CHAPTER 11

CONCLUSIONS

Ever tried. Ever failed. No matter.
Try again. Fail again. Fail better.

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(1906 - 1989)

Keywords: assembly line, evolution of assembly line, line layout, project proposition.

1. We attained...

Despite the number of works on assembly line design and balancing, academic algorithms are rarely used by industrial companies. This is because despite their effectiveness and the easiness of their use, they use little data and suffer on substantial loss of information leading solve fictitious rather than industrial problems. As many practical optimisation problems, the assembly line design must be formulated as a multi-objectives problem rather than to aim minimising the number of stations or the imbalance between stations. Efficient methods of LB and RP should be able to deal with conflicting objectives or take users preferences into account. They should be quick enough to allow the designer to test many alternatives.

In order to deal with assembly line balancing–which is the main part of the design of assembly line–we introduced a new algorithm called equal piles for assembly line. The hard constraint of the problem is the fixed number of stations, the aim is to find the best balanced assembly system. The proposed approach is based on the so-called 'boundary-stones' and several heuristics embedded in a grouping GA (GGA). In order to deal with the changes during operation phase of assembly line, we introduce a new concept of balance for operation (BFO). This concept permits to treat the balancing and the scheduling model at the design phase. In the case of hybrid assembly line, the resource planner aims to select equipments to carry out the assembly tasks. We presented a new method which is based on a multiple objective GGA (MO-GGA), and the PROMETHEE II method. The accent is put on how to deal with user's preferences in design problems. The optimality of the proposed solutions is quite subjective, so one have to talk more with design satisfaction than optimisation.

The academic-industrial phase of the whole job is already done. Everybody says 'it works perfectly…', in fact the sentence must be '… perfectly on *academic* instances…'. Still to validate the academic methods on industrial problems. It is known for the optimisation community that search methods (algorithms) do not behave in the same way on different search spaces and for different objectives… There is still a long way. The next step is to enhance the proposed models to deal with real-world assembly line design problems.

2. Tendencies and orientations

A lot of money (a billions of dollars) are spent annually on the construction of new facilities. Apart from the magnitude of costs involved in facilities, the frequency with which layout decisions are made is also important. It is estimated that the layout of most facilities is modified approximately every 2 to 5 years. This continuous change is required to keep pace with changes in demand, new product introductions, process changes, improved tooling and technology, new legislation, etc. With the increased diversified demand in production, manufacturers tend, depending on the type of production, to use mixed-model assembly line or batch production. The evolution of the demand forces designers to re-configure their assembly line. Techniques that allow to deal with the evolution of the architecture of assembly line over the time are more asked for than methods that propose designs from *scratch*. This involves an increasing need for fast computer-aided design tools to follow the frequent changes. The aim is to develop assembly line design (ALD) tools which allow to take this evolution into account.

One of the classical questions about the *operator* (*human*) is how much it costs to enrol it, and how he is skilled? Only few methods take into account the tasks difficulties, how much time it really takes a given task to be done, etc. The workers on the assembly line have a lot of knowledge, but they do not have opportunities to express that knowledge to the larger society[1]. In order to efficiently design assembly line, knowledge about tasks complexity, preferences on tasks grouping, the process time, etc. must be taken into account. An interactive and iterative method 'design for human' can allow the introduction of such knowledge to computer aided design methods. The designers propose a set of alternatives of assembly line to a given

[1] There is a need to collect that knowledge and then to articulate it so that the voiceless (workers) can have a voice.

product, while operators give their experience and criticism on the proposed solutions.

3. Data collection

There is a clear need for a line design approaches based on realistic input data. Indeed, almost all industrial approaches to design problems suffer more-or-less from the same drawback which is the amount of data the designer has to deal with. On the other hand, existing academic algorithms, requiring little input data, cannot be applied on industrial problems–even if they get good results on tests problems. This is because despite of their efficiency, their user-friendliness and the easiness of their use, they use little data and suffer from substantial loss of information, leading to solve fictitious rather than industrial problems. There is thus a great need (and a big challenge) to overlap both approaches. An intensive collaboration with industrials is asked for to collect the data needed to model the full real-world assembly line design problem.

4. Model formulation

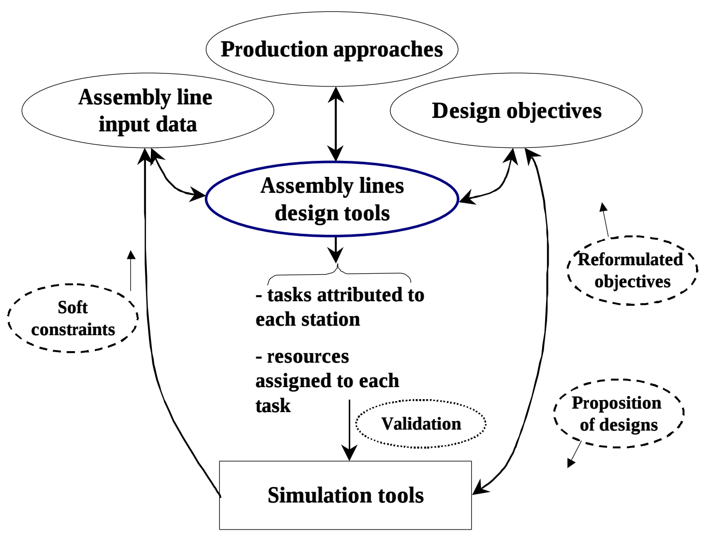

Figure 11.1. An Integrated method to assembly line design.

The line layout module assigns tasks to stations, and decides about the position of stations and resources on the plant floor. Line layout is decomposed into logical and physical layouts. The logical layout assigns tasks to stations, while the physical layout module thereafter determines the space requirements taking into account station dimensions and material storage, handling systems and so on. The line layout problem is an iterative and interactive procedure whose philosophy is illustrated in Figure 11.1.

- The production approach: help to decide among batch and mixed production.
- The line description: it is the input data of the design method. It allows to describe the problem at hand as preferences and constraints.
- The design objectives: allow to express the criteria to optimise as well as designers desiderata.
- The design tool propose the assembly line architecture tacking into account designer preferences.
- The simulation module permits the verification of the proposed design.

The approach must be iterative and interactive. Thus, design tools propose a set of architectures while the simulation module checks their validity. Then, designers can reformulate their desiderata and soften some constraints and re-run design tools, an so on until a solution is accepted.

5. Validation and output analysis

A classic question is 'how is good the proposed design?' First of all, a clear definition of input as well as output of the system if asked for. It also require that a good understanding of the design process must be achieved before developing any appropriate tools.

One of the main objectives of assembly systems designer is to increase the efficiency of the assembly line by maximising the ratio between throughput and required costs. Line performance is the outcome of interactions between these components. Performance evaluation involves generally two steps: (1) mathematical model, and (2) model solution. Since it is difficult to find a simple model to describe a studied system, a simulation method must be used. A standardisation of *performance indices* of line layout design must be defined as well as the factors that may affect the performance of the system.

6. A proposed approach

We propose a project composed of seven phases with the following structure (Figure 11.2).

Line evolution

This task has as objectives the identification and the modelling of the evolution of assembly line. Line designers and resource planners can help to understand the phenomenon. This phase will permit us to tight the gap between design industries approaches and academic ones.

Design constraints

This task has to model the interaction between designers and workers. Human factors like tasks complexity, reliability, worker's experience, human skills, etc. must be studied and integrated into the design process. Depending on production approaches and design objectives, the constraints of the design problem, the complexity to find a good solution may vary. The second sub-task is to develop mathematical models to analyse the complexity of the problem at hand.

Database enrichment
The aim is to describe efficiently the line design problem. An enrichment of a database with information to help design tools is asked for. Useful information must be stored in database, while useless information must be discarded.
Also research in the field of graphical representation of graphs for complex products have to be done. The aim is to help designers to get quickly an idea of the implication of these graphs on the possible balancing.

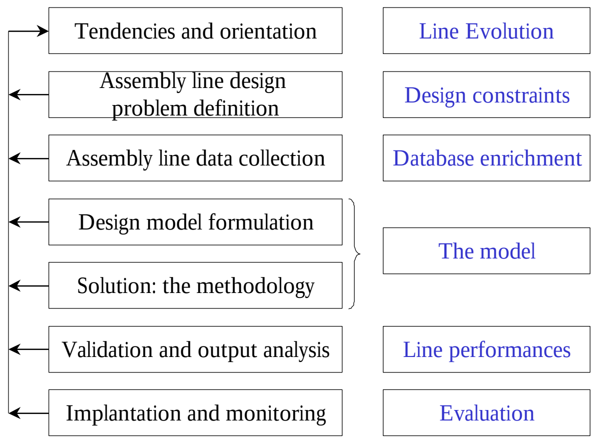

Figure 11.2. Development of an approach to design of assembly line.

The model
Once all the input data of the assembly line design have been collected and confirmed, the next step is to model the design tool to define the output data, the interaction between the different modules, the methods to develop, and so on. The model has to take into account the results of the tasks cited above.

Line performances
The aim of this task is to define the performance indices of line layout design. Since ALD is a multiple objective search problem, the goal is to define an easy way to select the best line design from existing ones. The method will be based on multi-criteria decision aid methods. The aim is to exploit the features of GA to allow designers to deal with user's preferences.

Evaluation
A user-friendly interface must be developed in order to facilitate the access to the assembly line data stored in many different databases. In order to validate the different algorithms and methods, we have to integrate design tools in these design packages such as CATIA and simulation models such as AUTOMOD.