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Improving allocation and layout in production logistics

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Abstract: The article deals with the principled solution of allocation and layout of workplaces in a company producing of variety building components. Allocation and layout are very important areas for ensuring the efficient operation of companies engaged in production as well as in commercial activities. Both allocation and layout solutions have a strategic importance for companies. The investigated company produces construction metal elements as a part of modern construction technologies. The problem is related to the constant improving activities in the company in order to ensure its competitiveness on the market. The production process of construction metal elements consists of workplaces such as cutting, drilling, milling, welding and galvanizing. Workplaces for inspection and loading of finished products are non-production. The solution of the project was aimed at streamlining activities in terms of logistics, material flows as well as in terms of safety.

1 Introduction

While searching for possibilities to increase the production capacities of the manufacturing of building elements in the investigated company, the problem arose how to effectively allocate and place production equipment, warehouses, buffers, to implement transport routes in their production hall where building elements are made. This is also attended by streamlining of the layout of production and interoperation equipment, storage and interstorage areas in the hall to meet technological, safety and capacity requirements.

The procedure for effective solution of allocation and layout consists of the following parts:

- Measurement of premises, production machines, equipment and workplaces.
- Analysis of spatial parameters, possibilities and limitations, machines and equipment, material inputs and outputs of products, material flows in a space, storage possibilities and legislative regulations and standards.
- Design of logistic elements, handling units for the needs of effective activities in production.
- Design of the allocation and layout of production workplaces, machines and equipment for the placement of material at the entrance and during production, the location of the entrance and exit of products for galvanizing and the location of finished products.
- Process-efficient storage of semi-finished products, efficient transport routes within the production hall, creating paths for the safety movement of workers.

2 Literature review

Allocation and layout are an important element for the effective increase of capacities in logistics. The importance of allocation and layout solutions is still the same for any manufacturing company. Many companies approach the solution of allocation and layout systematically, but some make layout more efficient only over time, based on their acquired experience and knowledge. The authors Gabajová, et al. state in their publication that: *"Designing a workplace may be a challenging task. It is important to make sure that the new workplace will prevent unnecessary resource waste, but also create a safe working environment for employees"* [1].

Solution of allocation and also, within certain limitations, layout is a strategic solution that will be implemented in practice for several years. For this reason, the solution must be approached with all seriousness. Allocation is a process that results in the location of the company, warehouse, production, machine and everything that can be allocated on an area or in a specific space [2].

In terms of effective allocation and layout solutions, many methods and procedures can be used. The authors Kronová, et al. used, for example, the Cluster Analysis method for solving layout, which is described in their work [3]. Many authors use computer simulation as an effective means of solving allocation and layout problems [4-8].

According to authors Grznár, et al. *"The one of the most important tasks in designing is detailed design. In this process, the final layout of the elements, together with their demands for space in a common 2D and 3D view, plays a rather complex matter"* [9].

One of the popular methods for solving of the mentioned problem is the CRAFT method (Computerized Relative Allocation of Facilities Technique), which belongs to the group of enumerative methods and gives the optimal solution under defined conditions and constraints. The application of the above method is practically described in the papers [10-13].

There are a number of procedures and methods that can be used to solve a strategic decision of allocation and layout in practice. Therefore, the authors of this paper, when writing the article, limited themselves to the factual side and defining the principle procedures that can be used in general in the subject matter with a practical demonstration of the solution of the specific task.

3 Methodology

Inappropriate allocation and layout of production facilities leads to inefficient logistics, prolonged material flows, longer transport times and an increased need for intermediate warehouses (buffers) for materials, semi-finished and finished products. All this increases the costs associated with the production itself. Allocation and layout efficiency concentrates capacity, material, economic, safety and technological rules in order to minimize subjective approaches in the allocation and layout of workplaces and production facilities.

The solution of the problem applies a project approach with the basic postulates of logistics such as the systems approach, algorithmic thinking, coordination, planning and global optimization, which are contained in the parts forming the methodology:

- The global objective of the project solution is to increase productivity, increase the capacity utilization of equipment, reduce costs and increase safety at work.
- To analyse the actual state of layout of production and interoperation equipment, storage and interstorage areas, including pallets, crates and boxes that form small buffers.
- To define and describe the criteria and principles for the deployment of production and interoperation equipment, storage and interstorage areas and buffers in the production hall, where building elements are made.
- To develop a system for deployment and to propose deployment options taking into account the defined criteria.
- To design logistics elements, handling units for the needs of streamlining operations in production.
- To define the criteria for the selection of the most efficient variant.
- To design an efficient layout of production and interoperation equipment, storage and interstorage areas and buffers by means of a system solution under defined conditions.

4 Result and discussion

Considering the new trends in building industry, the company is focused on the development and production of construction elements that serve both to ensure and to implement construction operations and processes. The priority of the production of construction elements is a sustainable state of effectively spent costs for their production, which is achieved by: streamlining logistics processes, streamlining production processes and using suitable technological equipment and suitable materials as well as their streamlining allocation and layout.

4.1 Presentation of the offered services

Since its establishment, the company has been engaged in the development and production of iron building elements of its own construction. In addition to the production of iron construction elements, the company offers services in the field of processing and implementation of operations related to mechanical production and processing of iron elements such as sheets, "roxors" (reinforcing steel), steel bars with various profiles (I, L, T, U, □, ○, etc.), pipes, prisms, etc. Classification of offered services is followed:

- Cutting - circular saw, automatic band saw, plasma cutter.
- Carving by plasma.
- Drilling - manual, stand drill, automatic.
- Turning.
- Thread milling.
- Welding - electric arc welding in a protective atmosphere of inert gas, spot welding.
- Bending - manual, machine.

4.2 Material flow analysis

There are 6 main material flows in the company (Figure 1), which are characterized by parts with final production or with production for the finalization of building elements.

The material flow analysis shows that material flows through the production hall according to the production technology of each product. In the production of individual products, many of the production operations are identical (cutting, welding, drilling, milling, cleaning and re-drilling after galvanisation, storage, affixing ID labels). The production operations have their own product-specific parameters, which creates considerable variability in terms of equipment set-up and therefore handling time requirements, as well as space requirements for the storage of materials at the start of production, work-in-process materials, semi-finished products, pre-galvanising or galvanising products, and finished products.

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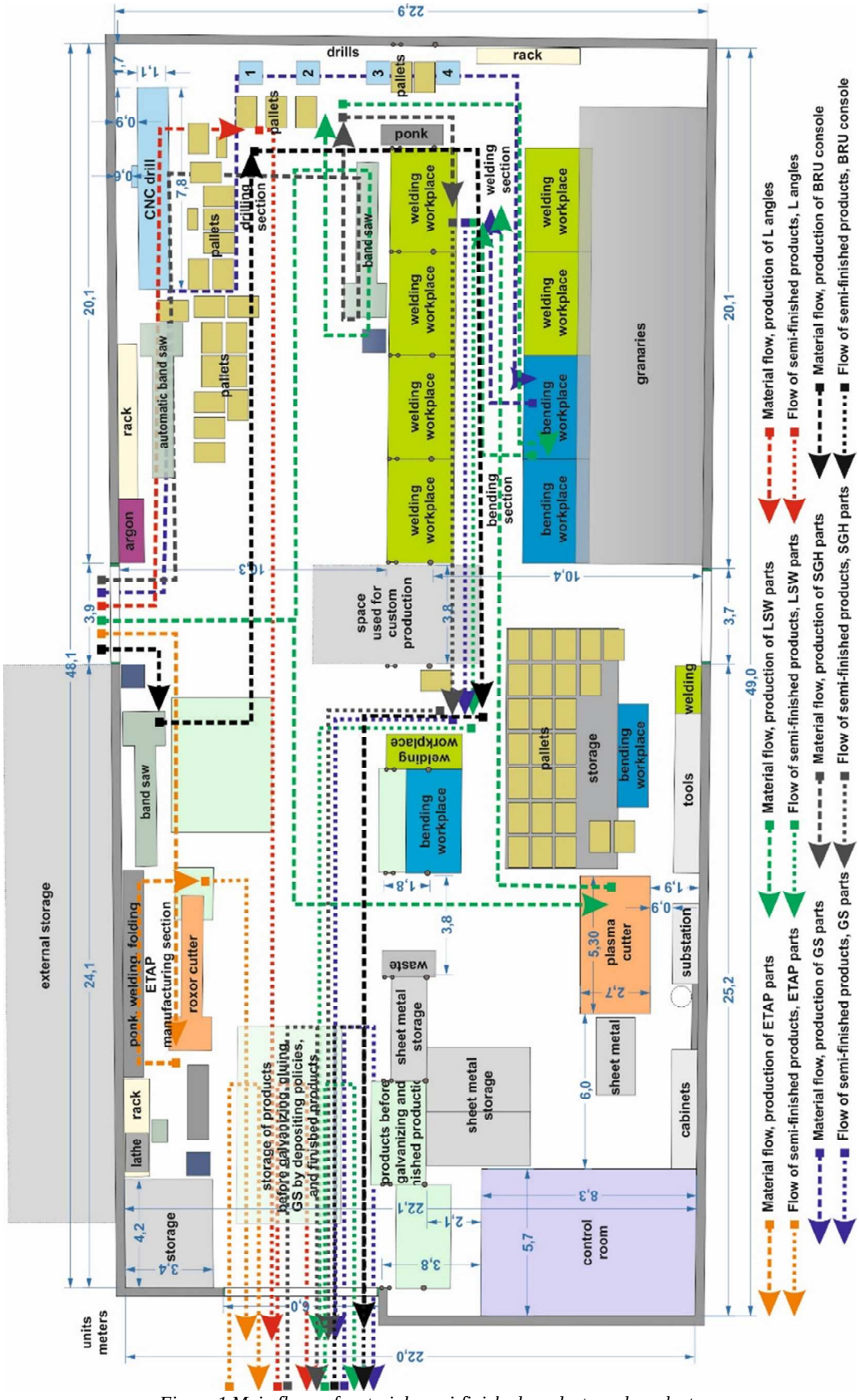

Figure 1 Main flows of material, semi-finished products and products

4.3 Identification of deficiencies in terms of material flows

There are following findings and shortcomings found from the system analysis of the company's activities focused on the allocation and layout of production equipment, materials, semi-finished products, products, waste and material flows:

- The company places its work-in-progress, semi-finished products, products and waste in a large area within the production area (Figure 2).
- Materials in production, semi-finished products, products and waste are stored in various non-standardised "boxes or containers" (paper and polystyrene boxes, plastic crates, iron containers, buckets, wooden boxes, etc.), many of which are not suitable in terms of strength, technically and safety.
- "Containers" with production material, semi-finished products, products and waste are placed on several different types of pallets.
- Downtime on special production equipment, such as automated drilling machines, caused by lack of qualified personnel and production planning.
- Inefficiently used space around the plasma cutter or blocked space around the plasma cutter with various materials and production waste (Figure 3).
- Inefficient use of space for the dispensing and receiving of semi-finished goods and products.
- Crossing of material flows in the production hall.
- Repetitive loading and unloading of semi-finished and finished products in and out of crates, on and off vehicles.

Figure 2 Location of materials, semi-finished products, products and waste in the production hall

Figure 3 Inefficiently used space around the plasma cutter in the production hall

4.4 Design concept for the allocation and layout of the workplace and production facilities

There is advisable to implement the following measures to get the operation of work in the production hall more efficient, which include production and interoperation equipment, storage and interstorage areas, including pallets, crates and boxes and buffers:

- To introduce standardised pallets into the production process.
- To introduce standardized pallet metal boxes and handling units into the production process.
- To introduce standardized pallet racks, stacking of pallets into the production process.
- To introduce storage racks and a shelf stacker for metal sheets (plates) into the production process.
- To streamline the layout of workplaces while respecting technical, technological and safety conditions and constraints.

As many non-standardised crates, boxes, as well as different types of pallets are used in production, it is necessary to introduce standardised pallets, crates and boxes to streamline handling, moving and storage operations.

4.4.1 Storage - handling units

The design of handling units for the storage of materials, semi-finished products, work-in-progress and finished products is based on the existing dimensions of the most common used euro pallets 800 x 1200 mm (Figure 4), in addition to specialised transport units. The height of the euro pallets is set at 144 mm according to STN 26 9110 standard. Its possible load capacity is as follows (according to the mentioned standard):

- 1 000 kg, if the load is arbitrarily distributed on the upper surface of the pallet;
- 1 500 kg, if the load is evenly placed on the top surface of the pallet;

- 2 000 kg, if the load in solid form fits evenly across the entire upper surface of the pallet;
- 4 000 kg an additional load when stacking, if the load is on a pallet adjacent, full flat on a horizontal and rigid surface.

Figure 4 Standard Euro pallet size 800 x 1200 mm

The design of the internal handling unit (hereafter referred to as the box) for use with a standard Euro pallet (but also without it) is 600 x 400 x 200 or 400 mm (l x w x h) for small-sized elements (Figure 5). According to the above pallet and enclosure dimensions, the shape and especially the dimensions of the handling boxes and the arrangement on pallets (Figure 6) are designed to be 1200 mm x 800 mm or 1200 mm x 1000 mm.

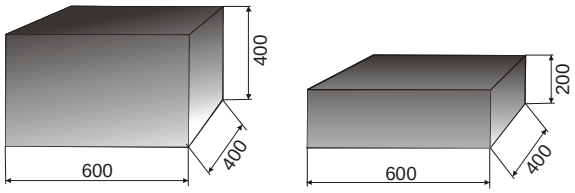

Figure 5 Design of handling boxes and their dimensions

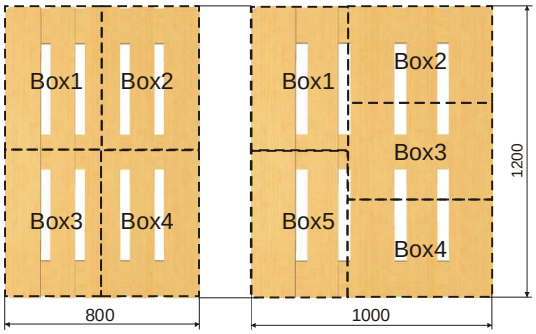

Figure 6 Stacking of proposed boxes on standardised pallets

4.4.2 Allocation and layout of workplaces in compliance with technical, technological and safety conditions and restrictions

The solution and design of the allocation and layout of workplaces, production and interoperation equipment, storage and interstorage areas and buffers must take into account the requirements and restrictions defined by legislation, Slovak technical standards, manufacturing technology and observe safety at work.

The basic constraints and requirements that need to be taken into account when designing the layout are:

- Corridors widths and space around machinery and equipment.
- Width of transition aisles.
- Escape routes.
- Taking into account the sequence of flows of materials, semi-finished and finished products.
- The needs determined by the manufacturing technology.
- Workers requirements.
- Limitations due to the technical condition of the production hall.

The layout designs (Figure 7, Figure 8) of workplaces, production and interoperation equipment, storage and interstorage areas and buffers are based on the following conditions:

- The area around the headquarters (Control and Personnel Centre), has to form a safe zone for the production floor personnel. No forklift or other vehicles shall enter the zone, any other elements restricting movement such as materials, sheets, cuttings, products, etc. cannot be placed in the zone. The zone with the entrance and exit at the Control Centre will form one of the main green escape routes.
- The transition corridor in the middle of the hall must be clear, without serious restrictions. In addition to the material entrances and exits, the corridor also serves as an escape route, located in the centre of the hall between the two opposite doors. It must be kept clear from the point of view of its functionality and to ensure the continuity of material flows, supply and safety.
- The functional form of the products is given by the welding workplaces. Welding processes form the essence of production, it is advisable to centralize them and place them among the columns in the production hall with dimensions per one welding workplace of about 4 x 4 meters. The material flows are concentrated at the welding workplaces, which have their own material inputs and outputs that are dimensionally heterogeneous and as well as they are related to each other in terms of technological processes. For these reasons, it is advisable that the workplaces should have dimensional variability on both, the input and output sides of the workplace.
- The production operations, with their technical support, which form the main content of the production and are carried out regularly, consisting of several types of similar or identical equipment (drilling, cutting), will be cumulated within their sections. This measure can have the synergistic effect of increasing production and the substitutability of production equipment in one section, without the need for unnecessary material transfers.
- Production operations, with their technical support, which do not form the main content of production and are carried out sporadically, will be located at the end or at the wall in the production hall (turning, thread cutting, milling).

- It is necessary to use standardized logistic racks as well as available, non-standard but safe free areas, e.g. on the roof of a tool-warehouse-shelter in the production hall for the needs of efficient location and storage of tools, templates, matrices and other elements for production needs.
- It is necessary to use the storage of the sheets in a specialised self-supporting rack, which is not connected to the supporting columns in the hall (as it was before) for the efficient and safe placement of the steel plates (sheets), for the plasma cutter zone. This solution opens up the possibility of variability for the location of the sheet metal storage in a different location of the production hall columns.

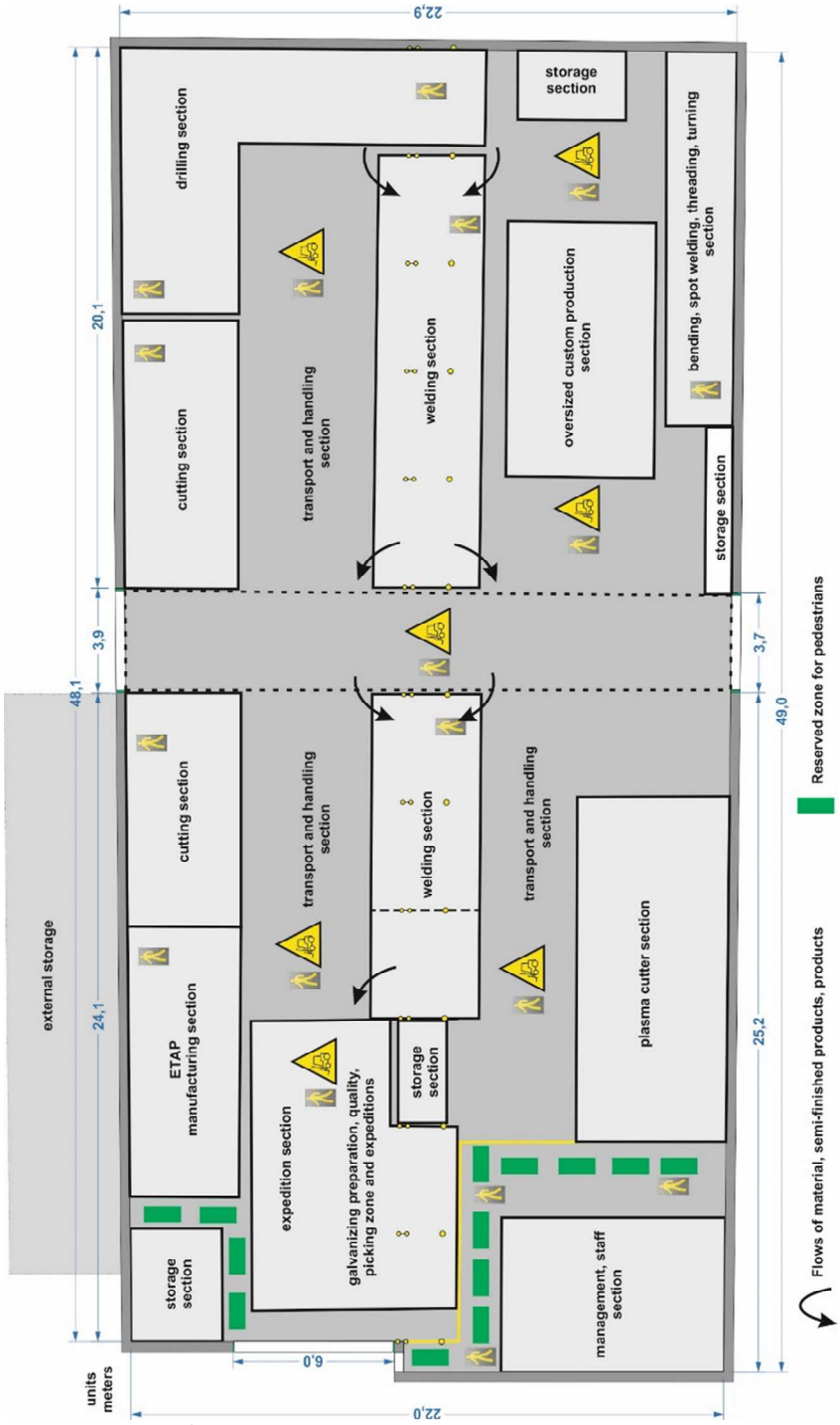

Figure 7 Design of the section layout in the production hall, schematic representation

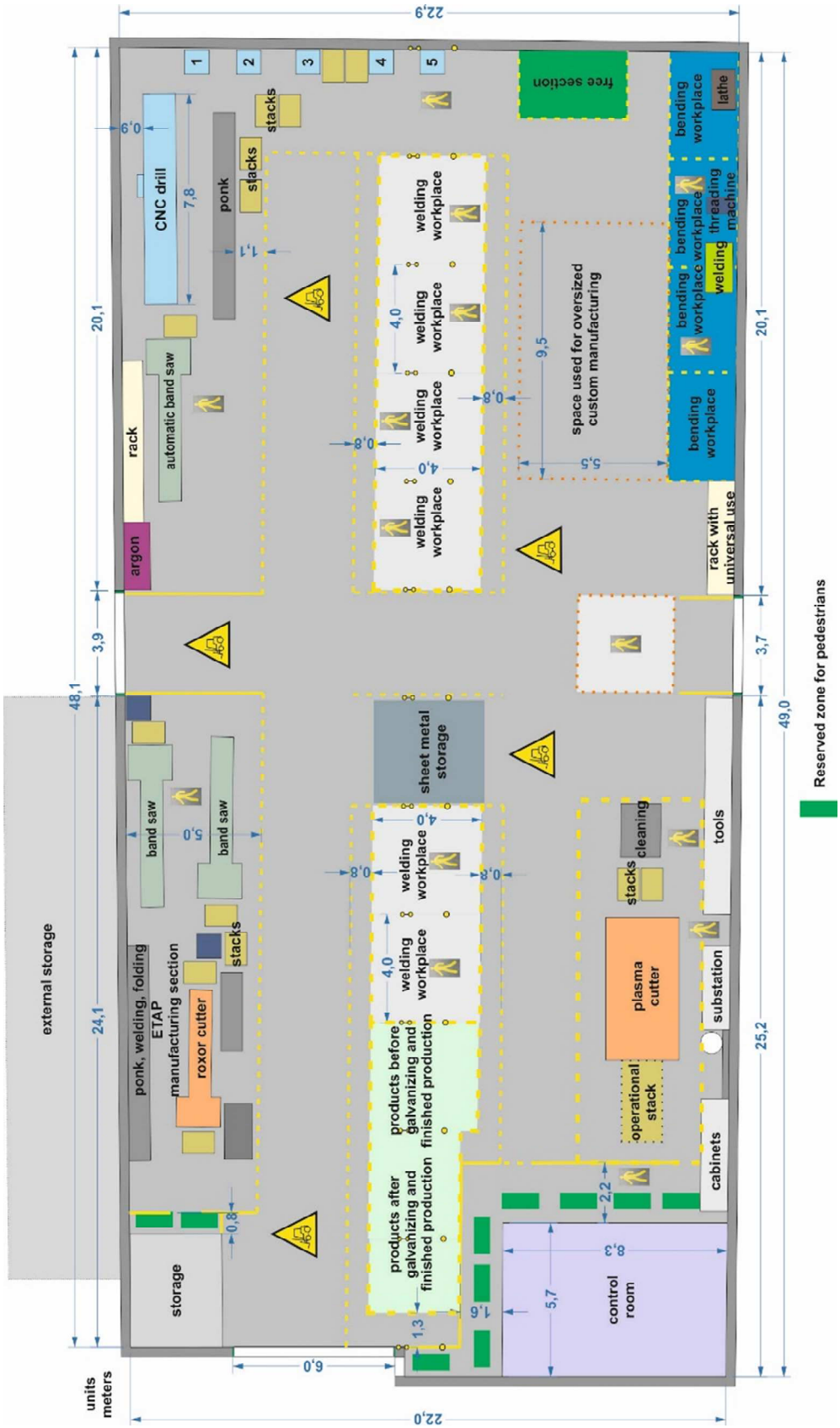

Figure 8 Design of the section layout in the production hall

5 Conclusions

The actual solution of allocation and layout has its own laws, rules, techniques, procedures and methods. In many scientific papers, it is possible to find procedures whose solution is based on common regularities such as the use of computer simulation [14-17], the use of modelling and CAD systems [18-21], the use of multi-criteria decision making [22-25] or other approaches to solve efficient allocation and layout [26-30].

The intention of the allocation and layout solution was to design an efficient layout of metal building elements production workplaces based on their operations and processes as well as logistical patterns for the needs of production efficiency and layout of production and interoperation equipment, storage and interstorage areas and buffers in the production hall, while meeting the defined technical, technological, safety and optimization criteria.

The conceptual solution of allocation and layout for the company engaged in the production of metal building elements brought savings in the form of 30% reduction of crossing material flows, increased safety at work, created workplaces that were arranged according to the procedure defined by the technology of products manufacturing, which ensures smooth material flows, safe zones without mechanization that were defined for workers, standardization was introduced in terms of technical, production and logistic means, small buffers located in a considerable area in the production hall were eliminated and other places without practical use were eliminated too.

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