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Investigation and Rationalization of Assembly System Productivity using the "Mean Time Between Failures" Parameter

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Abstract

In this paper the problem of modelling and simulation of a technological assembly processes (TAP) is presented by taking into consideration the "mean time between failures" (MTBF) parameter. The parameter based on examples of real assembly of the dashboard in the car body. The organizational variant (simulation model) of the analysed assembly section is presented. In the final part of the paper the results are presented and the conclusion resulted from the experimental research carried out.

Keywords: technological assembly process, mean time between failures, model, modelling, simulation.

1 Introduction

Modern assembly enterprise, with the conditions of serious market competition (dynamic and continuous product development, shortening the production series, etc.), and the common globalization of the economy, higher and higher quality requirements and minimization of widely understood manufacturing costs, requires continuous organization improvement and technological flexibility while implementing automated and robotised systems [3, 5, 8].

The correct strategy for carrying out assembly line modernization in the future, to obtain the expected economic and productivity improvements, requires carrying out research into the simulation by taking into consideration the assumed parameters (e.g. time of operation duration, productivity) and all possible disturbances (e.g. breakdowns expressed using the MTBF parameter). In order to obtain the notable features of the simulation, research should be carried out in the preliminary stage of the design taking into account the multi-variant assembly system conception, to enable the establishment of the required parameters for the design system and to minimize the eventual costs of future changes [4, 6].

So far modelling and simulation of assembly processes were mainly used in the conditions of mass and large-scale production. Rapid development of computer systems, methods of solving optimization algorithms and the easy access to professional software have enabled simulation techniques to be used for the conditions of small scale production [5, 8].

2 Mean Time Between Failures

The "mean time between failures" (MTBF) is a parameter for determining the mean declared time of failure-free working time of the machine (appliance). Most frequently it is given in hours, and is determined with special test procedures and formulas. These are statistical values determining the number of normal working hours until the moment of failure or a defect arising. In fact the MTBF is a measure of appliance reliability and it is the total operation period of a particular element of the system (machine, appliance, unit etc.) divided by the number of failures, which can be defined by a relationship [1, 7]:

$$MTBF = \frac{operation\ period\ of\ the\ system\ component}{failures\ \ number} \tag{1}$$

Making use of the MTBF parameter is useful especially for determining the key performance indicators (KPI) of production and for example the overall equipment effectiveness (OEE) of appliances. The above mentioned indicators have an influence on taking decisions concerning the activity of the analysed system, enabling among others the accurate planning of production and overhauls (inspections), estimating the costs of production unit conservation, decreasing the sources of losses (failures), which leads to notable economical savings. In the analysed example of the assembly section there the MTBF parameter was used to describe the time of failure in free operation of manipulator utilized to assemble the dashboard in the car body. For the assumed statistical values of the MTBF parameter of the manipulator experimental research was carried out for the assemby efficiency.

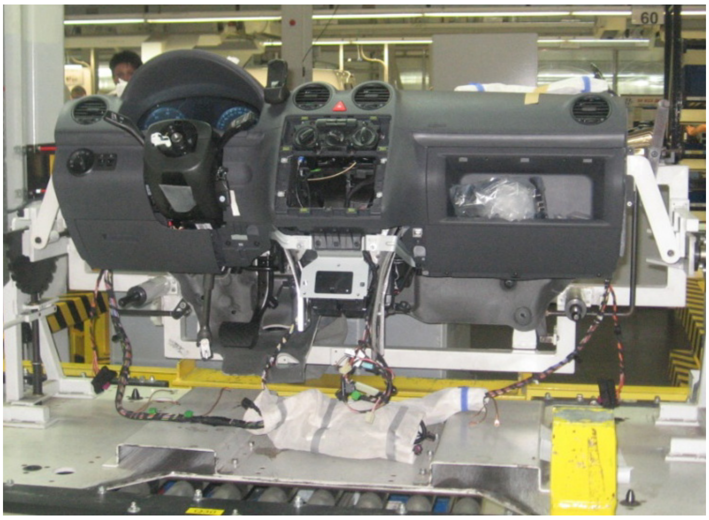


Figure 1: The dashboard for a multi-purpose car on subassembly station

3 Technological process of assembly: the dashboard in the car body

The technological process of assembly of the dashboard in the car body (Figure 1-3, Table 1) comprised two main operations is carried out on two stands creating an assembly section with a six worker team. This work was done in a closed production (assembling) hall, seven days a week in three shifts. The efficiency of the section is on average 1360 assembled dashboards into the car bodies [4].

Figure 2: Assembly of the dashboard to the car body with utilization of the industrial manual manipulator

In order to determining the proper time duration and the efficient carrying out at normal working rate of the assembly operations during the assembly of the dashboard and the car body the timekeeping observations used were presented in detail [4]. The final results (mean values) of observations for the research of carried out are presented in Table 1.

4 Modelling and simulation for the assembly section for assembling the dashboard into the car body

In analysed case it was assumed that the quantity of dashboards assembled and the car bodies in the particular time intervals is equal and is carried out on the same stands. The results of the specified manufacturing programme and the technological process organization are given. For the discussed technological process of assembly of the dashboard and the car body the sequence of the operations carried out and the procedures resulted directly from technological process list (Table 1) and was carried out with the so called serial flow without the possibility of returns or bypassing of the assembly stands. The elaborated graph of operations and procedure sequence during the assembly of the dashboard and the car body of the multi-purpose car is presented in Figure 3.

CHART OF WORKING TIME MONITORING WITH TIMEKEEPING			
Operation No.	Procedure No.	Operation (name) description	Labour consumption, mean values [min]
1	1.1	Preparation and chart drawing	0,54
	1.2	Sticking of Chart into the car documentation	0,25
	1.3	Drawing of the dashboard	0,70
2	2.1	Scanning of the car body documentation	0,16
	2.2	Putting the dashboard to the car body	0,42
	2.3	Acknowledgement of putting of the dashboard	0,51
	2.4	Assembly of the dashboard with using of manipulator	0,24
	2.5	Putting out of manipulator	0,21
	2.6	Paste of quality listing (to the car chard)	0,16
		Total:	3,19

Table 1: Timekeeping measurements for assembly process of the dashboard into car body (mean values) [4]

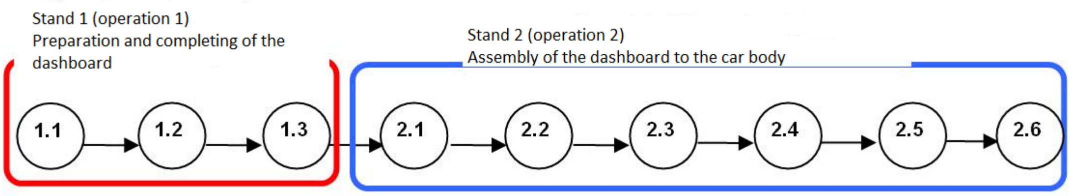


Figure 3: Operations and procedures sequence graph for the assembly of dashboard into the car body; operation numbers according to Table 1 [own elaboration]

The modelling and simulation of the separated section for the assembly of the dashboard in the car body in the final assembly line were carried out with the use of the simulation software "FlexSim_v4" developed by FlexSim Simulation Software Products Inc. [2]. The main target of the modelling and simulation of the section work was the comparative analysis of the realised assembly process with the elaborated simulation model taking into consideration the mean time between failures for the manipulator with respect to its efficiency. The assembly section simulation model (Figure 4) was created based on the organization schedule of the real section for assembly of the dashboard in the car body during the final assembly (Figure 5).

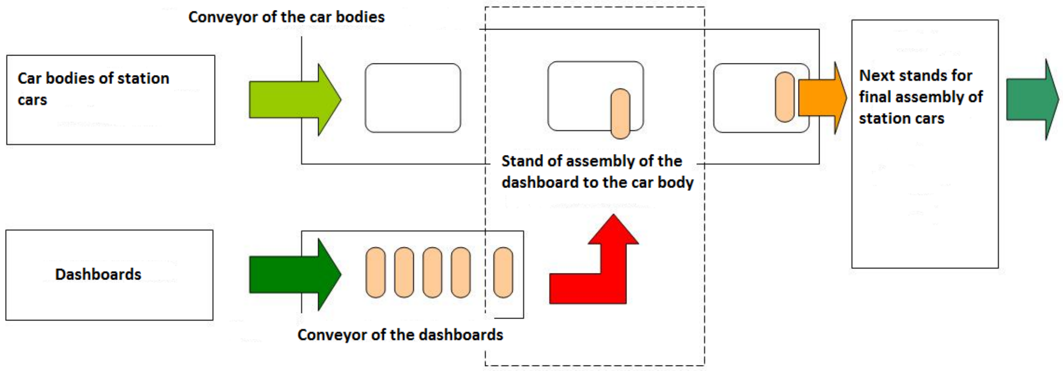


Figure 4: Structure and organizational schedule of the assembly section of dashboard assembly into car body during final assembly process

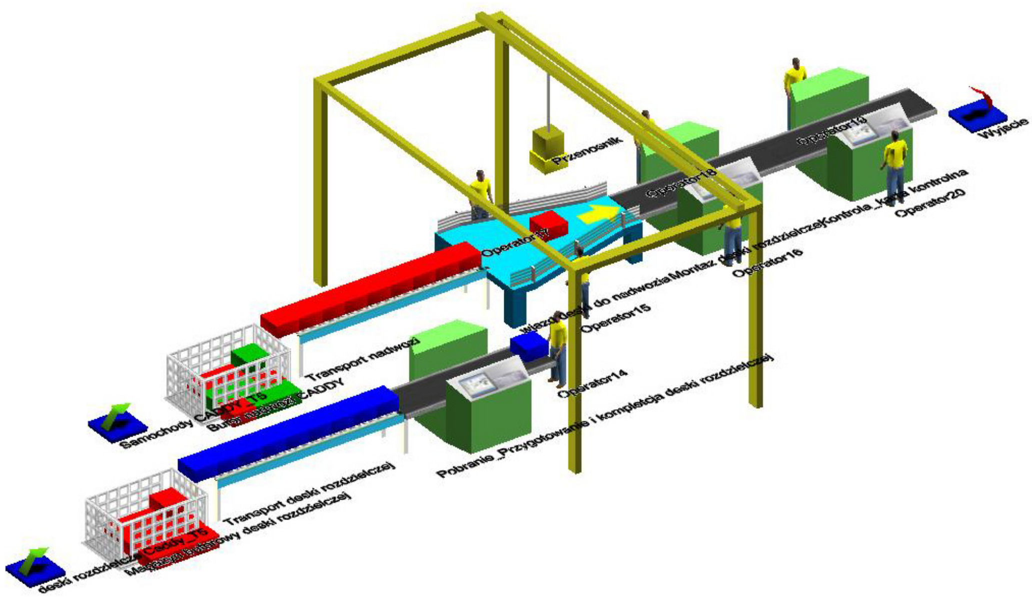


Figure 5: Simulation model of the dashboard assembly into car body performed in FlexSim v4

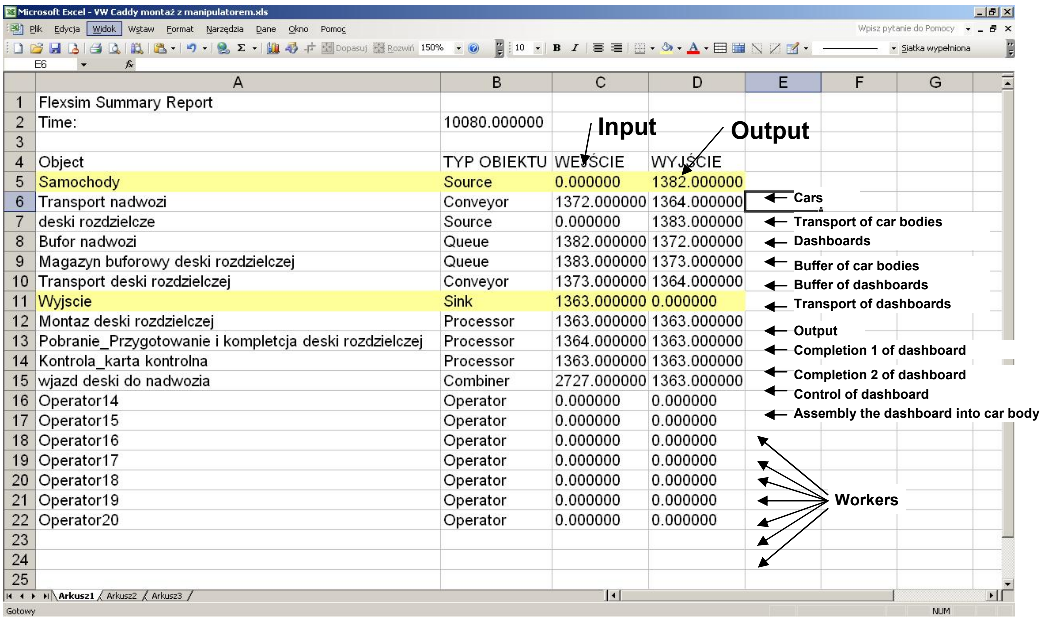
The manipulator's MTBF parameter, for the sake of accurate missing information, was taken as a statistical exponential distribution [7] that presented the mean failure intensity as 1 time per 1000, 2000, 4000, 6000, 8000 and 10000 min. of work (Table 2) and a random mean time to repair the manipulator MTTR in the range of 50 to 100 min.

From the research carried out the results that taken into account in the simulation model of the system operation disturbances (manipulator breakdown) determined with the parameter MTBF enabled the increase of the model detail, which makes increasing difficulties during the modelling process and an increase in data quantity, which must be processed during the simulation experiment. As the results from the simulation research shows, the efficiency of the analysed assembly section of the cockpit assembly in the car body decreases in accordance with increasing of failures number in the analysed work-time.

The results from the analyses carried out for the mean values of the MTBF parameter for the industrial manipulator are presented in Table 2 and a demonstration report from the section of working simulation research is presented in Figure 6.

Variant No.	Value of parameter MTBF (exponential distribution)	Number of assembled dashboards to the car bodies [pcs.]
1.	–	1363
2.	(0,1000,1)	1255
3.	(0,2000,1)	1299
4.	(0,4000,1)	1333
5.	(0,6000,1)	1355
6.	(0,8000,1)	1356
7.	(0,10000,1)	1358

Table 2: Result of efficiency simulations of the section of the dashboard assembly into car body



	A	B	C	D
1	Flexsim Summary Report			
2	Time:	10080.000000		
3				
4	Object	TYP OBIEKTU	WEJŚCIE	WYJŚCIE
5	Samochody	Source	0.000000	1382.000000
6	Transport nadwozi	Conveyor	1372.000000	1364.000000
7	deski rozdzielcze	Source	0.000000	1383.000000
8	Bufor nadwozi	Queue	1382.000000	1372.000000
9	Magazyn buforowy deski rozdzielczej	Queue	1383.000000	1373.000000
10	Transport deski rozdzielczej	Conveyor	1373.000000	1364.000000
11	Wyjscie	Sink	1363.000000	0.000000
12	Montaz deski rozdzielczej	Processor	1363.000000	1363.000000
13	Pobranie_Przygotowanie i kompletcja deski rozdzielczej	Processor	1364.000000	1363.000000
14	Kontrola_karta kontrolna	Processor	1363.000000	1363.000000
15	wjazd deski do nadwozia	Combiner	2727.000000	1363.000000
16	Operator14	Operator	0.000000	0.000000
17	Operator15	Operator	0.000000	0.000000
18	Operator16	Operator	0.000000	0.000000
19	Operator17	Operator	0.000000	0.000000
20	Operator18	Operator	0.000000	0.000000
21	Operator19	Operator	0.000000	0.000000
22	Operator20	Operator	0.000000	0.000000

Figure 6: Example of simulation results report of the dashboard assembly into car body for organizational layout variant according to Figure 5

5 Summary

The subject of the research described was the elaboration of simulation model of the real section for assembly of the dashboard in the car body and obtaining an answer concerning the influence of disturbances on the production system. Disturbances were determined by the MTBF parameter. The results of the simulation research carried out and presented here have shown that the section of the simulation model (variant No. 1) corresponds to real production conditions, and its detailing leads to more precise forecasts concerning the system operation. The research carried out on the simulation confirmed that the use of the industrial manipulator (variant No. 2-7) caused a greater decrease in the number of assembled cockpits if more failures or defects occured in the period analysed than was occurred in reality.

Further research will concern the detailing of reliability information, enabling the determining of the efficiency of machines and appliances used in the production processes and this research will enable the determination of efficiency indicators for the manufacturing processes with respect to losses (failures, defects, shutdowns that resulted e.g. from improper supply to stands) in the usage of machines.

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