Using WITNESS™ Simulation Software as a validation tool for an industrial plant layout

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Abstract - Modeling and Simulation techniques are often powerful tools devoted to analyze the best layout for an industrial plant. In fact, these methodologies allow investigating the most suitable features or parameters regarding for instance buffer capacities or the number and type of machines and facilities, like for in-stance handling means. In literature, there are many examples of simulation models aiming at reproducing different plant layouts through the use of "What if" analysis.

The focus of this work is on a plant layout simulation model developed by the Department of Production Engineering, Thermoenergetics and Mathematical Models of the University of Genoa, with the use of the commercial software WITNESS™, that enables the discrete event simulation. After the description of the model, the results obtained are presented and discussed, highlighting the importance of using this kind of simulation for layout design purposes.

Key Words – Plant Layout, Simulation, What if analysis, Logistics, WITNESS™ Software

1. Introduction

The implementation of a new plant layout is a typical matter studied by logistics experts using Modeling and Simulation (M&S) techniques, and it is also one of the major aspects discussed in academies to educate young engineers and researchers about industrial engineering. There are in fact several aspects to be taken into account during the design and implementation of a new plant layout, like distances, buffer capacities (if present) and number and types of machineries and ancillary facilities, like forklifts, human re-sources and so on. For these reasons the authors propose an application of simulation for the design of an industrial plant layout with the goal of analyzing flows, criticalities and bottlenecks, using WITNESS™ software. This tool allows the formulation of "What If" analysis and animated simulations in two and three dimensions.

The paper is divided in the following sections: after this introduction, which explains the aim of this research, a short literature review is proposed in Section 2, while Section 3 provides a short description of the model developed in WITNESS™. Finally, Section 4 provides some results and conclusion on the model developed.

2. Literature Review

The plant layout design is a typical matter that can be approached with a modeling and simulation approach. As a matter of fact, in literature, there are many examples of simulation models devoted to analyze this topic, and most of them have been implemented using common commercial software like Simul8™ or Arena™. Smutkupt and Wimonkasame (2009) utilized Arena to develop a model that overtakes the limited results provided by the implementation of the CRAFT (Computerize Relative Allocation Facilities Technique) methodology, by showing more information of the design layout like the total time in system, waiting time and utilization. This is made possible thanks to the simulation model developed in ARENA™ which it is properly connected to the design system and to an output report system using ad hoc Microsoft Visual Basic™ interfaces.

Simul8™ is used in Magoulas et al. (2002) for the design of a steelworks facility. This stochastic model allows handling the uncertainties that arise from stochastic elements in the environment and in the objective function evaluation process.

The authors themselves developed, in (Briano et al. 2004) an easy SIMUL8 model devoted to analyze the performance level of a dental technician lab.

Taking into account the wide literature regarding the layout design, the authors propose the use of simulation in order to validate a widget plant layout scenario. More specifically, the simulation is used to evaluate the utilization coefficient of the forklift truck used for handling the various parts, for determining the average and maximum number of parts in queue waiting to be processed and the average WIP (Work in Progress) value and time. In order to do this, the authors have used another commercial software: WITNESS™ from Lanner Group. WITNESS is a process simulation software commonly used for both educational and business purposes, and it is one of the most suitable for simulating plant layouts. In different real business cases this tool has been successfully used to design and validate plant layouts; in the recent past this software has been used to support the European aeronautics company Airbus in de-signing the wing production facility for the new passenger aircraft A380, the world's largest airplane ever produced. Airbus used WITNESS to ensure a lean wing production process and to provide a good overall view of the factory life. Moreover the model was able to give a detailed perspective about all the process phases. Finally, he layout designed using WITNESS brought significant savings in terms of equipment.

3. The WITNESS™ Simulation Model

This section provides a description of the model implemented by the authors for the proper design of an industrial plant layout. In particular the simulation model developed reproduces a widget production line, where different flows of parts and materials are managed using just one normal forklift of the capacity of 2000 kilograms. The objectives of the simulation model are to identify any criticalities in the system in order to validate an hypothetic plant layout considering a certain daily flow of materials, to dimension inter-operative and machine buffers and to evaluate the saturation coefficient of the different types of productive machines. The model allows formulating "What if" analysis in order to identify eventual bottlenecks on the system. Finally the model has been used in academy to train young engineers and researchers to become confident with stochastic simulation and “What if” analysis.

In detail, the model reproduces a widget plant in which different flows of materials are interfaced. Each one of this flow feeds a series of different machines devoted to transform the semi finished products in a finished widget ready to be sent to the shipping warehouse; each flow has a buffer, near to the referring workplace, where the queuing different parts wait before being processed.

In WITNESS software it is possible to set characteristic parameters for machines, forklifts and buffers, like the capacity, the processing times or the speed (for the forklift), allowing “What if” analysis on different scenarios. The model developed presents a unique forklift serving all the machines and the flows inside the plant, including also the possibility to take semi finished products from outside, moving along predefined segments which connect machines, buffers and entry points; the logic behind the forklift picking sequence is a “taxi” one, where the forklift presents a list of missions to be satisfied and added in the queue once a buffer or a machine “calls” the forklift. In the unloading procedure it is foreseen to set “parking points” for the forklift devoted to hold it when it is idle along some of the segments.

Forklifts and machines in WITNESS can assume different status:

- Idle: the object is inactive;
- Busy: the object is working;
- Blocked: the object is not able to manage the missions due to the high workload.

But there are other status typical of the forklift:

- Demand: the forklift is in mission going to pick up a part;
- Transfer: the forklift is moving along the tracks searching for a mission;
- Loaded: the forklift is carrying a part towards a machine or a buffer.

All the status are reported both in a tabular and a graphical form, showing a chart states for the objects. Buffers have also characteristic parameters, in terms of capacity, which can be set by the user, in order to fix an upper limit to the parts entering the system. It is possible to see significant output parameters like the WIP, both in terms of time and number of parts, or the average and the maximum number of parts in queue, in order to identify criticalities and bottlenecks of the system.

However, several of the input parameters have to be set in the track object: here it is possible to insert the loading/unloading time of the forklift, the real length of the track and its capacity (in case of more than one forklift); in the same object it is inserted also the sequence logic of the forklift mission with the SEARCH function.

WITNESS allows implementing different logics for the parts assignment to the machines, making possible the use of specific functions and statements, like FOR cycles, IF statements and so on. In particular, in the model developed by the authors, the WRAP function has been used, which assigns randomly the parts to the first free machine and then follows a sequential feeding configuration. WITNESS allows also input initializing, in order to start the simulation with a particular configuration of busy machines, editing a text file (extension “.sta”) which contains the desired parameters.

4. Conclusion

The WITNESS model has been developed in order to evaluate the feasibility of serving all the different machine types with only one normal forklift, considering a certain inter-arrival time between the two parts for each machine. Six different types of machines transforming each one a different raw material part in semi-finished products have been considered, as represented in Figure 1, that represents the conceptual model of the production flow with the six different parts feeding the productive machines working in parallel. The semi finished products, stored in their relative buffers, are then assembled in the final assembling machine and then sent to the shipment warehouse.

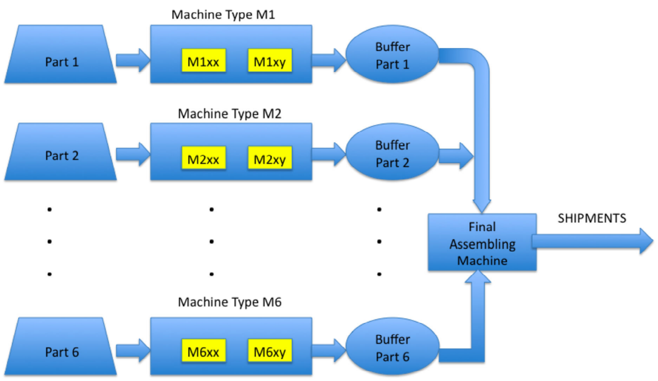


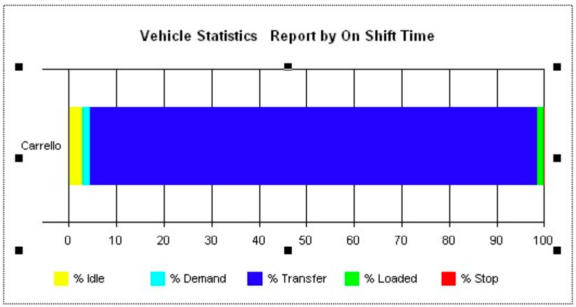
Figure 1: The conceptual model

In particular the attention has been focused on the most critical flow referred to Part1, which is the main component for the final widget. Setting the parts' inter-arrival time for each machine of each series, the saturation coefficients for the forklift and the machines themselves have been analyzed, in order to evaluate the presence of bottlenecks and the feasibility of the plant layout using just one forklift. The WITNESS™ software allows analyzing the results of the simulation in two different ways: both in a tabular form, considering the percentages of the simulation time in the different status seen in the previous section, and in a graphic one, underlining the different status in different colors.

Figure 2 represents the status chart for the forklift in the base case scenario, considering an inter-arrival time for Part1 of 300 minutes.

Figure 2 – Chart Status for Forklift Saturation

The graph represented in Figure 2 shows that the forklift for the most of the time is in transfer in the plant (that means that is moving to different points of the



plant called by the various operators), it is idle (parked) for a little time, and it carries parts for a short time. This implies that in the buffers significant queues are generated. This means that the warehouse is definitely not optimized. The percentages in detail are presented in Table 1.

Table 1: Forklift Saturation Percentages

Name	Forklift
% Idle	2.86
% Demand	1.71
% Transfer	93.93
% Loaded	1.49
% Stop	0.00
% Blocked	0.00
Distance	142747.19
Loads	613

Table 1 shows how the forklift is saturated for more than the 97% of the time, but it is always in transfer from one point to another of the plant because it is not able to satisfy all the missions. For the same reason the parts, especially Part1, accumulates in queue in the buffers; this implies that the machines are idle for the most of the time, as shown in Figure 3, representing the Chart States of Machines M11-M14 trans-forming Part1 in semi-finished products.

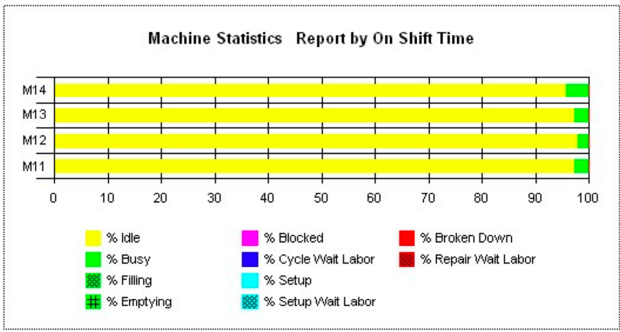


Figure 3: Chart Status for M11-M14

The numerical results are reported in Table 2:

Table 2: Status Percentages for M11-M14

Name	M14	M13	M12	M11
% Idle	95.83	97.22	97.92	97.22
% Busy	4.17	2.78	2.08	2.78
% Filling	0.00	0.00	0.00	0.00
% Emptying	0.00	0.00	0.00	0.00
% Blocked	0.00	0.00	0.00	0.00

% Cycle Wait Labor	0.00	0.00	0.00	0.00
% Setup	0.00	0.00	0.00	0.00
% Setup Wait Labor	0.00	0.00	0.00	0.00
% Broken Down	0.00	0.00	0.00	0.00
% Repair Wait Labor	0.00	0.00	0.00	0.00
No. Of Operations	6	4	3	4

Table 2 shows that the machines M11-M14 are not working for the most of the time, because the parts are queuing in the buffers; this is confirmed also by the number of the operation processed by each machine.

In conclusion, the forklift is sufficient for the parts handling inside the plant, but there is no doubt that an optimization of the handling process must be implemented: this is possible by increasing the inter-arrival time of the parts or reducing the distance between the warehouses and the plant itself. The segment length is in fact one of the most significant variable to improve the system performance reducing the saturation coefficient of the forklift and, contemporarily, increasing the saturation coefficient of the different machines types.

Finally, it can be stated that WITNESS provides a powerful tool to implement simulation models de-voted to analyze plant layouts and to perform feasibility analysis; in particular, it supports decision makers in formulating "What If" analysis before performing significant investments like a new plant layout or the purchase of expensive handling means.

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