

Reconfiguring of Manual Workstations Designated for Customized Production

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Abstract The aim of this article is to interpret the analysis of the challenges to changes in construction of manual production system. The goal is to present the example of manual workstations solutions that correspond with modular and reconfigurable designing approach to achieve the production structure appropriate for customized manufacturing. The theoretical part provides an overview of fundamental design principles and characteristics to formation the flexible workstations. The next section of the article provides the specification of model solution of adjustable production platform with modular frame that allows the reconfigurability.

Keywords: manual production system, modular workstations, reconfigurability, adaptability, designing

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1. Introduction

In order to achieve an optimal cost / benefit ratio in manufacturing, the production base must adapt continuously to meet the demands of increasing quantities, product modifications or the degree of automation. Manufacturing competitiveness is highly dependent on the companies' ability to rapidly reconfigure their production and assembly systems. In the customized mode of production, stand-alone solutions combining workstation and disposal unit are often the preferred choice because they flexibly accommodate for the frequent relocation of workplaces in a changed workflow. Modular structure of equipment in manual production line can be easily modified to improve material flow, add or remove features, or change dimensions, and the work area can be quickly rearranged to accomplish the customized orders. These modular workstations feature an ergonomic design, enabling workers to optimise them according to their specific needs and applications.

The objective of this paper is to present the manual workstations concept based on modularity, convertibility and reconfigurability trends. The modular structure allows an individual and flexible adaptation to varying requirements but also the realization of low-cost solutions for creation of new or modernized production base. The interpretations of information presented in this article are based on the mapping data set of different reports and analysis of the studies published recently.

2. Attributes of Adaptive Production Systems

Responsiveness is an attribute enabling agile manufacturing systems to quickly launch new products on

existing flexible production basis and to react rapidly and cost-effectively to customer's orders. This is achieved by designing production systems according to modular principles and reconfigurability style. [2]

The reconfigurability is regarded, in general, as a capability to achieve flexibility of production system. Represents the design of a system (and its machines and all equipment) for adjustable structure that enable system reconfigurability in response to market demands and system/machine adaptability to new products. [3] Reconfigurability is the ability to repeatedly change and restructure the components of a production system in a cost-effective way. Structure of workstations may be adjusted at the system level (e.g. adding conveyor, or new functions must be added to the workplace) and at the machine level (changing type cast of machine). [5] The reconfigurable workstations allows flexibility not only in producing a variety of parts, but also in changing the production system elements structure itself. Reconfigurable workstations are workplaces whose structures can be changed to provide alternative functionality. [1] The human configuration implies for example reallocating human re-sources or reconfiguring the job task. [3] With reconfigurable workstations design, the production system capacity and operational functionality are not fixed but change over time in response to market demand and customer's orders.

To aid in designing reconfigurable systems, a set of system configuration and integration rules must be established. The characteristics supported production system's agility are e.g.: structural components are modular; there are interfaces for rapid integration; workstations are designed for capacity and functionality change and also designed for diagnostics. [4]

The characteristics of reconfigurable production systems (so called Koren's principles) are considered [1,4,5]:

- Modularity: are all production system's elements designed to be modular?
- Mobility: it is easy and quick to move and install production systems? – the characteristic in terms of easiness of moving around and relocating elements and subsystems (or movement of manufacturing equipment), as shows example at Figure 1.

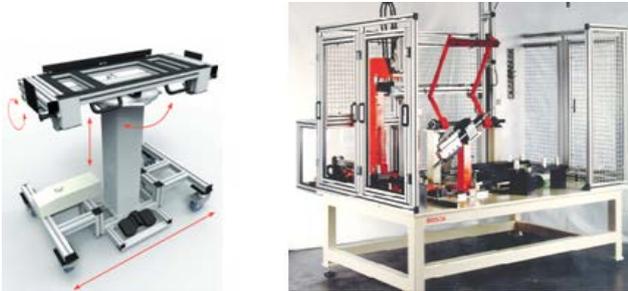


Figure 1. Example of mobile and adjustable module of manufacturing equipment. [7]

- Integrability: modules (existent and future) are easy to integrate into the rest of the production system? - the ability to integrate modules rapidly and precisely by a set of mechanical, informational, and control interfaces that enable integration and communication - means that the system and its components (elements) are designed for both ready integration and future introduction of new technology. Figure 2 present manual workstation structure composed from building- block kit based on aluminium profiles, connectors and accessories. The modular workstations can be integrated via material transport system such as conveyors to form a reconfigurable system in production lines.

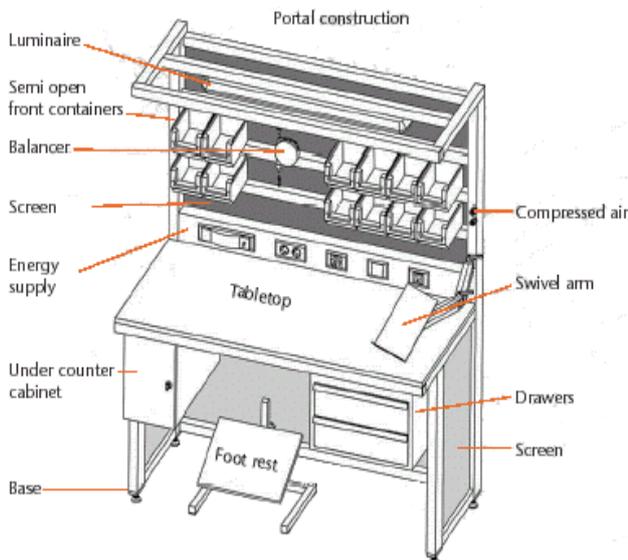


Figure 2. Structure of modular workstation and its application [7]

- Convertibility: it is easy to adapt the production system to future products manufacturing? - the ability to easily transform the functionality of the existing production system and its included subsystems and elements to meet new production requirements (implies how the machines, workstations, and material handling devices are arranged). Visualisation of adaptable production base

arranged in line of manual workstations is shown at Figure 3.

- Adaptability: it is easy to change the operations and quick to switch between existing products? - the ability to rapidly adjust and change the functionality of the production system.
- Scalability: it is easy to enlarge and downsize the production system? - involves both capacity expansion and reduction (according to the volume changes).



Figure 3. Example of modules composed to adaptable manual production system [6]

- Diagnosability: it is quick to identify the sources of quality and reliability problems? - the ability to read the current state of a system to detect and diagnose the root cause of output product defects or machine failure and quickly correct operational defects.
- Automatability: is enabled a dynamic level of automation? - the ability to change (upgrade and downgrade) the degree of automation, this means that production systems include both human operators and automated mechanism at workstations, as presented example solution at Figure 4.

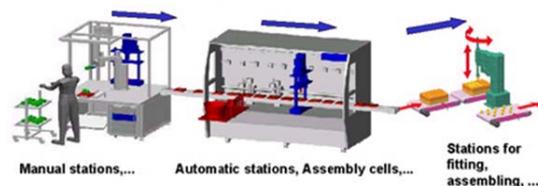


Figure 4. Integration of workstations with diverse automation mode in production system [7]

Modularity is often described as the key factor (e.g. in literature [1,3,4]). In a reconfigurable production system, all major components (structural elements) are modular. When is necessary, the modular components can be replaced (add, and/or move.), rearrange to better suit new applications. Modules are easier to maintain. Increasing modularity thus reduces reconfiguration time and effort. Selection of basic functional modules and construction frames, and the way they are connected, must allow for the creation of flexible workstations that can be easily integrated, diagnosed, adapted, adjusted or converted. [2]

3. Example of Reconfigurable Workstations with Modular Design Based on Building-Blocks

Modular architectures are characterized by well-defined interactions among structural building blocks and these interactions generally are fundamental to the

primary functions of the workstations. [1] Modular building block system based on aluminium profiles and attachments for workstations and accessories have been designed and developed to provide a natural integration between worker, environment and task. All components are modular; 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 manual station in a progressive assembly system (see Figure 5). [6]

Anodized aluminium profiles offer a practical alternative to steel sections. No welding needed which means quick and accurate assembly without warping or distortion. A variety of connectors allow profile frames and structures to be assembled quickly. The flexibility of the connectors also allows members to be moved or disassembled if required. Almost any structure can be quickly assembled without special tools or skills. Modularity also simplifies workstation design and assembly. Flexible expansion allows adaptation to changing manufacturing surroundings. And because the framework is constructed using anodized aluminum, the profiles look clean and are aesthetically pleasing needing no painting or other finishing (they won't chip, rust, or show dust and dirt like typical fabricated sheet metal structures). [7]

With a broad selection of accessories available, applications can be extended beyond simple frames and bases to complete multi-functional structures and every component is infinitely reusable – making it simple and inexpensive to modify as needs change. A range of accessories are available to complement the profile system (accessories include e. g. a range of hinges, handles, latches and rollers for doors, sliding panels and draws, screw adjustable feet, fixed floor brackets for heavy duty applications and castor wheels for mobile projects, end cover caps and plastic infill strips to cover slots; overhead lighting, conveyors, linear units, information boards, material shuttles grab containers, footrest, height- adjustable worktable, tool holders, hanging cabinets, protective housing, protection and partitioning panels, ...) [7].



Figure 5. Example of reconfigurable manual production system with profiles frame [7]

The arguments for application of modules from aluminium profiles system and building- block concept to manual production workstation composition are summarized as follows:

- Cost advantage: simple assembly of frame construction, any structure can be quickly assembled without special tools or skills (no welding, just screw connectors); no mechanical machining is necessary;
- Errors in construction can be rectified more easily: CAD product library and software to support designing is available for use as a construction aid to designers;

- Compatibility: easy and fast set up of guarding, workstations and assembly platforms thanks to modular design because aluminium profiles can be combined with products in other ranges of kit;
- Appearance: optimum function and ergonomics with attractive design because connection is not visible from outside and therefore not a disruptive factor when using accessories;
- Resistance: profiles are secured against twisting by the connecting technology - profile design ensures a torsion-resistant structure with good carrying characteristics.

A number of reconfigurable workstations with universal modular platform have been put into commercial use. In the context of this article was presented the example of the modular system solution based on aluminium profiles building block kit and accessories [7].

4. Conclusions

To stay competitive in a global economy, manufacturing companies must use production systems that allow for rapid response to consumer needs. Every manufacturing enterprise focused on customized order should have three main goals: produce at low cost, enhance product quality, and possess capabilities for quickly responsiveness – and reconfigurable production base is focused on achieving these. Flexible, agile and reconfigurable manufacturing systems concern the adaptation of the production to new market conditions. Flexible production systems that use reconfigurable components and modular architectures of manual workstations can offer a much greater benefits to manufacturers than traditional structures (e.g. welded construction of worktables in lines etc.). With using the building- block kit to manual workstations system design can be achieved e.g. unique flexibility and versatility for the widest variety of combinations.

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