Plant Simulation as an Instrument of Logistics and Transport of Materials in a Digital Factory

Simulacija postrojenja kao instrumenta logistike i prijevoza materijala u digitalnoj tvornici

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Summary

The competition of international manufacturing networks creates pressure to increase the efficiency of manufacturing systems. In addition to this, indicative for the present period is the fact that the number of technical components in many products is increasing, and at the same time the requirements are growing for corresponding assembly, transport and logistical processes. These requirements can be administered and recognized in the scope of their complexity only through the use of an array of rapid and efficient methods in the form of a digital factory. This contribution points to the practical application of the Plant Simulation software module from the portfolio of the digital factory of Siemens PLM. This complex instrument with an environment for controlling the life cycle of a product enables repeated utilization of data, supports effective cooperation between individual units, and provides relevant data for each user who needs it, mainly from the viewpoint of strategic decision-making. The simulation of the entire flow of material, including all relevant divisions of manufacturing, storing and transport activities, is considered as the key component of the digital factory in industry and from this day forward is the most often used.

KEY WORDS

ergonomics
quality production
digital plant
digitalization workplace
3D scanning
augmented reality

Sažetak

Rivalstvo međunarodnih mreža proizvođača stvara pritisak kako bi se povećala učinkovitost proizvodnih sustava. Osim toga, svojstvena za sadašnje razdoblje jest činjenica da broj tehničkih komponenti u mnogim proizvodima raste, dok istovremeno rastu potrebe za odgovarajućim procesima sastavljanja, prijevoza i logistike. Ove potrebe mogu se primjeniti i prepoznati u svojoj složenosti samo kroz upotrebu niza brzih i učinkovitih metoda u obliku digitalne tvornice. Ovaj rad ukazuje na praktičnu primjenu software modula simulacije postrojenja iz portfelja digitalne tvornice Siemens PLM. Ovaj složeni instrument koji ima uvjete za kontrolu vijeka trajanja proizvoda omogućuje ponovnu upotrebu podataka, podržava učinkovitu suradnju individualnih jedinica i daje relevantne podatke svakom korisniku koji ih treba, uglavnom sa stanovišta strateškog odlučivanja. Simulacija cjelokupnog kretanja materijala, uključujući sve relevantne dijelove proizvodnje, pohrane i prijevoza, smatra se ključnom komponentom digitalne tvornice u industriji i u najnovije doba se najčešće koristi.

KLJUČNE RIJEČI

ergonomika
kvalitetna proizvodnja
digitalno postrojenje
digitalizirano radno mjesto
3D skeniranje
augmentirana stvarnost

INTRODUCTION

The purpose of running simulations varies from strategic to tactical up to operational goals. From a strategic point of view, users answer questions like which factory in which country suits best to produce the next generation product taking into account factors like consequences for logistics, worker efficiency, downtimes, flexibility, storage costs, etc., looking at production strategies for the next years. In this context, users also evaluate the flexibility of the production system, e.g., for significant changes of production numbers – a topic which becomes more and more important [1]. On a tactical level, simulation is executed for a time frame of 1–3 months in average to analyze required resources, optimize the sequence of orders, and lot sizes. For simulation on an operational level, data are imported about the current status of production equipment and the status of work in progress to execute a forward simulation till the end of the current shift. In this case, the purpose is to check if the target output for the shift will be reached and to evaluate emergency strategies in case of disruptions or capacities being not available unexpectedly[4].

TOOLS AND METHOD

The application part of the presented paper is derived from the basic framework model of digital workplace creation. This model consists of the following steps:

1. Video analysis of workplace - a fast identification of the input requirements using "video-data".
2. Simulation of a manufacturing system

VIDEO ANALYSIS

Video analysis (Fig.1) of employment is helpful for modeling that after a comprehensive inspection of video and audio recording is possible to identify critical points in which there are an unacceptable job positions and disruptive external influences working environment.

SIMULATION OF A MANUFACTURING SYSTEM

The simulation model of a manufacturing system for the production of crown caps (CC) in an organization was compiled using the Plant Simulation instrument for simulation of discrete systems (hereinafter the software) from the portfolio Tecnomatix from the company Siemens PLM.

Creation of a simulation model of the manufacturing system of organization

The model is made up of objects representing the individual processes of a manufacturing system which create added value and objects representing the input of material to the process of processing and the output of products from the process.

Defining the goals of the simulation

The goal of the simulation of an organization's manufacturing system is to identify time reserves in manufacturing processes and to propose measures to minimize these reserves. The proposed measures are subsequently implemented into the simulation model and through changes of the current parameters of processes how the changes introduced in the course of the processes are reflected on the overall productivity of the manufacturing system and the increased transport of the individual products is determined.

The simulation model contains these processes:

- lacquering of sheet metal – line LTG2,
- pressing of the sheet metal – line LTG1,
- setting of the lacquer – 24 hours (without equipment),
- CC production – 2 series of SACMI lines.

In the simulation model the share of processed metal sheets will be considered as a service (59%) in the output from line LTG1 and as the input to the process of setting-out (41%); thus, the amount of processed metal sheets will be monitored with regard to their further use.

Selection of input data and compiling of the simulation model

The collection of input data was carried out by video analysis, by observation and measuring in the operation, by interviews with the individual operators of the equipment and by analysis of the statistical outputs of the internal information system. The collected data were analyzed and converted into the form required by the simulation software. One pallet of sheet metal, which represents 1340 pieces of sheet metal, was selected as 1 unit of production (1 entity in the software). The exact number of sheet metal pieces on one pallet shifted in the range of 1260 – 1420 sheets, depending on the thickness of the sheet metal.

The simulation model considered the following parameters (see Tab. 1):

- period of processing,
- period of setting the equipment,
- duration of a change of lacquer, colour and average frequency,
- duration and frequency of planned maintenance,
- period of setting of lacquer and capacity of the place for setting.

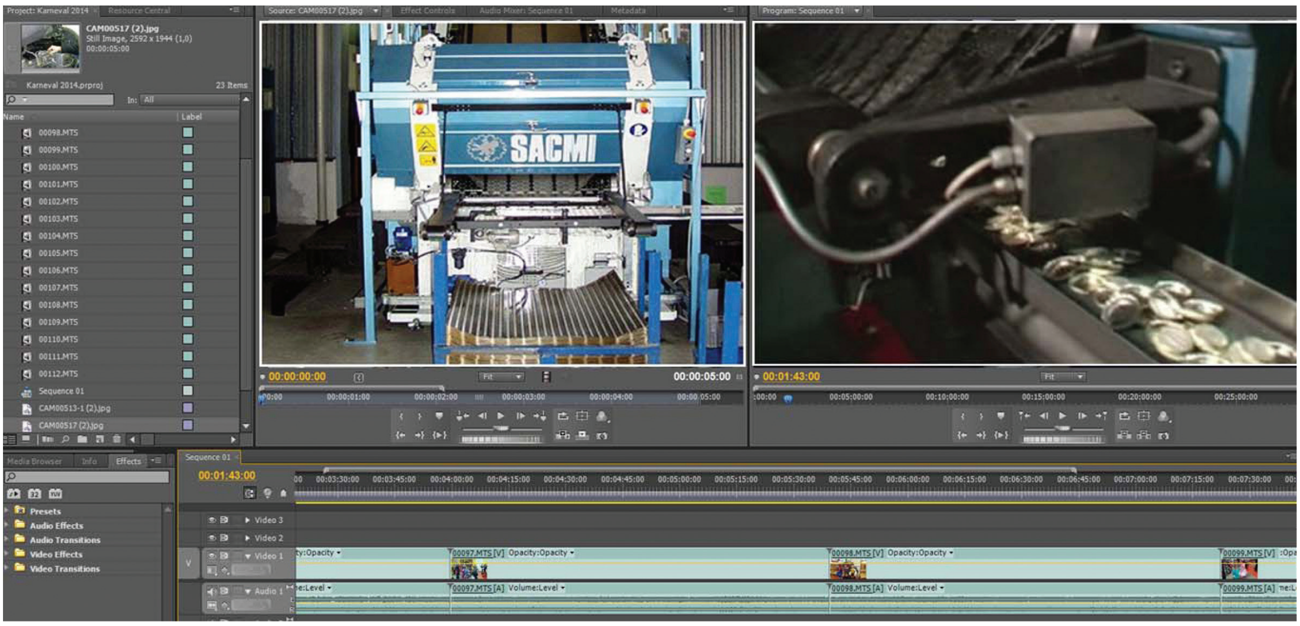

Figure 1 Video analysis working place

Source: Authors

Table 1 Input data on the operation of equipment used in the simulation model

Object	Processing time for 1 pallet	Adjustment time after processing of 1 pallet	Average number of changes of lacquer/ colour per change	Time for changing lacquer/colour	Capacity of the place for setting of the lacquer
LTG2	22 min.	0	2	30 min.	-
LTG1	24 min.	1 min. 33 s	8	30 min.	-
SACMI 1, 2	3 h. 21 min.	1 min. 33 s	-	-	-
Buffer	24 h.	0	-	-	15 pallets

For all equipment the parameters for planned maintenance in the sense of the maintenance plan were defined in the software (see Tab. 2)

Table 2 Input data on operation of the equipment used in the simulation model

Type of maintenance	Distance	Duration
Daily	8 h.	15 min.
Month	30 days	8 h.

In the simulation models (see Fig. 2) the dispositional solutions of the workplaces were not taken into consideration, because the transport tracks of the material and time of its transport between the individual pieces of equipment is in comparison with the duration of individual processes omissible, and these parameters were incorporated into the time for setting the equipment.

Description of the simulation model

The material enters into the material flow in object LTG2, which represents the lacquering line, including the gas-fired oven. The period of operation of the object is limited by the interval and the duration of the planned maintenance and the interval of duration for a change of the lacquer. Object LTG2 generates 1 entity (representing 1 pallet of sheet metal) every 22 minutes (see Fig. 3).

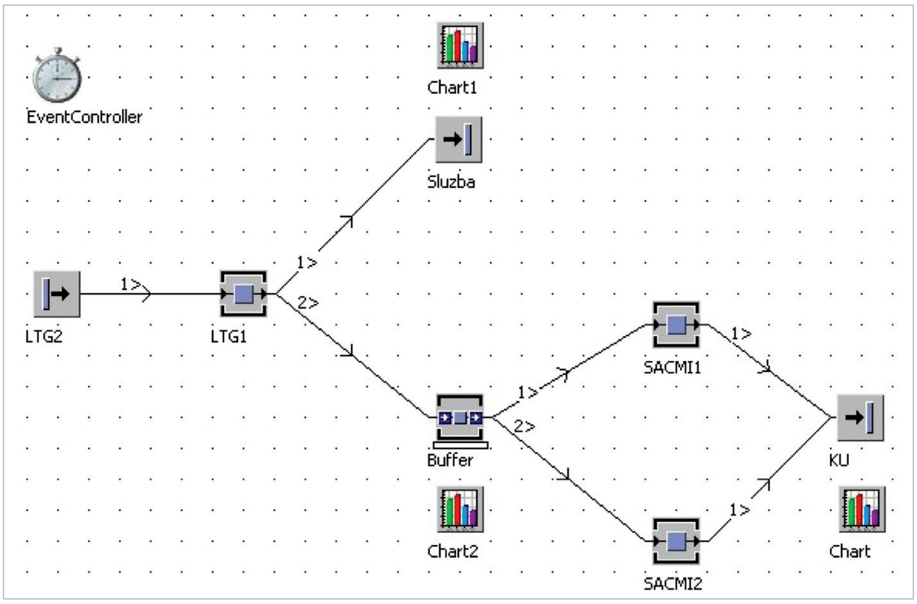

Figure 2 Simulation model of a real manufacturing system

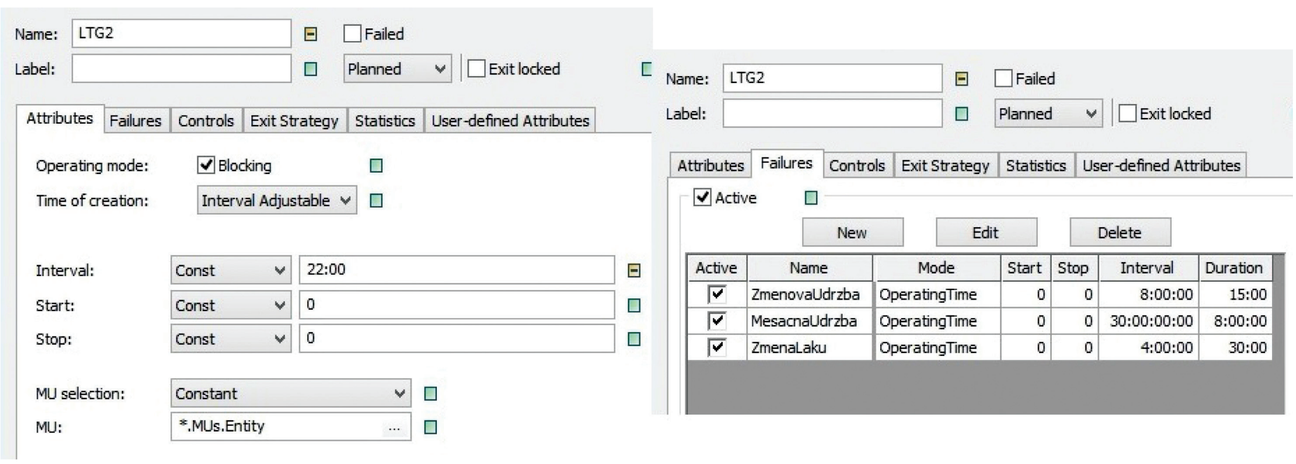

Figure 3 Setting of object LTG2

The generated entities subsequently enter into the process of colour-printing of the metal sheets, which in the model is represented by object LTG1 (the printing line). The operation of object LTG 1 is defined by the period of processing 1 entity in 24 minutes and limited by the time interval setting of 1 min. 33 s after the processing of each entity, the period and duration of the planned maintenance and the interval and duration of a change of colour (see Fig. 4).

After processing in LTG1 the flow of material is divided into two lines, which represent the division of manufacture for service and the actual processing of metal sheets for the purpose of CC manufacture.

100% of processed entities is then divided into the following objects as follows:

- 59% of entities head for connector 1> to the object Service, which extracts the entities from the manufacturing process,
- 41% of entities head to connector 2> to the object Buffer, which represents the place in the operation where the processed metal sheets for the purpose of CC manufacture stand for 24 hours due to the setting of the lacquer.

The object Buffer is defined by the capacity of 15 entities and the period of processing of 24 hours. After the passage of this time the Buffer shifts the individual entities to the following process of manufacture by means of FIFO - First In First Out (see Fig. 5).

The final objects in the simulation model, which form the added value, are SACMI1 and SACMI2. The Buffer divides the entities equally between these 2 objects, according to their occupancy. These objects represent 2 series of SACMI lines, on which the manufacture of CC runs (the striking of the caps from the sheet metal, application of the insulation). The objects are defined by the period of processing of 1 entity for 3 hours 21 min., the setting up time of 1 min. 33 s after each processed entity and the interval and duration of planned maintenance (see Fig. 6). After processing the object moves the entity to the CC object, which extracts the processed entities from the manufacturing process.

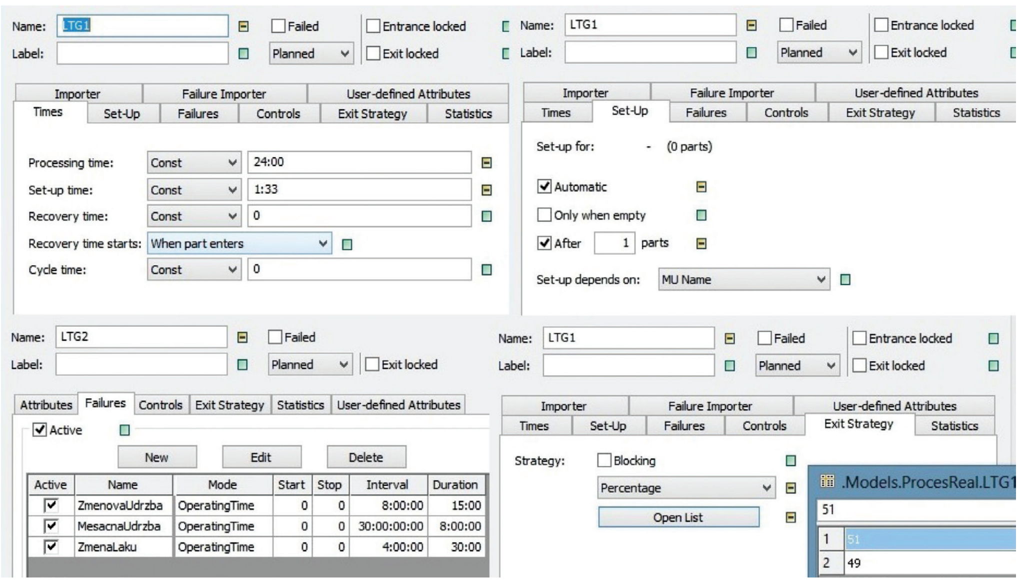

Figure 4 Setting of object LTG1

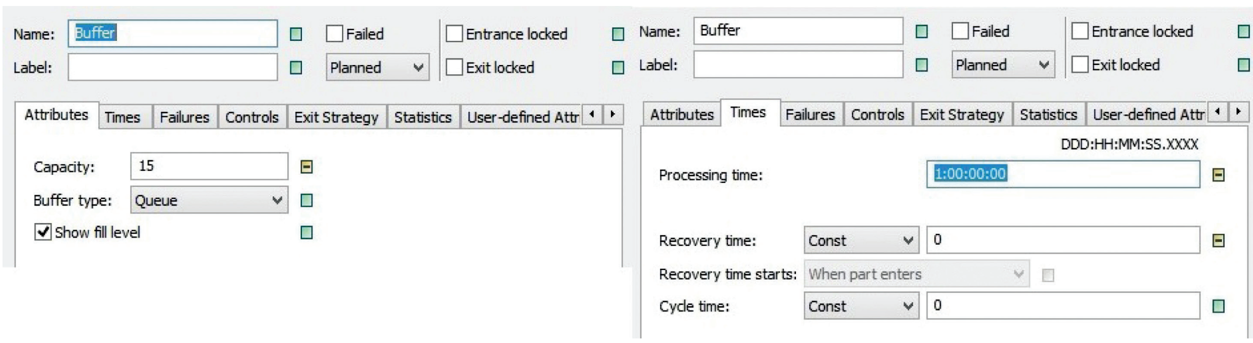

Figure 5 Setting of object Buffer

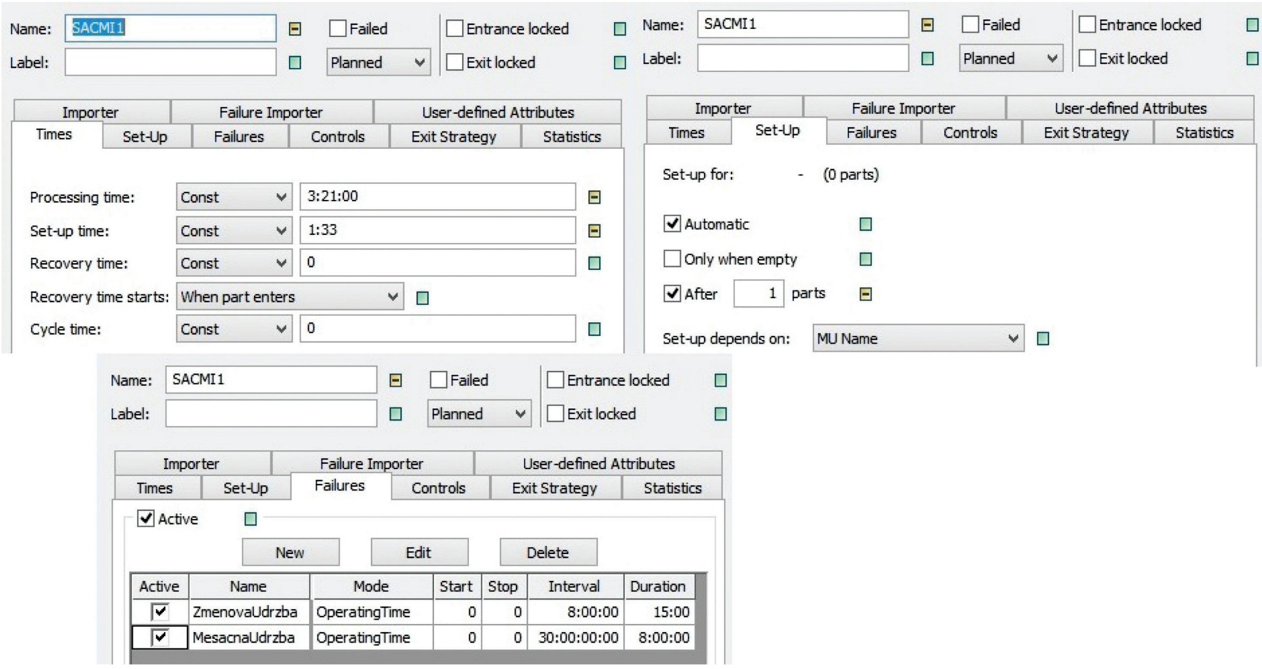

Figure 6 Setting of object SACMI1

RESULTS, DISCUSSION AND CONCLUSIONS

On the basis of the monitored simulation representing 30 days of manufacturing and the statistics generated by the software 3 places in the production system were determined as having potential for improvement:

1. In the scope of the total operation time of object LTG1 they form a significant part of the idle time caused by a change of colour. The object Buffer is 100% loaded for more than 70% of operation time, which may be caused by:
2. Long period of processing (24 hours).
3. Insufficient capacity of the SACMI lines.

With simultaneous setting up of the simulation model the manufacturing system in the course of 30 days duration of the simulation produces:

- 598 entities for the output Service, which represents the number of pallets of sheet metal processed as a service,
- 398 entities for the output CC, which represents the number of pallets of sheet metal processed for CCs.

In the continuation of this contribution solutions to these problems will be proposed, their introduction into the manufacturing system will be simulated in the presentation by the basic simulation model through the simulation experiments. The experiments will be performed so that the model of the manufacturing system will be implicitly inserted as the original copy and the parameters of objects will be modified in the sense of the proposed solution. The resulting statistical

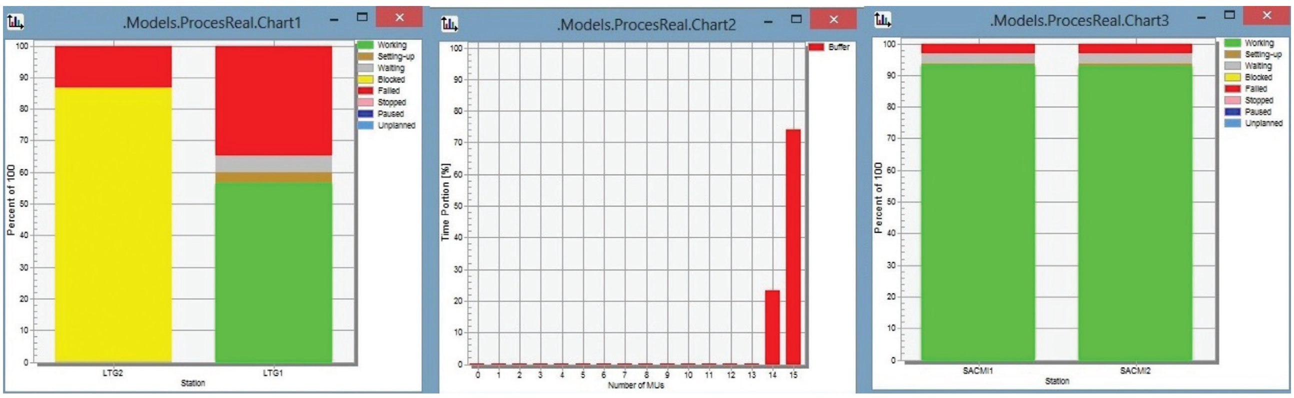

Figure 7 Use of the operation time of the equipment

outputs are compared with the outputs from the basic model.

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