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Flexible Manufacturing Process with Scheduling Algorithm Based on Distributed Fuzzy Control System Design Using MATLAB

Hsu Myat Tin Swe[1, *], Hla Myo Tun[1, *], Maung Maung Latt[1, 2]

[1]Department of Electronic Engineering, Yangon Technological University, Yangon, Myanmar

[2]Department of Electronic Engineering, Technological University (Taungoo), Taungoo, Myanmar

Email address:
hsumyattinswe.ytu@gmail.com (H. M. T. Swe), hlamyotun.ytu@gmail.com (H. M. Tun)
[*]Corresponding author

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Abstract: The paper mainly focuses on the development the flexible manufacturing process with scheduling algorithm based on distributed fuzzy control system design using MATLAB. The research problem in this study is to find the scheduling algorithm for autonomous control system for modern industries based on flexible manufacturing process. The solution for the main research problems is to utilize the fuzzy logic controller design for scheduling algorithm based on distributed situation. The objective of this research could be fulfilled to observe the flexible manufacturing process for modern industries. In this paper, an Individual fuzzy logic controller is designed for the DFC control of the Manufacturing Process. With the use of Distributed Fuzzy Control in the manufacturing, the result is more benefit in scheduling policies, resource management and on-time delivery and processing of work. The Fuzzy Logic Controller for each machine is constructed first and the FMP is demonstrated by using a sequence control and processing of three machines equipped with the design fuzzy logic controller. The main advantage is automatic scheduling of the system (fully intelligent). The high Flexibility of controller and Good resource management confirm that the Less Human intervention in real world application. The results in this analyses confirm that the developed scheduling algorithm would be applied in real world applications because the performance of the control system was met the outcomes from the experimental studies.

Keywords: Distributed Fuzzy Control (DFC), Flexible Manufacturing Process (FMP), Flexibility, Fuzzy Logic, Scheduling of Manufacturing System

I. Introduction

A flexible manufacturing process is a manufacturing process that is designed to produce the many un-same parts simultaneously and effectively without changing the machine position. In general, a flexible manufacturing process (FMP) comprises of a numerically controlled machine and a material handling system (typically a robot). When a Flexible Manufacturing Process (FMP) is being planned, the objective is to design a system which will be efficient in the production of the entire range of parts [1-2].

This cannot be achieved until the design, production planning, scheduling, and controlling stages work well. Depending on the required measure of scheduling performance, many different approaches to the scheduling problem can be generated. Scheduling methods of FMP can be classified into different approaches, such as combinational optimization, artificial intelligence, simulation-based scheduling with dispatching rules, heuristics-oriented, and multi-criteria decision making [3-6].

However, production scheduling in an FMP is usually very complicated, particularly in dynamic environments. Many manufacturing systems, therefore, need scheduling for dynamic and unpredictable conditions, so artificial intelligence and heuristic-based approaches have been considered in FMP scheduling [7-10].

The complexity of a scheduling and control problem is to a great specific extent case that is, it depends upon the given manufacturing system and also upon the level of detail which is considered appropriate. Development of scheduling and control algorithms using intelligent system has recently attracted attentions from researchers in different disciplines including operations researchers, control theorists and computer scientists. The scheduling and control of the FMP consists of not only the machines, parts and raw material but also the control personals, technicians and labors that are consist to produce these parts [11-12].

The fuzzy logic is now applied to the various industrial control problems. The advantage of the fuzzy logic system approach is that it incorporates both numerical results from a previous solution or simulation and the scheduling expertise from experiences or observation, and it is easy to implement. Several fuzzy logic based scheduling systems have recently been developed, although direct comparisons between them are difficult due to their different implementations and objectives [13-16].

The rest of the paper is organized as follows. Section II presents the system description. Section III mentions the consideration of system. Section IV points out the conclusion of the research works.

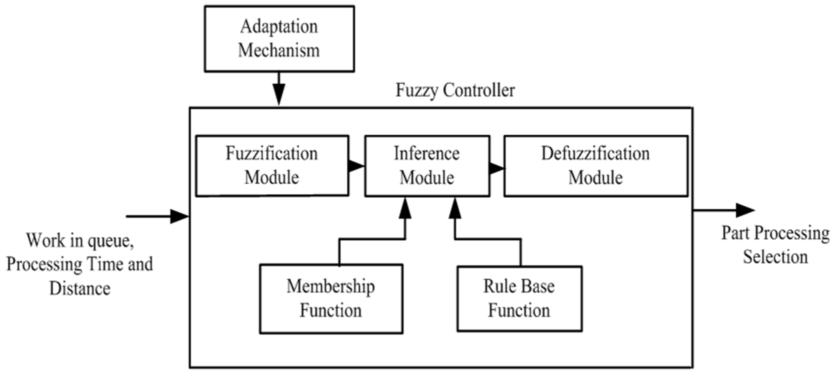

Figure 1. *Block Diagram for Fuzzy Controller for Each Machine.*

2. System Description

The adaptation mechanism handles the part and transfers the parts to the specific machine. The amount of work in queue, time requirement for processing the part are determined by using the fuzzy logic and decide what part to be processed for the optimum production rate and best operation sequence.

3. Consideration of System

The considered system model is the manufacturing process of the system which processed the numbers of part which are going to the manufacturing process on a conveyor driven system or AGV based part routing.

The convenient level of each buffer must be defined in order to keep the system in stable and safe operation. In this simulation, the level of buffer1 and buffer2 are limited to the maximum number of about 30, the maximum buffer level of the buffer3 is set to 20 numbers and the part processing time of the production process is consider at the maximum of 30 seconds. The considered system model is shown in Figure 2.

Three membership functions are set in each of the input variable. The range of the membership function and associated input variable are shown in Table 1.

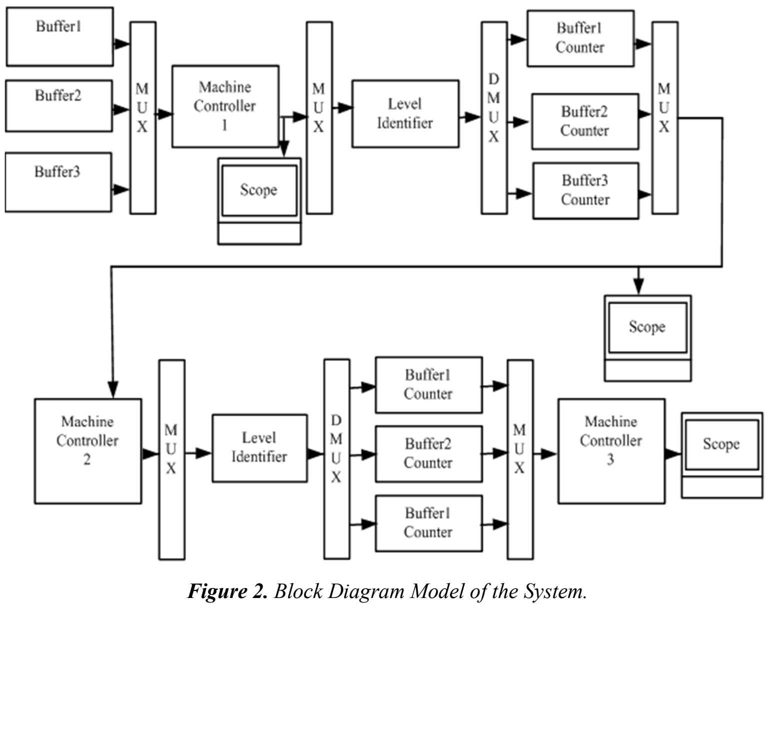

Figure 2. *Block Diagram Model of the System.*

Table 1. *Range Of Variable in the System.*

Variable	Low	Medium	High	Min	Max
Buffer1	0-11	4-26	19-30	0	30
Buffer2	0-11	4-26	19-30	0	30
Buffer3	0-7	3-17	13-20	0	20
P. P. T	0-11	4-26	19-30	0	30
P-Selection	0-1.25	0.75-2.25	1.75-3	0	3

A. Consideration of Input and Output for Fuzzy Controller

The distributed fuzzy controller for the Flexible Manufacturing Process provided in this paper by using the three machines. The input condition for each machine is considered as each part buffer level and part processing time. The output of each machine controller is the part selection i.e.: the selected part for the next time t is P1, P2 or P3. The input/output information of the system is shown in Table 2.

Table 2. *I/o Assignment of the Controller.*

Input	Output
Buffer Level of Part1 Buffer Level of Part2 Buffer Level of Part3 Part Processing Time	Part Selection

For defining the membership function for each input of the fuzzy controller, the validation and set of data for the associative part must be defined. The conditions for the input of process are as follows:

Buffer1 Level Low = 0 < BF1 < 11

Buffer1 Level Medium = 4 < BF1 < 26

Buffer1 Level High = 19 < BF1 < 30

Buffer2 Level Low = 0 < BF2 < 11

Buffer2 Level Medium = 4< BF2 < 26

Buffer2 Level High = 19 < BF2 < 30

Buffer3 Level Low = 0 < BF3 < 7

Buffer3 Level Medium = 3 < BF3 < 17

Buffer3 Level High = 13 < BF3 < 20

For Part Processing Time, the unit is defined in seconds in this paper.

Part Processing Time Low = 0 < PPT < 11

Part Processing Time Medium = 4 < PPT < 26

Part Processing Time High = 19 < PPT < 30

The only membership function for the output of the fuzzy controller is designed according to the following facts.

Part Selection is Part 1 = 0 < P* < 1.25

Part Selection is Part 2 = 0.75 < P* < 2.25

Part Selection is Part 3 = 1.75 < P* < 3

IV. Simulation Result Of Controller

The structure of the membership function and the main SIMULINK file can be run and seen from the GUI.

A. Simulation Diagram of Three Machines

The simulation diagram of three machines is shown in Figure 3. In this figure, the structure of each controller is included as subsystem.

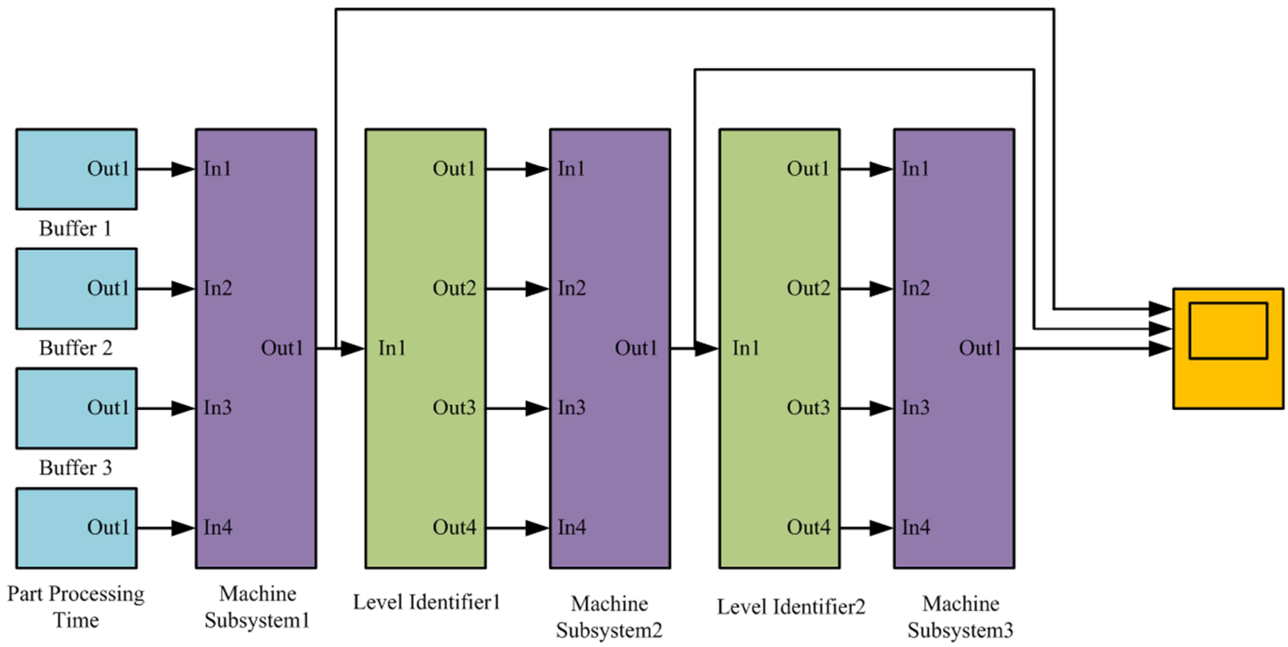

Figure 3. *Overall SIMULINK Model.*

The internal structures of the each subsystem block are shown in the Figure 4 and Figure 5. The main SIMULINK models include only two main subsystems, namely machine subsystem and interface subsystem.

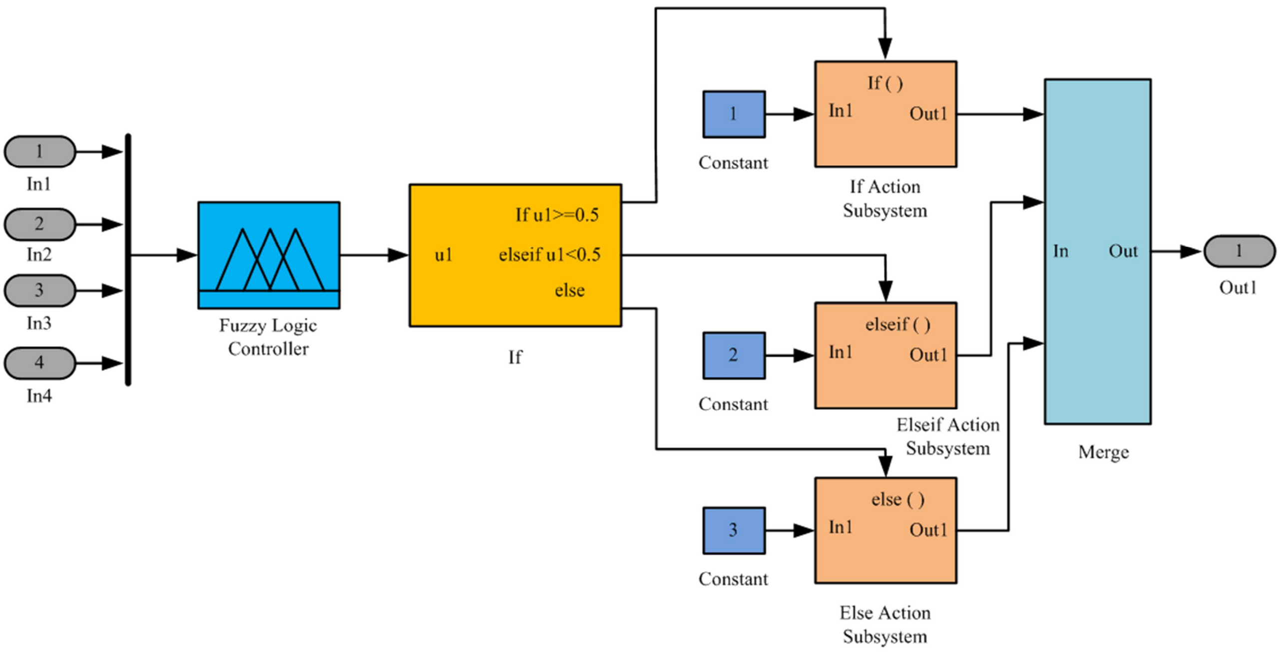

Figure 4. *Internal Structure of Machine Subsystem.*

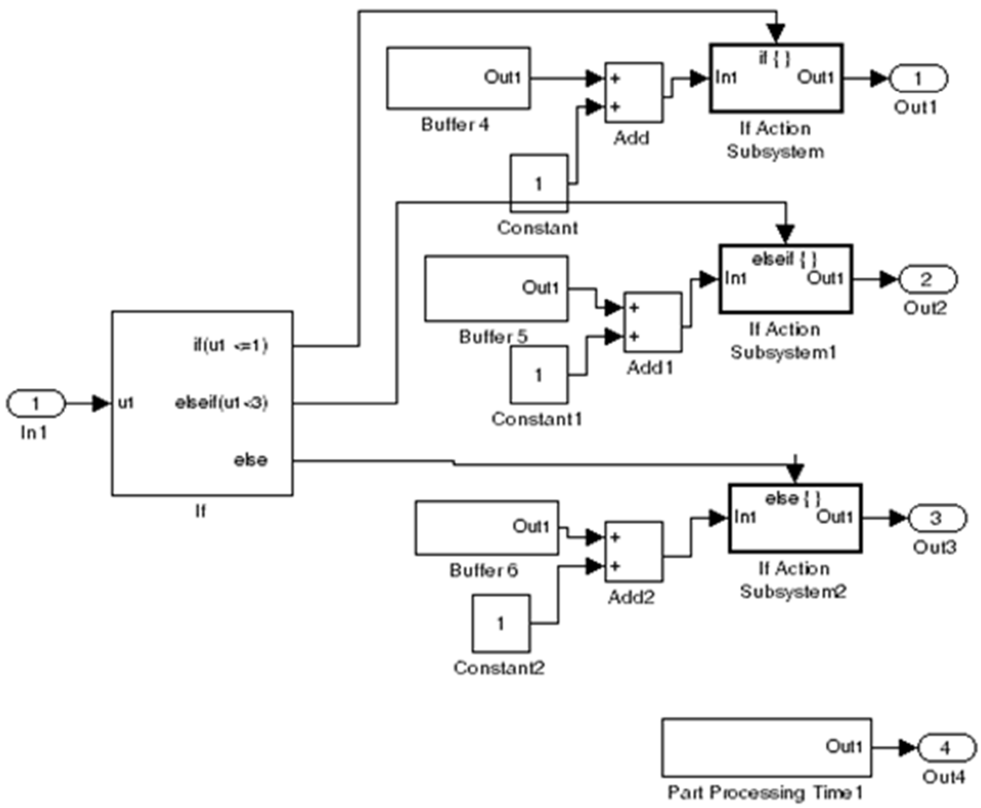

Figure 5. *Internal Structure of the Level Identifier.*

B. Fuzzy Logic Controller for Each Machine

The SIMULINK model of the system included four inputs, one fuzzy logic controller and a scope for viewing the output response of the controller. The user can change the input condition by selecting the parameter of the signal generator or gain slider in the input subsystem. The fuzzy logic controller must be supplied with the FIS structure. To produce this FIS structure, the FIS structures is open via the fuzzy logic tool box and generate the FIS structure to the MATLAB work space. The Fuzzy logic controller for each of the machine in the Flexible Manufacturing Process is shown in the Figure 6.

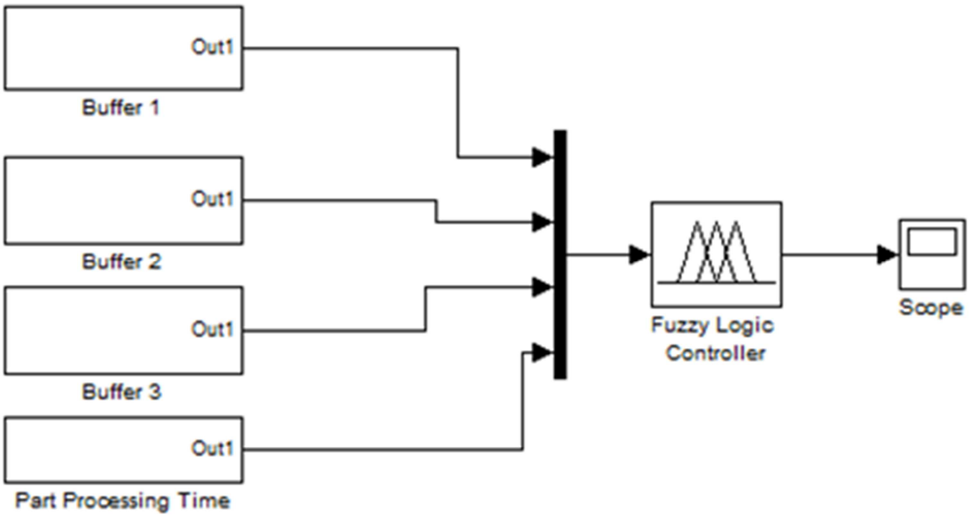

Figure 6. *Fuzzy Logic Controller for Each Machine.*

C. Simulation Result of the Fuzzy Logic Controller

The simulation result of the controller for the various input condition is shown in Figure 7 through Figure 9. Where the buffer sizes are adjust by three conditions. The simulation result of the fuzzy logic controller shows that the controller has the satisfactory output for the manufacturing process. The controller is then embedded to the main SIMUINK model.

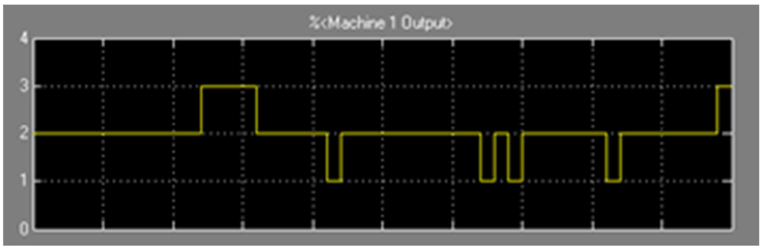

Figure 7. *Output result for condition 1.*

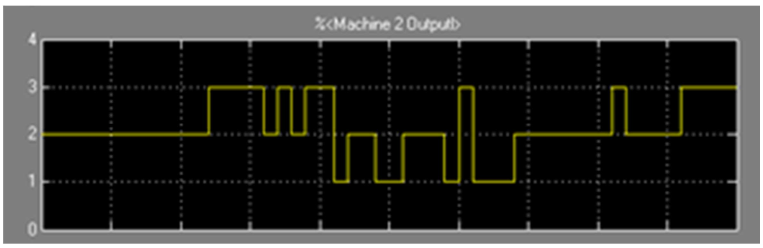

Figure 8. *Output Result for condition 2.*

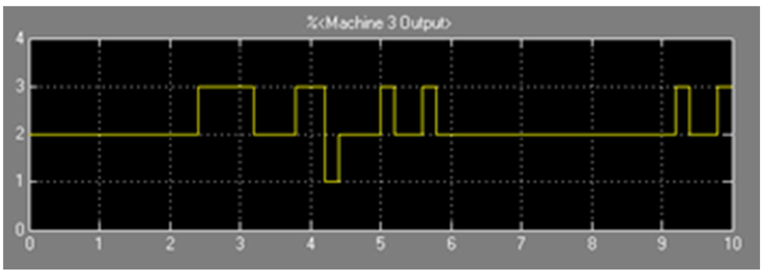

Figure 9. *Output result for condition 3.*

In this simulation the fuzzy controller for the each machine in the manufacturing process is used as subsystem. The outputs of the machine controller are then input to the level identifier and the result is transformed to the part type P1, P2 or P3. The part selected is then processed by using the part counting subsystem. The part counting subsystem will increment the part buffer when the associated part is transferred to the machine. These part types and processing rate are then executed by the next machine controller.

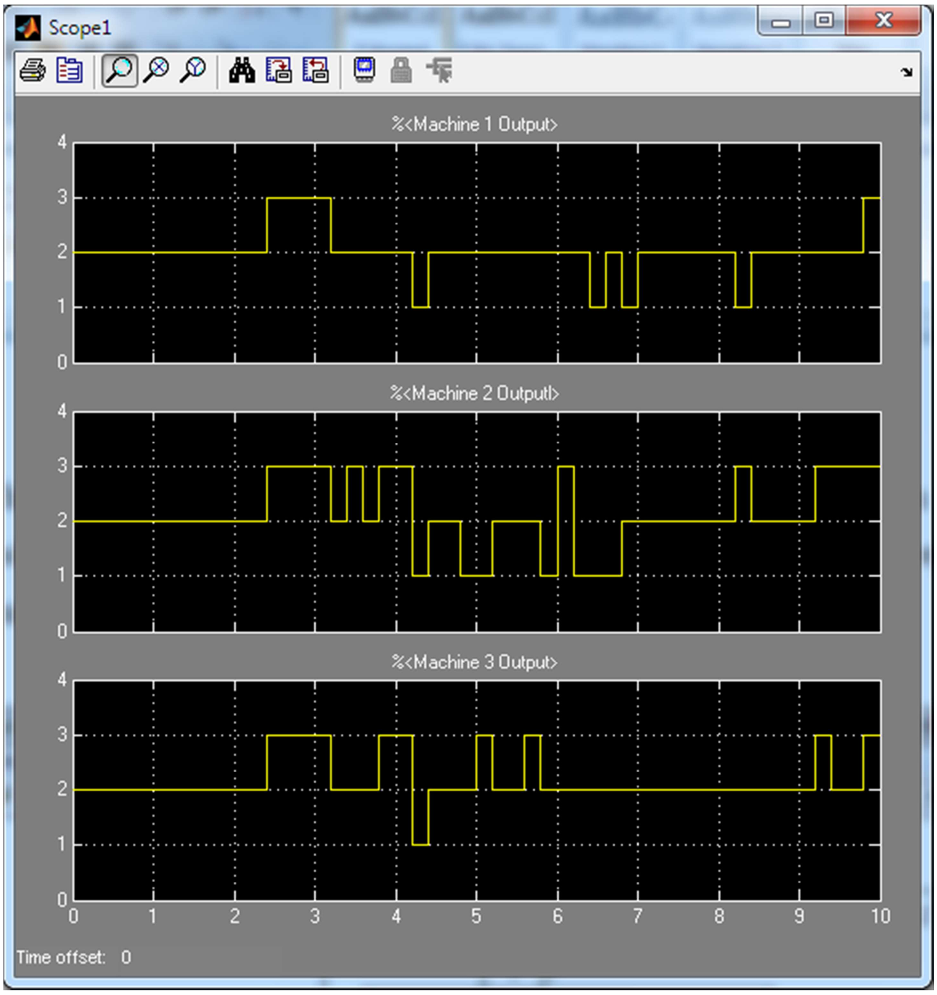

Figure 10. *Simulation Result of the Process with each controller output.*

The simulation results of the overall manufacturing process with each controller output are shown in Figure 10. In this result, the outputs of the each stage from the controller are not the same. So the controllers are responded to each condition of the output of earlier stage. The process is said to be distributed control.

4. Conclusion

The experience in the process control industry is required for the rule developing personnel is crucial. Because of the response of the production process is not always linear and resources are in-predictable. Possibilities of the resource conditions, labor, and state of product are required to have the more complete scheduling results. This paper intended to introduce the use of the fuzzy logic controller and important of DFC in the flexible manufacturing process. In the near future, the FMP will be started to introduce in the industry. The fuzzy control of the FMP will get satisfactory result in the high part variety and low part level production. The DFC was the best scheduler among all scheduling in the scenes that it attempted to make the peak value of each buffer level and maximum backlog smaller by sometimes allowing their averages to be slightly larger. The performance of the DFC can be improved by increasing the size of buffer level. DFC is regarded as the most intelligent controller for the FMS.

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