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Int. J. Production Economics 64 (2000) 311–318

international journal of
production
economics

www.elsevier.com/locate/dsw

A concurrent engineering approach to chemical process design

Paulien M. Herder*, Margot P.C. Weijnen

Department of Systems Engineering and Policy Analysis, Group of Industrial Systems and Environmental Resources, Delft University of Technology, P.O. Box 5015, 2600 GA Delft, Netherlands

Abstract

Much confusion still surrounds the concurrent engineering design concept in the chemical engineering world. The conventional hierarchical design method is compared to the concurrent engineering concept, and it is shown that the CE concept particularly improves the way a chemical design engineer deals with "external factors" that influence a process design. A framework is introduced to easily identify and classify these external factors. Through a number of industrial case studies, the current design methods have been analyzed, and improvements are identified. The flexibility of the plant can be improved by using a concurrent approach. © 2000 Elsevier Science B.V. All rights reserved.

Keywords: Chemical process design; Concurrent engineering; Hierarchical design; Flexibility

1. Introduction

In industrial practice, the design of a new chemical plant or the retrofit (redesign) of an already existing plant is usually executed according to the hierarchical engineering method as described by Douglas [1,2]. The hierarchical method is used by process engineers in many different companies and taught at many universities. Interviews that were held with process engineers in several different companies, showed, however, that the hierarchical method has one major drawback. It is encountered in the effectiveness of dealing with the so-called external factors. Here we will address this drawback and investigate whether a concurrent engineering approach will better incorporate external factors into the design process and into the final design of the plant.

2. External factors

During the design process of a chemical plant, the design engineer has to account for numerous external factors. We define external factors as

> "factors that influence the design process or the design of the plant, but cannot be manipulated by the process design engineer, thus posing either constraints or opportunities to the designer".

External factors differ from the "basic design criteria" or "basis of design" of a plant, which is a well-defined list preceding each design project, in the sense that the basis of design contains only a subset of all possible external factors.

* Corresponding author: Tel.: + 31-15-278-2823; fax: + 31-15-278-3422.

E-mail address: paulienh@sepa.tudelft.nl (P.M. Herder)

0925-5273/00/$ - see front matter
PII: S0925-5273(99)00068-7

Furthermore, external factors are not only factors that occur outside the boundaries of the plant, but they can also rise from within the plant. A factor is thus "external" relative to the design engineer, as has been stated in the definition.

External factors are found in three different environments of the plant. Examples from the physical/technical environment are options for heat integration, the site infrastructure or the utility systems. The second environment is the economic one and examples from this area are market dynamics, competitor's behavior or raw material price and availability. The third environment of the plant that can be recognized is the social/public environment. Here we can find legislation or lobbyist groups as external factors to the process design. Note that these three levels can again be divided into sub-levels, by taking into account the organizational aspects of a design process. We can then distinguish several layers of "power" or responsibility. However, we will not further address this subdivision in this paper, in order to prevent irrelevant complications.

To be able to classify the external factors in an orderly fashion, three different levels of aggregation have been defined. The three types of external factors, that are described above, can be found in each aggregation level. The levels are:

- plant; strictly one plant, excluding utilities;
- site; the site of the plant (if applicable), including utilities, excluding transportation to and from the site;
- world; the entire environment of the plant, outside the site.

Table 1 gives examples of external factors from the three different environments. They are classified into the aggregation level of their *occurrence*. We are only interested in factors that influence the plant design, so we will not explicitly address the external factors that *affect* the aggregation levels "site" and "world", but it should be kept in mind that the site is also influenced by external factors, and that the site at its turn influences the plant design.

Table 1 shows only a few examples per category, but it is evident that there are many more external factors in any design case. In the case study section of this paper, more specific examples of external factors will be given.

3. The hierarchical approach

In a strictly hierarchical approach, the amount of detail of the design increases as the design process progresses. In the first stages, major design decisions are made concerning the basic process flowsheet of the plant. Amongst others, the reactor and recycle structure is chosen and the basic layout of the separation section is determined. The decisions that are made in these first stages are not supposed to be changed later in the project, because that would imply much rework and higher design cost.

Table 1
Classification of some external factors.

	Technical	Economic	Social/public
Plant	• Heat integration • Physical boundaries • Process control	• Waste disposal cost • Life cycle costs	• Preferences of designers • Strategic behavior of designers
Site	• Heat integration • Utility systems	• Utility cost	• Site specific preferences • Site regulations for HSE
World	• Climate • Possibility of earth quakes	• Product revenues • Competition	• Government regulations for HSE • Image of the company