Research Article

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Use of simulation model for measurement of MilkRun system performance

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Abstract: Intra-plant transport systems within their operation directly impact on the performance of production systems. For their effective operation, it is, therefore, necessary to realize evaluation of operational performance and effectivity. For the realization of this type of evaluation, in addition to a wide range of sensors that can be difficult for installation and operation, we can also use indirect methods that are equally able to provide reliable operational characteristics. Indirect analytical methods are presented above all by the approach which is based on the use of simulation methods. The method of computer simulation provides a wide range of options for the evaluation of efficiency and performance. The paper describes the use of a simulation model created in the program Tecnomatix Plant Simulation for analyzing the supply of production workplaces within the MilkRun system.

Keywords: AGV, simulation, MilkRun, transport, analysis

1 Introduction

The process of workplaces supplying within different types of production processes can be realized by a wide range of transport technologies. The choice of suitable transport technologies depends on the particular production, the final product, production capacity and other factors. In the context of the present time, with the philosophy of the Industry 4.0, automatization of enterprise processes gains ground, and automatized logistics systems are preferred within intra-plant transport, which is capable of

self-navigation and moving within the production areas [1]. They are most often named as AGV or FTS.

In both cases, it is the same type of transport system. This system most often consists of autonomous vehicles or it is presented by vehicle combination with towing vehicle and transporters, *i.e.* peripherals [2]. Within production units, the route can be guided to meet different criteria [4]. Various methods and approaches are used by the implementation of these transport systems to the systems of intra-logistics. Their aim is to adapt to the transport system as much as possible to the operating conditions. One of the possible solutions is described for example by Johnson and Brandeau [5].

For their reliable operation, it is also important a navigation system, which is used by AGV systems [6]. The system of vehicles control is also depended on the choice of the type of navigation [7]. AGV vehicles are in most cases applied in a continuous operating mode, moving on predetermined fixed transport routes and providing a continuous flow of material for workplaces and production lines. The system MilkRun is the most often used system for this process [8–13].

2 Characteristics of the system MilkRun

“The system MilkRun is delivery of material from the store on precisely defined logistics routes with a precise delivery schedule. It is a set of several transporters pulled by one vehicle that runs on the planned route with specified stopping places” [14]. The use of the system MilkRun is common in lean production. It allows more frequent supplies of material and supplies to more than one mounting area. Supply by the system MilkRun is increasingly used in firms.

“The principle is to distribute material from a store according to a pre-agreed schedule and unload material at precisely defined locations. At the same time, empty transport units are transported back to the store. They are more expensive, but the difference between them and a forklift

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is about the same as between taxi and public transport. The taxi goes in one direction loaded and the other empty, as well as a forklift, so it is filled only to 50%.” Handling devices which are the most often used are so-called trains [15].

Figure 1: Set with AGV towing vehicle within the system MilkRun

3 Simulation model

Measuring of the AGV system performance within MilkRun is a challenging process that needs to reflect a large set of operational indicators and helps to understand the functioning of the transport system. One of the tools we can use is a computer simulation. The application of this method for the need of the system of MilkRun will be presented by an example that will describe the creation and use of a simulation model of AGV transport system.

The simulation model was created with the intention of using it to supply of workplaces within the existing MilkRun system. The creation of this system was based on the analysis of the current state of the transport route (Figure 2). Each section of the route was created separately for a better change of details, for example by changing directions. The individual part of the route has its length that was divided into several smaller parts due to the variability of changes. Within the route, the locations of stops were defined for loading and unloading of material. For this purpose the function of sensors was used, where the AGV set is due to stop and load, or unload metal extrusions 1, metal extrusions 2 or EURO Kanban crates.

Further, within the simulation model, five types of handling units MUs of the type “Transporter” were created, specifically the first transporter with the title “AGV”, the second transporter with the title “transporter 1”, the third transport with the title “transporter 2”, the fourth transporter with the title “transporter 3” and the last fifth

transporter with the title “transporter 4”. In addition, two “Entity” were created, the first with the title “metal extrusion 1” and the second with the title “metal extrusion2”, to which colour was assigned for recognizing them. As the last MUs was used the “Container” and named as “EURO-container”.

For the simulation of the process of material loading and unloading on the individual stops within the system MilkRun, the method of additional programming was used. Individual statements created by the programming language SimTalk were used in the block “Method”. AGV set circulated along a predefined route among the first and thirteenth stop.

There was a store of containers beyond the thirteenth stop in the simulation model, and all EURO containers, that were collected by the set during the AGV ride, were unloaded. Subsequently, the set continued to the place of loading of transported components and after its realization continued in the ride along the circuit and supplying workplaces.

Two Sankey diagrams were inserted into the model, which allowed to monitor the material flow of metal extrusions (Figure 3).

Within the workplaces, the possibility of utilization evaluation was implemented in the simulation model. The results are presented as histograms (Figure 4).

4 Results

The created simulation model was used for the analysis of changes of MilkRun system performance in the case that the number of transporters in the set towed by AGV vehicle is reduced from four to three. From the simulation model, with the cancelled transporter 4 (Figure 5), it is evident that after this change the vehicle “AGV” worked at 81,89% and its waiting is 18,11% - The “transporter 1” worked at 81,90% and waiting of the transporter 1 is 18,10%, the “transporter 2” worked at 81,66% and waiting is 18,34% and the “transporter 3” worked at 80,38% and waiting was 19,62%. The average occupancy of the vehicle “AGV” and three transporters was 81,46%.

The second experiment with the applied simulation model was based on reducing the number of stops on the transport route, while the number of transporters in the tandem vehicle was original. Specifically, stops number 6, 9 and 10 were cancelled. The reduction was within the simulation model realized by simply removing the corresponding sensors.

Figure 2: Layout with the definition of MilkRun route and stopping places

Figure 3: Demonstration of material flow for metal extrusions 1 and also metal extractions 2

Figure 4: Demonstration of visualization of the results of workplace occupancy

Figure 5: Statistical occupancy of the “AGV” vehicle and “transporters” by cancelling of the transporter 4

From the simulation model with cancelled three stops (Figure 6), it is evident that the vehicle “AGV” worked at 85,16% and its waiting was 14,86%. The “transporter 1” worked at 84,63% and its waiting was 15,3%, “transporter 2” worked at 83,85% and waiting was 16,15%, “transporter 3” worked at 83,33% and its waiting was 16,67% and the

“transporter 4” worked at 82% and its waiting was 18%. The average occupancy of the AGV vehicle and its four transporters with three cancelled stops was 83,79%. In comparison with the simulation model with thirteen stops, the occupancy of the AGV vehicle and transporters with three cancelled stops was higher by 1,52%.

Figure 6: Statistical occupancy of the “AGV” vehicle and “transporters” by cancelling of three stops

5 Conclusion

Measuring of transport systems performance within individual logistics processes has great importance for their effective operation and reduction of operating costs. Their operators must have sufficient information providing them with a real state about applied vehicles, the volume of transported material and other operational indicators. In this way, it is possible from time to time to debug these systems and effectively operate. Computer simulation is currently a robust and powerful tool for a meeting of these requirements, which do not demand costly investments af-

ter the creation of the simulation model and it can be used within different types of engineering analysis.

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