Process Systematic Research Initiatives on Decommissioning of Nuclear Power Plants – 15493

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ABSTRACT

This paper considers how process systems engineering (PSE) principles can be employed in the process of decommissioning and decontamination of nuclear power plants. PSE has been associated with design, operation, control, and optimization of chemical and physical processes. It has been shown to be very powerful in the context of analysis, synthesis, and evaluation of chemical and petrochemical industries. This paper aims to identify the research opportunity in employing the PSE principles in the decommissioning of nuclear power plants in order to minimize their cost and time.

INTRODUCTION

Most power plants such as coal, gas and nuclear, have a finite life beyond which it is not economically feasible to continue operation. Generally speaking, early nuclear plants were designed for a life of about 30 years, though some have proved capable of continuing to operate well beyond this. Newly built plants are designed for a 40 to 60 year operating life. At the end of the life of any power plant, it needs to be decommissioned, demolished and the site remediated to make it available for other uses. For nuclear plants, the term decommissioning includes all clean-up of radioactivity and progressive dismantling of the plant [1].

Nuclear power has been an important energy supplier in the present and will continue to be so in the foreseeable future. Managing such a large scale involves the entire cycle of the plant from the beginning to an end. The cycle generally consists of construction, operation and decommissions, etc. All three tasks should be treated with equal consideration. Many countries including South Korea have been mainly interested in operating nuclear power plants in order to respond to increasing electric demands without delay. As the early build nuclear power plants are coming to the end of their life cycle, the less considered phase of the cycle, mainly decommissioning and decontamination (D&D) is receiving increasing attention.

DECOMMISSION AND DECONTAMINATION

Decommissioning involves a series of processes such as removing the used nuclear fuel from the reactor, dismantling nuclear power generation containing radioactive products and cleaning up the corresponding facility.

Considerable experience has been already gained in decommissioning various types of nuclear facilities in some countries. About 85 commercial power reactors, 45 experimental or prototype power reactors, as well as over 250 research reactors and a number of fuel cycle facilities, have been retired from operation. Of the 140+ power reactors including experimental and prototype units, at least 15 have been fully dismantled, over 50 are reported to be in the process of being dismantled [1].

Decommissioning incurs both significant cost and time to achieve. Therefore it is critical to approach the

entire D&D process with the aim of minimizing both. It is very important to developing individual D&D strategies and orchestrates them. In South Korea it is now the appropriate time to commence the preparation of the necessary D&D research and development (R&D) and to gather appropriate associated technologies. Some of these may be commercially available while others may be further explored through further R&D. The management of and experience in decommissioning and decontamination are mostly found in IAEA related materials such as [2], [3].

Because D&D consists of a series of chemical and mechanical processes an understanding of process systems based engineering effort would be very helpful in addressing D&D. Typical factors for decision-making for decommissioning are time, cost, spaces needs, waste and interaction with other techniques.

PROCESS SYSTEMS ENGINEERING (PSE)

Chemical processes are generally very complex to design rigorously and very expensive to construct. Delicate features including high purity, high pressure and temperature often cause the operation very challenging. In order to obtain the economically optimal configuration and compute the operation condition, a variety of thermodynamic, unit operational and process associated issues should be considered concurrently. Most of these calculations cannot be done manually but should be based on computational methods that are connected in a systematic way. Process systems engineering (PSE) is the discipline aiming to address the computation. Many researchers in the universities such as Prof. Roger Sargent in Imperial College London, Ignacio Grossmann in Carnegie Mellon University plus other academic collaborators have been addressing PSE. Algorithms, computation software tools such as gPROMS©, ASPEN Plus©, have been the result of their work. There are many reviews available but recent work by Klatt [4] is worthy of mention.

Recently the main interest of PSE has been expanded from the process itself into the level of enterprise-wide corporate level using the concept of supply chain management. The expansion can be justified by the fact that the process operation is affected by the inventory level of warehouses that is away from the location of the production processes. The decisions at the operation of processes in one place is affected not only their operation constraints as well as customer and inventory constraints.

PSE is concerned with developing methodologies and tools to support process modeling, simulation and optimization (MSO). These are implemented in the decision-making of designing, controlling and operating chemical process systems in a holistic manner. PSE may be the ideal solution by combining chemical engineering, applied mathematics and computer science with the focus on specific model-based methods and tools.

DECOMMISSIONING AND DECONTAMINATION EMPLOYING PROCESS SYSTEMS ENGINEERING (PSE)

In chemical process industries such as petro-chemical refinery, fine chemical, pharmaceutical manufacturing, PSE has been shown to be an essential discipline in developing academic progress as well as industrial implementation. Nuclear power plants are also very delicate and complex and their decommissioning should be approached by systematic procedure because of radioactivity and large volume structure. It is obviously desirable to assume the decommissioning should be based on systematic procedures and methodologies.

Some of the D&D technologies must be based upon the systematic ways similar to PSE. It is not realistic to assume that PSE is the only rigorous method in addressing D&D. however the advantages of PSE are proven to be beneficial in making the existing D&D process more efficient with reduced cost and time.

Because decommissioning involves multiple processes such as mechanical, thermal, hydro-dynamic, chemical processes, D&D should be approached from the perspective of optimization.

An understanding of process systems can be used to address the inherent complexity of processes and the multi-objective nature of decision-making procedures of D&D. Various kinds of illustrations would be followed with the benefit of saving cost and eliminating redundancies of resources.

CONCLUDING REMARKS

Dismantling old nuclear power plants is drawing increasing attention. Most of the associated technologies are generally already available. The challenge is to minimize the associated costs and prevent accidents during the operation caused by natural as well as artificial factors. There is much to be done for the Chemical Engineering Community in developing energy industries including nuclear power generation and the associated business. Systematic expertise of PSE can be proven to be an effective methods and tools to address the issues of Decommissioning & Decontamination

D&D involve much of chemical engineering oriented practices and have an opportunity for PSE practices to play an important role. D&D projects can sometimes span over 30 years and incurs large costs. Such projects need to be effectively managed using proven systematic project engineering practices, the past experiences of PSE are expected to be of great help in achieving this. Many nuclear power plants in Korea will be closed down within decades and a series of decontamination and decommissioning works will be emerging realistic agenda and the wide range of R&D strategies need to be prepared in order to create a new emerging industry.

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