Preface

Modern industry puts a lot of challenges on all the people involved. High quality standards and high customization, tight deadlines, and small volumes of orders already pose a lot of problems to the managers, industrial engineers, and ordinary workers. With fierce competition in the market added to this, the picture becomes even more dramatic.

Good old days when improvement of a manufacturing process was rather a hobby of the managing person than his perpetual task are gone. An ongoing improvement today is a matter of survival in a tough environment rather than just a matter of higher income. It is not enough just to improve; it is crucial to improve more than all (or, at least, most of) the competitors. That is why an improvement, or optimization, of a manufacturing process becomes a complicated problem that one cannot resolve without having suitable tools at his disposal.

Optimization of a manufacturing process has multiple "facets" and includes layout design, jobs scheduling, workload control, etc. Each of these subproblems provides a broad area for research and deserves a separate book. That is why we have chosen only a small problem in the field of layout design—the cell formation (CF) problem aimed at decomposing a manufacturing system into several subsystems so that a particular objective (classically, a mutual independence of cells) is optimized.

Though the cell formation problem is usually seen in a rather narrow context of a cellular layout, we argue that it is much more general. As a matter of fact, virtually any manufacturing system is somehow subdivided into departments, production lines, cells, etc. We believe that any such subdivided system can be described in CF terms using a proper definition of objective and similarity between machines. Generally speaking, most of the layout design problems can be viewed as a clustering problem where machines must be grouped into clusters based on some similarity between them. For example, in functional layout, the machines are grouped based on the similarity of functions that they perform, in production lines—based on the sets of products that are processed on a sequence (line) of machines, and in a classic cellular layout—based on the similarities of sets of products they are needed for. To sum up, any possible grouping of machines may be seen as a clustering according to a certain similarity measure.

It should be noted that the cell formation problem is not as well defined as most of the combinatorial optimization problems, like the p-median problem. It rather exists as a collection of approaches, each equipped with its own objective function and constraints, aimed at a general goal of clustering machines and products (physically or logically) so that the performance of the manufacturing system can be improved. In this book we make an attempt to consider the cell formation problem in a systematic and formalized way and propose several models, both heuristic and exact. Our models are based on quite general clustering problems and are flexible enough to allow for various objectives and additional constraints. This means that their application domain goes beyond the classical cell formation aimed at making independent cells, moreover, that of the underlying mathematical problems goes far beyond the layout design. We also provide results of numerical experiments involving both artificial data from academic papers in the field and real manufacturing data to certify the appropriateness of the models proposed. We thus provide a flexible and efficient tool to managers and industrial engineers for designing optimal cells based on their own vision of optimality and constraints involved.

This book, however, is intended not only for managers and industrial engineers but also for academic researchers and students because of two reasons. Firstly, it poses several mathematical problems that may be of certain interest and importance from both theoretical and applied point of view. Secondly, it demonstrates a certain research methodology—of (re)considering the problem and choosing a suitable model—that allowed us to advance the techniques for solving the problem extensively studied for more than 50 years.

While working on this book we tried to make it understandable for the broadest audience: all algorithmic details are given a detailed description with multiple numerical examples, informal explanations are provided for the theoretical results and detailed introductions into each of the problems considered are provided. However, a basic understanding of manufacturing, combinatorics, and linear programming is a prerequisite. Further, each chapter is self-contained to a certain extent, which, we hope, will make reading the book more pleasant.

Finally, we would like to mention that this book includes our recent papers on cell formation. Since the papers are published in many different outlets, namely, Journal of Combinatorial Optimization, Computational Mathematics and Applications, Mathematical and Computer Modeling, Lecture Notes in Computer Science, Computational Management Science, Operations Research and Mathematics and Statistics, the authors have decided to organize them within a book with the purpose to attract more attention of the research community, engineers, managers, and students dealing with different sides of decision making within a very wide area of industrial engineering. We are grateful to all our co-authors for their great contribution to the corresponding papers cited properly in this book and listed here: Mikhail Batsyn, Ilya Bychkov, Pavel Sukhov, Jannes Slomp, and Julius Zilinskas.

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