An Inter-Departmental Educational Curricular for Low Carbon and Green Growth and Green Industrial Complex

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Abstract

Low Carbon-Green Growth is a 50-year vision declared by the Korean Government that is followed by a series of governmental policies including enactment of "Low Carbon-Green Growth Law." The Hankyong National University located in the southern part of Gyeonggi Province is planning a special graduate-level educational curricular that will focus on the Low Carbon-Green Growth education by the departments of Architectural Engineering, Chemical Engineering, and Environmental Engineering. The inter-departmental program consists of the education for the low carbon emission, low energy consumption, and the development of the new renewable energies. Located within 80-km distance from the Hankyong National University, are some of the Korea's major steel industry, heavy chemical industry, and cement industry that are three main sources of GHG emission and natural resources consumption in Korea. Students are expected to come from nearby industrial complexes including Po-Seong, a national industrial complex. Graduates from the suggested inter-departmental program are expected to develop their career in the steel industry, cement and concrete industry, and industries of chemical and environmental engineering. A green industrial complex is also suggested that showcases a green scientific exhibition hall, educational facility, and a research center located in the southern region of Gyeonggi Province near the Hankyong National University.

Key words: inter-departmental, educational curricular, low carbon, CO2 emission, natural resources, renewables.

Introduction

Hankyong National University (HKNU) was originally established 70 years ago, and the university has a rich tradition in research and education in the area of biological and environmental technologies. Recent demonstrating example of such expertise of the HKNU in these areas is the operation of a Research Center on EFBFT (Environmentally Friendly Bio-Fusion Technology) funded by the Brain Korea 21 (BK 21) and a Biogas Research Center (BRC) co-funded by Gyeonggi Province and Anseong-Si. The BRC, for example, is currently conducting a research for the production of renewable energy using the biomass and it is capable of producing the biogas of 350 m3 / day and a co-generating system that can convert the biogas to the electrical power of 720 kWh.

Three engineering departments, Architectural Engineering, Chemical Engineering and Environmental Engineering plan to offer an inter-departmental graduate educational curriculum. The proposed educational curricular are in line with the "Low Carbon-Green Growth" policy of the Korean government, a 50-year vision declared by the government in Aug., 2008.1 The educational curricula will focus on the technologies for the utilization of the industrial bi-products and wastes, the technologies for the utilization of industrial wastes to produce renewable energy, and the control of green house gases (GHG). At present, the specific educational emphasis is placed on the application of knowledge to the cement, concrete, and the construction industry. The scope will be expanded in the future to encompass other environmentally important industrial fields such as steel and chemical industry.

It is noted that some of the Korea's major steel industry, heavy chemical industry, and cement industry that are three main sources of GHG emission and natural resources consumption in Korea are located within 80-km distance from the Hankyong National University. The Po-Seung, a national industrial complex, is also located only 40 km to the west of the HKNU. Many local industrial parks surrounding the HKNU are within 30 km distance. It is expected that the incoming students consist of CEOs, administrators, and engineers of industrial firms of both national and local industrial complexes as well as regional and provincial government officials.

Environmental Issues in Chemical Engineering Curricular

Knowledge in the basic principles in Chemical engineering is required to clearly understand the environmental issues and develop insight toward the solutions to the environmental problems that we face today. Therefore the basic courses are offered in the area of thermal and energy engineering and environmental chemistry. Understanding the nature of GHG and the process to control the GHG emission is also very important. An in-depth study on the CO2 emission control including the CO2 sequestration methods is offered. Clean Development Mechanism (CDM) is an emerging issue for the global environment. The course covers the political and technological aspects of the CDM and includes the inventory, the analysis of the green house effect materials for the field, the biomass tasks for CDM, and the fossil fuel source and their controls in the energy usage factory. The topic will consider both of the biomass and non-biomass CDM.

Environmental Issues in Environmental Engineering Curricular

The environmental engineering education in this study concentrates on the green-control and the management of wastes. Also a course on environmental microbiology is offered at a basic level. The topics include fundamentals of microbiology, biotechnology of pollution control, energy generation of organic wastes, application of wastewater and biological treatment as well as public health microbiology.

Environmental Issues in Architectural Engineering Curricular

Environmental Issues in Cement and Construction Industry

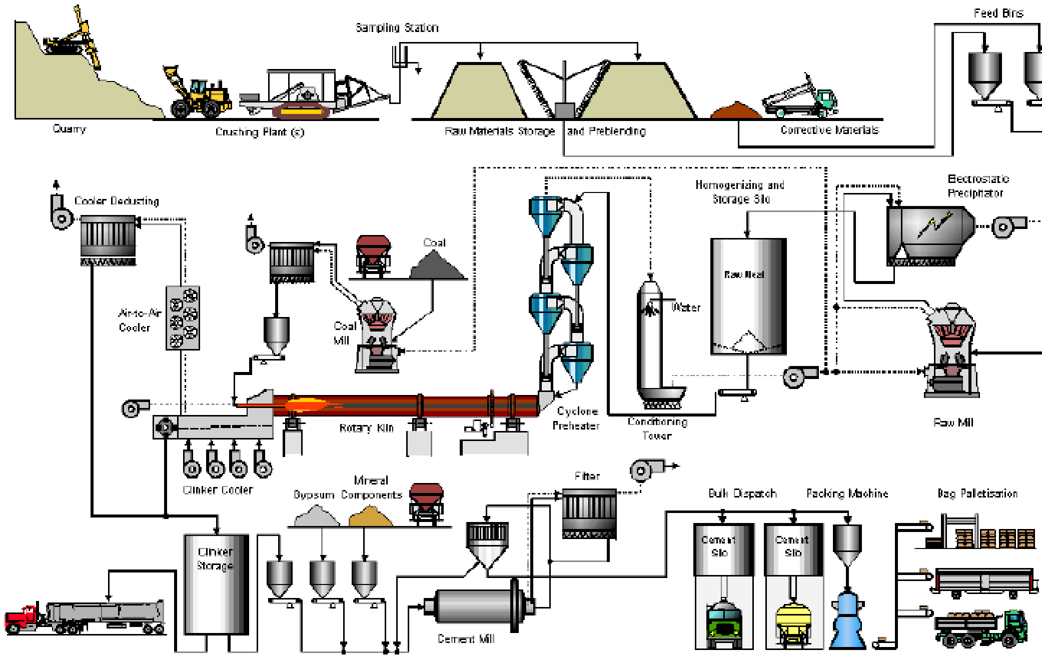
- Energy Consumption and GHG Emission during Cement Production

The Portland cement, along with structural steel and wood, is one of the most important building materials in the world. The production of Portland cement, however, requires large amount of natural resources and consumes significant amount of energy. For example, the production of 1 ton of cement requires about 4 GJ of energy and 1.5 tons of natural resources (mostly limestone) and at the same time produces about 900 kg of CO2.[2] It is estimated that, as 47 million tons of cement was produced in 2005, about 36 million tons of CO2 was emitted.[3] The amount of CO2 emission from the cement manufacturing alone corresponds to more than 6% of the total amount of CO2 emissions in Korea in 2007.

An available method for decreasing the energy consumption and the GHG emission in the cement manufacturing process is the use of cementitious materials such as ground blast furnace slag, fly ash, and silica fume which are biproducts of blast furnace, coal fired power plant, and silicon metal or ferrosilicon alloy industry, respectively. Two types of cementitous materials are currently available in significant quantities in Korea: ground blast furnace slag (9 million tons per year) and fly ash (5 million tons per year). Currently about 70% of these materials are being utilized as cementitious materials (as replacement of Portland cement) so that the cement production can be reduced by about 9.8 million tons which means a reduced emission of 7.5 million tons of CO2. It is noted that the level of utilization can increase as high as 80% which will bring about additional energy savings and further reduced CO2 emissions in the future.

Figure 1 illustrates a Portland cement manufacturing process. About 50% of all CO2 emissions is produced during the calcination (i.e. in the rotary kiln in Fig. 1) while the other 40% is produced as a result of burning the fossil fuels for the kiln. Remaining 10% is produced for the electricity generation needed to operate the grinding mill (cement mill in Fig. 1) and for other reasons including the transportation of the law materials.

Fig. 1 Production of Portland Cement (Dry Process) [4]



- *Inventory Data for Cement Manufacturing*

The “Low Carbon Green Growth” law which currently is under enactment process in Korea stipulates that the amount of energy consumption and the GHG emission from the cement industry be reported in an internationally accepted manner. Several international guidelines are available for this purpose such as IPCC guidelines and WBCSD-CSI CO2 Protocol.[2,5]

- *Environmental Management for Concrete Industry*

It is said that the construction activities have been consuming almost 50% of natural resources and energy used in all industries in the world.6 In Korea, for example, more than 350 million tons of new concrete is produced and, at the same time, over 40 million tons of waste concrete is generated every year. The total volume of the construction waste consisted 53% of all waste generated in Korea in 2006. As the service lives of many existing structures built after 1970s (the economic boom of Korea started from early 1970s and many structures were constructed in that period) are coming to an end, it is expected that the volume of waste concrete will increase very rapidly in the near future. It is possible to recycle most of these waste concretes as the law materials as the fillers in the road base construction and as recycled aggregates for the production of new concrete.

The evaluation of the environmental impact of the concrete industry in terms of the consumption of the energy and the natural resources, waste concrete generation, recycling of the waste concrete, and the generation of GHG related to the construction activities is therefore very important. Due to its large size and various activities involved, however, it is a complicated task to evaluate the environmental aspect of the concrete industry. Fortunately, the environmental concerns for the concrete industry in the engineering profession have led to the completion of some draft guidelines with which the verification of the environmental performance of concrete structures has now become possible[6,7]

Environmental Management of Building Design

The buildings have been traditionally designed for its aesthetics, serviceability, structural safety, and durability. Recently environmentality has emerged as new design criteria The U.S. Building Council‘s LEED (Leadership in Energy and Environmental Design) is a good example where a building may be rated according to its degree of greenness. It is divided into six categories: sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, and innovation and design process. The ratings are given in four categories:

platinum, gold, silver, and basic. [8]

Educational Curricular

Basic Courses

- Introduction to Thermal/Energy Engineering (Chemical Engineering)

Applying thermodynamic concepts to energy systems, The topic introduces energy systems with emphasis on quantifying costs and designing/optimizing energy systems to convert environmental inputs into useful forms of energy. It focuses on the technologies and the engineering process system. Energy resources, their conversion to electricity or mechanical work, and the environmental consequences of the energy cycle are discussed. Topics include: energy resources and economics; coal-based electricity generation; nuclear reactors; solar power; and energy conservation and air pollution control. The course gives analytical answers on the supply and demand, operating systems and costs for energy in the any given process. The course also includes the economic drivers used in simulating energy systems and consumption factors. Also, it will take the interplay between energy, environment, politics, economics, and sustainability. Students will experience simulating complex energy systems and cost-benefit analysis.

- Introduction to Environment Chemistry (Chemical Engineering)

This course is for a study of the chemical and biochemical phenomena that occur in natural places. It also includes some topics of the green chemistry, which seeks to reduce potential pollution at its source. It can be defined as the study of the sources, reactions, transport, effects, and fates of chemical species in the air, soil, and water environments; and the effect of human activity on these. Environmental chemistry is an interdisciplinary science that includes atmospheric, aquatic and soil chemistry, as well as heavily relying on analytical chemistry and being related to environmental and other areas of science. Environmental chemistry is that branch of one, which deals with the study of chemical and biochemical phenomena that occur in natural places like air, soil, and water. Environmental chemistry involves first understanding how the uncontaminated environment works, which chemicals in what concentrations are present naturally, and with what effects. Without this it would be impossible to accurately study the effects humans have on the environment through the release of chemicals. Students, who finish this course, have a basic understanding of concepts from chemistry and various environmental sciences to assist in their study of what is happening to a chemical species in the environment.

- Environmental Microbiology (Environmental Engineering)

- Fundamentals of microbiology
- Cell structure, Cell material, Microbial groups, Nutrition and growth, Microbial metabolism
- Biotechnology of pollution control
- Energy generation of organic wastes, Application of wastewater and biological treatment etc.
- Public health microbiology
- Pathogens, Microbial indicators of fecal contamination, Disinfection etc.

- Plain Concrete (Architectural Engineering)

A basic course on cement manufacturing, selection and properties of constituent materials for concrete, mix design including issues related to workability of fresh concrete, strength and durability of hardened concrete.

Advanced Courses

- Carbon Dioxide Emission Control and Sequestration Engineering (Chemical Engineering)

Control and function of the carbon dioxide will be taken for the process. Reducing the carbon dioxide emission and sequestration in the various processes are the main topics in this course. Begins with a review of the basic controlling of the factory processes, and then considers the clean chemical cycling of carbon and other re-usable for the emission controlling of the carbon dioxide. Topics include clean-chemical industrial processes and the technologies relating to the industrial processes. The sequestration technology for the emitted carbon dioxide includes the storage and the separation technologies by the membrane technologies, the adsorption technologies, and the sorption technologies, etc.

- Clean Development Mechanism (Chemical Engineering)

Clean Development Mechanism (CDM) is an emerging issue for the global environment. The course covers the political and technological projects for the CDM. The course includes the inventory, the analysis of the green house effect materials for the field, the biomass tasks for CDM, also the fossil fuel source, and their controls in the energy usage factory. The topic will consider both of the biomass and non-biomass CDM. Students will learn about the CDM management, controlling technologies for the green house effect gases (CO2, CH4, N2O, HFCs, PFCs, SF6, etc.) for the related industries, including the analytical and technological tools. Also, students can obtain the knowledge for political tools for CDM.

- Introduction to Bio-energy and Its Applications (Chemical Engineering)

This course provides a comprehensive overview of renewable energies, including solar energy, wind power, hydropower, fuel cells, biomass, and alternative transportation options. Students will learn the subject of biomass and its conversion to bio-energy and its applications in detail. Bio-energy is stored energy from the sun contained in materials such as plant matter and animal waste, known as biomass. Biomass is considered renewable because it is replenished more quickly when compared to the millions of years required to replenish fossil fuels. The wide variety of biomass fuel sources includes agricultural residue, pulp/paper mill residue, urban wood waste, forest residue, energy crops, landfill methane, and animal waste. Energy in the form of electricity, heat, steam, and fuels can be derived from these sources through conversion methods such as direct combustion boiler and steam turbines, anaerobic digestion, co-firing, gasification, and pyrolysis. Topics of properties, resources, Bioconversion, stoves, gasifiers, biopower, combustion, and environments are included. The student will investigate the potentials of renewable energy technologies to help solve environmental and economic problems within society. Objectives and components of an effective energy management program are discussed.

- Green-control and Management of Wastes (Environmental Engineering)

- Energy generation of combustible wastes
- Pretreatment of combustible wastes, Use and utilization of Refuse-Derived Fuel (RDF) etc.
- Utilization of biomass
- Biomass residues
- Material Flow Analysis (MFA)
- Decision support for control and management of wastes
- Optimal management of CDM
- Network optimization of Supply/Demand, Optimal-connected energy sources (gas, fluid and RDF etc.) from wastes (organic wastes, biomass and combustible wastes etc.)
- Unit operation of fermentation
- Production of bio-diesel, Consolidated methodology for energy generation etc.

- Understanding IPCC Report and WBCSD-CSI CO2 Protocol (Architectural Engineering)

The 2006 IPCC (Intergovernmental Panel on Climate Change) is a comprehensive reporting guideline with which one can quantify the energy requirement and the amount of GHG related to a specific sector. The WBCSD (World Business Council for Sustainable Development) CSI (Cement Sustainability Index) has also published a CO2 protocol which is similar in nature to the IPCC guide and used by 18 members of WBCSD-CSI.

- Concrete Industry and Utilization of Recycled Resources: Technologies and Policies (Architectural Engineering)

The introduction and discussion of the cementitious materials and the recycled resources (vs. natural resources) in cement and concrete industry. The LCA (Life Cycle Assessment) is emphasized as a structure goes through a life cycle of design, construction, operation and maintenance, and dismantling and recycling.

- Introduction to LEED (Architectural Engineering)

The U.S. Building Council's LEED (Leadership in Energy and Environmental Design) is a rating system of a building according to its degree of greenness. The program is divided into six categories: sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, innovation and design process where the ratings are given in four categories: platinum, gold, silver, and basic.

Green Industrial Complex

The green industrial complex is a multifunction education-and-research center currently under early planning stage which will be located in the southern region of Gyeonggi Province near the Hankyong National University. It is intended to showcase a green scientific exhibition hall, educational facility, and a research center. To emphasize its green image as much as possible, the reinforced concrete structure will be constructed using 100% recycled material: i.e. the concrete using Type IP cement containing industrial bi-products, recycled aggregates, and even recycled water. The heat and electric energy supply comes from self-supplying renewable energy sources: a co-generating system that uses the biogas or wood pellet. The facility will be equipped with large rain water tank for recirculation and supply of water, secondary geothermal and solar energy heat/cooling system. In the scientific exhibition hall, the green industrial products/systems developed by HKNU and nearby industrial companies will be on constant display. It is not only an education/research center of the HKNU but also a place for a visit for the young Korean students to have a hand-on experience with the various renewable energy system and green products in a structure built using recycled resources.

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