THE INTERACTIVE PROCESS BETWEEN SOME DISPATCHING MECHANISMS AND INTERRUPTED MACHINE CENTERS IN FMSs

M.A. Shouman**, *G.M. Nawara**, *A.H. Reyad** and *A.M. El-Sadek**

* Industrial and Systems Engineering Department,
Faculty of engineering, Zagazig University.
** High Institute of Technlogy (Matruh)

ABSTRACT

Scheduling in flexible manufacturing systems (FMSs) differs from that of a conventional job shop because each operation of a job may be performed by any one of several machines. In the current paper, the interactive process between routing flexibility index (single route index up to 192 route index are classified into nine route flexibility indices), different interruption ratios (zero up to 100 % are classified into six interruption indices), as well as sixteen dispatching policies are studied. The dispatching mechanism that will perform the best with the considered measuring performance criteria for each route flexibility index and model configuration has been determined. Global conclusions and trend of variations have been highlighted.

Keywords: Flexible Manufacturing Systems, FMS Scheduling, Interruptions in FMS, Flexibility of FMS.

INTRODUCTION

Product deliverability is becoming more important in today's competitive markets. While it used to suffice to manufacture products of high quality and low price, today's manufacturing practices necessitate on-time product deliveries for customer satisfaction. Thus scheduling plays a crucial role not only in the efficiency of operating the system but also in customer satisfaction. The emergency of flexible manufacturing system (FMS) has sparked an increased interest and appreciation of real-time planning, scheduling and control. FMS is defined as a manufacturing system consisting of automatically reprogrammable machines, automated tool deliveries and changes, automated material handling and transport, and coordinated shop floor control. Pertinent areas of interest include job releases, loading sequences, dead-locks, and response to resource disruptions such as machine break downs (interruptions) or tool failure. Drake *et al* [1] introduced a flexible simulation technique that facilitates automated experimentation of different scheduling rules. An enhanced version of Arena/SIMAN is used to develop an extremely high fidelity model of the manufacturing system. A procedure for design and scheduling of cellular manufacturing systems for implementation in small-to-large size manufacturing systems has been developed by Logen [2]. This procedure has focused on group scheduling, machine break downs and batch size, increasing flexibility by increasing process plans of part types. The combined interactive process between material handling systems and dispatching mechanisms in FMS has been studied by Shouman *et al.* [3]. It has been noticed that the considered interactive process has a great influence on the performance of the system. The rules that perform the best have been determined. The interaction between planning and scheduling stages in a hierarchical production planning system is developed by Hatchuel *et al.* [4]. The results show that significant lead time performances improvements result from a specific combination between MRP, PERT, and some dynamic priority rules. An extended dispatching rule approach, which applies different dispatching rule combinations in the mechanisms, and a search algorithm to find an appropriate dispatching rule combination has been advised by Ishii *et al.* [5]. The study showed better effectiveness as an on-line scheduling frame work for batch process management. A classification, scheme for scheduling problems in flexible manufacturing systems (FMSs) based on an analysis discussion of scheduling decisions in an FMS has been presented by Liu *et al.* [6]. The scheme identifies and describes all the major factors that affect the modeling of, and the solution to, FMS scheduling problems. A new shop-based and predictive scheduling heuristic for cellular manufacturing has been developed by Mahmoodi *et al.* [7]. This heuristic includes a feature for dynamically assessing variations in a subfamily's arrival rate, enhancing suitability for realistic transient-state conditions as well as minimizing aggregate times required for major sequence-dependent machine setups at a work center. An effective tabu search (TS) approach to the job shop scheduling is applied on 56 test problems by Barnes *et al.* [8]. The procedure starts from the best solution which rendered a set of 14 heuristic dispatching solutions. It makes use of the classical disjunctive network representation of the problem and iteratively moves to another feasible solution reversing the order of two adjacent critical path operations performed by the same machine. A vast majority of production scheduling process involves the determination of schedule over a certain time frame assuming all problem characteristics are known. Such schedules are often produced in advance in order to direct production operations and support other planning activities such as tooling, raw material delivery, and resource allocation. The (TS) approach gives superior solution in some problems and achieves the optimum in the others. A decision rule for real-time dispatching of parts, each of which may have alternative processing possibilities, has been developed by Chander *et al.* [9]. For the effective use of the system's routing flexibility, an intelligent part-selection strategy that takes into account the current state and trends of the system has been designed. This procedure has been found to achieve better shop performance than some of popular dispatching rules. A two level distributed production control system (DPCS) is developed for on-line scheduling in a multi-cell flexible manufacturing system in case of operating in a produce -to-order environment by Arzi [10]. The DPCS allows autonomous and simultaneous operation of each cell-controller, utilizing only local and short term information as well as heuristic rules. Simulation experiments show that DPCS achieves good results in throughput, tardiness of orders and WIP inventory level and it is robust to machine and handling device failures. Unfortunately, in a dynamic environment such as the job shop, as soon as the schedule is released to the shop, it is immediately subject to random disruptions which may render the initial schedule obsolete. These disruptions or "rescheduling factors" include machine break downs, delays in the arrival of materials, arrival of rush orders, cancellation of orders. Dead-locks and response to resource disruptions are vital parameters in FMS performance. As a matter of fact, most rescheduling factors can be modeled as machine break downs [11] and since they involve a disruption in the processing of operations on a machine or machines of a period of time; The main objective of the current work is to study the interactive process between some dispatching mechanisms at different interruption ratios and route indices on disrupted machine centers in flexible manufacturing system.

SIMULATOR, MODEL FEATURES, AND STUDY OBJECTIVE

Many simulation softwares are classified at three different levels: system, application, and structural [12]. Also, many aspects that are considered as essential and desirable features in the selection of simulation software product. Those that are pertinent to manufacturing environment are: input flexibility, modeling conciseness, macro capability, material handling modules, standard statistics generation, data analysis, animation, interactive model debugging, and micro/mainframe compatibility. According to the above considered groups of criteria, SIMFACTORY II.5 has an advanced position based on a simulation software survey provided by Hlupic and Paul [13]. In this software no programming is needed, model construction and data input are simplified through the menu-driven interface, there are no arbitrary limits to the number and type of items that the model can include, you can get an animated picture of your factory at the work during the simulation not after the action is over. Moreover the most of the above cited aspects are provided by SIMFACTORY II.5. Interruption to normal processing activities in FMS can be either planned interruptions which are passive in nature (preventive maintenance) or unplanned interruption, which have priority over any current operation (typically involves the failure of work station or transporters). Interruption is considered as one of the main affecting parameters on FMS operation concerning system throughput and makespan. No dispatching rule has been shown to consistently produce better results than all other rules under a variety of FMS configuration and operating condition ... it is impossible to identify any single rule as the best in all circumstances [14]. FMSs are believed to be an important means to improve manufacturing flexibility so as to respond quickly and economically to all customer needs. The assignment of different routes to complete a set of jobs subject to process constraints has a great influence on the system flexibility and its performance. The actual time allocation of the considered machines to the job is referred to as scheduling or dispatching. Sixteen dispatching rules are considered for the evaluation of the present study under different interruption ratios and route indices. These rules are: RANDOM(1), BY TURN(2), LOW USAGE(3), HIGH USAGE(4), CLOSEST(5), FARTHEST(6), SHORTEST IDLE(7), LONGEST IDLE(8), FEWEST PARTS(9), MOST PARTS(10), OLDEST PART(11), NEWEST PART(12), LOW STATION PRIORITY(13), HIGH STATION PRIORITY(14), LOW PART PRIORITY(15), and HIGH PART PRIORITY(16).

PROBLEM TREATMENT

The arrangement of work-stations inside FMS layout has normally been carried out in the planning phase. The work-stations can be increased or re-arranged for a well flexible FMS in the case of either changing the design of part type or increasing number of available routes, obsolete facilities, market environments, and poor worker environment. In the current work nine configurations as route indices for a single part type (GEARSET) are considered for the tackled problem. These route indices are: single route, double routes, 4 routes, 8 routes, 16 routes, 32 routes, 64 routes, 128 routes, and 192 routes. Six unplan ned interruption indices for work stations are considered for each route index. These interruption indices are: zero unplanned interruption, 20% unplanned interruption, 40% unplanned interruption, 60% unplanned interruption, 80% unplanned interruption and 100% unplanned interruption. All model configurations consider planned interruption for changing the plating liquid used for covering the final gear set produced by the considered system. The cited dispatching mechanisms for smoothing the work flow within the work-stations per each interruption ratio are applied. Transfer lines (routes and directions), transfer means and the total available area are vital parameters in the considered configurations. Due to the scope of the tackled problem, the available configurations within the specified plant layout area are considered deterministic. The suggested procedure for solving this problem is summarized as follows:

1. Construct and determine the primary model layout.
2. The operations of part type(s) and the flexibility of work centers to perform these operations are determined.
3. Based on the flexibility indices, the routing configurations for the model under consideration is obtained.
4. The dispatching mechanisms that are applicable for each route configuration have been pointed out.
5. The measuring performance criteria for evaluation are considered.
6. Prepare each model configuration for simulation experiments.
7. Run the experiment for all the dispatching mechanisms and measure their performance.
8. For each model configuration, the interruption ratios are considered, simulation experiments are applied, and performance measures are evaluated.
9. A comparative evaluation has been performed for all model configurations to clarify the trend of variation for the interactive process under consideration. However, Figure 1 exhibits the flow chart for the considered problem.
10. Two options of the considered simulation options are selected. The first one is, trace processing events to point out the arrival time (R) and completion time (C) while the second one is, stations status option.
11. A data base program is designed and constructed to calculate the measuring performance criteria.

DESCRIPTION OF MODEL EXPERIMENTS

Nine simulation experiments named by M1, M2, M4, M8, M16, M32, M64, M128, and M192 each with machine tool centers, buffers, receiving area, transfer network, and material handling device are considered for the application of the proposed treatment. Figures 2 and 3 exhibit the physical layout, transfer network, and flow of part type for model configurations under consideration. The machine stations are structured in serial mode starting with receiving area, grinding machines (grinders A, B, and C), washing center (washer A, and B), polishing center (polisher A. and B), inspection center (inspector A, and B), assembling station (assembler A, and B), plating center (plater A, and B), curing center (cure A, and B), and shipping center.

The model configurations are based on the following assumptions :

1- Each part type consists of more than one operation and operation is indivisible.

2- There are one or more machine which can process each operation in each work stations and each machine can process one operation at a time.

3- The part moving time is assumed not to affect the lead time.

4- Set up times and tool-change over times are included in process time and tool magazine capacities are not binding constraints due to the availability of an automatic tool handling system.

5- System congestion is assumed to be prevented by limiting the total service time of each machine station to the capacity of that station.

6- Data on all alternative routes and processing times can be provided.

7- Five interruption ratios (20 %, 40 %, 60 %, 80 %, 100 %)are assumed for physical layout of the model.

8- Arrival rates, due dates, transporter speeds, setup and tear down(for plating station) times are deterministic.

9- Due date is calculated according to the following equation (1) which is suggested in the current work.

$$\text{Due date} = \frac{\sum \text{mean flow time of models}}{\text{number of models}} \quad (1)$$

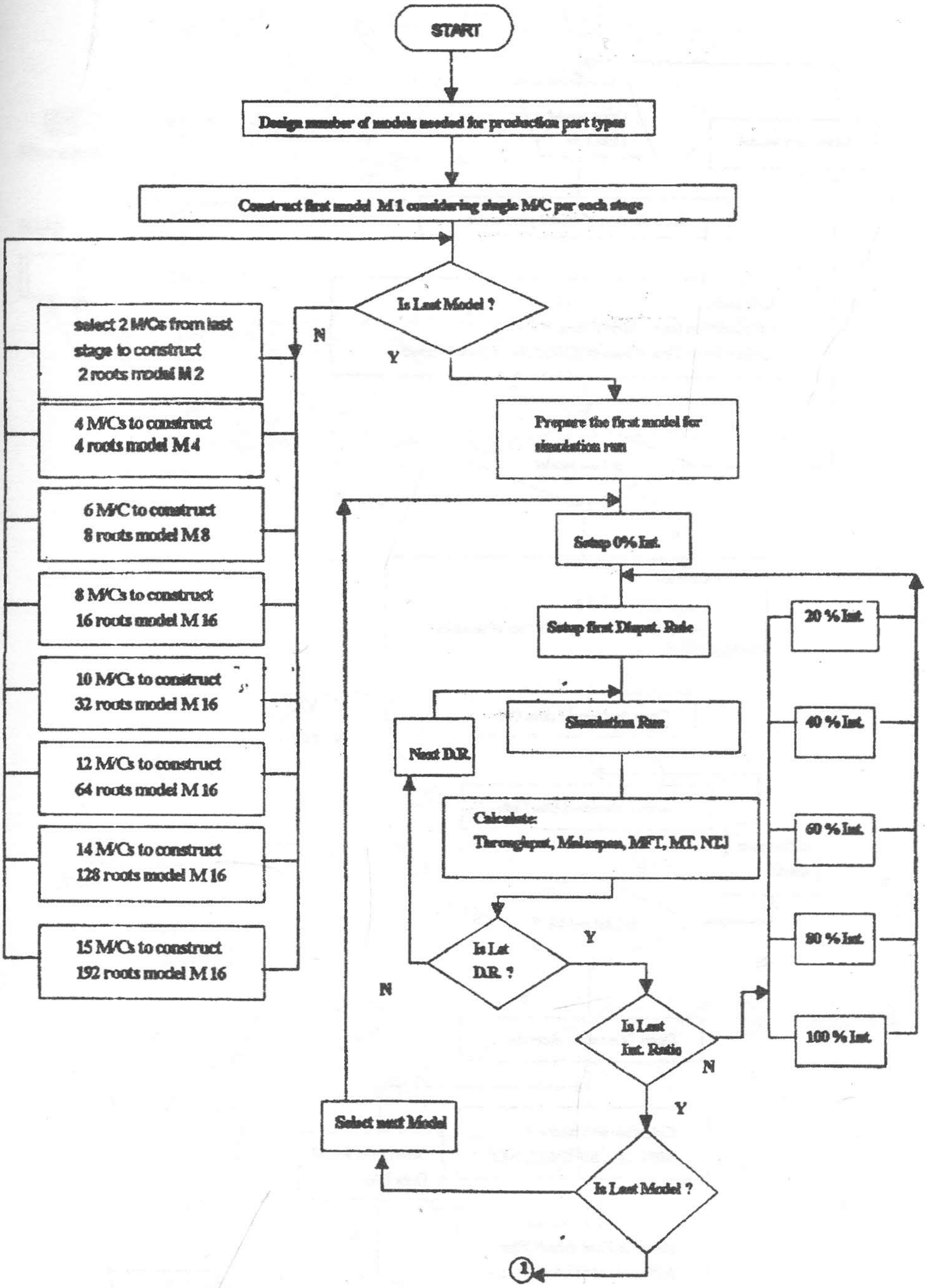

Figure 1 Problem Flowchart

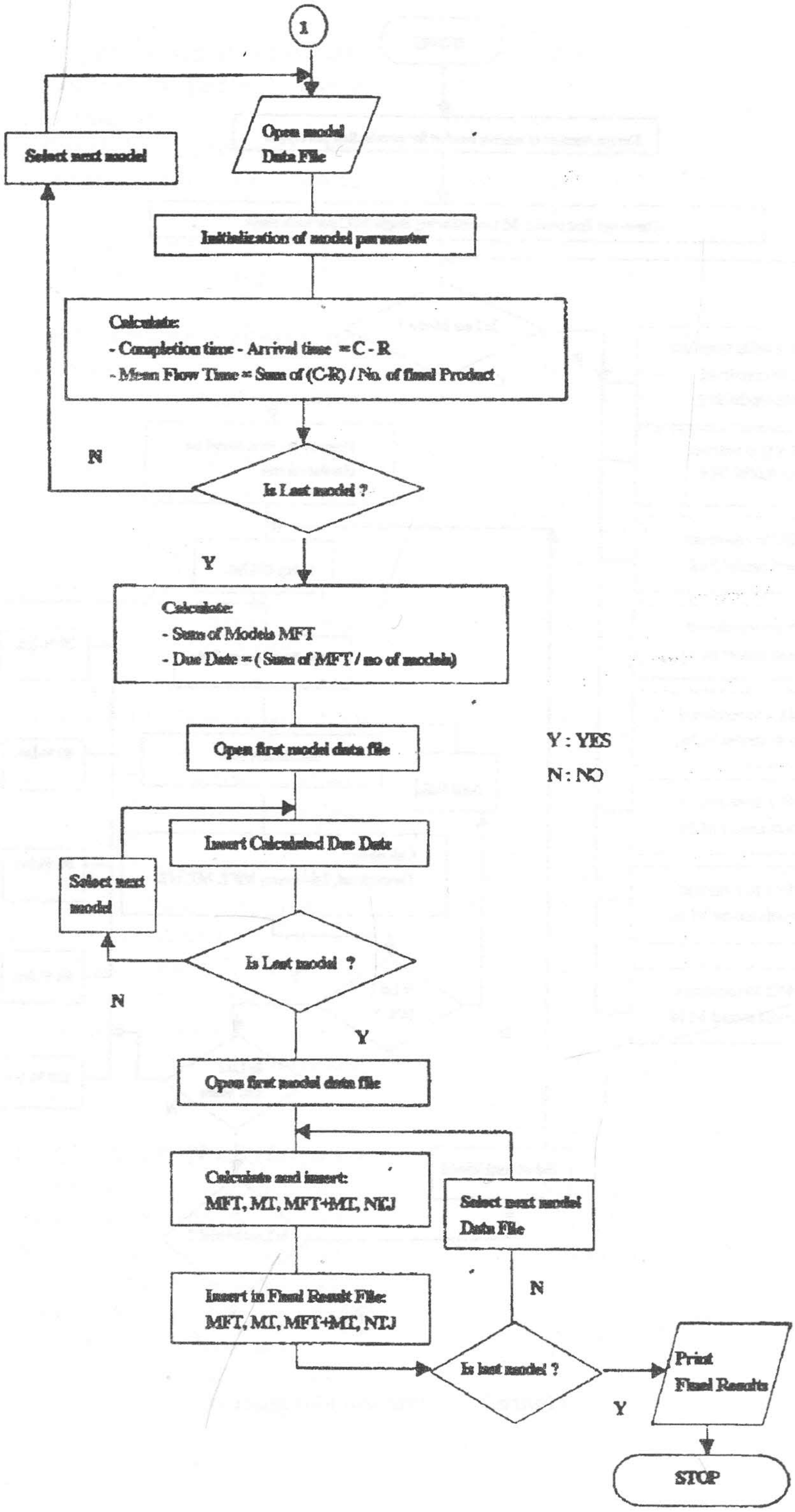

Figure 1 Problem Flowchart (*Cont'd*)

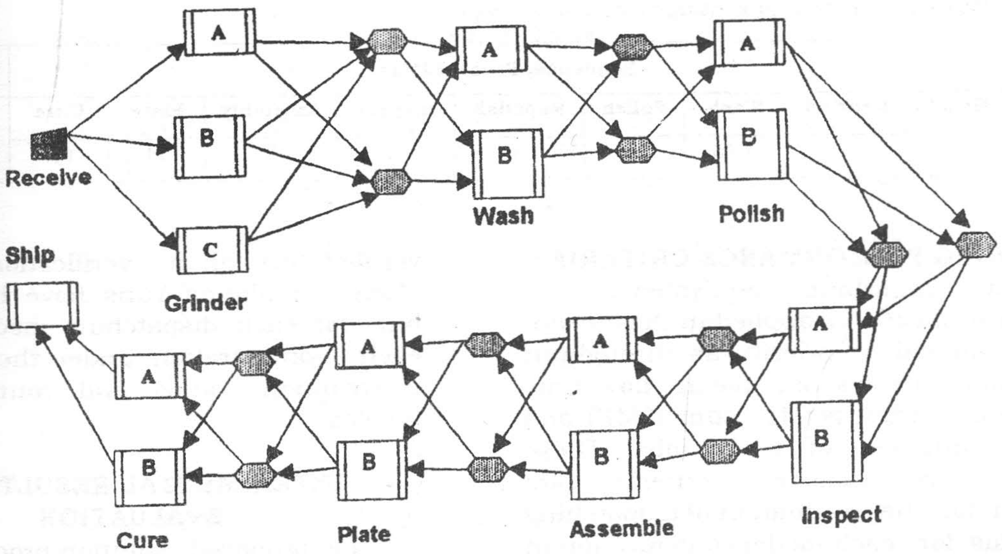

Figure 2 Physical layout and flow of part type of the moder under consideration.

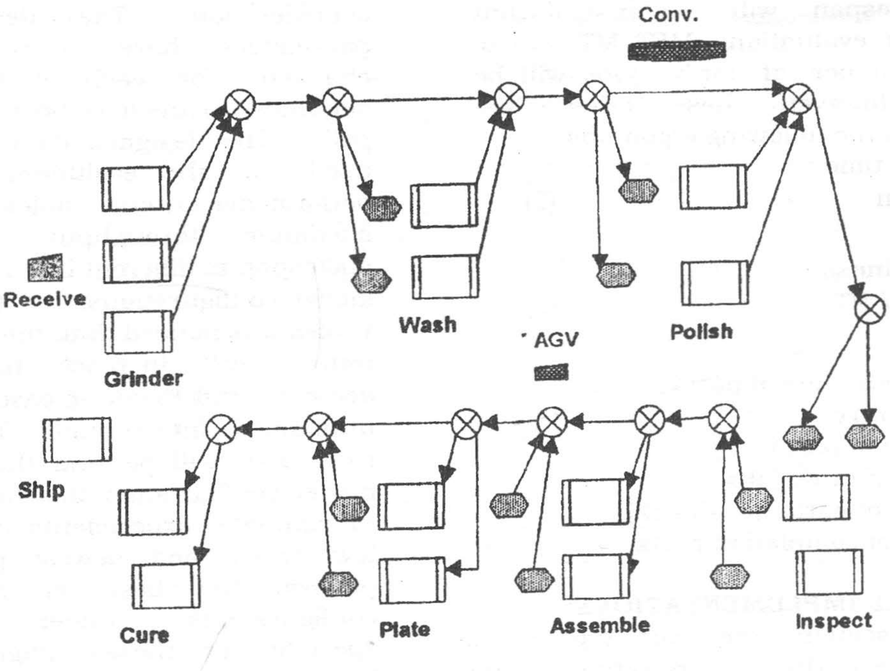

Figure 3 Transfer network of part type for the considered model.

In this study, the recommended standards for the detailed specifications of AGVs as a material handling system, maximum storage capacities of receiving and local buffers, and patterns of arrivals of raw material entered the model are considered. A crane is used in plating station for loading and unloading operations. Table 1 lists the part type sequence, processing times, and the evaluated due date.

Table 1 Part type sequence, processing times, and due date.

Part	**Sequence, Process time**									**Due date min.**
	Grind	**Regrind**	**Wash**	**Polish**	**Repolish**	**Inspect**	**Assembly**	**Plate**	**Cure**	
Raw	10	4	2.75	6	3	2.5	5	14	120	1857.33

MEASURING PERFORMANCE CRITERIA

A few important equivalencies in performance measures applied in the current work are ranked in priority as throughput rate, product makespan, mean flow time (MFT), mean tardiness (MT), sum of MFT and MT, and number of tardy jobs. These measuring performance criteria are considered for the evaluation of dispatching mechanisms for each model configuration in order to determine the dispatching rule that will perform the best. When throughput and product makespan will be insignificant parameters for evaluation, MFT, MT, sum of both, and number of tardy jobs will be considered. However, these criteria are estimated as in the following equations.

1- Mean flow time

$$\sum(C_i - R_i) / n \qquad (2)$$

2- Mean tardiness

$$\sum \max(0,L_i) / NT \qquad (3)$$

where:

C_I : Completion time of part i
R_I : Time of entry
Di : Due date of part i
NT: Number of tardy jobs
L_I : Lateness of part i (C_I -R_I- Di)
n : Number of completion parts

MODEL IMPLEMENTATIONS

In this section, the part type flow, transfer networks connecting the subsystems of material handling are designed and constructed for each model configuration. All these details are described in part type process plan. The complete data information for each model configuration as well as the process plan are addressed in SIMFACTORY II.5 and verified through its verification procedure. Many simulation runs have been carried out for each dispatching mechanism per each configuration under the considered interruption ratios and route flexibility indices.

EXPERIMENTAL RESULTS AND EVALUATION

The proposed solution procedure along with selection strategies were implemented on the model configurations under consideration. The designed system parameters have been systematically changed for each strategy and the simulation runs have been applied for each policy. The designed data base program is used for the evaluation of measuring performance criteria. Tables 2 and 3 present maximum throughput and minimum makespan at different interruption ratios for model configurations. By the aids of these Tables it is noticed that, the increase of part routes will increase throughput and decrease makespan in case of planned and unplanned interruption. The dispatching rule that will perform the best for each model configuration has been pointed out. In simulated experiments, it is obvious that low usage and newest part rules will perform the best for most of model configurations under consideration specially for those configurations having low number of part routes. While fewest rule will perform the best for those configurations of high part routes. Also, for the same model configuration, the increase of interruption ratio will increase the makespan and decrease throughput.

Table 2 Maximum throughput at different interruption ratios for model configurations.

model conf.	**Interruption ratio**					
	0 %	20 %	40 %	60 %	80 %	100 %
M1	23.3 (R2)	21.7 (R12)	21 (R2)	22 (R3)	20.3 (R5,6,9)	21.7 (R9)
M2	23.7 (R3)	20.7 (R10,12)	21.7 (R3)	22 (R12)	21.6 (R4)	20.3 (R8)
M4	24.3 (R3)	21.3 (R13)	21.3 (R13)	21.3 (R1)	21.3 (R8)	21.7 (R14)
M8	23 (R9)	21.7 (R14)	21.3 (R7,9)	21.3 (R5,6,12,13)	22.7 (R12)	21.3 (R3)
M16	24.7 (R6)	22.3 (R8)	21.3 (R16)	22.3 (R1)	20.7 (R7,10)	21.3 (R1,3)
M32	24.3 (R7)	21.3 (R3,5)	20.7 (R9)	22 (R5)	21.3 (R6,12,15)	20.7 (R1,4)
M64	23.3 (R5)	21.3 (R6)	20.3 (R6)	21.3 (R8)	22.3 (R14)	21.3 (R10,12)
M128	46.3 (R10)	42.3 (R15)	42.3 (R11)	41 (R2)	41.7 (R9)	42 (R9)
M192	58 (R4,9)	58.3 (R11,15)	57.3 (R3,9)	56.3 (R15)	55.7 (R4,8)	56 (R7)

Table 3 Minimom makespan at different interruption ratios for model configurations.

model conf.	**Interruption ratio**					
	0 %	20 %	40 %	60 %	80 %	100 %
M1	225.7 (R12)	226.8 (R2)	234.3 (R2)	235 (R2)	239.7 (R16)	248.3 (R10)
M2	224.2 (R4,10)	228.8 (R12)	233.4 (R2)	234.4 (R12)	236.8 (R4)	252.1 (R16)
M4	231.6 (R12)	233 (R10)	229.9 (R14)	241.9 (R14)	237.8 (R14)	257.3 (R1)
M8	230.7 (R10)	237 (R10)	243.6 (R10)	249.1 (R8)	238.7 (R10)	259.6 (R8)
M16	231.3 (R8)	243.2 (R10)	242.6 (R8)	240.1 (R10)	240.5 (R8)	254.9 (R10)
M32	222.8 (R8)	229.7 (R3)	234.4 (R10)	232.5 (R10)	234.8 (R10)	254.4 (R10)
M64	220.4 (R10)	224.9 (R3)	235.3 (R8)	233.3 (R8)	231.5 (R3)	274.8 (R8)
M128	216.5 (R3)	221.4 (R10)	220.6 (R10)	224.2 (R3)	227.3 (R10)	239.9 (R3)
M192	227.3 (R8)	231.6 (R3)	238.6 (R10)	270.7 (R4)	194.7 (R10)	218.3 (R12)

This trend of variation has been obtained for all model configurations except that configuration model of maximum part route. In that model both maximum throughput and product makespan have no great influence by increasing interruption ratio. This is due to the increase of route flexibility added to the system. Table 4 lists the interruption ratios achieved maximum throughput and minimum makespan for model configurations. From this Table, it is observed that the increase of route flexibility in model configuration will affect the interruption ratios that will attain both maximum throughput and minimum makespan. In this aspect the best performance is achieved in model M16 at interr. ratio 60%. In such case, although the interruption ratio in some models are relatively high, both maximum throughput and minimum makespan are achieved. This means that; both maximum throughput and minimum makespan can be achieved at certain specified route flexibility index. Table 5 points out the average machine utilization at different interruption ratios for model configurations. In this Table, and for the same interruption ratio, the increase of route flexibility will increase the machine utilization's. While for the same model, the increase of interruption ratio will decrease the machine utilization.

Table 6 lists measuring performance criteria (MT, MFT, MT+MFT and TJ) for model configurations at different interruption ratios. In this table, it is clear that for the same model configuration, minimum MT and TJ have been achieved individually at certain specified route flexibility index. While minimum MFT and MT+MFT have been achieved at the highest route flexibility index. Also in case of increasing interruption ratio, the minimum value for each of the above measuring performance criteria has been obtained at certain specified route flexibility index.

Table 4 Maximum Thr. and Minimum MS for different configurations at Interruption ratios achieved.

Mode name Item	M1	M2	M4	M8	M16	M32	M64	M128	M192
Max. Throughput	60 %	60 %	100 %	80 %	60 %	60 %	80 %	40 %	20 %
Min. Makespan	20 %	20 %	40 %	20 %	60 %	20 %	20 %	40 %	80 %

Table 5 Machine utilization at different interruption ratios for different model configurations.

Model Conf.	Interruption ratio					
	0 %	20 %	40 %	60 %	80 %	100 %
M1	24.5	22.7	23	22.6	22.7	22.1
M2	26.8	24.9	25.1	25.4	25.6	24.9
M4	27.9	26	26.1	26.1	25.7	26
M8	27.8	26	25.8	25.9	26.5	25.7
M16	28.4	26.8	28.7	26.2	25.8	25.9
M32	28.4	26	25.8	26.8	26.3	26.3
M64	28.9	26.6	25.7	26	26.4	25.8
M128	48.7	45.3	45.4	44.7	45.4	44.4
M192	59.4	59.2	59.5	58.8	58.6	58.4

Table 6 Measuring performance criteria (MT, MFT, MT+MFT, No. of TJ), model configuration, interruption ratios.

Meas. Perf. Crit.	**Reference [No Interruption]**									**20 % Interruption**								
MPC	**M1**	**M2**	**M4**	**M8**	**M16**	**M32**	**M64**	**M128**	**M192**	**M1**	**M2**	**M4**	**M8**	**M16**	**M32**	**M64**	**M128**	**M192**
Mean Tardiness	826.8	878.7	812.2	895.9	862.5	837.7	807.2	* 763.2	796.1	849.2	878.7	831.9	841.8	801.9	* 751.3	782.5	862.3	796.1
Mean Flow Time	1815	1904	1892	1848	1873	1756	1814	1764	* 1611	1863	1904	1983	1810	1892	1957	1927	1774	* 1641
MT + MFT	2641	2782	2704.2	2743.9	2735.5	2593.7	2621.2	2527.2	* 2407	2712.2	2782.7	2714.9	2651.8	2693.9	2708.3	2709.5	2636.3	* 2437
No. of Tard. Jobs	44	* 36	40	42	43	43	46	85	127	38	36	36	36	36	* 33	34	76	126
Meas. Perf. Crit.	**40 % Interruption**									**60 % Interruption**								
MPC	**M1**	**M2**	**M4**	**M8**	**M16**	**M32**	**M64**	**M128**	**M192**	**M1**	**M2**	**M4**	**M8**	**M16**	**M32**	**M64**	**M128**	**M192**
Mean Tardiness	848.3	907.5	858.4	825.6	789.7	903.5	817.6	* 772.4	813.7	813.6	907.5	* 756.3	794.7	864.4	768.5	861.8	812.4	798.3
Mean Flow Time	1935	1851	1815	1799	1919	1994	1955	1783	* 1631	1873	1851	1933	1876	1836	2057	1885	1711	* 1641
MT + MFT	2783.3	2758.5	2673.4	2624.6	2708.7	2897.5	2772.6	2555.4	* 2445	2686.6	2758.5	2689.3	2670.7	2700.4	2825.5	2746.8	2523.4	* 2439
No. of Tard. Jobs	37	36	40	38	35	* 30	32	78	122	37	36	37	37	39	* 32	34	86	119
Meas. Perf. Crit.	**80 % Interruption**									**100 % Interruption**								
MPC	**M1**	**M2**	**M4**	**M8**	**M16**	**M32**	**M64**	**M128**	**M192**	**M1**	**M2**	**M4**	**M8**	**M16**	**M32**	**M64**	**M128**	**M192**
Mean Tardiness	868.4	907.5	906.1	812.6	794.9	814.3	687.8	* 678.2	772.9	816.3	861.7	877.3	777.9	860.5	759.1	* 751.8	792.3	777.3
Mean Flow Time	1834	1815	1994	2037	1897	1843	1961	1915	* 1642	1986	1910	1913	2041	1852	1960	1955	1733	* 1635
MT + MFT	2702.4	2758.5	2900.1	2849.6	2691.9	2657.3	2648.8	2593.2	* 2415	2802.3	2771.7	2790.3	2818.9	2712.5	2719.1	2706.8	2525.3	* 2412
No. of Tard. Jobs	34	36	* 29	32	35	39	36	64	121	34	35	34	* 32	34	35	33	82	125

*** Minimum value**

CONCLUSIONS

The interactive process between dispatching strategies, route flexibility index and interruption ratio has crucial influence on the performance of flexible manufacturing system. The dispatching strategy that will perform the best for each route index and interruption ratio has been determined. The present study clarified that; although the interruption ratio may be relatively high for some model configurations, the best performance is achievable at certain specified route flexibility index. Also one of the main conclusion of the current work is that; the increase of performance utilization is achievable at higher route flexibility index. Hence it is recommended to study the interactive process between dispatching strategies along with interruption ratios and route flexibility for FMS under consideration to pick up its configurations under which the performance will be utilized.

REFERENCES

1. J.S. Drake, Smith and B.A. Peters, "Simulation as Planning and Scheduling Tool for Flexible Manufacturing Systems", Department of Industrial Engineering, Texas A and M University, pp.1-13. (1998)
2. R. Logen, "Celluar Manufacturing Systems Research", Department of Industrial Engineering, Texas A&M University, pp.1-3, (1998)
3. M.A. Shouman and T. A. Husien, "The Combined Interactive Process Between Material Handling Systems and Dispatching Mechanisms in FMS" , AEJ, Vol. 36, No. 1, pp. A19-33(1999).
4. A. Hatchuel, D. S. Kabeche and J. C. Sardas, "Towards a New Planning and Scheduling Approach for Multistage Production Systems", International Journal of Production Research, Vol. 35, No. 3, pp. 867-886. (1997)
5. N. Ishii and M. Muraki, "An extended Dispatching Rule Approach in an on-Line Scheduling Frame Work for Batch Process Management", International Journal of Production Research, Vol. 34, No. 2, pp. 329-348, (1996).
6. J. Liu and B. L. MacCarthy, "The Classification of FMS Scheduling Problems", International of Journal Production Research, Vol. 34, No. 3, pp. 647-656, (1996)
7. F. Mahmoodi and G. E. Martin, "A New Shop-Based and Predictive Scheduling Heuristic for Cellular Manufacturing", International Journal of Production Research, Vol. 35, No. 2, pp. 313-326, (1997)
8. J. W. Barnes and J. B. Chambers, "Solvin the Job Shop Scheduling Problem With Tabu Search", IIE Transactions, Vol. 27, pp. 257-263, (1995)
9. J. Chandra and J. Talavage, "Intelligent Dispatching for Flexible Manufacturing", International Journal of Production Research, Vol. 29, No. 11, pp. 2259-2278. (1991)
10. Y. Arzi, "On-Line Scheduling in a Multi-Cell Flexible Manufacturing System", International Journal of Production Research, Vol. 33, No. 12, pp. 3283-3300, (1995)
11. R. J.Abumaizar and J. A. Svestka, "Rescheduling Job Shop Under Random Disruption", International Journal of Production Research, Vol. 35, No. 7, pp. 2065-2083, (1997)
12. Halder and J. Banks, "Simulation Software Products for Analyzing Manufacturing Systems", Computer Simulation of Manufacturing Systems, pp 98-101, July (1986).
13. Law and S.W. Haider, "Selecting Simulation Software for Manufacturing Applications: Practical Guide Lines and Software survey", Industrial Engineering, Vol. 34., pp. 33-46, (1995).
14. N.Ishii and J. J. Talavage, "A transient-Based Real-Time Scheduling Algorithm i FMS", International Journal of Productio Research", Vol. 29, No. 12, pp. 2501-252 (1991)

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The Interactive Process between Some Dispatching Mechanisms and Interrupted Machine Centers in FMSs

التفاعل المشترك لبعض إستراتيجيات قواعد الدفع بالمنتجات و نسبة أعطال الماكينات فى نظم التصنيع المرنة

محمد عباس شومان* ، جمال نوارة* ، عبد الناصر حسين* و أحمد الصادق**

*قسم الهندسة الصناعية والنظم - جامعة الزقازيق
** المعهد التكنولوجى العالى (مطروح)

خص البحث

يتناول البحث التالى دراسة التأثير المتبادل بين كل من نسبة الأعطال الفجائية للماكينات والمسارات المختلفة لإنتـــاج تج فى نظم التصنيع المرنة عند استخدام العديد من استراتيجيات قواعد دفع المنجات . تمت هذه الدراسة على عـــدد تســعة ذج من نظم التصنيع المرنة لكل منها عدد متباين من مسارات الانتاج (تتدرج من مسار واحد وحتى ١٩٢ مسار) وقد اجــرى حث على هذه النماذج عند نسب مختلفة للتوقف المفاجىء للماكينات ٠تتدرج من صفر الى ١٠٠٪)وذلك باستخدام ســتة ر قاعدة من قواعد الدفع. وقد خلصت الدراسة إلى أن التأثير المتبادل بين قواعد الدفع ونسب الأعمال والمرونة فى المسلوات ت تأثير حيوى وهام على أداء نظم التصنيع المرنة كما أنه قد تم تحديد قاعدة الدفع التى تعطى أفضل مستوى أداء فى كل حـل لة من الحالات التى تمت دراستها . كما خلصت الدرأسة إلى أنه بالرغم من وجود نسب توقف عالية فى بعض النظم إلا أنــه كن رفع مستوى أداء النظام بتعدد مسارات الإنتاج وبعض قواعد الدفع .