IMPROVING PRODUCTIVITY OF HST WINDOWS MANUFACTURING PROCESS IN THE MTO SYSTEM

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Abstract

If a company is to generate profit it must actively react to the changing demands of the market. In order to meet current customer demands a company must make sure it is adhering to the 7R rule. With the modern market however, meeting this single condition may not be sufficient to maintain competitiveness. It is becoming increasingly common for today`s client to expect a product precisely matching his requirements (or personalized). This forces companies to create/design flexible processes and abandon MTS (Make to Stock) in favour of MTO (Make to Order). The company model discussed in this article specializes mainly in the production of windows, doors and window blinds. In the special products section, the client may influence the final look and functionality by choosing features such as shape, dimensions or accessories of the manufactured stock. This is a 100% custom production. One of such products is the HST Hebe-Schiebe-Tur window. A significant increase in demand forces changes leading to an improvement of the production process. A simple analysis allowed for the processes to be uniformized to a degree and to devise a new work-system organization proposal.

Keywords: Cellular structure, Make-to-order

1. INTRODUCTION

In the Make-to-order production system it is not the manufacturer, but the client who decides on the final features of the purchased product. The manufacturer offers a range of components making up the final product [1]. This fact determines certain characteristics of the production system, which should ensure it is sufficiently flexible. In most cases such a process is set on executing small orders for no more than a few items, we may therefore assume that the MTO system executes piece production. [2] The planned production process and the structure it will be realized upon must be tuned to this assumption. In such conditions, meeting the logistic goals of the company is advised, i.e. cutting the production process execution time, which in the case of a Make-to-order system is a direct cause of shortening order execution time. For this reason it is necessary to aim at limiting needless transportation, stoppages and generally reducing the waste within the process. Production is initiated by an order coming in from the client, which determines the necessity of organizing production in the pull system. This way the manufactured amount of products exactly meets the markets` requirements. It may therefore be said it is best to create an uninterrupted product stream through the production cells.[3,4] The manufactured products may vary in size, shape, utilized materials or even functionality. This necessitates the use of a frame technology log for a certain family of products instead of a particular product. At the same time it is impossible to assume specific timeframes and a permanent production cycle. Order execution times will vary depending on the product being available immediately - from storage, or needs to be ordered, and on the actions planned for the product in question. The times of particular operation may also vary depending on the construction features of a particular product variant.

Diversification of the manufactured products is typical for Make-to-order production. This however also causes the technology used varied for different products. This means that using expensive machines useful only for manufacturing a limited number of products and a high level of automation is pointless. The main characteristic for workstations used in the production structure should be flexibility. For this reason in custom production departments it is common to use universal machines. The tools may be modest and may comprise of simple equipment, which in turn must be compensated with an experienced and highly skilled personnel. The above make up a versatile machine park able to cope with various tasks.

However, the desire to maintain a continuous flow of material requires the application of a group layout [5] (**Figure 1**). Regardless of whether the production is carried out in the cells or on the production line, machines should be aligned in accordance with the order of the technology operations performed. [6,7].

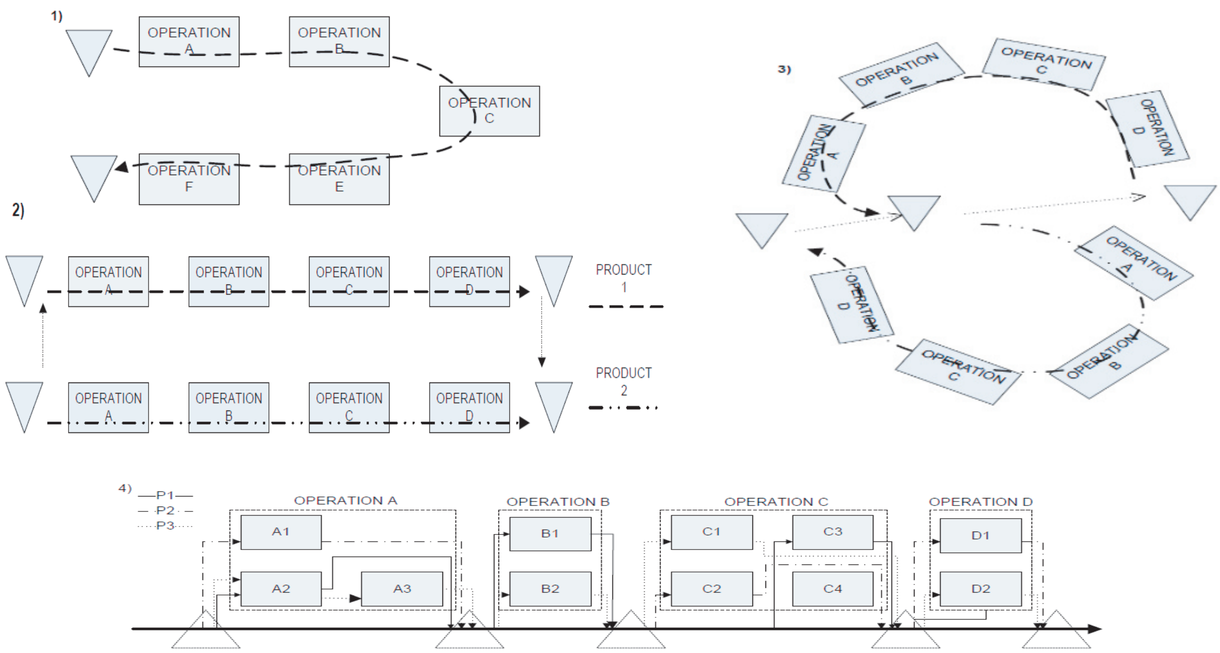

Figure 1 Diagrams of exemplary cell structures:
1 - U-cell, 2 - „equal sign" cell, 3 - S - cell, 4 - technology-based layout

The make-to-order manufacturing system is by definition focused on the production of a wide range of goods. These are usually products with a similar overall technological process but it may vary significantly in terms of details, for example as regards the installed equipment. Each machine or device has an assigned task to perform one specific technological operation in line production, so their specialisation or process automation may be beneficial. As such, lines are used for the production of larger series and also for make-to-order production of, for example, products similar in terms of dimensions but with different equipment installed. In the production of custom goods, cellular layouts will have a wider application. [8]

2. CHARACTERISTICS OF THE PRODUCTION PROCESS

OKNOPLAST is a polish company manufacturing PVC windows, exterior doors, window shades and other accessories having an application in windows. The production process is governed by the MTO (Make to Order) concept. The client may choose: dimensions, profile shape, colour, and accessories (burglar-proof glazing and fittings, noise-dampening windows, shades).
The basic elements making up the whole product (**Figure 2**) are:

- vinyl polychloride - PVC,making up the structure of the leaf or frame,
- internal steel profiles reinforcing the construction,
- boundary profiles, elements responsible for functionality (opening, closing, pivoting)
- double glazing,
- window accessories (handles, drainage air inlets etc.)

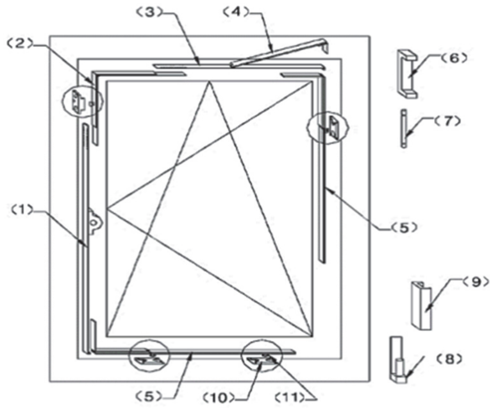

Figure 2 Diagram of basic elements of the window. Items description : 1- slam, 2 - corner, 3- guide, 4- schoulder, 5-closure, 6- upper hinge, 7- pin, 8- bracket, 9- lower hinge, 10- hook, 11-plug

Nearly all components necessary to execute an order are delivered by external suppliers (**Figure 3**). The only elements manufactured by the company are glazing units. Executing a production task in accordance with the MTO concept requires preparing each component of the ordered HST window.

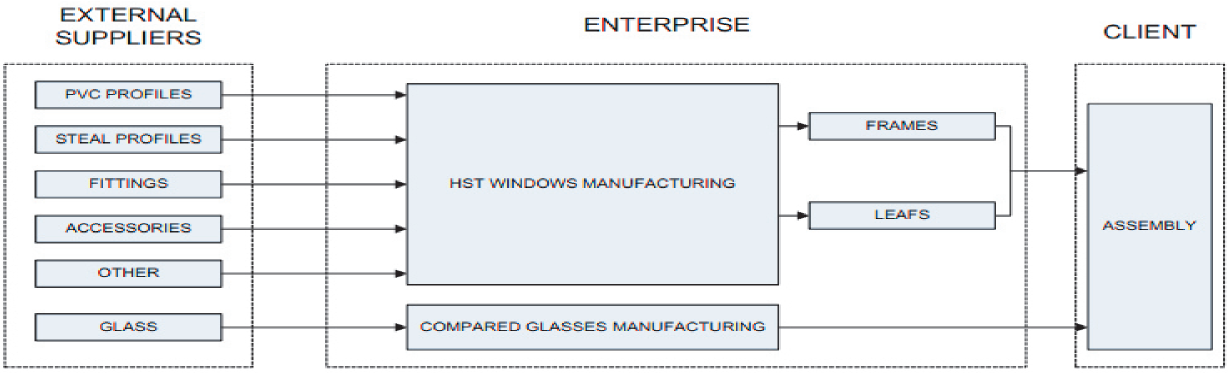

Figure 3 Scheme of HST Windows production process

Technologically preparing the elements for assembly takes place in the processing center. The prepared elements (after cutting, welding, milling, and drilling necessary technological slots) are being stored in buffers, from which they are subsequently collected onto the assembly stations. **Figure 4** describes a general production schematic for sliding HST windows in Oknoplast S.A.

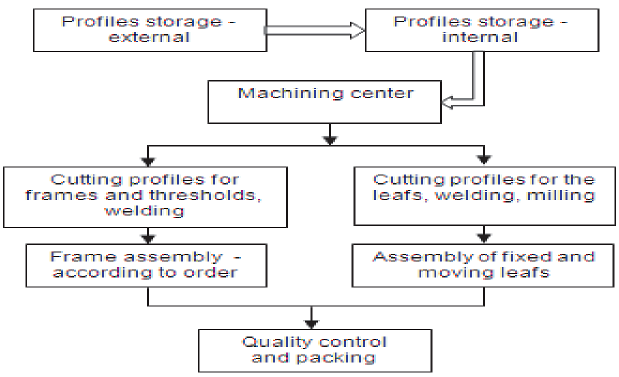

Figure 4 Production process diagram for HST

In addition to classic windows (square shaped) the company also manufactures custom-shaped products (triangular, trapezoidal, round and oval). The custom production department also manufactures sliding windows - HST(germ. Hebe-Scheibe-Tür) HST are dooors manufactured in the lifting-sliding technology. The doors have a glazed surface of up to 13.8 $m^{2,}$ and due to the application of lifting-sliding fittings are easily opened despite their considerable size: 1600 to 6000mm in width, 1800 to 2600 mm in height. These fittings also allow the window to be set to a micro ventilating position and if electrically controlled, may ventilate rooms at specific times of day. The manufacturer offers four types of HST doors, depending on how they open: HST A - one sliding and one immobile leaf, HST D - two sliding leafs, HST C - two immobile (external) leafs, two sliding (internal), HST CC - two immobile leafs (external), one sliding (middle).

Lifting-sliding HST doors are composed of:

- a frame connected by screws and stiffened by aluminum profile,
- a PVC sill reinforced with an aluminum profile,
- leafs manufactured from PVC shapers welded in the corners and moving on a trolley riding along aluminum guidebars.

Currently the assembly process takes place on five parallel stations -the entire assembly is executed in five nests, which includes (**Figure 5**):

- assembling the frame and sill (screwing),
- assembling immobile leafs,
- mounting the immobile leafs into the frame,
- assembling sliding leafs,
- mounting sliding leafs into the frame.

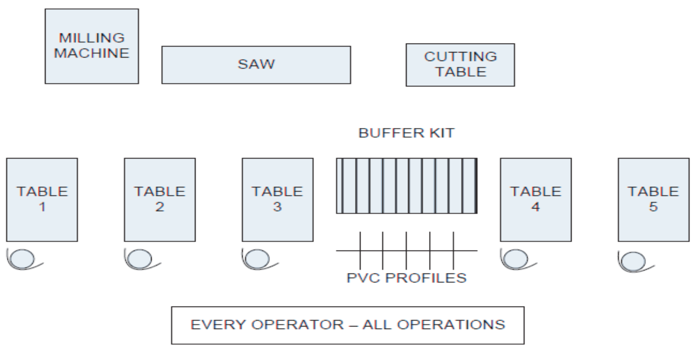

Figure 5 Current system of work organization

The manufacturing process ends with quality control and preparing the ordered HST set for shipment to the client. Due to the considerable weight of the sets and safety precautions the prepared frame and leafs, glazing and protection strips are shipped in separate transport units. Assembly of the HST set takes place at the destination - the client.

Installing the frame, immobile and sliding leafs requires many preparation and operational activities.

3. RESEARCH AND ANALYSIS OF THE PROCESS

Recently, the company has met a significant impact of the number of orders. With the current form of production organization, the productivity of HST windows assembly cells is insufficient to meet the current needs of the market. In order to improve the efficiency of the process. In order to improve efficiency in the HST window mounting sockets, a multilateral process analysis was carried out. It included:

- identifying the movements of the employee during technological operations at the workstation,
- timing all the performed actions.

Such analysis also allows establishing:
- the incorrect sequence of performed actions
- unnecessary actions,
- the fact that the time of executing the same operational action may depend on the operator performing the task.

As a result of a detailed analysis of the operators actions while executing tasks the following has been noted:
- assembling the frame and sill: 29 actions,
- assembling fixed leafs: 16 actions,
- mounting fixed leafs into the frame: 8 actions,
- assembling sliding leafs: 19 actions,
- mounting sliding leafs into the frame: 6 actions,
- quality control and preparing the set for shipment: 26 actions.

All actions were timed on five assembly stations (**Figure 7**).

Assembling a sliding HST window comprises of 6 separate phases. **Table 1** depict a time summary for particular window assembly stages. The research indicates that the longest stage is assembling the frame, which on average takes 1 hour and 32 minutes. The shortest stage of the process is mounting the sliding leaf in the window, taking around 10 minutes. The total window assembly time from the moment of receiving the first frame part to putting the prepared HST window on the stand amounts to an average of 3 hours 34 minutes and 47 seconds (excluding break time).

Table 1 Time compilation of subsequent HST assembly stages

Action	Frame assembly	Assembling fixed leaf	Mounting fixed leaf into frame	Assembling sliding leaf	Mounting sliding leaf into frame	Quality Controll And packing	Total time
Average time [hh:mm:ss]	01:32:26	00:37:24	00:17:58	00:41:08	00:10:36	00:15:16	03:34:47

The assembly process requires many additional preparation actions (eg. - cleaning components, unpacking, measuring, additional cutting operations). Preparation actions take approximately 30% of the total window production time. These actions add the most time to the entire HST window production process.

4. NEW SYSTEM PROPOSITION

Currently each employee executes all production stages, (**Figure 5**) i.e.:
- frame assembly,
- fixed leaf assembly,
- mounting fixed leaf into frame,
- sliding leaf assembly,
- mounting sliding leaf into frame,
- packing,

on a single assembly table.

The new worksystem would depend on dividing tasks (**Figure 6**):
- frame assembly: two employees,
- leaf assembly: two employees,
- mounting leafs into frame and packing: one employee.

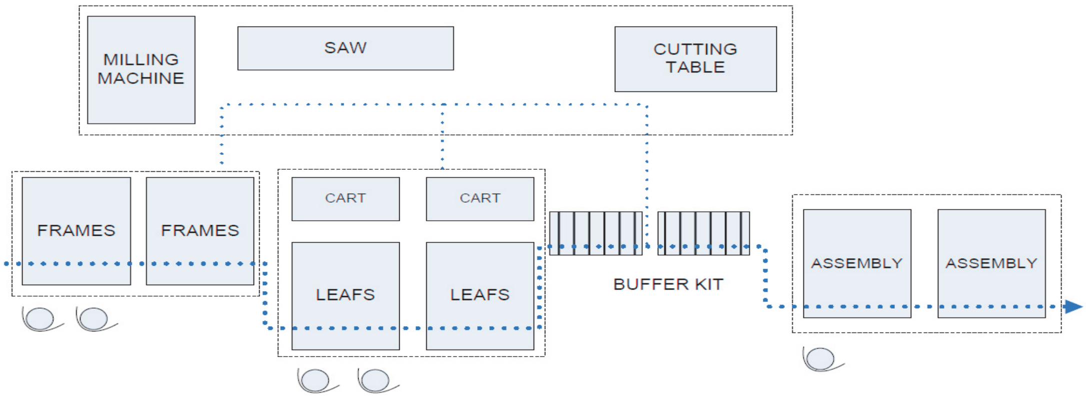

Figure 6 Proposition of New working system.

Table 2 summarizes the results of the analysis.

Table 2 Time compilation of HST assembly in new system

Action	Frames assembly (2 work.)	Mounting leafs (2 work.)	Mounting leafs into frame and packing (1 work.)	Total time
Average time [hh:mm:ss]	00:34:35	00:30:41	00:30:27	01:35:27

The production time of the window before the change was 3 hours and 34 minutes. After changing the working system, the window production time was 1 hour and 37 minutes. Thus, after the change, it is possible to increase the capacity of the slot from 10 to 14 windows per shift.

5. CONCLUSION

Sliding window production in OKNOPLAST S.A. is extremely advanced. Owing to the performed analysis based on execution time measurements of particular actions, excluding operations which did not add value to the process and changing the layout, it was possible to identify the most problematic areas which could be improved to increase efficiency. Basing on the performed analyses it was concluded that the greatest improvements could be made to material preparation operations. This part of the process takes 30% of the total time necessary to manufacture a window. The second area with a large improvement potential is the production system. Calculations suggest that once the nest system is introduced, productivity may rise from 10 to 14 windows per shift, which equals to a 40% increase. It is worth emphasizing that the main benefits of the potential changes a faster client order execution, a more flexible production process and multiple savings. Task time analysis on several production stages allowed for a full understanding of the entire process and to identify the processes best left unchanged (e.g. assembly method), those needing to be changed (e.g. production system) and those which need to be eliminated (e.g. component preparation).

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