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# SELECTED EXAMPLE OF SUPPORT THE FLEXIBILITY IN PRODUCTION STRUCTURES BASED ON MODULAR DESIGN

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***Abstract:*** *The objective of this paper is to present the modular workstations concept based on miniaturization and re-configurability trends. The article focuses on presentation of sample production system, referred as agile, with a modular construction structure made up of aluminium profile system by building-block principles. The modular architecture allows an individual and flexible adaptation of workstations to varying requirements of production tasks. In the first part of this article are discussed the specification of basic flexibility types in production system and the main impacts influencing design of manufacturing structures. The closing section of the article provides the specification of example solution of adjustable production platform with modular frame.*
***Keywords:*** *modular workstations; reconfigurable structure; flexible production basis*

## INTRODUCTION

*Growing cost pressures, continuing miniaturization of products and ever-shorter product life cycles – these are the challenges facing manufacturing operations in a wide range of industries today. Manufacturing competitiveness is highly dependent on the companies' ability to rapidly reconfigure their manufacturing and assembly systems. The paradigm changes, the main trends influencing design process in many modernization projects of production basis are miniaturization, function integration, and densification: miniaturized products are required and manufactured, miniaturized production equipment are proposed and ultimately miniaturized factories are realized. The term "micro or desktop factory" appeared in various contributions and represents: small desktop-size production systems suitable for fabricating and manufacturing of small size parts and products, in the field of high-precision. The flexible and reliable way to the most economical production system offers building block concept of design. With this solutions can be achieve an objective: space saving, energy saving, materials saving and in general can be obtain environmental friendly, agile and point-of-need manufacturing syste.*

## BACKGROUND OF FLEXIBLE PRODUCTION SYSTEM

*The production system must adapt continuously to meet the demands of increasing quantities, product modifications and the degree of automation. In general, there are 11 basic types of manufacturing systems flexibilities as given below [2, 7]:*

- *Machine flexibility: the different operation types that a machine can perform - the number of operations performed without set-up of machine or control unit change.*
- *Process flexibility: the set of products that the system can produce - the set of part types that can be produced without major set-up changes.*
- *Transferring flexibility: the ability to move the products within a manufacturing facility - refers to flexibility in transferring various types and sizes of components.*
- *Routing flexibility: the different routes (through machines and workshops) that can be used to produce a product in the system - flexibility in part chosen and transfer a part from one workplace to another.*
- *Operation flexibility: the ability to produce a product in different ways - the different operation can do by interchanging machine or control unit on work piece.*
- *Product flexibility: the ability to add new products in the system - ease to ordering product place in an existing product mix.*
- *Actual flexibility: it's the ability to overcome concrete given changes - the number of products a system currently can produce.*
- *Potential flexibility: it refers to capability of coping with an undefined universe of change - the ability of the system to adapt to market demands.*
- *Volume flexibility: the ease to profitably increase or decrease the output of an existing system - the system should have economy of scope and not economy of scale.*
- *Expansion flexibility: the ability to build out the capacity of a system - the ease to capable, when needed, through physical change to operational system.*
- *Control program flexibility: the ability to run a system automatically - the capability to operate operation by intelligent machines tools and control software system.*

*Manufacturers must accommodate changes in requirements to satisfy a variety of needs. The scope for actual designing of flexible production systems characterizes these main impacts [5]:*

- *Environment sustainability: minimizing energy consumption, saving energy and resources for machinery building and operation such as power sources lighting, and air conditioning; reduced emission of heat, vibration, acoustical noise, waste.*
- *Enhanced cell manufacturing methodology: freedom of configuration and proportion in machine design will increase; improved equipment portability for installation, reconfiguration, replacement, disposal; process integration – conventionally separated processes for individual dedicated machinery or heterogeneous processes can be systematized.*
- *Customization: fast supply/manufacture/delivery of customized and personalized product of varying volumes (fast increase/decrease of quantities); products should have shorter product life cycle and there must be more variants of each product.*
- *Agility: easy and fast re-configurability of processes and production basis; dynamic scalability for changes in production volume; easier maintenance.*
- *Cost efficiency: cut initial/running costs; efficient use of space; product price must be lower – lower investment.*

*Modular structure of production basis easily accommodates changes. A number of miniaturized stand-alone production machines and lines with universal modular platform have been put into commercial use. [6]*

***EXAMPLE OF MODULAR MANUFACTURING STRUCTURE: DESKTOP FACTORY***

*Example of presented modular production system in the form of lines provides solution from Bosch Rexroth, labelled Desktop factory. [4]*

*This is a concept for manufacturing and assembly lines that offers standardized factories in mini format. A future-oriented concept of production system is based on standardized structural frame designs, as well as process modules and plug-in modules with compact dimensions. Each plug-in module takes over one work step. Several plug-in modules can be placed next to each other in the frames in a flexible arrangement to correspond to the entire manufacturing process (see fig. 1). Standardized, modular construction and a reduction in complexity provide decisive advantages that are not achievable with more traditional manufacturing systems. [8]*

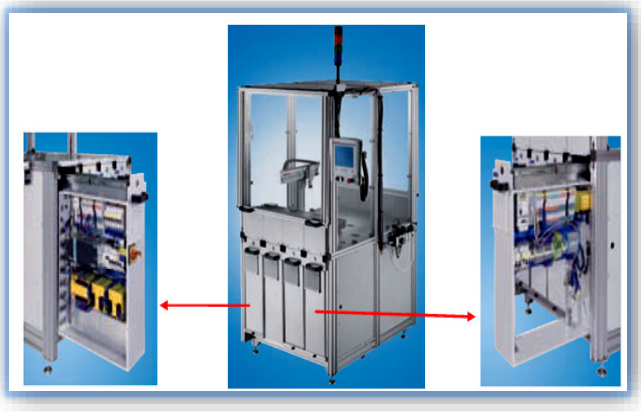

*Figure 1. Basic frame of workstation with standardized plug-in modules. [8]*

*Desktop Factory (DTF) is a technically sophisticated, widely applicable production platform. It is a solid foundation that system builders and integrators can expand on when designing more sophisticated systems. The offering includes the basic structure consisting of a standardized basic cell with transfer, process and supply units, as well as electro-pneumatic equipment. The architecture is based on standardized modules, as shown in fig. 2. Various modules, e.g. for assembly, welding or press fitting, can be arranged in sequence in prefabricated plug-in units within one basic frame. Each module represents one operation. [1]*

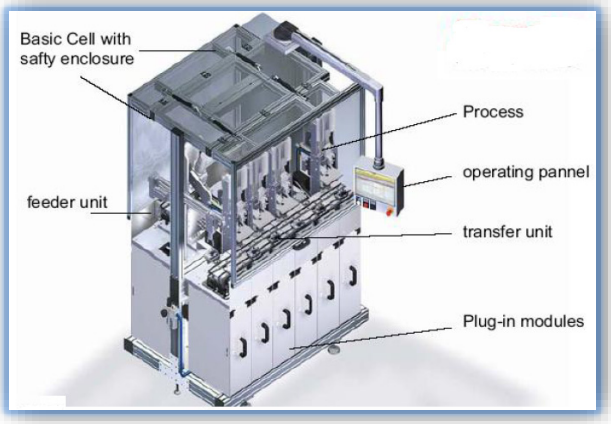


*Figure 2. Example of DTF structure. [1]*

*The solution is available for many applications to manual and automatized production system and makes it possible to [1]:*

- ✓ *Reduced costs*

*Thanks to consistent standardization and a reduction in complexity, investment costs can be lowered by up to 15% compared to more traditional concepts. Savings in indirect costs are even more substantial. For example, power consumption can be cut by up to 20% and required space by up to 75% in contrast to conventional systems. Component reusability provides additional cost advantages and a high level of investment security.*

- ✓ *Maximum reliability*

*Independent process modules and the "plug & produce" system ensure fast, reliable start-ups. The DTF concept also permits easy transfer of processes proven effective during prototype build into further use in series production. A reduction to one process step per module results in high transparency and availability.*

- ✓ *Enormous flexibility*

*This modern, adaptive production system ensures fast and easy adaptation to quantity or product changes, also making step-by-step investment possible as the processes evolve. Even the degree of automation can be specified and adapted as needed, which makes it possible to implement manual workstations just as easily as partially and fully automated workstations.*

*The advantages of a DTF line can be seen in almost any industry – provided that certain product and process-specific requirements are met. The diagram below (see fig. 3) contains the most important criteria for orientation. DTF is an economical solution for the assembly of small products with weights up to 500 grams, for example such as switches or*

*thermostats, for the automotive, electronic, and electro-technical sectors as well as medical technology and household appliances. [4]*

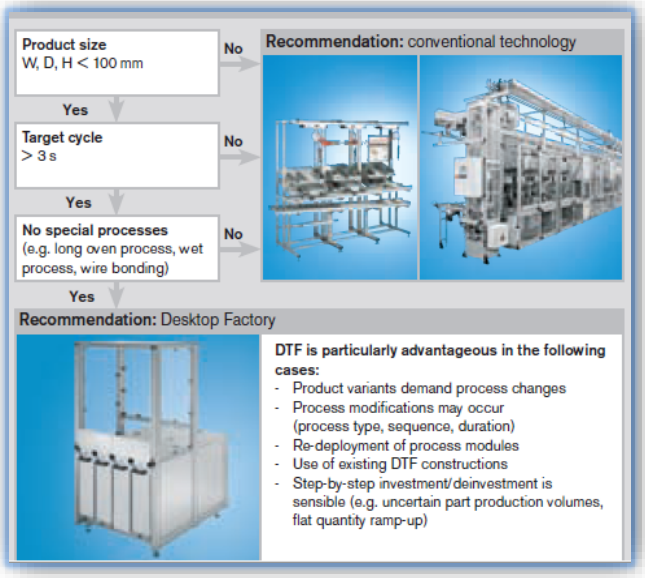


*Figure 3. Decision criteria for a DTF assembly concept. [4]*

*The individual modules can be replaced and extended easily, making it fast and simple to adapt to new requirements such as higher production volumes. The degree of automation can also be chosen simply and varied according to demand – from manual workstations to fully automated manufacturing lines, as shown in fig. 4.*

*Figure 4. Process modules combined with a manual workstation. [3]*

*Existing high-performance design software of computer – aided tools allows to engineers solve the factory structures, layout and equipment in 3D visualisation. They declared significant reductions in the design effort by using pre-built components - modules. These programs help save time and allow them to develop simple and targeted planning variants. Computer aided tools to support design process of modular workstations systems can reduce engineering lead-time and cost by getting the ergonomic design right the first time through simulation (see fig. 5) and avoiding the need to go back and make changes later, when they will be more difficult and expensive. [8]*

*Figure 5. Examples of manual work cell design visualization. [8]*

*The workstation optimizes ergonomics in its design to maximize productivity within its work area. These units have been engineered to deliver improved productivity levels by means of improving aesthetic values, and providing better and safer working environments.*

*Each modular workstation system is easy and quick to customise and can be seamlessly combined with elements from modular conveyor systems and expansion ranges to create truly bespoke solutions that maximise productivity and profitability. Any workstation can be easily expanded, reconfigured, or relocated as work tasks change - start with a simple worktable for basic tasks and grow into a station in a progressive assembly system. Modularity also simplifies workstation design and assembly. Flexible expansion allows adaptation to changing manufacturing surroundings. [1]*

*The advantages of miniaturized manufacturing systems are considerable. Benefits of the analysed approach can be summarized. [3, 5, 6]*

- ✓ *Economical and ecological opportunities and challenges:*
- ≡ *Remarkable savings in investment, space, energy, and resources (incl. assembly processes, cleaning, compressed air & air controlling units)*
- ≡ *Desktop size supports better lean production and automation assisted manual production*
- ≡ *Smaller production facilities or more production in the same space*
- ≡ *Lower investments in production systems*
- ≡ *Reduced material costs, less waste*
- ≡ *Reduced energy consumption and lower running costs.*
- ✓ *Increase agility:*
- ≡ *Easy to change the production (layout, reconfiguration, flexibility)*
- ≡ *Shorter ramp-up time*
- ≡ *Ubiquitous manufacturing (on-site, mobile…) - production and customization closer to the customer - distributed production and delivery, point-of-need manufacture*
- ≡ *Change the long-established image of factories*
- ≡ *Improved portability of the production equipment*
- ≡ *Better performance: less mass to move, shorter distances to transfer, smaller dimensions.*

*The key benefit from using, in this article described, design principle is process flexibility: the standardized desktop factory modules can be quickly and easily adapted to production quantity, product, schedule, or sequence changes. The reusability of the individual desktop modules allowed the plant to develop a completely new platform in few months, including alteration of assembly sequences, development of new processes, and preparation for assembly application. [1]*

## CONCLUSION

*The "microfactory" concept – miniaturize manufacturing machinery and systems – was introduced in a Japanese national project in the early 90s, when the advantages of miniaturization were thought mainly to be saving energy, space, and resources. Beside the trend to miniaturization there is the agility trend - from full automation or flexible automated cells to adaptive production systems - adaptive to the production volume, which is changing over the lifetime of the products to be assembled.*

*With miniaturization, consistent standardization and modularization, in this article described design of the DTF modular system helps reduce investment costs by up to 15 percent. Power consumption can be cut by up to 20 percent and surface requirements reduced by up to 75 percent compared to traditional manufacturing equipment. Components can be reused after production conversions, providing additional cost advantages and high investment security. This solution provides the user with a cost-efficient and trend-setting manufacturing concept.*

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