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Proposal of the Reworking Station Model using Plant Simulation

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***Abstract* – This paper deals with the proposal of the reworking station in the automotive company. The paper consists of four parts. The first part is about Tecnomatix Plant Simulation, which is now one of the best software for simulation tasks. The second part deals with analysis of real production process in the selected company and some parts are also dedicated to the main product – external handle. The third part treats with simulation of production process in Plant Simulation in selected company and the final fourth part is oriented on proposal of the reworking station in Plant Simulation.**

***Keywords* – reworking station, plant simulation, external handle, production process.**

1. Introduction

Simulation is a research technique based on the replacement of a system by its simulator. When anybody wants to perform simulation, he will use the simulator and on this simulator will take place the experiment (process flow in simulated conditions), which will show the information about the original system in very short time.

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The term simulation also means putting the simulation model into motion. The essence of the simulation consists of replacing the real object of the examined phenomenon with a simulation model. With this simulation model we can use experimental techniques and then obtain information about the original examined system [1], [10].

The main tasks of the simulation are predicting, previewing ahead, analysing and optimizing problems, and replacing the "trial-error method" which is often very costly. The usage of simulation can be observed in various sectors such as space traveling, computer systems, company development, military operations, logistics and production systems, financial models, etc. [9], [11].

It is important to know that simulation is only an approximate method based on statistical evaluation of the examined problem and the obtained results have only probabilistic character. Depending on the number of experiments carried out, it is possible to achieve arbitrary accuracy of results, which is approximately the value of the square of the simulation. However, it is important to know that the costs of conducting a simulation increases linearly with its duration, and therefore it is necessary to set a clear goal in advance to avoid wasting time and costs [2].

2. Tecnomatix Plant Simulation – Tool for Modern Process Engineer

Tecnomatix represents a portfolio in the area of production solutions of the company, its planning respectively management. It is part of Siemens PLM Software, which today is one of the best solved software in this field [5].

Plant Simulation is a part of the Tecnomatix portfolio. It helps to design production system models and thus to increase productivity, reduce costs, optimize production, reduce stocks and reduce throughput time [1], [3].

The main features of Plant Simulation are as follows [4]:

- Creation of 3D visualizations and animations of the production process;
- Possibility of time analysis of individual processes;
- Possibility of bottlenecks analysis in the workplaces;
- Usage of pre-modelled objects library to facilitate the work;
- Possibility to model your own actions and objects and saving them in the library for another usage;
- Possibility of flow analysis between individual workplaces;
- Possibility of creating Sankey and Gantt diagrams.

Figure 1 shows the Plant Simulation working environment.

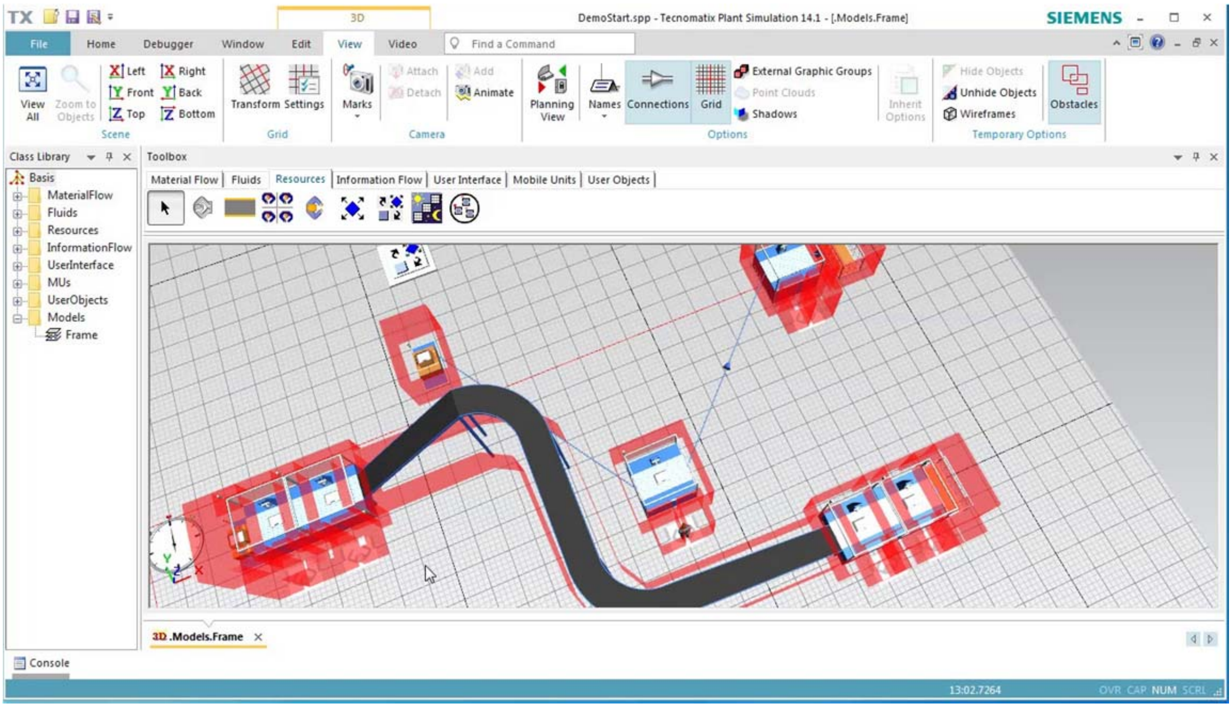


Figure 1. Plant Simulation working environment

3. Analysis of Real Production Process in the Selected Company

The company under investigation is a Japanese-based company, which produces certain automotive components. The company supplies produced components directly for car producers, in which is realized the assembly of the mentioned components into newly produced cars. The company's products can be grouped into the following main product lines (Figure 2 – left to right):

- Latches.
- Lock Sets.
- Handles.

In this paper, we will show in Plant Simulation the assembly production process of creating an external vehicle handle. In order to be able to model this process, it is meaningful to investigate this process in real form. The external handle consists of 7 parts, which have a purpose in the component.

Figure 2. Main product lines

The main parts are in Table 1 [6], [7]. Figure 3 shows a completed component mounted in a tray consisting of the previously mentioned parts.

Table 1. Main parts of external handle

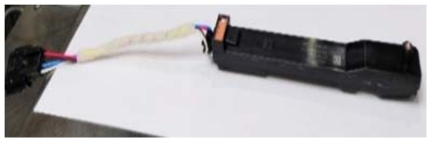
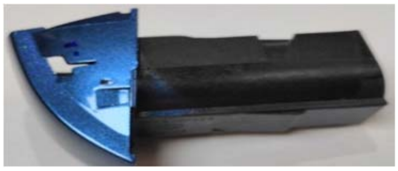
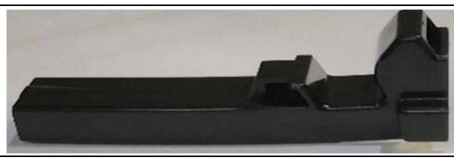
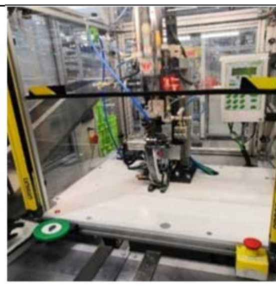
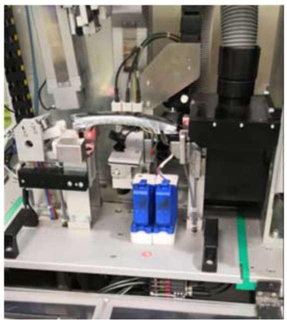
1. Handle body – forms the basic part of the whole component, to which other components are later mounted.	
2. Antenna – is an innovative component that is inserted into the handle body and is designed to unlock the vehicle without removing the key from the pocket and handling with it. Instead of this process, the antenna receives the signal from the key, if it is near the vehicle, and ensures its unlocking.	
3. Handle outer cover – mainly performs a safety function, where it is also mounted on the handle body so that it covers the antenna and thus protects it from damage. It also has an aesthetic function. This component is painted according to customer requirements.	
4. Lock body – nowadays cars are mostly unlocked by central locking or keyless entry. For this reason, manually opening is nowadays an unusual phenomenon. Nevertheless, when creating the handle, either the lock itself is made in case the fail of electronics or it is only blinded by a piece of plastic that gives the impression that the lock is there.	
5. Outer lock cover – it fulfils the protection function if the lock is in the handle. If the lock is not in the handle, it creates only the aesthetic impression of the handle. This component is painted according to customer requirements.	
6. Seal – the task is to ensure the waterproofness and dust resistance of sensitive components such as the antenna.	
7. Insert – the task is to improve the door opening itself and it also strengthens the stressed parts.	

Figure 3. External handle

The assembly process consists of 11 operations that are carried out in a logical sequence. Pre-prepared components are delivered to the individual assembly stations, which are listed above. In this production process, phases 1-5 are similar to phases 6-10 due to the production of the left and right handles of the car, where the left handles are mirrored to the right handles, so the production process has to be divided into production of right and left hand handles. The various stages of the assembly process of the component are listed in Table 2 [8], [9].

Table 2. Production process phases

1. Phase – consists of completion of the lock body and antenna at the assembly station without using automated equipment. The operator takes 1 piece of the handle body from the container and 1 piece of the antenna from another container and connects them together. The whole process is done manually and takes about 5 seconds. After the completion of the handle body and antenna, the subassembly is conveyed by a conveyor to a secondary station, where the second phase takes place of the assembly process. The conveyor can contain maximally 6 pieces of subassemblies.	 *Assembly station 1*
2. Phase – describes the completion of a subassembly made in Phase 1 with the outer handle cover using a preparation to fit the handle body to streamline the process itself and ensure component stability. The entire assembly is also carried out manually. Assembly station number 2 is similar to Phase 1. The preparation is attached by a quick-release joint to the station to replace it if necessary with another preparation. Subsequently, the assembled component is placed on a storage place reinforced with a foam insert to prevent deterioration of the varnished part, where it is ready for the next stage of the production process.	 *Assembly station 2*
3. Phase – consists of two operations and is carried out at the assembly station 3, which is equipped with an automatic screwdriver. First, the operator takes the subassembly from the previous assembly process, while it is prepared at a storage place reinforced with a foam insert and manually inserts the seal into it. Then he inserts the component into an automated device in a predefined manner. Once the automated device has determined that the component is correctly inserted in the machine, the process of screwing the handle outer cover to the handle body itself, which is now equipped with an antenna and a seal 25 to form a strong joint. The automated screwing process takes about 10 seconds.	 *Assembly station 3*
4. Phase – represents the process of automated inspection of the produced handle, where the connection quality is checked and also the antenna functionality that is in the component. Before inserting the component into the tester, the insert is inserted into the subassembly. Subsequently, the inspection is carried out on the automated device which is pre-programmed to carry out inspection activities. After leaving assembly station 4, the first part of the handle is finished. At station number 4 there is a conveyor on which pre-formed trays are stored. The made part of the handle is inserted into the tray, where it fits perfectly and thus ensures that it is delivered to the customer without damage. The tray is a simple plastic cover for the produced components. It contains 8 cavities into which the produced components can be inserted, and this represents the components directly for one car. There are 4 cavities for the handle itself (2 pieces on the right side and 2 pieces on the left side of the car) and 4 cavities for the door lock (2 pieces on the right side and 2 pieces on the left side of the car).	 *Assembly station 4*
5. Phase – consists of a simple manual connection of the lock body and the outer lock cover. The handle in the mentioned production process does not contain any lock, therefore only a plastic body is inserted into the door, which fits into the opening instead of the lock. After the completion of these two parts, the second part of the handle is also completed and is also inserted into the tray. After this process, the right part of the handle is finished. The tray is still waiting for the completion of one finished right handle and is moved to the next station. This is followed by the same production process for left handle.	 *Assembly station 5*
6. Phase – is carried out at the control station, where the controller gradually removes all 8 components from the tray and visually checks their condition. If the components are OK, the tray is put into the box and exported to the customer. If a defect is found on any of the components, the product is marked as unsuitable for export to the customer and has to be repaired.	 *Control station*

4. Simulation of Production Process in Plant Simulation in Selected Company

First of all, it is necessary to create models of individual components of the external handle. Plant Simulation offers tools for creating and editing objects, but not at a high level, because this is not the primary function of the plant simulation [10], [12]. For this reason, we decided to create individual component models in Solid Works for the highest quality in terms of shapes, dimensions and aesthetics of the models. The created models have been then converted to the format corresponding to the simulation program.

An overview of the modelled components in Solid Works can be seen in Figure 4.

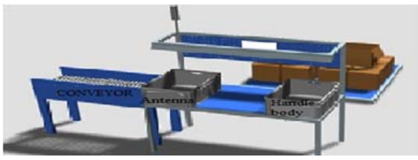
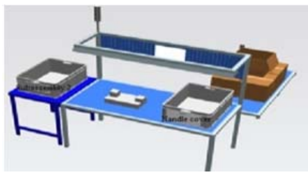
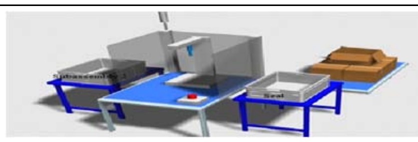
The created models fulfil the role of produced entities in the simulation. Before using this models, it is necessary to create a production process model in Plant Simulation, which consists of the phases that were mentioned above.

To simplify the simulation of the whole process, we ignore the difference between right and left handles, so thus we will shorten the simulation by 5 operations that are the same as the following first 5 stages of the process described below.

The procedure of simulation model creation of the external handle production process is in Table 3.

Figure 4. Composition of produced component

Table 3. Phases of simulation model creation of the external handle production process

1. Phase 1 – creation of a model for an assembly station 1 with two inputs, where the first input contains the handle body as the entity and the second input feeds the antenna as the entity. The assigned operator connects these two parts together and feeds the newly created entity to the next station. The entire assembly process takes about 5 seconds.	 *Assembly station 1 in Plant Simulation*
2. Phase – a subassembly made of assembly station 1 is fed to assembly station 2 through small conveyor where it is connected with another entity, the outer handle cover. The station is equipped with a preparation for attaching the component to simplify the assembly operation. After finishing this operation, a new entity is formed by connecting the subassembly from phase 1 and the outer handle cover, which is further fed to assembly station 3 as subassembly 2. The assembly process at this station takes approximately 15 seconds, including removal and insertion of the component into the preparation.	 *Assembly station 2 in Plant Simulation*
3. Phase – represents the assembly process of subassembly 2 with the entity seal at assembly station 3, and subsequent insertion into an automated screwdriver, where the screwing process takes 10 seconds, then subassembly 3 is fed to the next station.	 *Assembly station 3 in Plant Simulation*

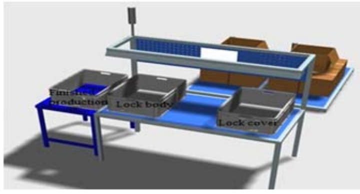
4. Phase – its role is to install the insert entity into subassembly 3, creating a final product that passes the functional and visual control directly at this post, avoiding any complaints. If the product is in order, the operator puts it in a container labelled as finished production. If the product is damaged or otherwise does not meet the customer's requirements, the product is placed in another box labelled as scrap (damaged component), which cannot be delivered to the customer.	 *Assembly station 4 and control in Plant Simulation*
5. Phase – represents a special process that does not follow up on other processes and consists of simple assembly of the entities lock body and lock cover.	 *Assembly station 5 in Plant Simulation*

Figure 5 shows a model of the whole production line consisting of the 5 above-mentioned assembly stations.

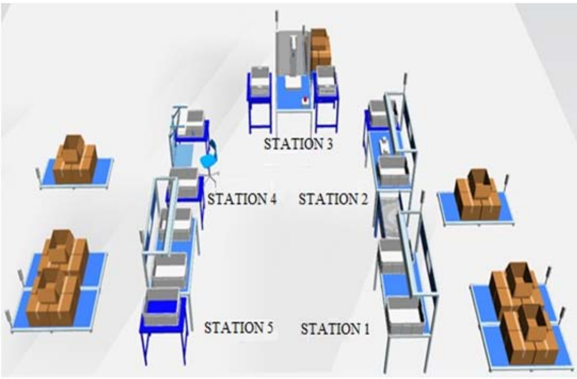


Figure 5. Assembly line model

5. Proposal of the Reworking Station in Plant Simulation

Unsuitable material, which originated during production process, is currently stored in the warehouse for unsuitable pieces, where it currently has not got usage. For this reason, it is necessary to design a reworking station for these defective pieces, where research will be carried out and we will investigate why the problem arose and also the disassembly of the product itself to its parts due to the reuse of the parts of which the component consists. During the disassembly process, the operator sorts the individual parts into usable or finally scrapped.

The layout of this research-disassembly line is 6x6 m2, where 2 entrances lead and the whole area is enclosed by a glass wall. There are 2 work desks in the room. Work desk 1 (Figure 6) represents a research post, where a microscope is stored, which mainly examines defects on painted parts and investigates the causes, why the unsuitable piece arose.

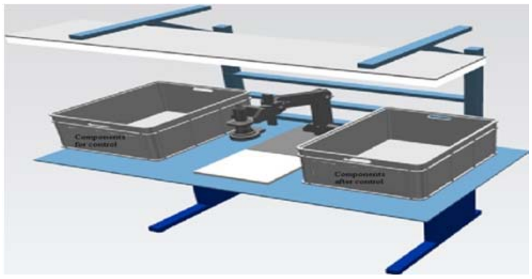


Figure 6. Model of work desk 1

Work desk 2 (Figure 7) is equipped with auxiliary tools for disassembly process of the components and also with the boxes into which the individual parts, of which the component consists, are sorted.

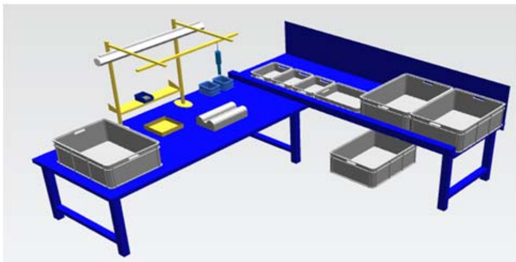


Figure 7. Model of work desk 2

The whole process consists of bringing the defective piece to the research table, where the operator performs the necessary actions to detect product defects and after evaluating and processing the results obtained from the research, puts the analysed product to the box which is located next to the research table. Subsequently, the parts that passed the analysis are fed to the work desk 2, where the disassembly of the component is carried out into individual parts and these parts are sorted into boxes. A model of the entire reworking station is shown in Figure 8.

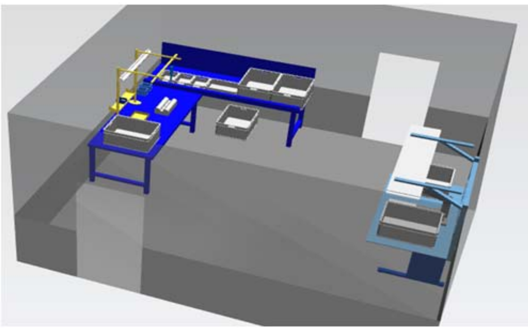


Figure 8. Model of reworking station

6. Conclusion

After analysing the selected component (external handle) and its production processes, the entire production was modelled in the Plant Simulation program, which shows an approximate and simplified model of the production line. After examination and identification of the disadvantages of the current production line, we decided to design a reworking station for components that did not meet the control requirements and thus did not reach the customer. This station should bring many advantages to the company in terms of cost savings as well as environmental protection, since defective pieces are reassembled at the reworking station and good parts obtained after disassembly process of the original component, which are assessed as undamaged and can be reused for further production. The proposed solution consists of modelling the reworking station in the Plant Simulation program, where the emphasis is mainly on the layout of the room and also on the layout of individual containers with disassembled parts and their movement on the station. This model should be beneficial for existing productions of this type, which do not deal with the recycling and reuse of good parts due to the lack of a reworking line of this type.

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