Reconfiguring of Manual Workstations Designated for Customized Production

Rudy Vladimír¹, Leskova Andrea¹, Smajda Norbert²

¹Technical University of Kosice, Faculty of Mechanical Engineering, Letna 9, 04200 Kosice, Slovak Republic
²Senzor spol. S r.o. Kosice, Park Angelinium 9, 04200 Kosice, Slovak Republic
*Corresponding author: vladimir.rudy@tuke.sk

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


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] Rerconfigurability 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 shown at Figure 1.

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

• Integrability: modules (existen 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.

• Automatibility: 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
element 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,
construction of worktables in lines etc.). With using the
building- block kit and accessories [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.

Acknowledgement

The research was supported by the Project KEGA 079
TUKE-4/2013 Innovation in laboratory technology
educational program of study Industrial Engineering and
the Project VEGA 1/0879/13: Agile, to market adaptable
business systems with highly flexible structure in
enterprise” - supported by the scientific grant agency of
the Ministry of Education of the Slovak Republic (ME SR)
and of Slovak Academy of Sciences (SAS).

References

ISBN 978-91-7485-079-6. Available at: http://www.diva-
portal.org/smash/get/diva2:545368/FULLTEXT01.pdf.

Available at: http://www.wilsoncenter.org/sites/default/files/Emerging_Global_
Trends_in_Advanced_Manufacturing.pdf.

Improve Flexibility and Quality in manufacturing By
Implementation of FMS & Green Manufacturing. [on-line].

