Chapter 2
Decision Support Framework for the Selection of a Layout Type

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ABSTRACT

One of the most important design decisions in a firm is the choice for a manufacturing layout type. This chapter shows which aspects have to be taken into account and suggests a systematic method for the decision problem. The method can be seen as a decision support framework, which links the various aspects. The framework is based on the AHP (Analytic Hierarchy Process) approach. A case study, concerning a Dutch firm, illustrates the applicability of the framework in a practical instance.

INTRODUCTION

The choice for a manufacturing layout is a strategic issue and has a significant impact on the performance of the operations function of a company (Meijers and Stephens, 2004, Francis et al. 1992). A variety of manufacturing layout types may be applicable in a practical situation. Table 1 presents some alternative layout types for high-variety/low-volume situations. The most dominant layout type in practice is the process-oriented functional layout, where machines of the same type are located in the same area (Slomp et al., 1995). An important alternative is the so-called Cellular Layout type, where machines are grouped in cells and each cell is responsible for the complete manufacturing of a part family. This product-oriented layout type has gained substantial attention in literature and in practice (Wemmerlöv and Hyer, 1989, and Wemmerlöv and Johnson, 1997). Both types of manufacturing layout have their advantages and disadvantages. Several authors present alternative layout types to cope with the disadvantages of the functional and/or cellular layout type. Rosenblatt (1986) suggested a dynamic plant layout where cellular
configurations periodically change depending on the demand in each period. Balankrishnan and Cheng (1998) present a review on the dynamic plant layout problem. Venkatadri et al. (1997) and Montreuil et al. (1999) propose a so-called fractal layout for job shop environments in order to gain the flow time advantages of Cellular Manufacturing and the flexibility of a functional layout. This type of layout is robust with respect to changes in demand and product mix. Another robust design, the so-called holographic or holonic layout, is proposed by Montreuil et al. (1993). Here individual machines, or machines types, are strategically distributed through the facility. Production orders are assigned to available machines which are located in the same area of the plant. A special case of the holonic layout is the so-called distributed layout (Benjaafar and Sheikhzadeh, 2000 and Benjaafar et al., 2002) where machine replicates are strategically distributed across physical space. Some researchers stress the need for a hybrid layout system which combines several layout types (e.g. Irani, 1993). Irani and Huang (2000) and Benjaafar et al. (2002) define a modular layout in which products have to be manufactured by one or more modules. Each module may have its own internal layout. A modular layout is an example of a hybrid layout. Wemmerlöv and Hyer (1989) show that many companies apply a hybrid layout.

This chapter presents a general decision support framework for the selection of a manufacturing layout type. Our focus lies on the selection of objectives, aspects and contributing elements for the selection problem. The framework applies the AHP (Analytic Hierarchy Process) approach (Saaty, 1980). This approach is useful for multi-criteria decisions where intuitive, qualitative and quantitative aspects play a role. The approach includes a hierarchical decomposition of the decision problem and a further decomposition of each decision level into pairwise comparisons of decision elements. Next, the “eigenvalue” method is used to estimate the relative weights of the decision elements. For a further explanation of the AHP method, we refer to Saaty (1980) or Zahedi (1986). As will be made clear in the remainder of this chapter, the AHP method offers several advantages in the layout type selection problem.

The next section will provide some further background to the selection problem. We will make clear that it is important to approach the layout type selection problem from a strategic viewpoint. In a subsequent section, we will discuss how layout types influence generic objectives of a company. We will then show how various aspects of layouts have an impact on manufacturing performance. The performance objectives and the various aspects are presented in the form of a decision hierarchy, according the AHP approach. After specifying the AHP approach, we present a case study to indicate the generic value of the defined decision hierarchy. The last section of this chapter is meant to reflect on the proposed selection methodology and to draw conclusions.

**BACKGROUND**

Literature on layout design problems falls into two major categories, algorithmic and procedural approaches (Yang and Kuo, 2003). Algorithmic approaches make use of simplified design constraints and objectives and can be used to generate layout alternatives efficiently (Meller and Gau, 1996). Algorithmic approaches are useful as a step in the design of a detailed layout. They assume the choice of a layout type. Procedural approaches may incorporate the choice of layout type and take care of both qualitative and quantitative objectives in the whole design process (Muther, 1973). A major disadvantage of a procedural approach is its dependence on the subjective judgement of one or more experienced designers. Furthermore, procedural approaches divide the design problem in several steps which may lead to suboptimality. In order to overcome this suboptimality, designers may develop alternative layouts, based upon different layout types, and a well-working methodology.