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THE CREATING SOFTWARE CONFIGURATIONS MODULAR PRODUCTION ON THE PRINCIPLES OF ERGONOMICS

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Abstract: This article is aimed at problems of designing and ergonomic optimizing of production systems with a modular construction structure made up of building-block principles on the basis of Al components. The modular structure allows an individual and flexible adaption to varying requirements and also the realization of low-cost solutions. Benefits to using the modular profile systems and building elements for creation of new or modernized production base of workstations configuration are mainly: simple fast assembly, short planning time, simple disassembly, easy construction, retrospective modifications, reassembling of all elements.

1 Introduction

This article deals about building principle of ergonomically designing manual workstation focused on modular profile systems.

Production demands can change rapidly, whether they are changing quantities, new product variants, or product generations – the manual production systems from aluminium profile technology can be flexibly adjusted to fit any need. The inventor of aluminium profile technology, in the field of assembly construction, offer alternative to welded steel constructions in the form of the basic mechanical elements and modular profile system.

Profile system is easy to process and quick to assemble- no cutting or welding, no grinding or polishing, no painting. All profiles can be combined in any way imaginable; the accessories provide functional and aesthetic solutions for a wide range of applications: machine bases, enclosures, guarding, work- assembly and inspection stations, transfer and supply trolleys, partitions and protective walls and cabins, special shelves etc.

The software packages (for example MTPro from BoschRexroth) using for computer aided design workstations of aluminium profile system include an up-to-date parts library and parts list information as well as 3-D graphics to help visualize design of production system. In contrast to conventional planning methods, this program helps save time and allows generate planning variants.

2 Modular profiles building block system

The basic elements of the building kit consist of profiles, connecting elements and caps. The extruded aluminium construction profiles are provided with grooves, which can be used in conjunction with connecting elements and can also perform a whole range of additional functions. The aluminium alloy is resistant to weathering and many chemicals and the surface of the profiles has been specially treated to make it permanently scratch- proof and has also been corrosion-protected. All profiles have been designed to deliver maximum strength for the materials used.

System profile technologies offer further modular combination possibilities (e.g. connections with existing constructions, machine frames, protective cabins etc.). With the universally applicable components in modular profile assembly system, it can quickly find a successful solution for all tasks: frames, enclosures, special and series machinery, workstations, supply of materials, etc.

Profit from the benefits of modular profile construction kit system [1]:

- user-friendly screwed connections, perfected, stability-oriented connectors, easy assembly due to standard elements, easily dissembled connections enable flexible modifications during the assembly phase,
- widest system profile range on the market, compatible modular system for all dimensions: 20, 30, 40, 45, 50, 60… mm, all profiles can be combined with each other, the 8 mm and 6 mm groove profiles are used in the construction of simple appliances, partition walls, stands or display cabinets,
- comprehensive range of accessories,
- short planning, design and assembly times, 3-D planning software available,

- high loading capacity with low self-weight, profile technology is fast, stable, and safe.

Profiles of different product lines and sizes can be combined into basic frames with the aid of special connectors. Using connectors with high load-bearing capacities, combined with particularly robust grooves and large central bores allow profile connections even for high static and dynamic loads. All profile connectors have one thing in common: they are screwed into place. Screwed connections can be made quickly and easily. They provide excellent stability, even under heavy loads. And they also have the advantage that can be rebuilt constructions made of basic mechanical elements at any time, or extend them for new requirements. This means you can reuse the same components again and again.

The following advantages are achievable with modular kit [1]:

- Speed: supports during the tender phase, planning and design phase of projects with individual engineering and 3D configuration.
- Risk reduction: by buying in modules at fixed costs the estimating security increases.
- Wide and deep modular system: the whole modular system is so wide and deep that it combines limitless flexibility and compatibility with specific reduction in special parts.
- Degree of assembly: it is possible receive the solutions – as an assembly kit or as a complete module.
- Attractive design of aluminium profiles.
- Combination of stability and function.
- Modern appearance of the whole workstation.
- Minimisation of the risk of injuries.
- No accumulation of dirt.
- No additional covers required.
- Ideal for clean rooms.
- High-quality design.
- No flame cutting and welding - threaded connections instead of welding.
- Profiles and elements can be reused after a system has been dismantled.
- No grinding and polishing - braces and beams can be easily removed or relocated; assembly changes are possible without visible traces and damage.
- No painting - profiles provide a clean surface with good finish; no making good necessary.

The building kit system is a cost-effective and flexible solution for producing a whole range of fixtures and equipment up to and including automated handling systems. The components can be used not only for building laboratory equipment, assembly workstations, electronic manufacturing systems or packaging machinery, but also in highly demanding construction applications such as clean room areas etc.

The products of the building kit system based on aluminium profiles are the perfect solution for everything from simple basic frames and testing stations to complex handling units.

3 Computer aided design of workstations

Computer aided design provides for example tools from Bosch Rexroth – "MTpro" light offers a quick introduction to layout planning software for assembly technology free of cost. MTpro is software for the planning and design of assembly technology systems that supports in selection, configuration and ordering of products from this producer.

Software includes the following functions [2]:

- ✓ Layout Designer for planning and design of complete frames and conveyor systems without a CAD system.
- ✓ Generation of order lists; Upload of order lists to eShop; Sending of requests for quotes to sales contacts.
- ✓ Multilingual content and graphical user interface: switch between 5 different languages at run-time (de/en/fr/it/es).

Advantages:

- o Configurable CAD volume models with direct interface to all standard current CAD systems, product configuration.
- o Catalog information and assembly instructions at the press of a button, catalog data sheets and assembly instructions.
- o Calculating of order lists.
- o No limitations to content or functions in the Layout Designer, Layout Designer for planning and constructing complete modules and systems.
- o CAD export of layouts created using the Layout Designer.

MTpro is professional software to help plan, design, construct and calculate production systems using building kit components and modules.

Layout Designer functions [2]:

- Combination of catalog components to form assemblies and systems in a virtual 3-D scene with support of a built-in rule engine.
- Drag and drop components directly from the product catalog into the 3-D scene.
- Fast connection and placement of components using the snap function and manipulation handles.
- Hierarchical user library where you can save and reuse your own constructions.
- Consideration of the environment: import floor layouts from 2D-DWG and DXF files; library with room planning elements (walls, windows, doors);

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import custom VRML, DWG and DXF models via drag and drop.

- Intelligent parts list calculation: parts list of all components in the assembly; consideration of additional parts; summary of parts into order units; further processing of the order list via clipboard and integrated report generator.
- Exporting the 3-D layout as a solid into all common CAD systems and save in CAD exchange formats (STEP, SAT, DXF…).
- Extended CAD interface to AutoCAD, Inventor, Solid Works and Pro/Engineer: transfer of CAD models with parts list information; subsequent loading of models from CAD systems into MTpro and reconfiguring them; generation of MTpro order lists from the CAD model.
- Saving the 3-D scene in common graphics and rendering formats, transfer to Office applications using the clipboard (DWG, DXF, 3DS, VRML, PNG).

The sample of planning software to building- block equipments in production system is at fig. 1.

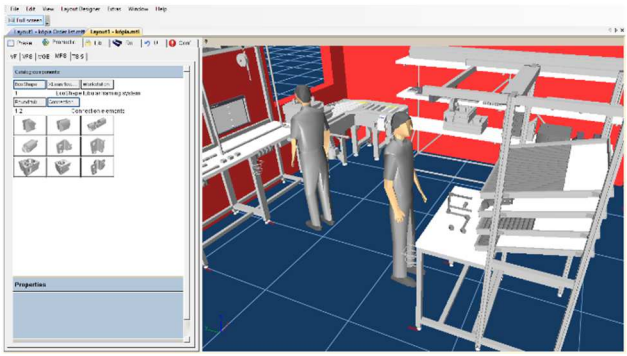

Figure 1 Design software with visualisation tools

Planning software uses icons or menu points and parameter-aided programming techniques so that assemblies, 3D models of humans or individual components of equipment for ergonomic workstations, can be quickly incorporated into a 2D or 3D drawing. The high quality display of the human form is one of the software elements. This enables workstations to be ergonomically planned, tested and optimised to suit every body size.

The example of designing of manual workstation according to customer requirements is presented at fig. 2.

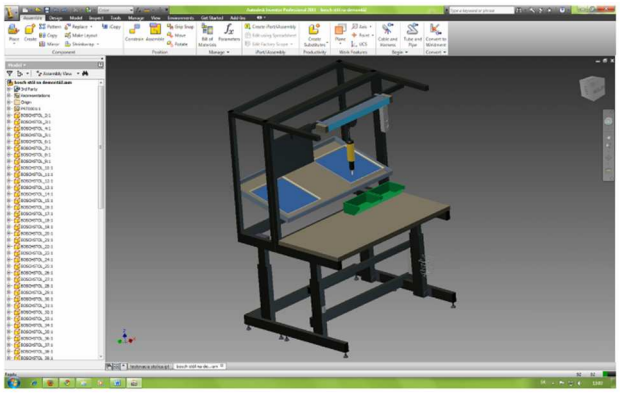

Figure 2 Planning configuration of custom workstation

4 Ergonomic design of modular workstations

An ergonomic workstation facilitates work, maintains health and motivates employees, thereby providing a solid foundation for high productivity and economic success. Ergonomic movements make processes safer, faster and smoother. Ergonomic workstations pay for themselves by facilitating work, reducing downtime, and increasing productivity.

Manual workstations must accommodate a wide range of body heights to ensure that the largest percentage of the population is covered. Country-specific differences and regional requirements must also be taken into account. Design of working systems by ergonomics is described under e.g. DIN ENV 26 385 [2]. Objective of ergonomic design is, among others, adaptation of workplace, working space, environment and lighting to human properties and skills. The modular system for designing individual workplaces enables optimal adaptation to task and individual employee concerned.

Correct workplace design has, to a high degree, positive effects on employees' health, performance, endurance and concentration [3]. The most important factors for designing work equipment are the working height, proper sizing of the reach zones and required legroom, as well as definition of the appropriate range of vision [4]. All of these dimensions are derived from a “standardized” body height.

Further criteria that must be taken into account :

- ✓ Foot and leg room, depth and adjustment range of the footrest;
- ✓ Size and variation of workpiece dimensions;
- ✓ Occurring forces and weights;
- ✓ Changing types of equipment and insert heights;
- ✓ Greatly varying vision distances;
- ✓ Local specifications (deviating body heights, legal requirements, etc.);
- ✓ Aspects related to methods, safety, and efficiency.

By incorporating ergonomic aspects into the design of production equipment in assembly workstations, it will be

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able to optimize working conditions and thus increase the motivation of workers.

Ergonomically and individually designed production systems ensure :

- Work with reduced fatigue;
- Increased productivity;
- Targeted and optimized use of capacities;
- Motivated workers.

An ergonomic workstation design plays a decisive role in reducing waste during production. Thus, for example, the movements for grabbing parts and the distances workers have to walk are directly related to the design of the individual workplace. From an ergonomic aspect, the main focus is on the worker. This is why these workstations are designed to fit each worker and not the other way around.

Designed stand up/moving and sit down/ stand up concepts are the foundation for dynamic, stress-free work. Both concepts are based on individually adaptable workstations with perfectly matched chairs. The building block profile systems provide all the modules that are need to ergonomically design and arrange of workstations. They have developed an ergonomics checklist that assists during workstation planning and design, which will help attain the greatest possible performance, safety, and motivation from workers.

Custom designed workstations offer a wide range of variable dimensions and individual solutions or select from standard products with fixed dimensions. At fig. 3 is example of image manual assembly worktable with accessory equipment.

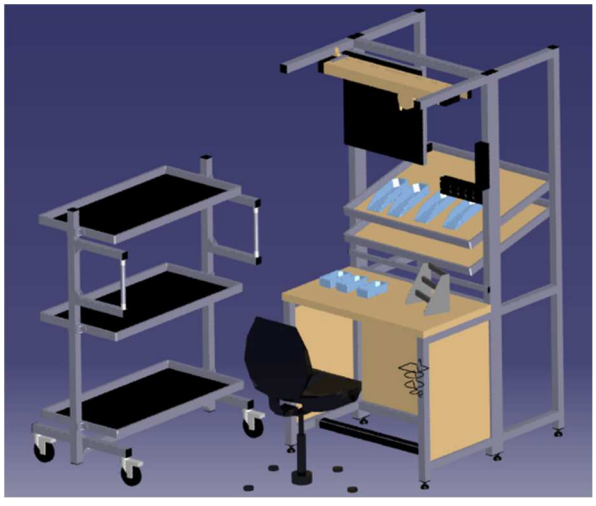

Figure 3 Example of modular workstation and mobile stock rack

The dimensions and position of the table top results from the dimensions selected for the workstation height, width, and depth. Height-adjustable levelling feet make it possible to compensate for floor irregularities and casters can be used to create mobile workstations. Height-adjustable workstations are the most flexible solution for dealing with extremely varied workpiece/component dimensions and large differences in employee heights. Height-adjustable workstations are perfectly suited for visual inspection and manual work (e.g. in wristwatch assembly or jewelry manufacturing).

The sample application of building-block principle equipments, composite to the manual production system structure, on the basis of Al-construction profiles is at fig. 4. Workstation systems and comprehensive accessories from building blocks construction systems can be individually adapted to different production needs.

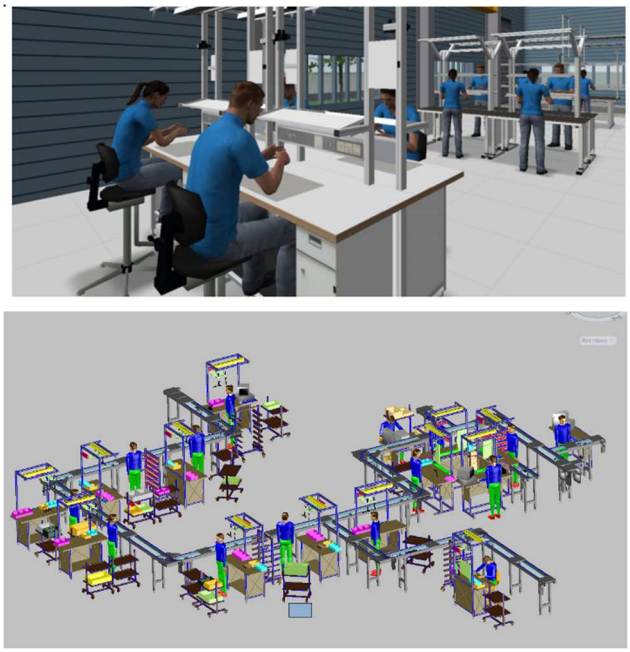

*Figure 4 Examples of a draft concept for workplace work standing up and a **seated position***

Workstation accessories - these functional workstation components can be used at any station and increase the efficiency of workers. They offer defined storage spaces, support work processes, and ensure optimum transparency and ergonomics. All workstations can be equipped with side panels and footrests, as well as cloth and bottle holders. It is possible equip the workstations with socket strips, system lamps, and compressed air strips. Suitable accessories make it possible to supply grab containers, tools, and information at the workstation. An accessory upright permits, for example, installation of material shelves for parts supply at the workstation.

All reach distances should be as short as possible to avoid redundant, no value- added movements. Grab containers and parts containers that are in direct reach of the employee are ideal. In addition, a comprehensive program of accessories consisting of workstation lighting,

power supply, and information provision and positioning of tools, components and swivel work chairs, is available.

To maintain performance and promote productivity, all work equipment near the workstation must be precisely adjusted to the employee and their activity. Correct adjustment of the table, chair, footrest, and grab containers, as well as the position of tools and material shuttles, minimizes movements, thus reducing physical exertion and employee absences.

A few important considerations :

- When adjusting the chair and footrest, make sure that the thighs and calves form a right angle.
- Information boards should be hung at eye level to avoid unnecessary head movements.
- The angle of the shelves for material supply should be adjusted to create short, direct reach distances.
- Use lifting aids to supply heavy parts.
- Monitor brackets and tool shelves can be adjusted to any height via the profile groove.
- With height-adjustable workstations, the optimum working height can be adjusted according to the size of the person or product.
- Information
- on information boards.

It is just small things that often count: handy accessories are necessary addition to perfect design of an optimal workplace. Everything must be on its proper place and instructions or information should be attached properly and clearly visible. Auxiliary equipment helping avoid loads and taking care of workplace overview noticeably support efficiency at reduced employees' stress.

Open system dimensions and numerous components enable individual designs for sit-down and stand-up workstations. It makes an almost unlimited number of designs possible with just a few components. The building kit system can be used to design a whole range of workbenches - from simple standard benches to special ergonomic solutions to meet specific requirements.

Modular assembly workstations have been tried in practice and constantly developed further. The workstation can be constructed from individual components or purchased as a complete and fully assembled system. Profile system contains a broad and highly performed accessory program, which guarantees an optimal adjustment to individual requirements. An adequate modification allows the working table to be integrated easily into existing assembly lines. A future-oriented concept of flexible assembly system compact of workstations is based on standardized structural frame designs, as well as process modules with compact dimensions.

5 Conclusions

The flexibility of modular building blocks profile system in assembly workstations provides a long list of benefits: start-up costs are lower, there is a shorter debug time, reuse reduces later capital investments, they can be reconfigured when production requirements change, simple fast assembly, short planning time, simple disassembly, easy construction, retrospective modifications, reassembling of all elements because offers a comprehensive, harmonised profile system.

The modular, standardized design of all building components means they can be shipped quickly for replacement, resulting in minimum downtime.

All profiles can be combined in any way imaginable; the accessories provide functional and aesthetic solutions for a wide range of applications: machine bases, enclosures, guarding, work- assembly and inspection stations, transfer and supply trolleys, partitions and protective walls and cabins, special shelves etc.

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