MANUFACTURING SYSTEMS FOR THE FACTORY OF THE FUTURE

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Abstract
The paper describes changed manufacturing environment in global competition and unpredictable frequent market changes. In this paper, general requirements of next generation manufacturing systems are discussed, and the strategies to meet these requirements are considered. The production paradigms which apply these strategies is the paradigm of Reconfigurable Manufacturing System.

Key words
Reconfigurable Manufacturing Systems, production strategies, globalization, flexibility

Introduction

The current day manufacturing environment is characterized by numerous challenges and changes. A typical manufacturing company faces constantly changing product volumes and mix. It is commonly recognized that traditional manufacturing systems do not fit to present market competition and a shift is needed. A great amount of research efforts has been put on looking for new manufacturing systems. However, many of these newly emerging approaches lack a unified global view of manufacturing and address only some perspectives of manufacturing. The requirements of product design in the 21st century present an ever-increasing challenge. Consumers now demand products that suit their specific, constantly changing, needs. The additional improved features to a product do not guarantee the customer will receive exactly what they want. The changes of customer requirements create a need for new designs of manufacturing systems. In order to sustain competitiveness in dynamic markets, manufacturing organizations should provide the sufficient flexibility to produce a variety of products on the same system. In this way, advanced manufacturing systems need to accurately consider economical aspects as well as engineering aspects; otherwise, they cannot obtain a reasonable share of competitive market to justify their investments.

Changed Manufacturing Environment

A manufacturing system transforms raw materials into products. Its ultimate objective is to gain value such as profit, reputation, and market share. An enterprise can survive only if this objective is achieved appropriately. Manufacturing environment has a great impact on the performance of a manufacturing system. Current environment has some critical requirements for a manufacturing system. Changed manufacturing environment characterized by aggressive competition on a global scale and rapid changes in process technology requires to create production systems that are easily upgradable and into which new technologies and new functions can be integrated. There are unpredictable market changes that are occurring with increasing pace during the recent years. These changes include:

- increasing frequency introduction of new products,
- changes in parts for existing products,
- more variants of products,
- large fluctuations in product demand and mix,

- changes in government regulations (safety and environment), and
- changes in process technology.

To survive in this new manufacturing environment, companies must be able to react to changes rapidly and cost-effectively. The shift from current production strategies to the strategies enabling changes is needed, (fig. 1).

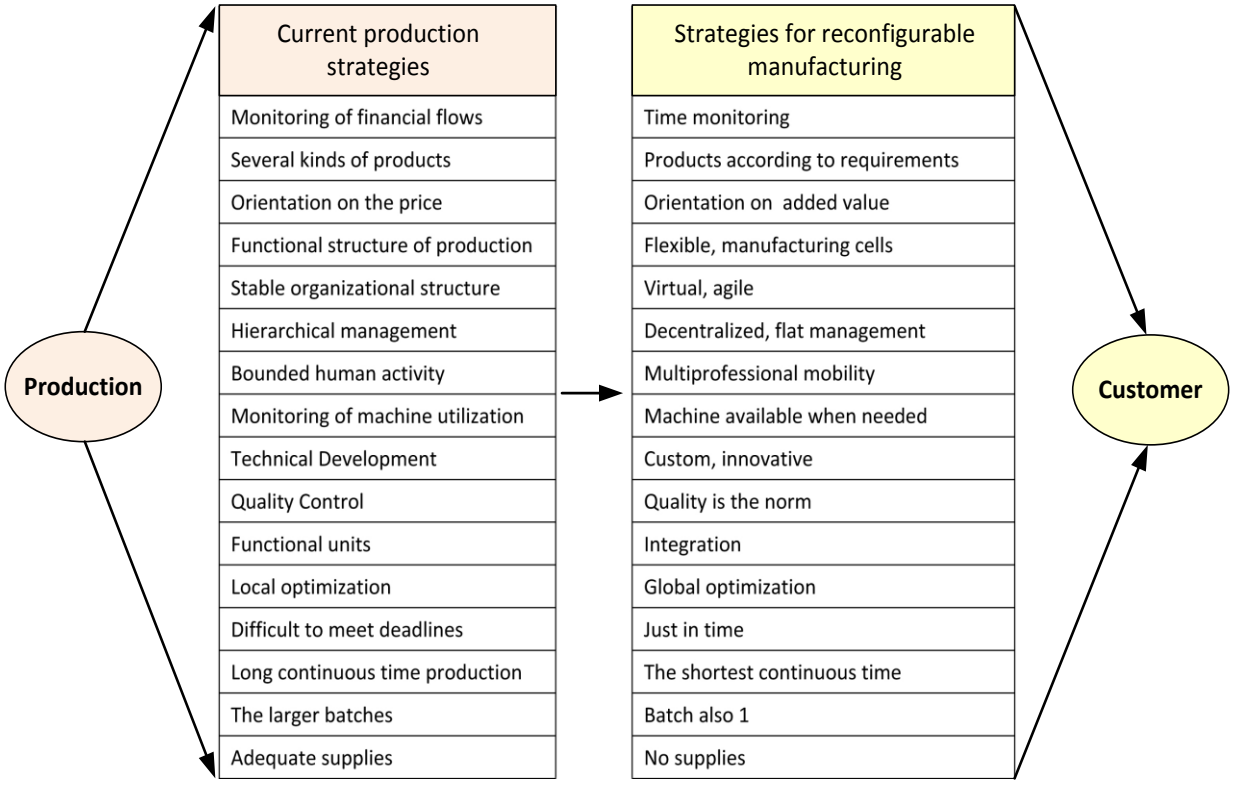

Fig. 1 Production strategies

These conditions require a responsive new manufacturing approach that enables:

- quickly launch of new product in the market,
- rapid adjustment of the manufacturing system capacity to market demands.
- rapid integration of new functions and process technologies into existing systems,

The manufacturing systems used for this new approach must be rapidly designed, able to convert quickly to the production of new models, able to adjust capacity quickly, and able to integrate technology and to produce an increased variety of products in unpredictable quantities. Manufacturing company must now be ready to change itself for uncertain and frequently changing environment.

A study done by the National Academies of Engineering identified six Grand Challenges facing manufacturing companies and came up with a ranked list of 10 Priority Research Areas needed to meet these challenges by the year 2020, [1]. The highest-ranked Priority Research Area was identified as "Reconfigurable Manufacturing Systems," defined as "adaptable, integrated equipment, processes, and systems that can be readily reconfigured for a wide range of customer requirements is a priority technology."

Another one foresight study, The Future of Manufacturing in Europe 2015-2020 [2] funded by the European Commission examined what technological, knowledge and organizational capabilities are required by European manufacturing if it was to remain both competitive and sustainable by the year 2020. The study outlines customization, flexibility and responsiveness as key success factors for the future of European manufacturing.

Reconfigurable Manufacturing Systems

In order to meet the need for responsiveness, Reconfigurable Manufacturing Systems has been proposed by Koren et al. [3].

Reconfigurability is a new engineering technology that enables cost-effective, rapid responsiveness to market and product changes.

Reconfigurable Manufacturing System (RMS) is a new manufacturing systems paradigm that aims at achieving cost-effective and rapid system changes, as needed and when needed, by incorporating principles of modularity, integrability, flexibility, scalability, convertibility, and diagnosability. RMS promises customized flexibility on demand in a short time. Capacity scalability is simply the ability to adapt to changing demand. A typical capacity scalability problem addresses when, where, and by how much should the capacity of the manufacturing system be scaled. Before RMSs, the scope of this problem was limited to capacity expansion. With RMSs, on the other hand, capacity scalability addresses the reduction of capacity besides the expansion. RMS enables to scale the capacity not only over the system level, but also over the machine level by virtue of its modular and open control structures. The cost of capacity expansion is traditionally justified by the economy of scale of the expanded capacity. In an RMS, it is assumed that capacity scalability is justified by reducing the shortage cost, since capacity is supplied when needed and it reduces the cost of the underutilized capacity, as the exact capacity is available where needed.

The RMS is designed to cope with situations where both productivity and the ability of the system to react to changes are of vital importance. Each RMS is designed to produce a particular family of parts.

The definition of an RMS is, therefore:
An RMS is designed at the outset for rapid change in structure, as well as in hardware and software components, in order to quickly adjust production capacity and functionality within a part family in response to sudden changes in market or regulatory requirements.
If the system and its machines are not designed at the outset for reconfigurability, the reconfiguration process will prove lengthy and impractical.

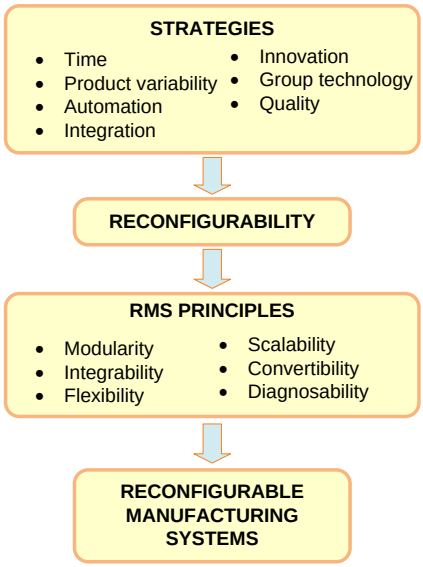

Fig. 2 Change of production strategies towards to Reconfigurable Manufacturing Systems

Reconfigurable Manufacturing system features	
Scope	Functionality and capacity are variable and configured as needed, when needed.
Pre-Requisite	Part Family - The range of products may be wider or narrower compared to Flexible manufacturing systems.
Systems Features	Variable routing between stages (soft/logical reconfiguration) planned as needed. Capacity expansion/modules of identical machines (physical/hard reconfiguration). Function expansion (physical/hard reconfiguration). Changeable infrastructure (physical/hard reconfiguration). Process plans alternatives re-configurable/changeable as needed (logical/soft reconfiguration).
Machines Features	Modularity, quick-change features and standard interfaces. Dedicated but changeable functions (axes, tools, etc.)
Controls Features	Changeable, re-configurable controls and open architecture.
Intelligence	Sensors feedback, adaptive control, intelligent features, future self-reconfiguration potential.
Life	Expandable by reconfiguration and re-use.
Cost	Incremental system capital cost as needed. Additional repeated reconfiguration and ramp-up costs over the whole life cycle.

Conclusion

There is a need for reducing cost and improving quality of highly customized products. Responsiveness, agility and high performance of manufacturing systems are driving the recent paradigm shifts and call for new approaches to achieve cost-effective responsiveness of the enterprise. It is becoming important that the manufacturing system can accommodate these changes and be usable across several generations of products and product families. The most promising manufacturing systems seem to be Reconfigurable Manufacturing Systems which are able to meet these requirements.

Kľúčové slová
Rekonfigurovateľné výrobné systémy, výrobné stratégie, globalizácia, flexibilita

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This contribution is the result of the project implementation: VEGA – 1/0810/11 "Principles of profiling and cooperation multirobotic systems".

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