grade encompassing all the privileges of Chartered Member grade.

Chartered Member – Internationally recognised level of professional and academic competence requiring at least 4 years of field experience and a bachelors degree with honours. Entitles the holder to the post-nominal MIChemE and registration as one or a combination of; Chartered Engineer (CEng), Chartered Scientist (CSci) and Chartered Environmentalist (CEnv). This also entitles the individual to register as a European Engineer with the pre-nominal Eur Ing.

Associate Member – This grade is for young professionals who are qualified in chemical & process engineering to bachelors with honours level or a higher. Typically this is the grade held by those working towards Chartered Member level or those graduates working other fields. This grade entitles the holder to the post-nominal AMIChemE. This grade can also lead to the grade of Incorporated Engineer (IEng) for those with some field experience but which falls short of the level required for Chartered Member grade.

Technician Member – Uses practical understanding to solve engineering problems and could have a qualification, an apprenticeship or years of experience. This grade can lead to the Eng Tech TIChemE post-nominal and now in conjunction with the Nuclear Institute the post-nominal Eng Tech TIChemE TNucI.

Non-qualified membership grades.

Associate Fellow – Senior professionals trained in other fields of a level comparable to Fellow in other professional bodies.

Affiliate – For people working in, with or with a general interest in the sector.

Student – For undergraduate chemical & process engineering students.

The Institution has been awarding Medals for different areas of Chemical engineering work since the first Moulton medals were issued in 1929. The medal was named after Lord Moulton who helped develop chemical engineering during World War I when he took charge of explosive supplies.[32] Today the institution gives out eleven medals related to research and teaching,[33] six medals in special interest groups,[34] four medals relating to publications,[35] two medals for services to the profession[36] and two medals for contribution to the Institution.[37]

III.RESULTS

The IChemE Innovation and Excellence Awards take place in November in the UK. The awards are highly regarded throughout the process industries for recognising and rewarding chemical engineering excellence and innovation. The first awards took place at the National Motorcycle Museum in Birmingham on 23 March 1994.[38]

There are 14 categories in total that applicants are invited to enter including; food and drink, energy, health and safety, bioprocessing, innovative product, nuclear innovation and young chemical engineer of the year, offering a broad scope for entries.[38]

The organisation is working on newer award programs in other countries and in 2012 events also took place in Singapore and North America.[38]

The Ashok Kumar Fellowship is an opportunity for a graduate to spend three months working at the UK Parliamentary Office for Science and Technology (POST). The fellowship was jointly funded by the IChemE and the Northeast of England Process Industry Cluster (NEPIC). However, NEPIC was unable to contribute in 2017 and the Fellowship was

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not offered in 2016.[39] As of 2015 it is jointly funded by the IChemE and the Materials Processing Institute (reflecting Kumar's employment with British Steel).[40]

The Fellowship was set up in memory of Dr Ashok Kumar, the only serving chemical engineer in the Parliament of the United Kingdom at the time of his sudden death in 2010. Kumar was an IChemE Fellow who had been the Labour MP for Middlesbrough South and Cleveland East.[39]

In response to a considerable reduction in applications to study the subject at UK universities[41] in 2000 the IChemE established an educational programme and website whynotchemeng? to help young people find out more about a career in the field of chemical engineering.[41][42] This was credited with the major rise in applications in the following years.[43][44] The programme included a website, YouTube stream, documents and outreach volunteers. In 2017 the web resource was moved from its own site to one within the IChemE.[41][45][46]

On 21 November 1879, Lancashire chemist John Hargreaves canvassed a meeting of chemists and managers in Widnes, St Helens and Runcorn to consider the formation of a chemical society. Modelled on the successful Tyne Chemical Society already operating in Newcastle, the newly proposed South Lancashire Chemical Society held its first meeting on 29 January 1880 in Liverpool, with the eminent industrial chemist and soda manufacturer Ludwig Mond presiding.

It was quickly decided that the society should not be limited to just the local region and the title 'the Society of Chemical Industry' was finally settled upon at a meeting in London on 4 April 1881, as being 'more inclusive'. Held at the offices of the Chemical Society, now the headquarters of the Royal Society of Chemistry, in Burlington House, this meeting was presided over by Henry Roscoe, appointed first president of SCI,[4] and attended by Eustace Carey, Ludwig Mond, FA Abel, Lowthian Bell, William H Perkin, Walter Weldon, Edward Rider Cook, Thomas Tyrer and George E Davis; all prominent scientists, industrialists and MPs of the time.

The society grew rapidly, launching international and regional sections. In 1881 Ivan Levinstein was a founder of the Manchester Section of the Society of Chemical Industry, later following Sir Henry Roscoe as chair of the Section. Levinstein also served as President of the Society of Chemical Industry between 1901 and 1903.[5]

Prominent early members included William Lever, George Matthey, Ludwig Mond, Henry Armstrong, Leo Baekeland, Rudolph Messel, Charles Tennant, Richard Seligman, Ferdinand Hurter and Marie Stopes.

The original membership fee was very steep for the time: The first subscription fee was set at one guinea, which would be equivalent to nearly £400 today. Four grades of membership were agreed at the time: member, associate, student and honorary, with most appointments made on the basis of a review of their 'eligibility' by the SCI council. Despite the high fee, by the time of the first official meeting of the Society of Chemical Industry in June 1881, it had attracted over 300 members. An Extraordinary General Meeting was held on 27 March 1906, under the direction of president Edward Divers and secretary C. G. Cresswell, to discuss a motion to apply for incorporation under a royal charter. The resolution was formally proposed by Sir (Thomas) Boverton Redwood. After some discussion, the motion was unanimously supported.[6] The society was formally incorporated, by Royal Charter, as of 17 June 1907, and its bylaws were published in the Journal of the Society of Chemical Industry. By that time, it had expanded to include a number of satellite chapters, including Canada, New South Wales, New York and New England as well as locations within Great Britain.[7] The first headquarters of the newly fledged Society of Chemical Industry was established in 1881 at Palace Chambers,[8] Bridge Street, Westminster, London. After a series of changes of address, the society finally moved to its fifth and present location at 14/15 – and initially 16 – Belgrave Square in 1955. Owned by the Duke of Westminster, along with the rest of Belgravia, the building was and still is part of the Grosvenor Estate and had recently been commandeered by the Ministry of Defence during World War II. The former Nazi commander Rudolf Hess is believed to have been interrogated in the building after he flew to Britain late in the war. SCI organises over 100 conferences and events per year which are focused on cutting edge scientific and special interest subjects. These are primarily organised through SCI member-led technical, international and regional interest groups.SCI runs free Public Evening Lectures,[9] both at its headquarters as well as online, through its SCITalks! programme.The society has an extensive awards programmes designed to raise awareness of the benefits of the practical application of chemistry and related sciences across scientific disciplines and industrial sectors. The SCI also confers scholarships and travel bursaries to

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student members, and celebrates accomplished scientists, educators and business people through a number of international awards, medals, and lectureships.

IV.CONCLUSIONS

SCI also publishes the well-established magazine Chemistry & Industry (C&I).[10]

Chemistry & Industry was launched by the society in 1923. From 1923 it has documented the advancements in chemistry and related science and the inventions being developed by large companies and start ups. It covers a diverse set of technologies and application areas and it is widely read across the community and is circulated internationally. The society has an extensive awards and honours programme.

The Honours programme was established in 1996 and is designed to raise awareness of the benefits of the practical application of chemistry and related sciences across scientific disciplines and industrial sectors and to celebrate accomplished scientists, inventors and entrepreneurs through a number of international awards, medals, and lectureships.

The most prestigious honours are the Society Medals, of which there are around 12, and these recognise those who exhibit leadership in promoting the objectives and values of the society. The Society Medals are awarded to persons who have made significant contributions in the field of chemical sciences, innovation and entrepreneurship.[11][12]

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