Analysis and Modeling of a Flexible Manufacturing System based on Petri Nets

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Abstract: - In a world where industrial mechatronic systems evolve from day to day, the intensity of these requirements influences the maximization of efficiency, the optimization of the safety of the working environment including human and the increase of the quality of services. This is why industrial computing is becoming a necessity for manufacturers and even researchers working on innovative and creative subjects. This paper deals with the analysis and the modeling of a flexible manufacturing system. Firstly, the study of the system engineering then the composition of the studied system was presented. Second, we presents an application of a modeling based on Petri Nets. Finally, the last present conclusion and future work.

Key-Words: - Flexible manufacturing system, modeling, Petri Nets

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1 Introduction

Today the competition between companies and industrial companies is more and more fierce, which forces them to use new technologies to increase their productivity and diversify their products. For this reason, the model industries contain several components and equipment such as robots, PLCs, industrial networks and field buses, sensors, actuators, numerical control machines, among others. All these equipment's will generate a huge amount of data that we will have to manage to ensure a perfect and optimal functioning of the different workshops and automated systems of production and manufacturing. The tasks of management, supervision and real time control of these systems are ensured by SCADA supervision, control and data acquisition systems [1], [2].

All of this has prompted researchers from various fields to study this growing boom by creating new centers of interest. Therefore, today we are not only talking about increasingly complex systems but also about studies from different points of view [3], [4].

Among the challenges to be taken up during the modeling of complex systems, we can cite the design and implementation of test devices dedicated to the studied objects, the determination of the correct complexity of the models developed to meet the needs posed and the positioning of the research strategy between academic research and industrial constraints [5], [6].

An approach that brings together these different types of modeling is then required for it to be based on new representations of a real system, while taking into account instability, chaos, ambiguity, disorder, vagueness and paradox but which thus touch the creative side of development [7], [8].

Computer engineering science then appeared to complete this approach and to implement developed computer tools with which human cooperates, intended for perception, observation, decision support and the management of dynamic industrial systems [9], [10].

In this context, computer-engineering science has as fields of investigation all the subjects or fields, which traditionally fall within the automatic control and establish concepts, specify models, develop methods and tools for the design and the realization of the command and control of these industrial processes. The programmable logic controller (PLC) [11] was used to carry out the formalism of the work steps based on the structuring of the data but also the communication steps. This study is divided into three parts; the first will be devoted to the study of mechatronic systems, through which we will present the field of mechatronics from different points of view namely mechanical, computer and electrical, and we will highlight the problematic considered through a case study detailed on the treated system and which presents a FESTO workshop flexible system. The second part presents the study of the modeling based on Petri Nets in which we will present the composition of the studied system [12], [13].

2 Presentation of a flexible manufacturing system

The flexibility manufacturing systems aims to create an industrial revolution, since a flexible manufacturing system comprises several numerically controlled machines integrating various stations which are connected to each other by a Fieldbus system. They are generally characterized by reprogrammable machines. Flexible systems are composed of complex and expensive machines, the number of which can be adjusted compared to other production systems. This allows a saving in cost and space of the order of 30% [14], [15], [16].

The figure 1 shows an example of type of mechatronic systems which is the flexible manufacturing system MPS 500 - FSM which will provide the axis of our study. It represents a multi-technological assembly owing to the merger and interactions between the different parts: mechanical, pneumatic, electrical, control and communication interfaces.

This manufacturing system has six stations linked together by a transport system, and presents a production chain organized as follows: a distribution station, a test station, a treatment station, an assembly station, a sorting and a storage station to manufacture cylinders with short strokes.

Fig.1: MPS 500 - FSM Station

Finally, the sorting station will have the task of sorting the jacks according to their nature (the red plastic station, black plastic or metallic coating).

Each station, on its own, represents a mechatronic system that obeys the descriptions and definitions that we have presented previously. If we take the sorting station as an example. This station merges the different fields of electronics, mechanics and computing to form a typical mechatronics system.

It has sensors that provide information about the status of the system. The reports are sent to the control part, which consists of an industrial programmable logic controller, which will consider this information and give the appropriate orders to the actuators, depending on the program implemented in the PLC.

The operational part is essentially composed of pneumatic cylinders and a mini conveyor to bring the cylinders to their respective stocks.

The flexible workshop consists of six stations, as shown in the following six figures, which are the Testing station, the Processing station, the Carrying station, the Sorting station, Distributing station and Assembly station.

Figure 2. shows the Test station which is reserved for checking the material and the height of the workpieces. Depending on the result of the check, the workpiece is either ejected or transferred to the adjacent station.

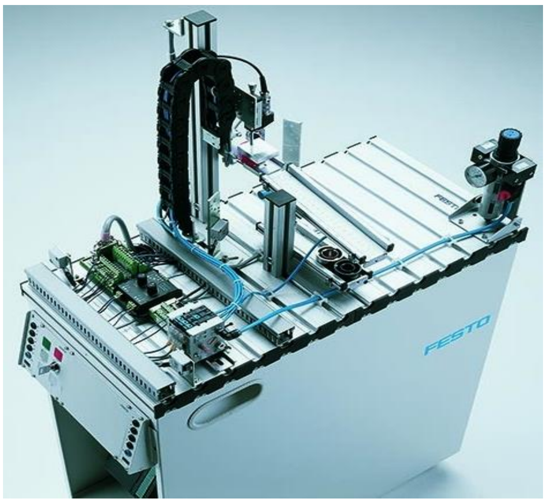

Fig.2: The test station

Figure 3 shows the processing station which is reserved for the control of workpieces, their machining and their transfer to the adjacent station.

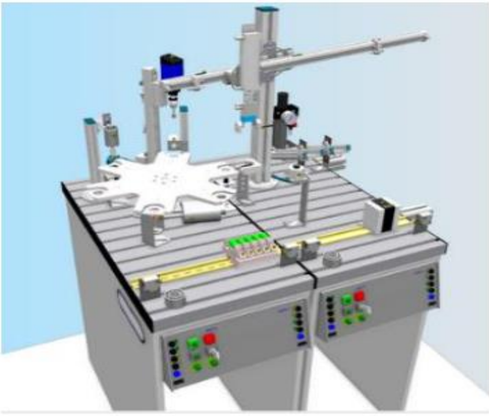

Fig.3: The treatment station

Figure 4 shows the transport station which is reserved for removing workpieces from receiving modules and then placing them on a slide depending on the result of the material check. Workpieces can also be transported to a nearby station.

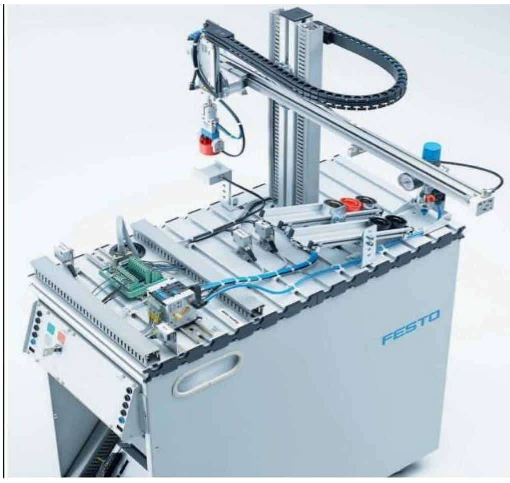

Fig.4: The transport station

Figure 5 shows the sorting station which is reserved for sorting workpieces according to their material and color.

Fig.5: The sorting station

Figure 6 shows the distribution station which is reserved for the separation of workpieces and their transfer to the adjacent station.

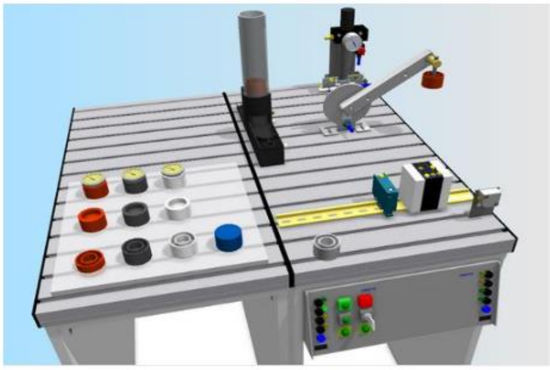

Fig.6: The distribution station

Figure 7 shows the assembly station which is reserved for assembling a model cylinder from a base body.

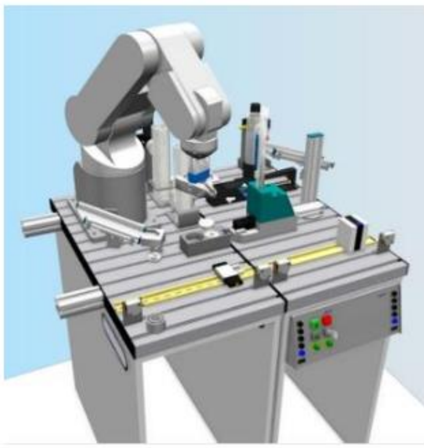

Fig.7: The Assembly station

3 Modeling based on Petri Nets

A Petri net is a graphic structure comprising a set of places and transitions, connected by oriented arcs, possibly carrying weights. These arcs are links between place and transition or between transition and place exclusively. In this structure move tokens (or marks) which appear in the places and are likely to cross the transitions according to certain criteria of crossability and crossing [17], [18].

This network has interesting features such as parallel behavior modeling and visualization, synchronization and resource sharing. In addition, their theoretical aspects have been widely studied and the theoretical results concerning it are very abundant.

It is a modeling tool generally used in the preliminary design phase of a system for its functional specification, modeling and evaluation [19], [20]

In this part, we present an example of modeling of the test station based on Petri Nets.

Legend:
P1: The presence of the piece
P2: Color selector (Red or Black)
and determine the material (Metallic or plastic)
P3: comparator with a given height: Compare the height of the piece with a predefined height.
P4: Moving the part to the next station
P5: the piece evacuation
T1: the entrance of the piece
T2: Piece Detected
T3: move the piece up
T4: conforming Piece: The movement of the piece to the next station
T5: Not conforming piece: Moving the piece down for evacuation

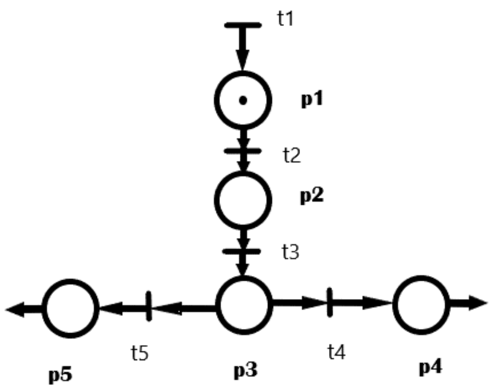

Fig.8: Petri Nets of Test Station

Figure 8 shows that after piece detection, the color and material of the inserted piece must be determined by sensors. Then the piece will be moved up to measure and compare its height. If the piece is compliant, it will be moved to the next station, otherwise it will be moved down and evacuated.

5 Conclusion

In this paper, we studied a FESTO flexible manufacturing system allowing manufacturing single-acting cylinders.

Uncovering the reality of a part of industrial computing has prompted us to find out how to use it to apply the methods used on complex systems that integrate dynamic components.

We therefore plan to find a solution to model the entire FESTO production line (the flexible workshop) which includes the different stations, based on the Petri Nets. Then, we will be interested in studying the exchange of energy flows between the different parts in order to supervise this data flow and test new supervision tools allowing to test the overall Petri Nets model of the system.

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Contribution of individual authors to the creation of a scientific article:

Youssef El Fekih has carried out the design of the models.
Jihen El Khaldil has participated in writing the paper. Mohamed Najeh Lakhoua wrote and he was responsible for the scientific continuation of this work.