2

Design Approaches

2.1 Introduction

Designing of manufacturing systems involves the design of products, processes and plant layout before physical construction [35]. CE, which is known as *simultaneous engineering*, allows an interaction among different levels of the design of flexible manufacturing systems. This approach is intended to force the developers and designers, to consider all elements of the product life cycle from conception through disposal, including quality, cost, schedule, and user requirements, *etc. Concurrent engineering is getting the right people together at the right time to identify and resolve design problems* [37]. Figure 2.1 shows the modules composing the CE concept, which can be divided as follows:

Product analysis (PA) is based on classical design for assembly (DFA) rules and proposes a first product design review and a first decomposition of the product into sub-assemblies [18]. It yields a precedence graph between the functional components of the product.

Operating modes and techniques (OMT) proposes an assembly technique (screwing, force fit, *etc.*) for each attachment between the parts, and possible modes (manual, automated, robotic) for each operation [92]. Then, the process time and cost are computed for each chosen technique.

LL assigns tasks to stations and decides on the position of the stations and conveyors.

In this chapter, Section 2.2 explains the difficulty of design, while the design and search approach is presented in Section 2.3. The gap between theory and practice of ALD is discussed in Section 2.4. An approach for the quality of a solution is presented in Section 2.5, and Section 2.6 is devoted to ALD evolution.

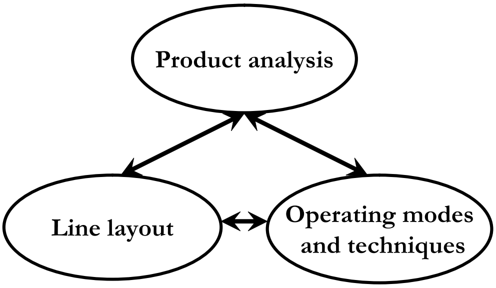

Figure 2.1. Flow chart of the CE

2.2 Why the Design is Difficult?

Design is a prescience phase and it must go through several stages before it constitutes a natural science. In mechanical engineering, a product or a component is evaluated under numerous interrelated criteria, such as quality, reliability, assembly, and maintenance, *etc.* Then, one or more approximate solutions to the problem are selected. Thus, design is very subjective and depends on the background of the designer [106, 108].

2.3 Design and Search Approaches

Design has not always been a rational process; it is often a chaotic affair where consultation and consensus are scarcely evident. The work of participants in the process is often departmentalised, each one with its specific expertise. Participants always explore their ideas unilaterally through virtue of their 'expertise', imposing constraints upon all others. The process begins with the identification and analysis of a problem and proceeds through a structured sequence in which information is researched and ideas are explored and evaluated until the 'optimum' solution to the problem is reached. As we glance through a number of design methods presented in the literature, many circles, arrows, paths, boxes, charts and diagrams can be observed [106, 108].

2.4 The Gap Between Theory and Practice

The operation research community has developed several algorithms to tackle the ALB and RP problems [12, 146]. The adaptation of such algorithms to real-world problems would yield very useful tools, since they are able to propose 'optimal' solutions for benchmarks. Only a few companies use published techniques to balance their ALs because they suffer from substantial loss of information [89, 129, 135]. In fact, little work has been done to model the full range of practical ALD considerations. Generally, we tackle linear ALs without separation into sub-lines. The common performance indices are the cycle time and the number of stations. In fact, other factors (*e.g.* traffic problems, station space, transportation networks, *etc.*) may also heavily affect the system performance. The following sections present some reasons which render the difficulties for academic methods to be applied to real-world problems.

2.4.1 Input Data

Most of the industrial approaches applied to design problems suffer from the amount of data the designer has to introduce. On the other hand, existing academic algorithms require small amounts of input data and cannot be applied to industrial problems [113]. They suffer from substantial loss of information, leading to solving fictitious problems rather than real (industrial) ones. Therefore, there is a clear need to overlap the two concepts and deal with more real constraints of the design problem, rather than spending time on a *benchmarking* fight.

2.4.2 Multiple Objective Problem

The ALD must be formulated as a multiple objective problem rather than minimising the number of stations or the imbalance between stations. Efficient ALD methods should be able to deal with conflicting objectives and consider the user's preferences. They should be quick enough to allow the designer to test as many alternatives as possible (see Chapter 5).

2.4.3 Variability

Most of the ALD parameters that can be accurately estimated by engineers are available in terms of their average values (*e.g.* the mean process time, the average cycle time, and the mean reliability of equipment). In some cases, assigning a fast operator, in the case of manual AL, to the operation with high variability may help to increase line productivity. Stochastic methods must be integrated into ALD approaches to deal with these types of problem (see Chapter 6).

2.4.4 Scheduling

Most research on ALs considers scheduling problems. The ALB and the variant ordering for mixed production have been considered as two separate but related problems. By separating the two problems, sub-optimal solutions are often obtained. Chapter 8 introduces a new concept, called the *BFO* to treat both problems simultaneously.

2.4.5 Layout

The design problem of organising an assembly system into workcentres in a plant is the well-known facilities layout problem. The position of each workcentre determines the costs of transportation and storage. Better solutions can be found by using the premises of the physical layout (PL) as input data for the LL and *vice versa* (see Chapter 9).

2.5 About the Quality of a Design

Performance evaluation generally involves two steps: (1) mathematical model and (2) model solution. Because of the large number of these components, it is difficult to find a simple model to describe a studied system. For this reason, simulation is frequently considered, where the purpose is to develop a mathematical model that resembles as near as possible the real decision situation. Then, a computer is used for solving the problem under various decision circumstances. It is highly important to take into account the operators knowledge (the person who really does the job), about the complexity of the tasks, the grouping of tasks, the process time, and all their experience on all the assembly methods. Thus, interactive and iterative methods have to be developed in order to introduce such knowledge to computer-aided design (CAD) tools. The designers propose a set of AL alternatives, while operators give their experience and criticism of the proposed solutions (Figure 2.2). The aim is to shorten the gap between *frequent talks* about human factors in ALs and the actual reality of things.

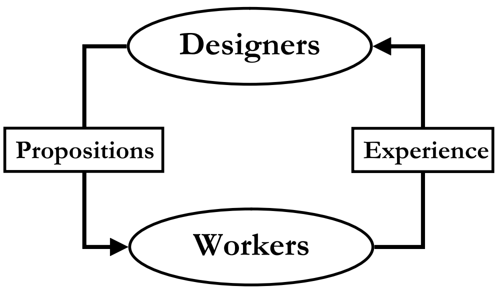

Figure 2.2. Interaction between designers and workers

2.6 Assembly Line Design Evolution

The introduction of new products and the modifications in the product yield frequent redesigns of the AL. Thus, with the increased diversified demand, manufacturers use multi-model ALs. In *batch production*, only one product is produced over a certain period, while in *mixed production* several variants of the product family are produced all the time. In the case of ALD, only a little research has been done on the methods that help to improve existing designs. The aim is to enable a computer to create new designs, with some preliminary or existing designs being supplied. The evolution of complex assembly systems at the same time seems to be more complex, and requires more reflections. As constraints and preferences evolve with time, the progress of design methods has to run parallel to them.

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