RESEARCH IN LOGISTICS & PRODUCTION

PLANNING MODEL OF PRODUCTION PROCESS IN A MANUFACTURING ENTERPRISE

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Abstract. The article focuses primarily on two major aspects affecting each manufacturing enterprise. Namely, the question of planning of production process as well as process preparation to manufacture a desired product will be discussed. The article shows planning and production actions on the example of a production enterprise. The technical scope necessary in preparation of each production was presented as well as selected ways for inseparable connections and machines found in manu-facturing halls were discussed. The characteristics of an enterprises manufacturing metal workshop furniture as well as workshop cars equipment was shown. The course of manufacturing process planning was depicted. Due to presented plans of the production hall it is possible to view the whole process. Some changes in that plan to streamline production and extend it in the future with a new range of products were suggested.

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1. INTRODUCTION

Nowadays, people are surrounded from each side by various objects, smaller, bigger, nice or less attractive, functional or completely useless. It all comes from the desire to possess all those goods. This is sometimes justified by the need to function comfortably and smoothly on a daily basis, but increasingly also by a simple desire or a fad to purchase the product.

In view of the above, manufacturers constantly try to compete with each other in inventing and creating constantly newer models of their products. Everything is designed to attract the largest possible number of customers and achieve commercial success by the company, with satisfactory profit.

However, before the product will be sold, it must be previously manufactured, which consists of several stages. Firstly, the company needs an idea for an article. What should it look like and which functions should it have? For that purpose, it is necessary to carry out market research or make a summary of statistics, conforming to the requirements of the users who purchase the products. Then, a design of the product, which the company wants to market, is made. In the further part, the action plan is drawn up and the targets and the preparation of the production process are determined, which will be further described in this article. After rigorous preparation of all stages, it is time to move on to product manufacturing, the marketing department starts its activities by providing an appropriate advertising and the sale of a finished product.

2. PRODUCTION PLANNING IN A MANUFACTURING ENTERPRISE

The concept of production planning has a broad meaning and is not defined explicitly, as it consists of a number of concepts. Planning certainly is the primary function present at all stages of production in an industrial enterprise. It also has an impact at the strategic level, taking into account the technical and economic aspects, as well as the tactical procedure. Planning is a kind of operation in which a previously set plan must be implemented. This requires constant control in order to rapidly response to apply amendments to the concept, which is associated with taking key decisions.

The planning process is made up of five primary elements. The first is to determine the target which the company wants to achieve. Then the situation which illustrates the benefits and obstacles resulting from its implementation is analyzed. The next step is to make a proper planning and develop all phases of production which lead to fulfillment of the target. In the next stage an implementation schedule of the predetermined target must be developed duly and comprehensively. The

last level of production planning is to ultimately make a decision on the implementation of a specific product (Durlik, 2004, pp. 193–194).

Once the production is started the only activity is to control the work progressing in various stages, and the possible application of the amendments to the manufacturing schedule. All steps and activities associated with the planning are reflected in the diagram shown in Figure 1.

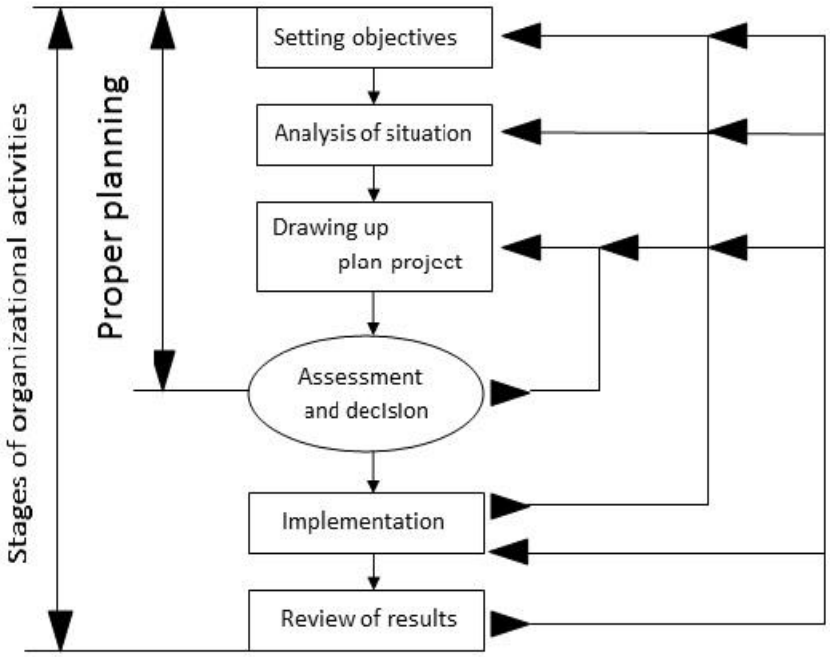

Fig. 1. Planning stages and organizational activities (Durlik, 2004, p. 195)

There are three main types of plans, resulting from the hierarchy of activities in an enterprise. The first of them are strategic plans, whose task is to achieve the main objectives and mission of the company. The second type are tactical plans which determine the method of the implementation of strategic plans, and are a kind of implementation instrument of objectives approved by the tactical plan. The last, third, are operational plans, responsible for strategies of implementing tactical plans for the achievement of the objectives agreed by the operational plans. After developing the missions that will be in the implementation of the aforementioned plans, the remaining activity is to illustrate the actions aiming to make the concept through the creation of schedules and initiation of realization of products. The only element that should be performed at the end is a constant control of pro-

duction to avoid many mistakes, rapid response of repair, and thus minimization of hidden costs.

3. PREPARATION OF THE MANUFACTURING PROCESS IN AN INDUSTRIAL ENTERPRISE

Planning of the production process is the most important step of the entire production in each enterprise. It determines how the whole process will be run and what the finished product will look like, whether it will meet the requirements of customers and how well it will sell to provide profit to the company.

The entire production process starts from the desire of the client to possess the object. Market research is conducted and customer needs are studied for that purpose. After completing this phase, the designers transfer their ideas on paper, most often using computer programs CAD. When a new project is created it is time to start manufacturing the specific item.

All these things, and many more, make up the production process. Therefore, it is so important to prepare the entire production plan so as to avoid losses and suit the users' tastes. While developing a new product, it is essential to meet the expectations of buyers, and thus obtain maximum income with minimum own contribution.

Before we move on to discuss the preparation of the production process, it should be clarified what manufacturing and production process involve. "Production is the use of a wide variety of materials, technical measures and services in order to produce new products and services required by the client" (Durlik, 2004, p. 8).

The production process is an orderly series of activities designed and organised to make a specific product or group of products, that takes place in accordance with the approved plan of action within a specified time period. The production process progresses dynamically due to variable quantities and qualitative characteristics, as well as using information technology, energy and material support. This dynamic process occurs thanks to the flow of information, materials and, above all, people (Gawlik, Plichta & Świć, 2003, p. 23).

According to another author, production process is a compound of actions necessary to produce a finished product with the specified material and use value, made from raw materials, materials or intermediates.

The production process turns out to be responsible for the overall manufacturing and promotion of the product. It includes such areas as: marketing, planning, purchasing, forecasting and process control until the finished product is made. After the completion of these steps the process also applies to the sale, distribution and service, all in order to satisfy the customer while using the desired product.

The production process can be divided into the following types: extracting, processing, machining and assembling.

Extracting production process involves recovering natural resources from such sources as water, earth, air or the sun. The extraction of products from the water includes: fishing, extraction of gravel as well as recovering electrical energy. Of course, one cannot forget about clean water, which is essential for every human's life, and for daily functioning in the society, and for production processes. Most benefits of nature are derived from the ground. This element supplies almost every industry ranging from the mining industry, agriculture, and rural tourism. From the earth man extracts all kinds of minerals, raw materials and substances of geological origin, for example, coal, oil, gas, iron ore, metals and precious stones. This also includes recovering wood or fruits and vegetables. However, from the air and the sun we get deposits of renewable electricity (Durlik, 2004, p. 62). In many cases, products derived from this process are subjected to subsequent processing in the machining processes, among others, metallurgy, thermal energy, processing of agricultural raw materials.

The processing production process involves the conversion of materials or raw materials in articles with amended chemical identity, state of matter, as well as mechanical and operating properties (Brzeziński, 2000, p. 27). Often the products from this process are subjected to subsequent processing in the machining process, however they can be eaten directly by consumers, for example in products derived from agricultural raw materials (Durlik, 2004, p. 63).

Machining processes change the shape, dimensions and characteristics of the surface and internal structure of products made of wood, metal and plastic. They also involve processing raw materials originating from a holding in the ready-to-eat food products. The machining process consists of multiple operations, among others, shaping, the aim of which is to obtain a semi-finished product or a finished part of the intended shape. Another operation is the physico-chemical heat treatment or other, which, in effect, changes the structure of the material from which the item was made with a specific shape. The last operation is the surface treatment, which is aimed at giving a required surface finish to the component. Machining processes are used, among others, in the engineering industry, electrical, clothing, jewellery, as well as in the food industry.

The assembling process has the task of mounting a semi-finished product or a finished product composed of two or more elements, and bringing it to be used in subsequent stages of production or purchased as a finished product by users. This type of process is used in many industries, for example electronics, machinery, furniture, construction, mechanical and in many other (Durlik, 2004, p. 64).

Having explained the basic concepts which will be referred to in this work one can move on to discuss the whole issue of preparation of the production process. It includes all activities prior to the start of production of the product concerned or the implementation of manufacturing work in the enterprise (Szatkowski, 2008, p. 17).

Thinking about the works preceding the start of the production process, we come across two similar concepts, i.e. preparation of production or technical preparation of production (TPP). The difference between them is that the preparation of

production is a broader concept than the technical preparation of production, extended by the sphere of scientific research. As a result, the production companies more often use the term "technical preparation of production." Technical preparation of production (TPP) is a collection of various activities undertaken within the company to determine the technical characteristics of products and their components as well as methods of their manufacture (Haratym, 1979, p. 45).

This type of activities include (Dworzyk, 1973, p. 22):

- research work aimed at new products, materials, manufacturing processes and manufacturing method;
- development of new products, technological processes, production equipment and specialized production machines;
- work related to the development of technical rules, as well as issuing the necessary technical documentation;
- work related to the introduction and control of new production and new methods of implementation;
- work related to current production management and improvement of already manufactured products.

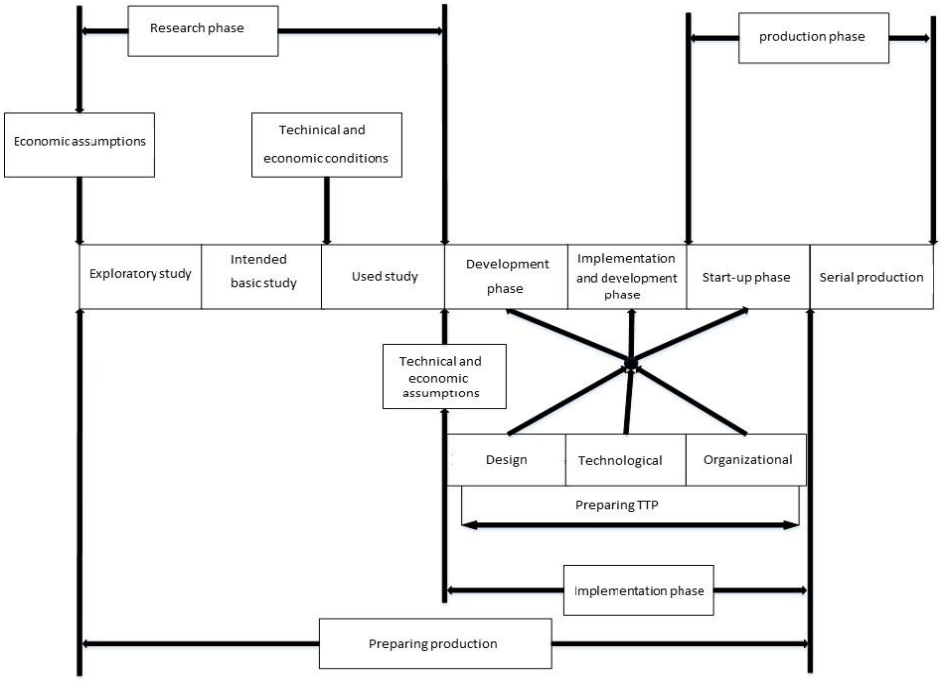

Fig. 2. Planning stages and organisational activities (Szatkowski, 2008, p. 19)

It follows that the main objective of technical preparation of production is planning projects for new products, methods of their manufacture and starting produc-

tion and continuous improvement of manufactured items. This is only possible due to the close cooperation between the research and development, design and implementation departments. There is a division of technical preparation of production into perspective and specific. Within the perspective technical preparation of production we can distinguish the following measures: (1) scientific and research, (2) advance preparation. However, the specific technical preparation of production includes activities such as: (1) experimental preparation, (2) preparing to start production, (3) control over the launching of production, (4) support for the implementation and operation, (5) improvement of products and processes.

It was found that the overall process of preparation of production can be divided into two parts, the research phase and implementation phase, so that it balances the technical preparation of production. Figure 2 shows a single system of product preparation, from which it is apparent that the technical preparation of production includes development, implementation tasks as well as the start of production, apart from any work related to science and research (Szatkowski, 2008, p. 18).

4. PRODUCTION PLANNING AND MANUFACTURING PROCESS ON A SELECTED PRODUCT

Each product has its origin in the mind of an individual and results from a need. Types of needs can be different, such as the desire for ownership, facilities or profit. In the case of a new product the idea stems from the need of the customer, for whom the device is necessary or from the manufacturer who wants to add some technical innovations to the product range. When developing a new product, it must comply with the technical and technological conditions related to the manufacturing capacity of the plant. All the information that defines the nature of the product, its functionality, construction and materials used come directly from the client side. Often, the expectations of buyers considerably exceed the specified frame, then it is time to include corrections to the project taking into account the production capacity of the company. The buyer often affects the purchasing price, which is why the design of the product must take into account the cost of manufacturing. The demand for the product has a big impact on the cost of manufacturing. In this respect, it is crucial that the manufacturer has experience, knowledge of the market and is willing to pay a certain amount of risk. To meet the demand of consumers, it is necessary to carry out market research. It is advisable to use reliable advisers, who have direct contact with the client. They are able to determine trends in sales. Another market research is keeping statistics by sales departments. On this basis it is possible to deduce the actual demand for a product.

After knowing the results corresponding to the question if the product will obtain good sales results, a product must be illustrated. This work is conducted by designers. With the help of computer programs, among others, SolidWorks (Auto-

CAD) they develop the project, in this case, the S-type tool box, by specifying its dimensions, number of drawers, closing systems, mobility, and sample colours. The finished design goes for approval by the head of the plant, and then is assessed by potential consumers. If customers have expressed the desire to purchase the product, it shall be placed on the product offer and shall wait for the order from the customer.

The manufacture of a new product also includes the improvement of an existing product. The demand for this type of change may result from the customer's needs, as well as from the internal need of the manufacturer, e.g. to reduce the costs, or attract more customers. Buyers are constantly watching the market and competition and are comparing the purchased products, and thus they are introducing changes and enhancements that meet their expectations. This affects directly the introduction of so called "Face Lifting" of an existing product. Most often, this involves "slimming down" the product by changing the thickness of the material, the introduction of plastic parts or aluminium, as well as the implementation of new technologies. Such changes are due to customers' needs for high-quality products at a low price.

Knowing the number of ordered items, equipment requirements and colours, the next stage is to plan the production line. This is a very complex process which may be supported by all kinds of programs, calculators or tables. However, the most important factor turns out to be the experience of people planning the production. Planning of the production process starts with determining the quantity of ordered items and the deadline on which they shall be made. This allows to plan the duration of individual steps, starting with ordering materials needed for the production, through the creation of the elements, to the assembly of the finished product. This information may be imposed by the client or proposed by the contractor. When planning a new production, the current state of the manufactured products should be taken into account. Provision should be made for all work centers for a given product, at a specified interval, given the transition to successive stages of production. The best option is the continuous movement of semi-finished products, between departments, without the presence of any technological distortions. However, some problems may always occur, but to avoid as many downtimes as possible, certain departments produce bigger number of elements than others. In the section of cutting machines, additional blanks are manufactured that, if necessary, are implemented into production. Other departments involved in the manufacture make exactly the same quantity which was included in the order. However, the assembly section prepares the so called departmental warehouses, in which there are ready-to-assemble semi-finished products (Topolska, 2016).

Therefore, production planning is about the use of individual sections of production in the most efficient way while avoiding downtime. In planning the manufacture of a product, it is necessary to take into account technological processes, quantities and types of necessary machinery and the number of employees that operate the places taken into account throughout the process (Topolski, 2015).

5. THE MANUFACTURING PROCESS OF S-TYPE TOOL BOX

The production process of S-type tool box is very complex. It contains many elements necessary to produce a functional and an irreplaceable product on multiple workstations. For better understanding of production a scheme was created and presented in Figure 3.

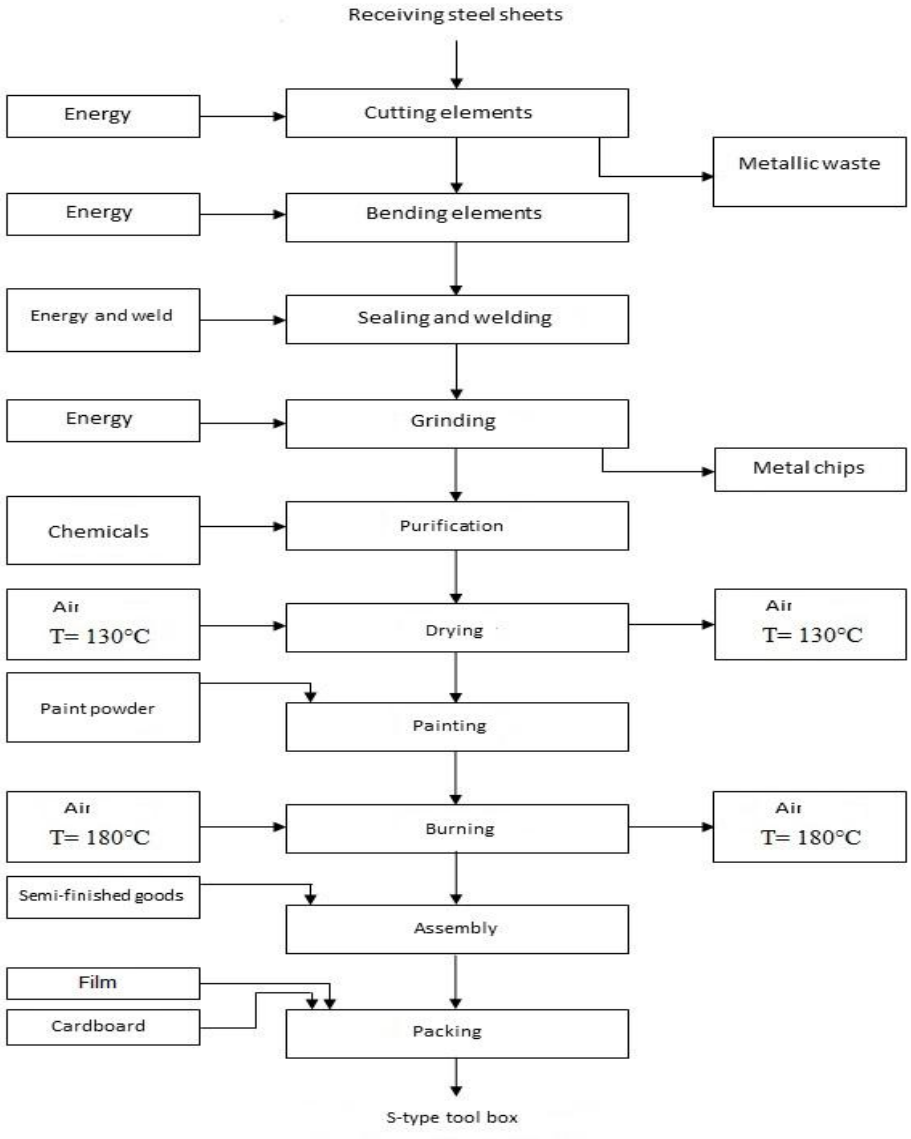

Fig. 3. Flow chart for production of S-type tool box; own study

For this purpose, the flow chart is used, having regard to all the stages through which the manufactured product passes. Input and output elements are also included.

In order to better illustrate the way through which the manufactured tool box goes, a layout of the production hall was developed and shown in Figure 4. On the plan, the production departments are designated, the equipment and the place intended for the storage of products from various stages of manufacture of S-type tool box. All types of machinery as well as sections are marked with a different color with a corresponding indication explained in the legend next to the drawing. A way was also designed, from the moment when materials enter to become intermediates as well as the route through which the semi-finished products go to become the finished product until they leave the enterprise. The following plans for production were created using the computer program Microsoft Visio.

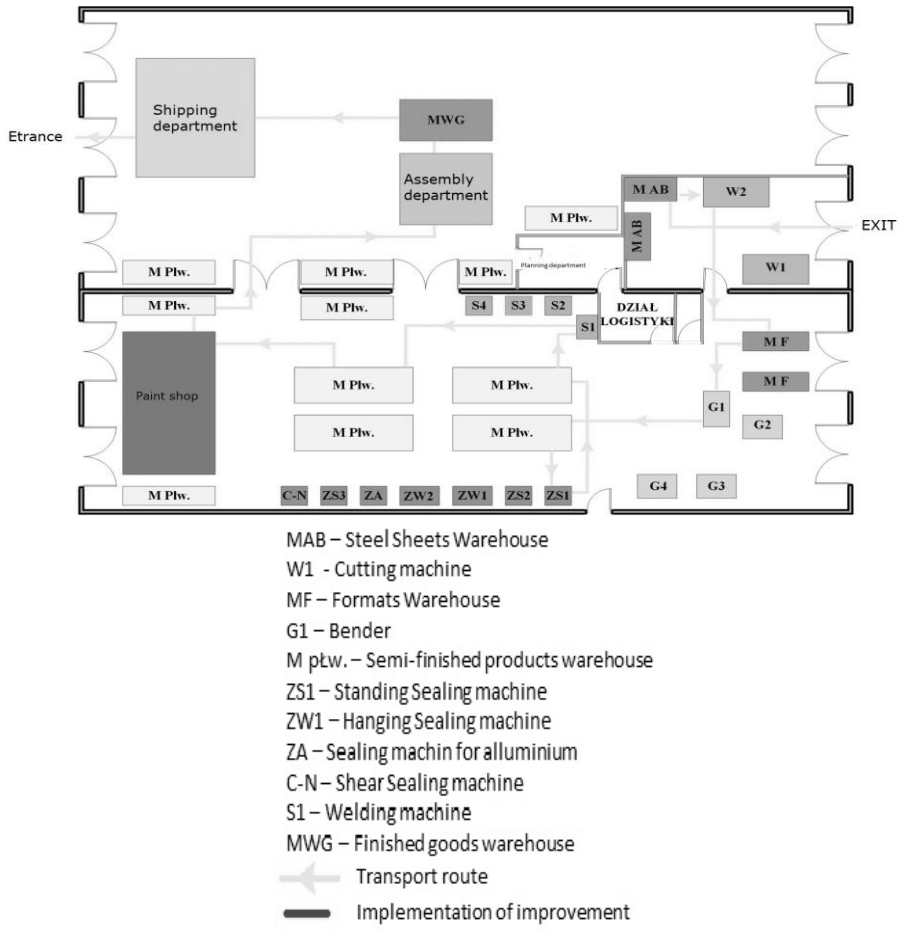

Fig. 4. Plan of production hall in an enterprise; own study

The production process of S-type tool box begins in the first section of the manufacturing hall, namely in the section of cutters. Stainless steel sheets with a thickness of between 0.5 and 2 mm and maximum length of 3 m go to an automatic cutter controlled numerically from the steel sheets warehouse. An employee programmes the machine on the appropriate parameters by setting the dimensions of the elements of body with seats on the holes. Formats needed to create drawers in different heights and other metal parts needed to assemble the finished product are cut on the same cutter. Waste from steel sheets is transferred as secondary raw material. Due to this solution the company recovers a portion of the cost of buying the original material.

The elements which were cut according to the appropriate design go to the formats warehouse, from which an employee of the benders department may obtain them freely. In both departments the machines used come from one manufacturer, TRUMPF, which greatly simplifies the maintenance process. The benders section also includes numerically controlled equipment, but there an employee places cut formats under the press of the bender so that a given part was bent in the right place and in the correct direction. All the elements necessary for the manufacture of the intermediate products that make up the finished product are bent here.

All bent components are transported to the warehouse of semi-finished products, to a neighbouring department, which is the sealing machines and welding machines department. Here, in the first place, the elements are welded together to give the desired body shape of the box and its drawers. The transit time may slightly be delayed due to the distance between sealing machines and welding machines. The company has four types of sealing machines made by company ARO, for aluminium, a table type, one hanging and one of shear type on a special oscillating arm, which is convenient in welding hard-to-access places. All sealing machines combine elements spot wise. After the process of sealing the solids are then welded at joints for better strength, giving a guarantee to the customer for the reliable use of the product by many years. In this section holes are drilled and elements are properly cut. Any imperfections of texture on the edges of the metal are ground before they go to the next stage of production.

Reinforced constructions of bodies and drawers, before they are transported to the pain shop, wait for chemical cleaning in the warehouse for semi-finished products, a section of the paint shop. The purification aims to eliminate as many defects in paint as possible, by removing all sorts of dust and sludge remaining after the previous stages of the production, and metal sheets degreasing. Chemical treatment occurs in the three zones in the tunnel. In zone I, the elements are degreased and phosphated. For this purpose, chemicals from company KLUTHE are used. This process occurs at 50–60°C by means of such chemicals as Decorrdal 40-88, Netzmittel 355-1, Puferlosung N 30. Then the elements are brought to zone II, where they are subjected to rinsing by the industrial water. This is followed by a second rinse in zone III. Demineralized water is used for this purpose. At this stage, reverse osmosis takes place. Before painting, cleaned items are dried in an oven at

130°C for about 20 minutes. Properly prepared parts go to the automatic powder paint shop which uses electrostatic technology, involving attracting the opposing charges. This kind of coating metal uses also hybrids with epoxy and polyester resin. The details leaving the automatic paint shop are transported to the manual paint shop with an average speed of 143 cm/min, using the overhead lift, whose length reaches 250 m. An employee completes the shortages of paint in hard-to-reach places such as refractions or edges using a PC paint gun. In automatic and manual painting cabins all available colours from RAL palette are used. Painted items go to the furnace with a temperature of 180°C. The heating of the furnace is through continuous airflow, obtained by a set of fans. In the process of heating the powder melts, and, as a result, on the surface a uniform structure is formed. It takes 10–15 minutes to fire one element. Powder paint technology ensures the best possible effect of coating and color depth, and thus protects the steel from corrosion. The great advantage of this method of coating material is its environmental impact, because it does not release harmful agents into the atmosphere. At this stage the manufacturing process ends, the process continues through assembling the finished product.

The solids of drawers and bodies are transported to the assembly department. In the first place grips (handles) are assembled to drawers with screws and properly cut blades, thanks to which the grip will be attached to the drawer. Next, the ready handle is attached to the drawer by means of rivets. A spring is put on one side, which helps to open the drawer. Having prepared the appropriate quantity of drawers the assembly of the finished product begins. Two fixed wheels and two swivelling wheels with lock are screwed to the body of the box. The prepared body goes to assembly line, where TOP is put to the top of the box, in the form of a rubber mat or plastic tray with compartments. The trademark and logo of the group are stuck. A central lock is placed inside the body, which locks all drawers. Drawer slides are also mounted and, on them, the drawers themselves, according to the pattern provided by the customer in the order. An aluminium handle is included with accessories required to mount it to the body of the box, personally by the purchasing side. The finished box is finally cleaned and packed in a protective film. The prepared product goes to cardboard boxes on a pallet and receives relevant product information, located on the label. Before shipping the product goes to binding and stretching for better protection.

Due to the unfavourable deployment of certain machines and places for the storage of raw materials and semi-finished products, Figure 5 shows some suggestions about how to change the places of deployment. The improvements (marked in red) were introduced in such a way as to improve the inner transport (yellow arrows), and at the same time to shorten the transportation times. Suggested ways concern indicative moving of production of the S-type tool box, therefore not all machines are involved in production, due to the production of other metal products by the company.

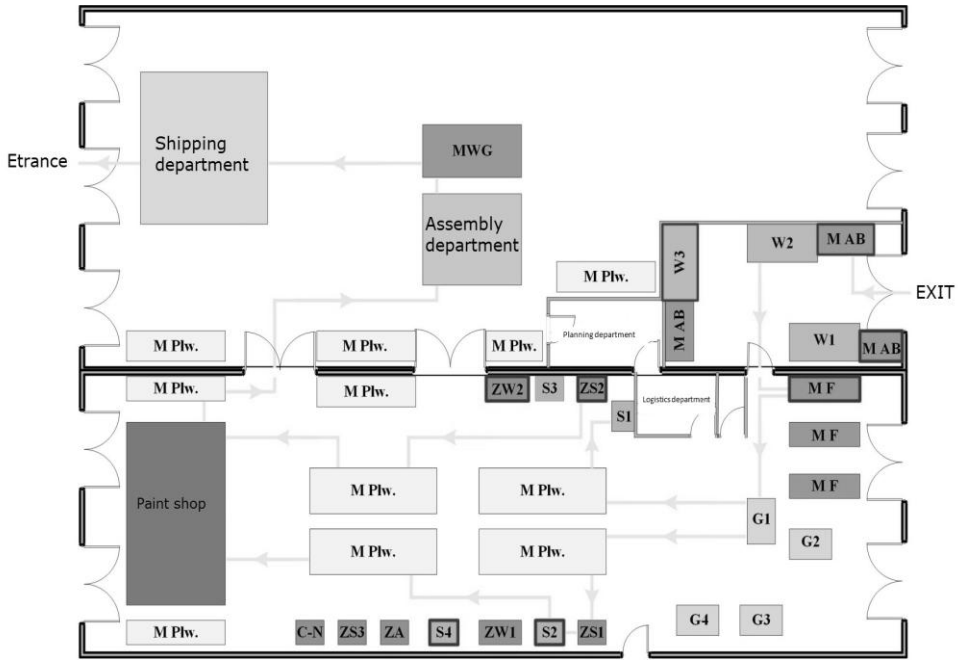

Fig. 5. Plan of production hall of enterprise together with implemented improvements; own study

The proposed improvements relate to the first three divisions of manufacture of semi-finished products, needed to produce the S-type tool box. In the section of sheet metal cutting machines the arrangements of metal sheets warehouses have been changed, and this has provided additional place to insert an extra cutting machine and one raw material storage place.

In the next section of benders, one warehouse was added for the formats, and a significant improvement is the exiting of elements from the bender into two warehouses of semi-finished goods. This is due to the conversion of places of two sealing machines (table and hanging) and two welding machines.

Thanks to this solution the creating of construction solid of boxes and drawers takes place at the same time, without waiting for the release of a device or acquiring a series of bodies. Then the assembly of a series of drawers takes place. After the scheduled steps have been completed, the ready solids wait for clean-up and painting in a warehouse for semi-finished products.

Performed operations, together with proper positioning of equipment and warehouse parts can lead to savings in transports time and prepare the surface for new machines and storage shelves, so that the company can increase production or extend it with new products.

6. CONCLUSION

Production planning is a complex process consisting of many elements, which has been proven in this work. Any production, or any venture cannot do without planning the course of events.

Production planning of the S-type tool box starts much earlier than in the manufacturing hall and includes many more aspects than just the creation of a specific number of units. Because planning arises from the need to create or possess the product.

This thesis, in the fourth chapter presents a suggestion for arrangement of machinery and equipment as well as warehouse spaces. The changes are presented in conjunction with the plan of production hall containing factual arrangement of selected elements of production, on the basis of which some conclusions were drawn:

- Along with the change of the position of machines and warehouse parts in the section of cutting machines, enough space was obtained to equip this section in an additional cutting machine and one storage shelf. This will allow to introduce more modern machines with automatic feeders of metal sheets, thanks to a short distance of shelves from cutting machines.
- In the section of sealing machines and welding machines, replacing the seats of these devices was used, in such a way as to reduce the distance between the machines and perform work in two places at once.
- Each proposal of relocating the elements of production triggered the reduction of the internal transport routes or distribution of the work on the specified devices.

To sum up the above considerations, it can be concluded that relevant planning has a significant impact on the course of the entire production process and is essential at every stage of production. It is also important to continuously monitor the course of manufacture of the product, because it is possible to react early enough so that the company did not suffer losses, but gained satisfactory result.

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BIOGRAPHICAL NOTES

Andrzej Bujak is a Logist and specialist in security and military issues. Professor of Banking Academy in Wroclaw, Director of the Institute of Logistics. Previously, the Rector of the International School of Logistics and Transport in Wroclaw and Vice-Rector of the Military Academy of the Army. Commander of various organizational units in military structures responsible for the management of national and international human teams Many years of research and teaching staff of the National Defense Academy. Author and co-author of more than 200 publications, including several monographs. He is a member of the Transport Committee of the Polish Academy of Sciences.

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