PROPOSAL OF SPATIAL OPTIMIZATION OF PRODUCTION PROCESS IN PROCESS DESIGNER

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Abstract: This contribution is focused on optimizing the use of space in the production process using software Process Designer. The aim of this contribution is to suggest possible improvements to the existing layout of the selected production process. Production process was analysed in terms of inputs, outputs and course of actions. Nowadays there are many software solutions aimed at optimizing the use of space. One of these software products is the Process Designer, which belongs to the product line Tecnomatix. This software is primarily aimed at production planning. With Process Designer is possible to design the layout of production and subsequently to analyse the production or to change according to the current needs of the company.

1 Introduction

Optimisation efforts in all areas of production should be a priority for all production companies that want to be successful in the market.

Nowadays there are many software solutions aimed at optimizing the use of space. One of these software products is the Process Designer, which belongs to the product line Tecnomatix. This software is primarily aimed at production planning. With Process Designer is possible to design the layout of production and subsequently to analyse the production or to change according to the current needs of the company [1], [2].

2 Description of selected production process

The production process, which we will deal in this paper, is focused on the production of cable harness used in car´s cooler. It is the assembly production process.

In figure 1 is the current layout of the workplace and we will try to find solution for optimization. Individual objects contained in figure 1 are:

- yellow objects – work tables, on which are made specific assembly operations,
- red objects – containers with material, which wait for assembly, work in process and finished cable harness,
- black objects – personal that perform the assembly operations,
- blue objects – the raw material entering the production process,
- grey objects – finished cable harnesses waiting for optical inspection,
- orange objects – box containing cable harnesses that have any signs of damage, respectively poor quality, which didn´t meet the visual inspection,
- green objects – finished cable harnesses, that wait for transportation to the warehouse of finished products.

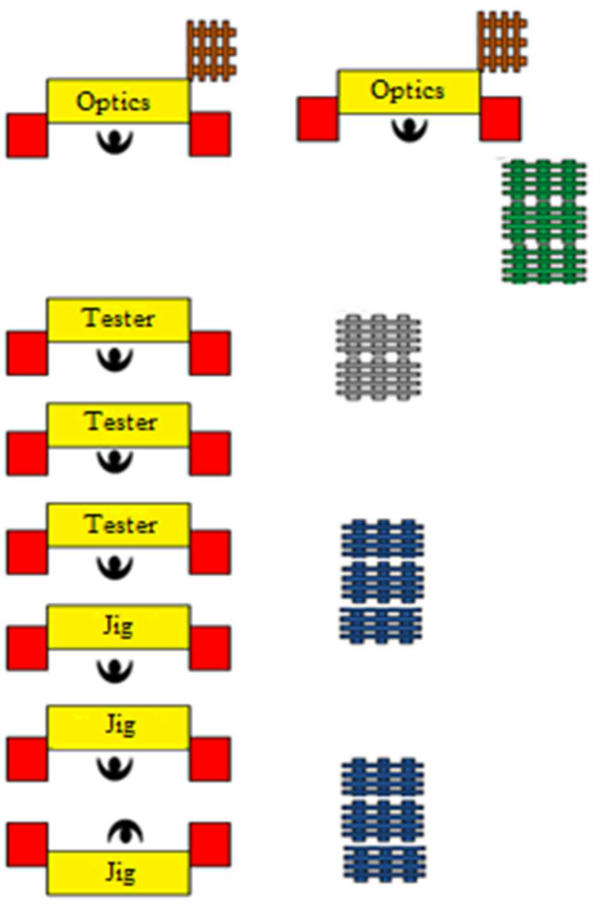

Figure 1 Current workplace arrangement

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The output of the production process is the cable harness, which is used in the coolers of cars (see Fig. 2). On the figure 3 is the detail of the produced cable harness.

Figure 2 Usage of cable harness in the car

Figure 3 Produced cable harness

3 Production process procedure

The production process, with which optimization we will deal, consists of the following steps:

1. Assembly of red and black cable – this assembly operation is performed on the first three workplaces of the production process. Processing step starts by placing "house" into the jig. There are blinded holes on the jig for assembly green and brown cable to avoid errors. These assembly operations perform workers manually. Workers at the assembly must ensure the correct position of the red and black cable.
2. Assembly of green and brown cable – assembly of these cables is done at three workplaces. "House" already fitted with red and black cable is plugged into the module 1 on the control measure. Then worker manually install green and brown cable.
3. Assembly of insulation tube and control – this working step is carried out in the same workplaces as previous step. Worker moves the wiring harness on the control measure from module 1 to module 2. The control measure will automatically implement Push – back test, while worker manually mount insulation tube on the cable. Push – back test result is displayed on the control measure. Based on this result worker moves cable harness to another workplace, respectively devalued it by shortening the cables in case of negative results to avoid false harness cable from the production process.
4. Visual inspection – visual inspection is the last step of the production process. In this step, workers don´t use any jigs or production equipment. Workers visually assess if there are any errors through assembly and they try to avoid mechanical damages on "house". Control of the cables is very important. It assesses whether there has been any curvature, respectively whether the cables are in the correct chambers. Workers also visually evaluate the correct position of the cable seal. Seal on the cables can´t exceed house.

In table 1 are listed characteristics of the time duration of individual work steps as well as the number of pieces that can be made.

Table 1 Production characteristics in terms of time and number of pieces

Working step	Time for one piece [s]	Pcs/work shift
1. Assembly of red and black cable	12	2250
2. Assembly of green and brown cable 3. Assembly of insulation tube and control	22	1250
4. Visual inspection	7	4500
Sum	**41**	

For single shift it can´t be made more than 1250 pieces, because of the bottleneck in the step 2 and 3.

In determining of the production time of cable harness in this case we don´t take into account the buffer stores, while the residence time of work in progress in the buffer stores is always different and depends on the current situation of production in the company, i.e. work in progress after the second operation may be located in

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the buffer stores two days to gather a sufficient number of semi-finished products for visual inspection.

Considering the nature of this paper we will not further describe each step of workplace creating in Process Designer, but whole workplace with a layout of individual units can be seen in figure 4.

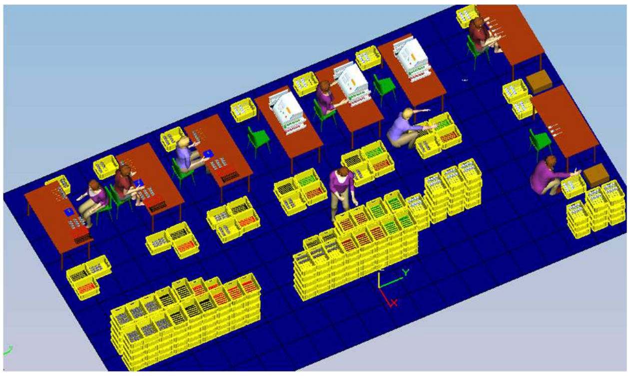

Figure 4 Workplace created in Process Designer

4 Deficiencies in the production process

Based on the implemented analysis we can identify some deficiencies in the spatial organization of the production process.

In table 1 it can be identified the bottleneck in the production process, which is represented by the second and third step that are realized at one workplace, i.e. control measure. Due to the larger number of operations, as well as the slowness of the process control, on the control measure it is not possible to produce more than 1250 pieces per working shift. After implementation of the first working step, where can produce 2250 units per working shift, is cable harnesses accumulated in the buffer stores. After the realization of the second step, the pieces are again temporarily stored in buffer stores in order to build up a sufficient quantity of units for visual inspection. Visual inspection allows for to test up to 4500 pieces of cable harnesses per working shift.

Considering the spatial characteristics of the room where is this production process performed, lot of buffer stores restricts the movement of workers, as well as container handling in the production process. Containers on the workplace are not colour coded, which leads to the formation of wasters. In this production process is frequent that the buffer stores with work in progress are in the workplace more days due to the transfer of staff to other production, because of the need to accumulate a sufficient amount of units for visual inspection.

Based on the conditions described in the production process can be therefore summarized as the following deficiencies:

- bottleneck in the production process causing the formation of large number of buffer stores,
- long persistence of work in progress in the buffer stores,
- limiting the workers mobility as a result of buffer stores,
- creating chaos in the workplace because of the wrong container location.

5 Proposal of optimization solution for spatial characteristics of the production process in Process Designer

In terms of spatial organization of the production process it seems to be an appropriate proposal to install a production line that would eliminate the bottleneck in production and thus prevent accumulation of work in progress in the buffer stores. Installation of this production line could also enable to increase the number of produced cable harnesses per working shift.

Structural line design was implemented in a software program Solid Works. It was made because of the need of saving production line in the format stp, which can then be converted using Autodesk Inventor software to JT. format needed to work in the Process Designer. Structural line design together with a description of the individual components is shown in figure 5.

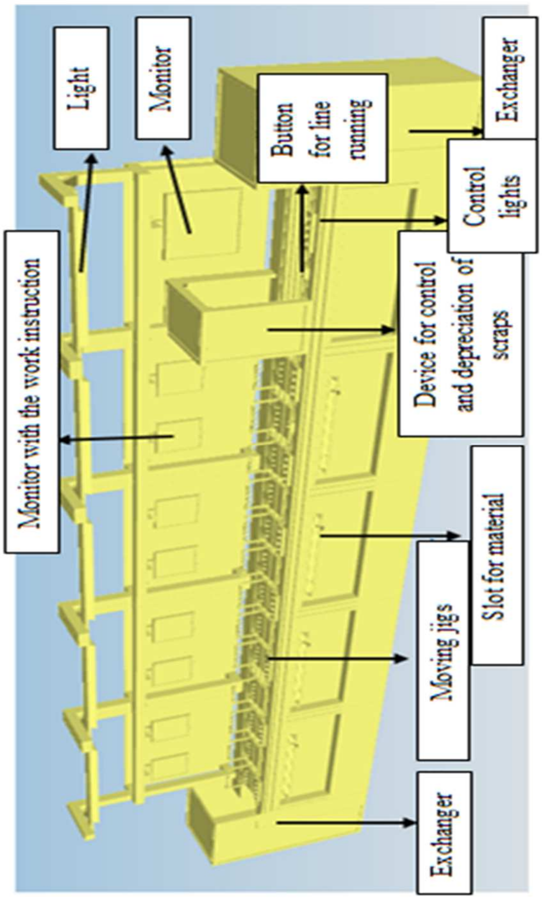

Figure 5 Proposed production line

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The proposed production line consists of nine basic components:

1. Exchanger – there are two exchangers on the production line. One exchanger is located at the beginning of the line, second is at the end of the line. In the exchanger there is a change of the position of moving products. Jigs located at the top of the line after the withdrawal of cable harnesses by workers fall down in the exchanger. With the bottom of the line, which is not visible, the jigs will return to the exchanger at the beginning of the line, where they get back up for the next assembly.
2. Jigs – they serve to attach “house” and the gradual installation of cables. At one moving jig it is possible to assembly four cable harnesses. The speed of jig movement from station to station is indicated by worker using the button for line running.
3. Slot – it is used to store material that represents “houses”, cables and tubing. Worker selects material from the container and put it in the slot. Consequently, when assembling, select the necessary material from the slot and assembles it on incoming semi-finished product.
4. Monitor with the work instruction – on these monitors is correct assembly scheme. Each workstation requires two monitors, considering the sequence of operations carried out. These monitors are necessary, because workers on the line can´t use jigs with blind holes and thus may occur more frequently mistakes.
5. Monitor – at the end of the production line is monitor that provides information to workers about the current state of standards achievement. On the monitor there are four lines that provide information about:
   - standards that must be achieved per working shift in terms of number of pieces,
   - number of pieces produced until now,
   - number of pieces produced until now as a percentage,
   - number of scraps.
6. Control lights – these lights are located on each of five stations. Each station has four lights, corresponding to the number of cable harnesses contained in one jig.
7. Device for control and depreciation of scraps – this device is the part of the last station of the production line, which is focused on control. In this device, there is a push – back test and test realized by compressed air. Based on the outcome of the control, cable harness either forwards where the worker released it from the lines for visual inspection, or discarded it automatically with cutting the cables.
8. Button for line running – this button provides the moving of the line.
9. Light – it is used to improve the visibility of workers at assembly.

As can be seen in figure 6, proposed production line consists of five stations. In each station is carried out some assembly operation.

In table 2 is sequence of operations as well as their duration.

Table 2 Sequence of operations and the proposed duration of the production line

	Operation name	Duration [s]
Station 1	Fixing „house“ in the jig	2
Station 2	Assembly of red cable	2
	Assembly of black cable	2
Station 3	Assembly of green cable	2
	Assembly of brown cable	2
Station 4	Assembly of insulation tube	2
Station 5	Control	2
Sum		14

Control in Station 5 is realized through Push-back test and test realized by compressed air. This inspection is aimed at detecting lightness of cable harness, because cable harness must be water-resistant. The principle lies in the compressing of air into the cable harness and then the sensor records and evaluates air leakage from the cable harness.

From the production line cable harness proceeds for visual inspection, where are detected various mechanical damage. Visual inspection of one cable harness takes 7 seconds. Total production time of one cable harness for the proposed production line is therefore 21 seconds.

The part of the new workplace organization is the use of different coloured boxes. In the original organization of the production process were used boxes of the same colour.

Each material as well as work in progress contained in boxes, had designated place in the space reserved for the realization of the production process, but often occurred errors in the placement of boxes by workers. Subsequently, there was a chaos in material, respectively work in progress searching.

Using different coloured boxes will increase transparency and therefore the efficiency of the production process.

In Fig. 6 we can see the final proposal of production process layout with production line in Process Designer.

Figure 6 Proposal of production process layout with production line in Process Designer

Proposed production line provides the following benefits:

1. removal of buffer stores,
2. reduction of staff,
3. increase the number of produced pieces.

Conclusion

Optimization of spatial organization of production is verz important and will ultimately lead to the increase of production efficiency. This optimization can influence material flows, mobility of workers, as well as vehicles and other units of production, production time characteristics, workplace safety and many others.

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