Preface

ABOUT THE SUBJECT

In the globalization era, the production environment of all countries comes to the stage of realizing the real prosperity. With the growth of markets towards globalization, all the firms need to deal with the challenges facing it. This has resulted in the materialization of automated industries with high performance of manufacturing systems. Traditional manufacturing systems are not able to satisfy these requirements. In the global market there is an increasing trend toward achieving a higher level of integration between designed and manufacturing functions in industries to make the operations more efficient and productive. Operations management needs to reflect on these challenges. “Cellular Manufacturing Systems” (CMS) is one among the emerging trends, which can be implemented without losing much of production run time, with low set up time, low work-in-process inventory (WIP), short manufacturing lead time, high machine utilization, and high quality of products.

Manufacturing systems traditionally fall into three categories of layouts: job shop production, batch production, and mass production. Obviously, a batch production presents the topical problem for layout designers and manufacturing managers. Since, in batch production the parts move in batches from one process to another process, each part in a batch must wait for the remaining parts in its batch to complete processing before it moves to the next stage. This will lead to increased production time, high level of in-process inventory, high production cost, and low production rate.

Taking this into account, this book is providing further understanding the subject with more fruitful ideas to academic researchers and managers of organizations in the pipeline.

ORGANIZATION OF THE BOOK

This book is compilation of 20 contributions to the field of operations management, especially of advance topics related to the layout design for manufacturing environments and production planning and scheduling in cellular manufacturing environment. These 20 chapters are written by a group of 43 authors from prestigious universities and firms.

“Operations Management Research and Cellular Manufacturing: Innovative Methods and Approaches” is organized in three sections.

Section 1: “Methods and Trends in Manufacturing Cell Formation” presents selected problems in plant layout designing. Decision making process in selecting the plant layout design is considered to be one of critical steps in a development of cellular manufacturing systems. Among other chapters in this
sections are those devoted to the development and comparison of optimization algorithms and techniques for cell formation problems.

Section 2: “Production Planning and Scheduling in Cellular Manufacturing Environment” offers some advanced tools and approaches in this domain. It is not by chance that classical theories of Scientific Management give the first consideration to production scheduling. Equally, the distributed scheduling for cellular manufacturing systems plays important role in achieving the effectiveness and success of cellular manufacturing.

Section 3: “Related Issues to Cellular Manufacturing Systems” covers a wider spectrum of viewpoints by specialists in their respective fields. In this section some aspects of flexible manufacturing cells and robotic manufacturing cells, apart from other objects of interest, are discussed. These forms of cellular manufacturing, in addition to other advantages, observe principles of agile manufacturing and thereby help to satisfy the growing requirements of customization.

The first section includes 9 chapters summarized below.

Chapter 1, “Developments in Modern Operation Management and Cellular Manufacturing” by Vladimír Modrák and Pavol Semančo, maps the major publications/citations in these fields and their evolving research utility over the decades. This survey traces modern concepts and tools of operations management and cellular manufacturing in a successive order. Finally, the relationships between concept or/and tools in both areas that are empirically considered as consequences or coincidences present an object of interest.

Chapter 2, “Decision Support Framework for the Selection of a Layout Type” by Jannes Slomp and Jos A. C. Bokhorst, presents a decision support framework based on the analytic hierarchy process approach for the selection of a manufacturing layout. The value of the framework is illustrated by means of a case application.

Chapter 3, “Comparison of Connected vs. Disconnected Cellular Systems: A Case Study” by Gürsel A. Süer and Royston Lobo, discusses differences between connected vs. disconnected cellular systems with respect to average flowtime and work-in-process inventory under make-to-order demand strategy. The study was performed in a medical device manufacturing company.

Chapter 4, “Design of Manufacturing Cells Based on Graph Theory” by José Francisco Ferreira Ribeiro, offers a comparative study between sequential heuristics, simulated annealing, tabu search and threshold algorithm for graph coloring and its application for solving the problem of the design of manufacturing cells in a job shop system production. The results obtained with these algorithms on several examples found in the literature are consistently equivalent with the best solution hitherto known in terms of numbers of inter-cell moves and dimensions of cells.

Chapter 5, “Genetic vs. Hybrid Algorithm in Process of Cell Formation” by R. Sudhakara Pandian, Pavol Semančo, and Peter Knuth, focuses on presentation of hybrid algorithm and genetic algorithm that are helpful in production flow analysis to solve the cell formation problem. The evaluation of hybrid and genetic algorithms are carried out against the K-means algorithm and C-linkage algorithm that are well known from the literature. The comparison uses performance measure and the total number of exceptional elements in the block-diagonal structure of machine-part incidence matrix using operational time as an input.

Chapter 6, “Design of Cellular Manufacturing System Using Non-Traditional Optimization Algorithms” by P. Venkumar, describes an experimental study based on the implementation and comparison of meta-heuristics for cell formation problems with an objective of minimizing exceptional elements.
The meta-heuristics were implemented on ten 16 X 30 sized benchmark problems. The final sections include the comparison of computational time for the compared algorithms and pertinent conclusions.

Chapter 7, “Similarity-Based Cluster Analysis for the Cell Formation Problem” by Riccardo Manzini, Riccardo Accorsi, and Marco Bortolini, describes an application of hierarchical clustering method for the cell formation based problem on the application of a threshold level of group similarity. The experimental analysis represents the first basis for the identification of the best setting of the cell formation problem. This chapter confirms the importance of this threshold cut value for the dendrogram when it is explained in percentile on the number of nodes.

Chapter 8, “An Estimation of Distribution Algorithm for Part Cell Formation Problem” by Saber Ibrahim, Bassem Jarboui, and Abdelwaheb Rebaï, presents a new heuristic algorithm for machine-part cell formation problem. The objective of this chapter is to identify part families and machine groups and consequently to form manufacturing cells with respect to minimizing the number of exceptional elements and maximizing the grouping efficacy. The proposed algorithm is based on a hybrid algorithm that combines a variable neighborhood search heuristic with the estimation of distribution algorithm.

Chapter 9, “Cellular or Functional Layout?” by Abdessalem Jerbi and Hédi Chtourou, essentially focuses on the development of an objective methodology framework to compare the cellular layout (CL) to the classical functional layout (FL). This methodology can be easily applied to any manufacturing context and provides trustworthy results with a minimum experimentation effort.

Section 2, “Production Planning and Scheduling in Cellular Manufacturing Environment” is composed of the following six chapters.

Chapter 10, “Cell Loading and Family Scheduling for Jobs with Individual Due Dates” by Gürsel A. Süer and Emre M. Mese, introduces a cell loading and family scheduling in a cellular manufacturing environment. What separates this study from others is the presence of individual due dates for every job in a family. Authors in this chapter propose two different approaches to tackle this complex problem namely, mathematical modeling and genetic algorithms. An experiment is carried out using both approaches and later the results are compared and a sensitivity analysis is also performed with respect to due dates and setup times.

Chapter 11, “Production Planning Models Using Max-Plus Algebra” by Arun N. Nambiar, A. Imaev, R. P. Judd, and H. J. Carlo, presents a novel building block approach to developing models of manufacturing systems. The chapter develops a generic modelling block with three inputs and three outputs. It is shown that this structure can model any manufacturing system. It is also shown that the structure is hierarchical, that is, a set of blocks can be reduced to a single block with the same three inputs and three output structures. Finally, several numerical examples are given throughout the development of the theory.

Chapter 12, “Operator Assignment Decisions in a Highly Dynamic Cellular Environment” by Gürsel A. Süer and Omar Alhawari, discusses concepts such as learning and forgetting rates with the aim to show how operator skill level varies from time to time; thus, the assignment decision is affected. The objective of this chapter is to propose better mathematical models for operator assignment and also compare the performance of two major strategies, Max and Max-Min, in highly dynamic cellular environments.

Chapter 13, “Alternative Heuristic Algorithm for Flow Shop Scheduling Problem” by Vladimír Modrák, R. Sudhakra Pandian, and Pavol Semančo, describes an alternative heuristic algorithm that is assumed for a deterministic flow shop scheduling problem. The algorithm is addressed to an m-machine and n-job permutation flow shop scheduling problem for the objective of minimizing the make-span when idle time is allowed on machines. In order to compare the proposed algorithm against the benchmarked, for this
purpose, selected heuristic techniques and genetic algorithm have been used. In a realistic situation, the proposed algorithm can be used as it is without any modification and come out with acceptable results.

Chapter 14, “Optimization and Mathematical Programming to Design and Planning Issues in Cellular Manufacturing Systems under Uncertain Situations” by Vahidreza Ghezavati, Mohammad Saidi-Mehrabad, Mohammad Saeed Jabal-Ameli, Seyed Jafar Sadjadi, and Ahmad Makui, introduces basic concepts about uncertainty themes associated with cellular manufacturing systems and brief literature survey for this type of problem. The chapter also discusses the characteristics of different mathematical models in the context of cellular manufacturing.

Chapter 15, “Planning Process Families with PROGRES” by Linda L. Zhang, develops a PROGRES-based approach to model: planning data, knowledge and planning reasoning. The PROGRES-based process family planning models are hierarchically organized. At the top level, a meta-model is defined to conceptualize process family planning in general. Based on this meta-model, generic models are defined for planning process families for specific product families. Finally, instance models are obtained by instantiating the generic models, representing production processes for given product family members. The proposed approach is illustrated with planning processes for a textile spindle family.

Section three, “Related Issues to Cellular Manufacturing Systems,” includes chapters 16-20.

Chapter 16, “Lean Thinking Based Investment Planning at Design Stage of Cellular/Hybrid Manufacturing System” by M. Bulent Durmusoglu and Goksu Kaya, focuses on providing a methodology for lean thinking based investment planning from the perspective of cellular or hybrid manufacturing systems. Its first part provides a general explanation of why lean thinking is so beneficial for managing manufacturing processes. The purpose of the second part is to explore axiomatic design approach it provides an overall view of what to do. The third part presents the actual use of the methodology with implementation of hybrid system at a furniture factory.

Chapter 17, “Performance Comparison of Cellular Manufacturing Configurations in Different Demand Profiles” by Paolo Renna and Michele Ambrico, aims to compare different configurations of cellular models through the main performance. These configurations are fractal CMS and cellular manufacturing systems with remainder cells, compared to classical CMS used as a benchmark. A simulation environment based on Rockwell ARENA® has been developed to compare different configurations assuming a constant mix of demand and different congestion levels.

Chapter 18, “Petri Net Model Based Design and Control of Robotic Manufacturing Cells” by Gen’ichi Yasuda, describes the methods of modelling and control of discrete event robotic manufacturing cells using Petri nets. A conceptual Petri net model is transformed into the detailed Petri net model based on task specification. Subsequently, detailed Petri net model is decomposed into constituent local Petri net based on controller tasks. Finally, simulation and implementation of the control system for a robotic workcell are described.

Chapter 19, “Equipment Replacement Decisions Models with the Context of Flexible Manufacturing Cells” by Ioan Constantin Dima, Janusz Grabara, and Mária Nowicka-Skowron, presents selected econometric models that are intended to solve a multiple machine replacement problem in flexible manufacturing cells with several machines. Firstly, models for a simple case multiple machine replacement problems are presented. Thereafter, the more complicated case is considered where technological improvement is taken into account.

Chapter 20, “Multi-Modal Assembly-Support System for Cellular Manufacturing” by Feng Duan, Jeffrey Too Chuan Tan, Ryu Kato, and Tamio Arai, proposes a multi-modal assembly-support system (MASS) which aims to support operators from both information and physical aspects. To protect operators
in MASS system, five main safety designs as both hardware and control levels are also discussed. With the information and physical support from the MASS system, the assembly complexity and burden to the assembly operators are reduced. To evaluate the effect of MASS, a group of operators were required to execute a cable harness task.

TARGET AUDIENCE

The book is intended to support the academicians and industrialists (teachers, doctoral scholars, decision makers in industry, and students educated in this field). It is also intended to support subjects of operations management.

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