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VERIFICATION OF PROPOSALS FOR INCREASING THE EFFICIENCY OF THE PRODUCTION PROCESS USING MANAGEMENT METHODS USING SIMULATION SYSTEM TECNOMATIX

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Abstract: The contribution is focused on the production line, which covers assembly in assemblies in the automotive industry. This process consists of several assembly stations. The paper contains a brief description of production positions. The production process was analysed, and a snapshot of work activities was created. We created a simulation using the Tecnomatix Plant Simulation software tool. To increase efficiency, we also use the Hoshin method, which is commonly used in industrial enterprises. Hoshin Kanri is used as a system management tool to develop an annual tactic to implement in all departments and functions within the company. It is for organisations looking for ways to create an effective plan for the future. It is a composition of tools and principles that we can say are helpful in a set of change management and planning systems.

1 Introduction

The contribution is focused on production in the automotive industry. It is the production and assembly of components into the car cranks. It describes the assembly process for a functional assembly used daily to open and close a car. Every business aims to make everything work as efficiently as possible and to achieve the maximum for the minimum amount of money spent. In improving each process, it is essential to use the tools available to achieve the highest degree of efficiency for both the business and the end-user, who often do not even realise what is behind the everyday things of daily consumption [3-6]. Such means are also simulation software and various management methods. It is essential to address the life cycle of a product and the means that it consumes and affects its final price. These are products and components of products, human as well as material resources entering the transformation process. When designing efficiency gains, we will look at several possible options for achieving this goal. These are modifications of existing machines, reassessment of the number of operators and distribution of individual jobs. It was necessary to break down operations into smaller parts and use the MTM method to improve efficiency. Under this proposal, efforts have been made to align operations to improve overall production times [7-9].

2 Production process and its properties

The production process analysed is the assembly of the handle holder. It is the part of the component located between the outer and inner handle on the car door (Figure 1). This part ensures the functionality and appearance of the car handle. Allows movement of the vehicle's outer and inner handles. The production line can produce 1,650 pieces of these components per shift. The time to build one handle is 110 seconds. One finished product leaves the production line every 13 seconds. One operator operates each workplace. There are ten operators on this production line, and their number may change as needed. Each component has its specification, e.g. dimensions, appearance, material and the like. This assembly process consists of assembly and testing operations. Assembly operations consist of eight positions where components are joined. During assembly operations on individual positions, it is necessary to distinguish to which car door the holder belongs [1,2].

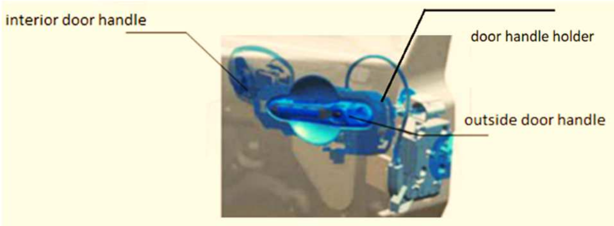
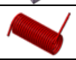
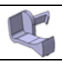
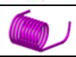
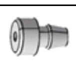
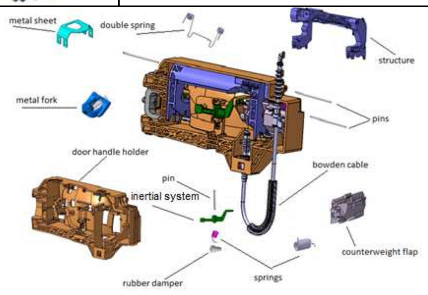


Figure 1 Car door handle holder

Table 1 Decomposition of a car door handle holder and its parts

component	description
	**bolt in the metal fork**
	**metal fork**
	**detail sheet**
	**double spring**
	**door handle holder (bracket)**
	**counterweight flap**
	**spring**
	pin
	**Slider**
	**inertial system**
	**spring**
	pin
	**rubber damper**
	**structure**
	**bowden cable**
	

2.1 *Decomposition of assembly unit and description of the production process*

Table 1 contains the decomposition of components that are part of the assembly unit. In other points, we can see a brief description of the assembly process, the whole product. The entire assembly process consists of the following operations:

1. Inserting the rubber damper into the counterweight flap,
2. Inserting the slider and springs into the counterweight flap,
3. Lubrication of the saddle and the insertion of the bowden cable liner,
4. Inserting double spring and fixing pins,
5. Insertion and lubrication of kinematic slider and pin insertion,
6. Inserting and push pins,
7. Mounting inerial system,
8. Pushing pins into the inerial system,
9. Product testing.

2.2 *Analysis and simulation of the manufacturing process of assembly*

We analysed the production process in its original state and simulated it using the software module Tecnomatix Plant Simulation (Figure. 2).

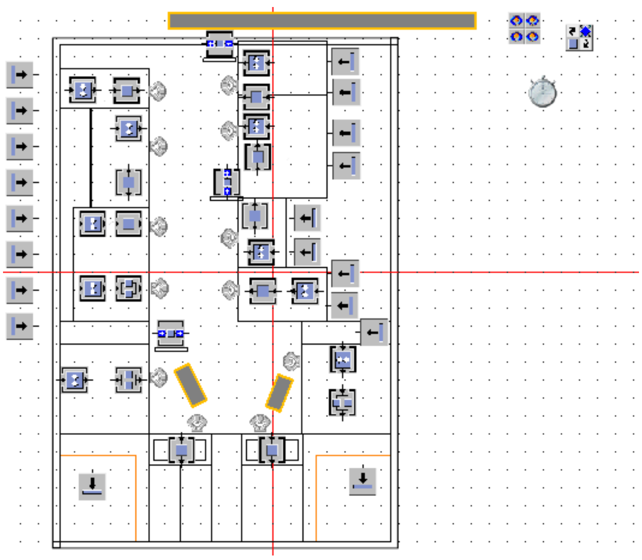


Figure 2 Simulation of the manufacturing process of car door handle holder

On the production layout, we can see 12 jobs in individual jobs. Ten employees operate the line. In the simulation, it is possible to see the sidewalk on which operators come to the line and two shorter sidewalks directly after these two operators move between working positions on the lines and occupy two positions in the production process [10-11].

2.3 Suggestions for improving the production process

Based on the production process analysis, mapping of the production process and subsequent simulation, we try to find the most effective variants that can help increase efficiency, fluency, and productivity [12-14].

2.3.1 Machine modification

With this variant of streamlining the production process, we adjust specific machine parameters, resp. We add the manufacturing operations in the manufacturing process that the machine will perform. Modification of the machine would be carried out by the company that manufactured the specific machine. The aim is to save assembly time as well as reduce possible errors. We can save time by combining the operations performed at the first and second production stations. With this proposal, we can save the work of one operator. An improvement suggests inserting a rubber damper into the counterweight flap automatically by the machine. At the second production position, the operator lubricates the counterweight flap, inserts a spring, slider into it, and then puts it into the machine. Rubber dampers will be automatically inserted into the machine while the counterweight flap is fixed in the machine. The detection of the presence of a rubber damper will be the same as now. The time and dimensions of the machine will be unchanged.

There is no risk of improper insertion of the rubber flap when loading the machine. The operator has been in this operation for more than 10 seconds. The machine can do it faster and without any errors.

Observing the manufacturing process and measuring the times, we found that the time needed to perform the operation at the first station is 10.6 seconds and the time at the second station is 15.3 seconds. By unification these two processes with machine modification, we can do two operations in 12.3 seconds. This will save 13.6 seconds. We have verified this proposal using a simulation.

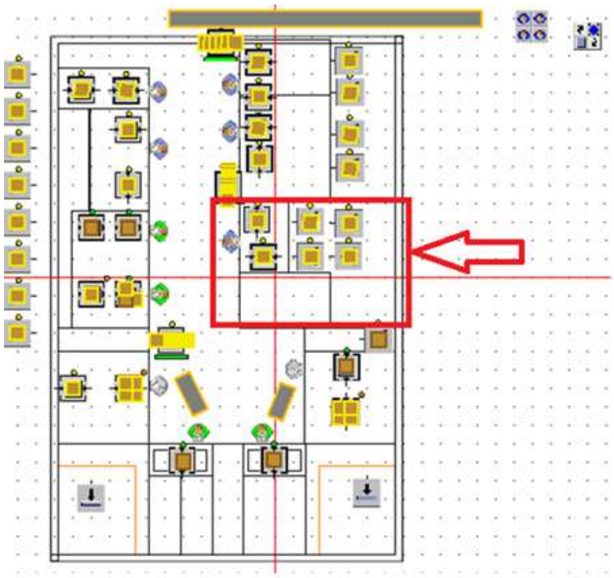


Figure 3 Proposal of machine modification in simulation

2.3.2 Truncation and harmonise manufacturing operations using the Hoshin method

Another variant of improving the efficiency of the assembly process is to shorten production operations. In this design, we used the Hoshin method and the MTM method [6]. On the production line, we performed the analysis by measuring the time of individual operations. We performed 20 measurements in one work shift (Table 2). We measured operations from the beginning of component assembly to the final product of the total product.

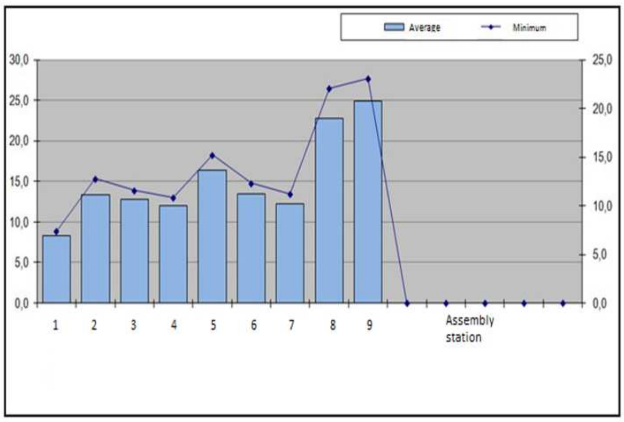


Figure 4 Production operations times

Table 2 Production operations times

Nr. of meas.	Pos. nr. 1	Pos. nr. 2	Pos. nr. 3	Pos. nr. 4	Pos. nr. 5	Pos. nr. 6	Pos. nr. 7	Pos. nr. 8	Pos. nr. 9
1.	7,4	14,0	13,8	12,5	16,2	13,0	12,1	22,5	26,9
2.	7,8	14,1	12,3	12,3	16,1	13,3	13,5	23,6	24,7
3.	8,6	13,3	11,6	12,5	16,3	14,3	13,5	23,7	24,3
4.	8,7	13,1	12,4	13,5	16,8	13,7	13,2	22,6	24,7
5.	8,8	13,1	12,1	11,8	16,2	13,9	12,5	24,4	25,1
6.	8,1	13,1	12,9	12,2	15,3	14,9	12,6	23,5	23,1
7.	8,7	13,2	14,1	12,0	15,7	12,8	12,1	22,1	24,4
8.	8,9	12,7	13,2	11,3	16,3	13,3	12,1	22,1	24,8
9.	8,8	13,7	14,1	10,8	15,7	13,5	11,4	22,4	24,7
10.	8,8	14,1	13,1	11,9	16,4	13,7	11,8	23,0	24,3
11.	8,1	13,5	12,1	11,3	15,2	13,6	13,1	22,1	24,9
12.	8,5	13,3	13,1	12,1	17,4	13,8	11,6	22,7	24,4
13.	7,8	13,1	13,3	12,1	16,3	13,9	12,4	22,5	26,8
14.	8,1	13,3	13,2	12,7	15,9	12,6	12,1	22,6	25,4
15.	8,9	13,1	12,5	12,5	16,9	12,6	11,4	22,1	25,1
16.	8,1	13,7	12,1	13,2	17,4	12,3	11,7	23,0	25,8
17.	8,0	13,6	12,5	12,6	17,7	12,9	11,4	22,7	24,6
18.	7,8	12,9	12,5	11,5	15,9	13,1	11,2	22,5	24,4
19.	8,8	13,8	12,6	11,2	17,3	13,5	12,5	23,1	25,3
20.	8,1	12,8	13,7	11,1	17,1	15,4	11,9	22,5	24,6
Overall	166,8	267,4	257,1	241,1	328,0	269,9	244,0	455,5	498,0
Average	8,3	13,4	12,9	12,1	16,4	13,5	12,2	22,8	24,9
Minimum	7,4	12,7	11,6	10,8	15,2	12,3	11,2	22,1	23,1
In %	13%	5%	11%	11%	8%	10%	9%	3%	8%

In the graph (Figure. 4) we can see how individual operations on the work posts move unevenly. In the next step, our goal is to break down individual operations into smaller operations. We choose the optimum time for operations to be approximately the same time. Small deviations are permissible.

In this improvement design, we will use the Hoshin method. We made more measurements. Our goal was to combine some operations. To increase efficiency, we will go to depth. We divide the operations into smaller operations using the MTM method. We have divided the operations carried out on the production line into small and detailed operations (Table 3). In this improvement proposal, we also counted on option no. 1 with a machine modification

Table 3 Separation of operations

Position	Operation type	Time in sec.
Pos. Nr. 1	Lubricating the counterweight flap	12,3 s
	Slider insertion	
	Inserting the spring	
	Inserting rubber damper	
Pos. Nr. 2	Lubrication of the handle holder	4,1 s
	Cable fixation	3,2 s
	Inserting the lever	5,6 s
Pos. Nr. 3	Spring lubrication	4,1 s
	Inserting the spring	4,8 s
	Inserting the pin into the lever	3,2 s
Pos. Nr. 4	Insert slider into internal structure and erase	7 s
	Insert internal structure and pin	9,4 s
Pos.Nr. 5	Inserting a pin	3,6 s
	Pressing pins	9,9 s
Pos. Nr. 6	Lubrication of inertial system	3,7 s
	Inserting a spring into an inertial system	3,9 s
	Inserting an inertial system into the handle holder	4,6 s
Pos.Nr. 7	Pushing pins into an inertial system	18,7 s
	Inserting sheet metal	4,1 s
Pos. Nr. 8	Insert the metal fork into the handle holder	4,0 s
	Testing the handle holder	13,6 s
Pos. Nr. 9	Car Door Handle Holder Pack	7,3 s

In this proposal, we tried to harmonise operations to no time jumps in individual production positions. Our goal was to improve production times and reduce the number of operators on the production line

In Table 4, we harmonised the manufacturing operations using the Hoshin and MTM method [7]. From nine production stations, we have reached seven production stations. This means we save the work of one operator on this proposal. The reconciliation of the manufacturing operations is also visible in the graph (Figure 5). It can be seen that the movement of times is much more even than in the first case.

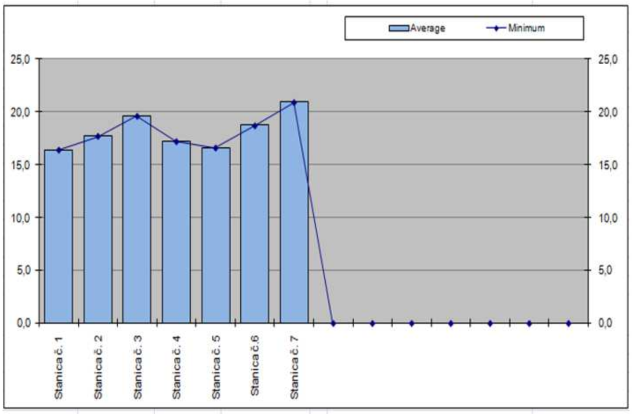


Figure 5 Graph of manufacturing operations after alignment

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Table 4 Alignment of manufacturing operations

Position	Operation type	Time in sec.	
Pos.Nr. 1	Lubricating the counterweight flap	12,3 s	16,4 s
	Slider insertion		
	Inserting the spring		
	Inserting rubber damper		
	Lubrication of the handle holder	4,1 s	
Pos.Nr 2	Cable fixation	3,2 s	17,7 s
	Inserting the lever	5,6 s	
	Spring lubrication	4,1 s	
	Inserting the spring	4,8 s	
Pos.Nr. 3	Inserting the pin into the lever	3,2 s	19,6
	Insert slider into internal structure and erase	7 s	
	Insert internal structure and pin	9,4 s	
Pos.Nr. 4	Inserting a pin	3,6 s	17,2
	Pressing pins	9,9 s	
	Lubrication of inertial system	3,7 s	
Pos.Nr. 5	Inserting a spring into an inertial system	3,9 s	16,6
	Inserting an inertial system into the handle holder	4,6 s	
	Inserting sheet metal	4,1 s	
	Insert the metal fork into the handle holder	4,0 s	
Pos. Nr. 6	Pushing pins into an inertial system	18,7 s	18,7
Pos. Nr. 7	Testing the handle holder	13,6 s	20,9
	Car Door Handle Holder Pack	7,3 s	

We also transferred the design to the simulation for the harmonised operations. As we can see on the line, we have lost another operator in this design, and the fluidity of the production process has also improved (Figure 6, Figure 7).

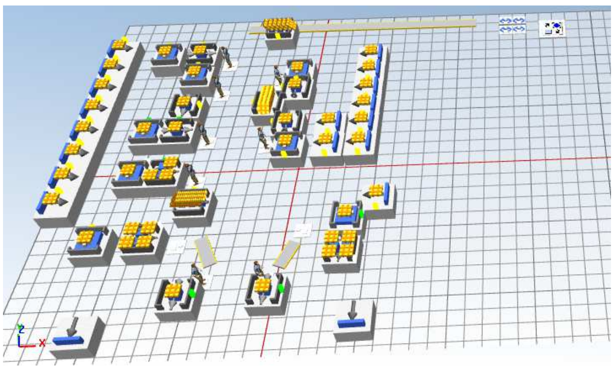

Figure 6 Simulation of harmonise operations in 3D

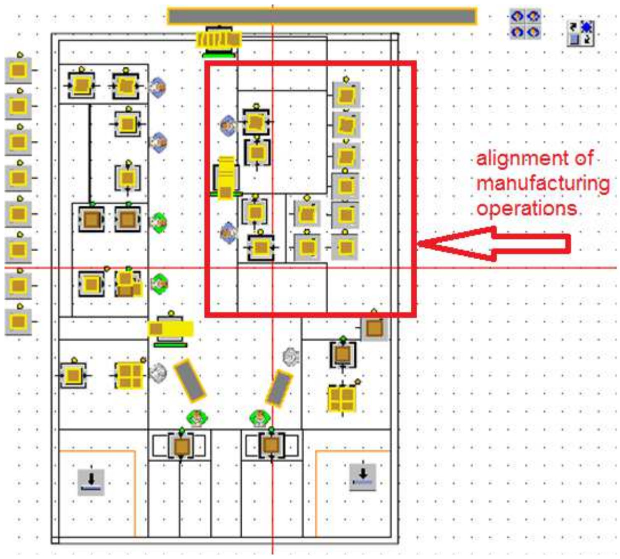

Figure 7 Simulation design of the reconciliation operation

3 Conclusions

As can be seen from the above suggestions and in normal business practice, it is often not enough to use only one means of evaluation and improvement to improve the production process. Still, it is necessary to combine and use several available methods. In this case, we used the simulation combined with the Hoshin and MTM method to achieve more efficient workplace reconciliation, time savings, and human resources savings. These methods complement each other and help managers in the company decide how and how to improve the manufacturing process.

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