SUMMARY

The design process is traditionally a time consuming, iterative business. First, a preliminary design must be created, which is then analysed, experimented or tested in use to determine its quality. The process of search and evaluation is repeated until the design is viewed as being acceptable. Computer aided-design software(s) and computer simulation and analysis tools are widely used today. In contrast automatic design or redesign techniques, are until now, less common. The recent success in design is due to the adaptive search techniques, in particular the genetic algorithms (GA). GAs are a powerful and broadly applicable stochastic search and optimisation technique. Perhaps, they are the most widely known type of evolutionary computation methods today.

Assembly lines are production systems composed of a succession of stations, connected by a conveyor, performing a set of tasks on the product passing trough them. The design of an efficient assembly workshop is a problem of considerable industrial importance. A production workshop can be set up following various topologies—line, cells, combination of several lines. The line layout problem is composed of a logical and physical ones. The logical layout is defined in the literature as the assembly line balancing (ALB) and the resource planning (RP) problems. The ALB is used specially for manual assembly lines and aims to balance loads of stations. For hybrid (manual and automatic tasks) assembly lines, the RP helps to find an assignment of tasks to stations and an assignment of resources to each of them. The main objective is to minimise the total cost of the line by integrating design (stations space, cost, etc.) and operation issues (cycle time, precedence, availability, etc.). The physical layout module determines the space requirements taking into account station dimensions, material storage, etc. The main objective of assembly systems designers is to increase the efficiency of the line by maximising the ratio between throughput and the required costs.

A line design problem often has a complex structure due to multiple components, e.g. tooling, material handling facility, and so on. A number of design alternatives may exist. The problem can easily become unmanageable if the designer has to consider all these alternatives. Most real-world problems involve multiple, often conflicting, objectives. In assembly lines design problems, designers deal with objectives such as line efficiency, cost, imbalance, reliability, stations space. Thus, many practical search and optimisation problems are better posed as multiple objective problems (MOP) and ask for a compromise among conflicting objectives. Since it is impossible to replace designer's intelligence, experience and creativity, it is more important to provide him with a set of assistance tools. These tools just investigate and propose several solutions and make the necessary evaluations. Based on this information, the designer tests some alternatives and makes his decisions. Due to the difficulty of assembly line design problems, metaheuristics are often used to solve this kind of problems. The resulting solutions are adjusted to create an acceptable design.

Applying GAs to solve MOP has to deal with the twin issues of searching large and complex solution space and dealing with multiple, potentially conflicting objectives. Selection of a solution from a set of possible ones on the basis of several criteria is considered as a difficult task. Classical methods reduce the problem to a mono-criterion one–the popular weighted-sum approach. Many studies adopted Pareto-based GA search to sample the entire Pareto-optimal solutions. The main drawback of Pareto approaches is the number of solutions the DM has to choose among them. The human cannot easily decide among more than few solutions. Few researchers have suggested ways of integrating the multi-criteria decision-aid (MCDA) and the GA search. The GA iteratively samples the tradeoff surface (Pareto solutions) while the MCDA method narrows the search.

In order to come out of the MOP stated by the cost function and especially in the case of grouping problems, we present a new multiple objective grouping genetic algorithm (MO-GGA). The method is based on the grouping genetic algorithm (GGA) a GA suited to grouping problems and an MCDA method called (PROMETHEE II). The choice of a solution over the others requires problem knowledge. It is the decision-maker's (DM) task to adjust the weights to help the algorithm to find good solutions. Optimising a combination of objectives has the advantage of producing a single solution, requiring no further interaction with DM.

In order to deal with line balancing, which is an important part of the assembly line design, we introduce a new algorithm called 'equal piles for assembly lines'. The hard constraint of the problem is the fixed number of stations (piles), the aim is to find the best balanced assembly system. The proposed approach is based on the so-called 'boundary-stones'. Many heuristics were also developed in this study: simple and multiple wheel, merge and split, pressure difference. This algorithm is used as an individual construction heuristic in the GGA.

In the case of the RP, the aim is to select equipment to carry out the assembly tasks. We present a new method which is based on the MO-GGA, the branch-and-cut algorithm followed by the MCDA method. The accent is put on how to deal with the user's preferences in design problems.

In order to deal with the changes during operation phase of assembly lines, we introduce a new concept of balance for operation (BFO). This concept permits to treat the balancing and the scheduling model at the design stage.

The balancing of assembly lines is most of the time uncoupled from the facility layout problem. This yields sub-optimal line layouts. An iterative procedure partially treating simultaneously the two problems is proposed. First, tasks performing alike activities are grouped together in a workcenter (a set of linked stations). This leads to a number of workcenters. Then, tasks are assigned to stations, which leads to a number of stations on each workcenter. The main concern of this approach is the quality of the resulting line in terms of balancing and its suitability to the material flow requirements of the production system.

The last part of this book is dedicated to the integrated method to design assembly lines. A concurrent engineering approach is presented; it shows the way to help designers using iteratively and interactively the different modules.