SCHEDULING USING PETRINET TO INCREASE UTILISATION OF RESOURCE IN FLEXIBLE MANUFACTURING SYSTEM

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ABSTRACT

Flexible Manufacturing System (FMS) is a mechanized assembling framework which has work shop adaptability and stream shop productivity. One of the real worries in FMS is booking of occupations to the machines with the target of expanding machine use. A Petri net is a graphical scientific displaying instrument appropriate to numerous frameworks and this is a promising device for portraying and contemplating data handling frameworks that are described as being simultaneous, non concurrent disseminated, parallel, nondeterministic and stochastic. The Petrinet idea is proposed to take care of booking issues. Disperse Search calculation is populace based met heuristic that used to join its answers and develop new arrangements. This technique creates a populace of arrangements. The dispatching rules calculation has assumed a noteworthy part in the entry of occupation to the machine as per the need of given determined parameter. Dispatching Rules resemble Shortest Processing Time (SPT), Longest Processing Time (LPT), Least Operation Remaining (LOR), Most Work Remaining (MWR), Most Operation Remaining (MOR) and Least Work Remaining (LWR). This paper manages demonstrating and booking of Flexible Manufacturing System (FMS) utilizing diverse Meta Heuristics calculations like Petrinet, Dispatching Rules and Scatter Search. The outcomes are thought about for three distinctive contextual investigations and it is watched that the Petrinet gives better outcome when contrasted and different calculations, for example, Dispatching Rules and Scatter Search calculation as for machine usage.

Keywords: Flexible Manufacturing System, Petrinet, Dispatching Rules, Scatter Search algorithm, machine utilization.

1. INTRODUCTION

Petrinet were named after Carl A. Petri, who made a net-like scientific device for the investigation of correspondence with automata in 1962. They were further created to address the issue in determining process synchronization, offbeat occasion, simultaneous operations, and clashes or asset shearing for an assortment of mechanical computerized frameworks at the discrete-occasions level.

In any physical net, we can discover two essential components are hubs and connections. Both hubs and connections assume their own parts. For instance, strengths could be exchanged starting with one end then onto the next through hubs and connections. Diverse hubs and connections may bear distinctive strengths. A Petrinet separates hubs in two sorts: places and moves. Spots are utilized to speak to condition or status of a segment in a framework. They are imagined by circles.

Moves speak to the occasions or operations. They are envisioned by purge rectangles or strong bars. Two basic occasions are "begin" and "end". Rather than bidirectional connections in some physical nets, a PN uses guided circular segments to associate from spots (called input places as for a move) to moves or from moves to places (called yield places). As it were, the data exchange from a place to a move or from a move to a place is one-way. Two routes Transfer between a place and move is accomplished by outlining a circular segment from a place to a place and another bend from the move back to the place.

Places, moves and coordinated bends make a PN a coordinated diagram called the Petrinet structure. The elements is acquainted by permitting a place with hold it is possible that one or a positive number of tokens imagined by little strong spots. These specks could speak to the quantity of assets or demonstrate whether a condition is valid or not in a place. At the point when all information places hold enough number of tokens, an occasion demonstrated by a move can happen called move terminating. This terminating changes the token in spots, implying change of framework states. The presentation of tokens and their stream controlled through moves permit one to picture the material, control and data stream unmistakably. Besides, one can play out a formal check of the properties identified with the fundamental frameworks conduct, e.g., priority relations among occasions, simultaneous operations, fitting synchronization and opportunity from halts, monotonous exercises, and common rejection of shared assets.

LITERATURE REVIEW

Petrinets are scientific formalism planned to be utilized for demonstrating, reenactment and examination of several types of frameworks (1). In software engineering, Petri nets are utilized for demonstrating an awesome number of either equipment and programming frameworks or different applications in FC systems. An exceptional favorable position of Petrinet is their graphical documentation, which decreases Petrinet learning time and disentangles their utilization (2). Henceforth Petrinets are utilized for instructing various ideas in software engineering (3). The trial strategies in software engineering have much of the time prompt to imperative improvements in both hypothesis and practice. Developing models and performing recreation are the center issues in test technique (4). A Petrinet can be distinguished as a specific sort of bipartite coordinated chart populated by three sorts of items. These items are places, moves and guided bends associating spots to moves and moves to places.

The focal piece of the Petrinet structure is a Petri net comprises of the Petri net essential ideas: places, moves and bend (5).

Hung et al., (6) shows a Petri net way to deal with displaying and recreation of a dispersion cell controller in an IC CIM System. Numerous semiconductor manu-
ufacture procedures are extremely mind boggling and managing deterministic circumstances at the procedure step level and vulnerability at a larger amount because of asset conflict, expected upkeep downtime and sudden disappointments. Consequently, diagnostic arrangements get to be distinctly inconceivable for these cases.

Xiong (7) proposed the utilization of Petri nets and heuristic inquiry calculations to timetable semiconductor test office. Two half breed systems are utilized and thought about. The biggest framework contains number of assets with their amounts fluctuating from one to fourteen, 30 occupations each with three test handle steps.

Cavalieri et al., (8) researched the utilization of shaded Petri nets as a structure to plan adaptable semiconductor fabricating frameworks in a genuine modern plant. A heuristic calculation is proposed to infer dispatching rules for each machine.

Silva et al., (9) Petri nets have been appeared to be fruitful instruments for displaying FMS as a result of the favorable circumstances, for example, the graphical nature, the succinctness of encapsulating both the static structure and the flow, and the accessibility of the numerical investigation methods. Be that as it may, when the demonstrating of a FMS is led with no confinements, breaking down the resultant net for such subjective properties as liveness is tedious and computationally unreasonable. To make the above issue tractable, diminishment and combination procedures are regularly utilized. Agerwala et al., (10) proposed a synthesis method which constructs nets by merging subnets through sharing usual places. Synthesis techniques can be defined as systematic methodologies of constructing net models. Previous work on Petri net synthesis for manufacturing modeling focused on guaranteeing properties without performing posterior analysis.

3. METHODOLOGY

The FMS is intended for its adaptability and it has four attributes, for example, entry of occupations, process time on machines, planning tenets and need for administrations. The issue which we need to tackle here is an occupation shop booking issue in FMS. The employment shop comprises of various preparing focuses called machines, which are fit for playing out numerous sorts of operations. A vocation is a requested arrangement of operations and the requesting is given in priority relationship. A section or incompletely completed item which enters and moves inside a FMS is known as a section. A completed part that leaves the FMS is known as an item. Every item is the consequence of a succession of procedures as indicated by its innovative prerequisites. Asset necessities are not considered in the procedures. A succession of procedures characterizes an item sort or an occupation sort. The landing of occupations are shifted relies on upon the procedure in light of the fact that diverse employments and distinctive operations, so the machine grouping of the item will be fluctuated. There are three contextual analyses utilizing planning for various occupations and distinctive operations like (9 machines X 2 employments, 14 machines X 3 occupations and 6 machines X 6 occupations). The three contextual investigations thought about for meta heuristics calculations Petrinet idea is the most better outcome and ideal machine usage. Utilizing the Petrinet apparatus MATLAB and watched the ideal demonstrating result. Here, the Petrinet is proposed to take care of planning issues and contrasted and Dispatching Rules and Scatter Search Algorithm in term of machine usage. look at the many contextual analyses taking care of the planning issues utilizing meta heuristics calculations the Petrinet idea is the most ideal machine use when contrast with other Dispatching Rules and Scatter Search Algorithms.

3.1 PETRINET

A Petri net is a graphical, scientific demonstrating device relevant to numerous frameworks and this is a promising device for depicting and considering data handling frameworks. As a graphical instrument, Petri nets can be utilized as a visual correspondence like stream outlines, piece charts and systems. As a scientific device, it is conceivable to set up state conditions, arithmetical conditions and other numerical models representing the conduct of frameworks. It is a specific sort of coordinated diagram together with an underlying state called the underlying stamping. What's more, tokens are utilized as a part of these nets to reproduce the dynamic and simultaneous exercises of framework. Petrinet can be utilized by both experts and theoreticians. In this way they give a capable medium of correspondence amongst professionals and theoreticians. Experts can gain from theoreticians how to make their models more orderly and theoreticians can gain from specialists how to make their models more practical. To effectively use the demonstrating approach, requires learning of both the displayed marvels and the demonstrating procedures.

The upsides of Petri net are formal intentions, graphical documentation, structure for simultaneity, accessibility of a few perception strategies. By utilizing MATLAB, the execution of adaptable assembling framework for the given contextual analyses is watched and the outcomes are looked at.

3.1.1 Components of the Petrinet
- Places are representing to a circle.
- Transition represents to a bar.
- Directed arc represents to connect the place to transition.
- Black dots are called as a token.

The components are used in Petrinet modeling and the diagram is shown in Figure. 1.

Figure- 1: Layout of Petrinet
Figure 1 shows the basic functioning of Petrinet. The current position \( P_1 \) having one token and it is ready to fire from its place and move to place \( P_2 \) with help of transition \( t_1 \).

A Flexible Manufacturing System comprises of an assortment of segments extending from robots, machines, crude materials, sensors, actuators, PCs and adornments identified with a procedure. At the demonstrating stages, one needs to focus on the genuine operations and their progressive or perspective, concurrent, or conflicting associations. The basic relations among these techniques or operations can be designated many.

1. **Sequential** If one operation takes after the other, then the spots and moves speaking to them ought to frame a course or successive connection in Petri nets. A case is appeared in Figure 2 (a).

2. **Concurrent** If no less than two operations are begun by an event, they shape a parallel structure starting with a move, i.e., no less than two spots are the yields of a same move. A case is showed up in Figure 2 (b). the synchronous operations can be addressed with a successively related course of action of spots/moves in which various spots can be stamped in the meantime or different moves are enabled at particular markings.

3. **Conflict** On the off chance that both of at least two operations can take after an operation, then at least two moves frame the yields from same place. An illustration is appeared in Figure 2 (c).

4. **Cyclic** On the off chance that a progression of operations tails in a consistent movement and finish of the last one begins the primary, then a cyclic structure is encircled among these operations. A representation is showed up in Figure 2 (d).

5. **Mutually Exclusive** Two methodology are absolutely disconnected in case they can't be performed meanwhile as a result of prerequisites on the utilization of shared resources. A structure to comprehend this is through a run of the mill put set apart with one token notwithstanding different yield and data round sections to institute these methods. For example, a robot may be shared by two machines for stacking and exhausting. Two such structures are parallel shared dismissal and successive basic denial discussed. A delineation is showed up in Figure 2 (e).

In the event that and have no consecutive affiliation or they are free without place and the related circuous parts, the structure is a parallel fundamental rejection. The focal points can be asked for into submitted and shared ones. The devoted part in a place with single information and single yield round sections just, the mutual ones a place with different information and various yield twists. A condition tending to the status of a sensor or an actuator is besides appeared with a place whose holding a token proposes reality of the showed condition. A relative sort of advantages might be tended to buy a place with the measure of tokens diverging from the measure of preferences. Start of an operation requires as frequently as conceivable two or three sorts of conditions and assets accessible appeared as a move with several information places. Finish of an operation may discharge two or three preferences and change the status of the conditions appeared as a move with a couple yield places.

![Figure 2 Examples of basic relations](image)

**Figure 2 Examples of basic relations (a) Sequential, (b) Concurrent, (c) Conflicting, (d) Cyclic, and (e) Mutually exclusive**

### 3.1.2 Properties of Petrinet

An imperative Properties of Petrinet in developed PN's as a numerical apparatus have various properties. These properties, when translated with regards to the demonstrated assembling framework, permit single to distinguish the nearness or nonattendance of the practical properties of the framework. Two sorts of properties can be recognized, behavioral and basic ones. The behavioral properties are those which rely on upon the underlying condition or stamping of a PN. The auxiliary properties, then again, don't rely on upon the underlying stamping of a PN. They rely on upon the Petri net topology or structure.

1. **Reachability** Given a PN \( Z = (P, T, I, O, mo) \) stamping is reachable from checking \( mo \) if there exists a grouping of move firings which changes \( mo \) to \( m \). Marking \( m \) is said to be quickly reachable from if terminating an empowered move in \( m \) prompts to \( m'. R \) (\( Z, mo \)) is utilized to speak to the arrangement of every single reachable checking. Achieve capacity checks whether the framework can achieve a particular state, displaying specific useful conduct. It is a behavioral property.

2. **Boundedness And Safeness** Given a PN \( Z \) and its reachability set \( R \), a place is B-limited if where B is a positive number. Z is B - limited if each place in \( P \) is B-limited. Safeness is 1-boundedness. These two properties are behavioral. The basic one is characterized as takes after: Z is fundamentally limited if Z is B-limited for some given any limited introductory stamping \( mo \). Spots are much of the time used to speak to capacity ranges for parts, instruments, beds, and mechanized guided vehicles in assembling frameworks. Boundedness is utilized to distinguish the presence of floods in the demonstrated framework. At the point when a place models an operation, its safeness ensures that the controller have no endeavor to start a continuous procedure. The idea of boundedness is regularly translated as soundness of a discrete
assembling framework when it is displayed as a lining framework.

3. Liveness A move is live if at any stamping m there is a grouping of moves whose terminating achieves a denoting that empowers A PN is live if each move in it is live.

4. A move is dead if there is with the end goal that there is no grouping of move firings to empower beginning from A PN contains a gridlock if there is at which no move is empowered. Such a stamping is known as a dead checking.

5. Deadlock Situations are as a result of unsuitable supply allocation policies or thorough use of some or all capital. For example, a deadlock may happen when a scheme is jammed or two or more process are in a circular chain, each of which waits for resources held by the process next in the chain. Liveness of a PN means that for any marking m reachable from the initial marking M it is ultimately possible to fire any transition in the net by progressing through some firing sequence. Therefore, if a PN is live, it has no deadlock. The above property is behavioral. The structural one is given as follows: a Petri net is structurally live if there is a finite initial marking which makes the net live.

3.2 SCATTER SEARCH

Scatter request is show up distinctively in connection to transformative met heuristics approach. It masses based issue fathomed to Combined the bended or non curved direct to yield better course of action. Standard headway procedures used to deal with the various streamlining issues complex to nature and hard. Disseminate look for estimation used to comprehend hard the arranging and upgrade issue. There has been growing eagerness to apply Meta heuristics strategies to deal with such sorts of progression issue. Considering distinctive objectives in arranging change is associated Meta heuristics approach of disperse interest in versatile amassing system. It has restricting together the joining game plans manage and to swear off making or duplicate courses of action are attempt flexible in memory lead in various periods of issue. For inspiration driving using unmistakable standard point of confinement the sit still time of the system. Disperse chase is built up on the begin that exact layout and methods for making new plans give benefits past those got from minor randomization. It uses procedures for interest improvement and elevating.

Steps for Scatter Search algorithm
1. Diversification generation method
2. Improvement method
3. Reference set update method
Subset generation method
Solution combination method
Diversification era strategy

It is creating an accumulation of various trial arrangements, utilizing a discretionary trial arrangement (or seed arrangement) as an info.

2. Improvement strategy

The change strategy takes after the era of another arrangement utilizing the enhancement era technique or the blend technique. An Improvement Method to change a trial arrangement into at least one upgraded trial arrangements. (Neither the info nor the yield arrangements are required to be practical, however the yield arrangements will more ordinarily be relied upon to be so. On the off chance that no change of the info trial arrangement comes about, the "upgraded" arrangement is thought to be the same as the information arrangement).

Subset era technique: A subset produces technique to work on the reference ser, to deliver a subset of its answers as a reason for making joined arrangements.

4. Reference set overhaul technique

The Reference Set overhaul Method comprises of two cases. The principal case is to decide the Ref Set from the underlying populace P. The second case is to keep up the Ref Set with Best" arrangements produced from the change strategy. The idea of "Best" does speak to arrangements with great quality as well as speaks to arrangements with great assorted qualities.

6. Solution mix strategy

This strategy utilizes the subsets produced utilizing the subset era technique with the point of making new arrangements. In planning the arrangement mix technique, the goal is to strike a harmony between arrangement strengthening and expansion. The blend strategy is a voracious heuristic technique that depends on a scoring component and depends on randomization as a sudden death round.

3.3 DISPATCHING RULE

Booking is a fundamental initiative process and it concerns the conveyance of the compelled resources for assignments after some time and is a basic part of creation systems since it fills in as a general game plan on which various other shop activities are based. By fittingly masterminding and timing of shop floor works out, various system execution measures can be streamlined.

Dispatching guidelines are among the practically sometimes associated in progress arranging, due to their straightforwardness of execution and low time multi-faceted nature. At whatever point a machine is open, a dispatching standard explores the holding up vocations and picks the occupation with the most hoisted should be taken care of next.

A dispatching fundamental is a choose that needs every one of the occupations that are sitting tight for process on a machine. At whatever point a machine has been freed, a dispatching standard audits the holding up occupations and picks the work with the most essential need. Dispatching rules contrast from each other in the way they compute needs. A confident course of action in the concentrated heuristic space is, thusly, given by a
progression (once-over) of dispatching guidelines. Each represent in this once-over is logically used to pick one operation (or social event of operations) to be doled out nearby its required machine.

There are two key parts in any reserving structure: arrange time and changes (checking and updating the timetable). It is classifieds two sorts as static booking and component arranging. Dynamic circumstances are in nature and distinctive intrusions called as steady events, which can change the system and impacts its execution. Dynamic arranging has considered innumerable time events and their possessions considering diverse amusing structures, for instance, stream shop and workshops. logistically events considered like instrument breakages, machine isolated, rough material unavailability, executive infection et cetera.

The benefits of dispatching principles are Very easy to actualize, Fast, can discover a sensibly decent arrangement in a generally brief time, Optimal for uncommon cases. Furthermore, the impediments of dispatching guidelines are Limited use practically speaking and can discover erratically terrible arrangement.

The basic dispatching rules are of limited use:
1) When a complex objective must be minimized, none of the basic dispatching rules can perform effectively.
2) Combination of basic dispatching rules can perform significantly better.
3) It is a ranking expression that combines several basic dispatching rules.
4) Each basic rule in the composite dispatching rule has its own scaling parameter that is chosen to properly scale the contribution of the basic rule to the total ranking expression.

3.3.1 Classification of Dispatching Rules
The dispatching rules have assumed a huge part in the landing of occupation to the machine as indicated by the need of given determined parameter.
1. Shortest Processing Time (SPT)
The most obliged arranging time lead engineers the organizations in the request of expanding dealing with times. At whatever point a machine is liberated, the most succinct occupation mastered at the time will start dealing with. This estimation is ideal for finding the base aggregate finishing time and weighted fulfillment time.

In the single machine condition with orchestrated time at 0 for all occupations, this estimation is impeccable in limiting the mean stream time, obliging the mean number of employments in the framework, compelling the mean holding up time of the organizations from the time of landing to the begin of dealing with, confining the most uncommon holding up time and the mean deferral.
2. Longest Processing Time (LPT)
The longest handling time governs the occupations in the request of diminishing preparing times. At whatever point a machine is liberated, the biggest employment prepared at the time will start handling. This calculation is a heuristic utilized for finding the base make span of a timetable. It plans the longest occupations first so that nobody substantial employment will "stand out" toward the finish of the calendar and significantly stretch the culmination time of the last employment.
3. Least Operation Remaining (LOR)
The Least Operation Remaining guideline arranges the occupations in the request of expanding preparing times. At whatever point a machine is liberated, the minimum operation containing occupation is prepared at the time will start handling.
4. Most Work Remaining (MWR)
The Most Work Remaining standard requests the occupations in the request of diminishing work remaining. At whatever point a machine is liberated, the most work remaining occupation is appointed at the time will start handling.

3.4 CASE STUDY
In this paper, the 9 machine X 2 product (case study-I), 14 machine x 3 products (case study-II) and 6 machine X 6 product (case study-III) are taken for the analysis and compared with Petrinet, scatter search and dispatching rule.

Table 1 Configuration of FMS for Case Study-I

<table>
<thead>
<tr>
<th>Layout type</th>
<th>No. of Machines</th>
<th>No. of parts</th>
<th>Load/Unload stations</th>
<th>No. of AGV</th>
</tr>
</thead>
<tbody>
<tr>
<td>U Loop</td>
<td>09</td>
<td>02</td>
<td>02</td>
<td>01</td>
</tr>
</tbody>
</table>

Table 2 Operation sequence for Case Study-I

<table>
<thead>
<tr>
<th>Part Type</th>
<th>Operation Sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>M2 M5 M3 M1 M8 M4 M6 M9 M7</td>
</tr>
<tr>
<td>P2</td>
<td>M6 M9 M5 M3 M1 M4 M7 M8 M2</td>
</tr>
</tbody>
</table>
Table 3 Operation Time for Case Study-I

<table>
<thead>
<tr>
<th>Part Type</th>
<th>Operation Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>M1 62 M2 9 M3 89 M4 87 M5 10 M6 66 M7 95 M8 49 M9 82</td>
</tr>
<tr>
<td>P2</td>
<td>M1 30 M2 95 M3 58 M4 61 M5 58 M6 60 M7 17 M8 8 M9 5</td>
</tr>
</tbody>
</table>

3.4.2 Case study-II

The Table 4 shows the operation sequence for different product (P-Knuckle, T200-Knuckle, Brake Disc) indicated in the table. And the operation time is shown in the Table 5 for different products indicated above.

Table 4 Operation Sequence for case study-II

<table>
<thead>
<tr>
<th>Product name</th>
<th>Operation Sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-Knuckle</td>
<td>1 2 6 7 8 9 11</td>
</tr>
<tr>
<td>T200-Knuckle</td>
<td>3 11 10 9 8 13 12</td>
</tr>
<tr>
<td>Brake Disc</td>
<td>4 5 13 - - -</td>
</tr>
</tbody>
</table>

Table 5 Operation Time for case study-II

<table>
<thead>
<tr>
<th>Part name</th>
<th>Operation Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>T200-Knuckle</td>
<td>M3 220 M8 22 M9 104 M10 210 M11 142 M12 143 M13 29</td>
</tr>
<tr>
<td>P-Knuckle</td>
<td>M1 4 M2 2 M6 13 M7 14 M8 11 M9 14</td>
</tr>
</tbody>
</table>

Table 6 Machine Types for case study-II

<table>
<thead>
<tr>
<th>Machine Name</th>
<th>SPM</th>
<th>CNC Lathe</th>
<th>VMC Drilling</th>
<th>VMC Milling</th>
<th>KPA Milling</th>
<th>Grinding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine No</td>
<td>1</td>
<td>2,3,4,5</td>
<td>6,8,10,12</td>
<td>7,9,13</td>
<td>11</td>
<td>14</td>
</tr>
</tbody>
</table>

4. RESULTS AND DISCUSSION

Keeping in mind the end goal to test the adequacy and execution of the proposed Petri net, Scatter Search and dispatching rules. By breaking down working on this issue investigation of 9 machine X 2 job, 14 machine X 3 occupation and 9 machines X 2 item. The outcome is given for the comparing contextual analysis and their required parameter.

The results for each case study by using petrinet modeling are given below.

Results for case study-I

The Table 7 shows the machine number and their machine utilization in terms of percentage by using petrinet modeling.

Table 7 Machine utilization for Case Study-I in Petrinet modeling

<table>
<thead>
<tr>
<th>MACHINE NO.</th>
<th>M1 80.12 M2 70.23 M3 93.59 M4 59.66 M5 92.75 M6 95.06 M7 49.77 M8 46.57 M9 84.23</th>
</tr>
</thead>
<tbody>
<tr>
<td>PETRINET</td>
<td></td>
</tr>
</tbody>
</table>

Table 8 Machine utilization for Case Study-III in Petrinet modeling

<table>
<thead>
<tr>
<th>MACHINE NO.</th>
<th>M1 70.6 M2 73.2 M3 64.9 M4 61.82 M5 93 M6 90</th>
</tr>
</thead>
<tbody>
<tr>
<td>PETRINET</td>
<td></td>
</tr>
</tbody>
</table>
The figure 1 shows the machine number in X-axis and Y-axis machine utilization as mentioned in the above table.

![Figure 1](image1.png)

**Figure 1** Performance of Petrinet for the case study-III

The results for each case study by using Scatter Search are given below.

**Results for Case Study-I**

The Table 9 shows the machine number and their machine utilization in terms of percentage by using Scatter Search.

<table>
<thead>
<tr>
<th>MACHINE NO</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>M7</th>
<th>M8</th>
<th>M9</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCATTER SEARCH</td>
<td>52.60</td>
<td>57.20</td>
<td>85.90</td>
<td>67</td>
<td>64.40</td>
<td>75.60</td>
<td>39.70</td>
<td>40</td>
<td>43.50</td>
</tr>
</tbody>
</table>

The figure 2 shows the machine number in X-axis and Y-axis machine utilization as mentioned in the above table.

![Figure 2](image2.png)

**Figure 2** Performance of Scatter Search for the case study-I

**Result for case study-II**

The Table 10 shows the machine number and their machine utilization in terms of percentage by using Scatter Search.

<table>
<thead>
<tr>
<th>Machines</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>M7</th>
<th>M8</th>
<th>M9</th>
<th>M10</th>
<th>M11</th>
<th>M12</th>
<th>M13</th>
<th>M14</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>13.50</td>
<td>43.80</td>
<td>66.00</td>
<td>69.00</td>
<td>46.00</td>
<td>19.20</td>
<td>16.00</td>
<td>16.20</td>
<td>13.50</td>
<td>21.00</td>
<td>42.30</td>
<td>14.30</td>
<td>8.90</td>
<td>2.50</td>
</tr>
</tbody>
</table>

The figure 3 shows the machine number in X-axis and Y-axis machine utilization as mentioned in the above table.
Result for case study-III

The Table 11 shows the machine number and their machine utilization in terms of percentage by using Scatter Search.

<table>
<thead>
<tr>
<th>Machines</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>46.30</td>
<td>32.60</td>
<td>63.20</td>
<td>61.80</td>
<td>58.80</td>
<td>27.10</td>
</tr>
</tbody>
</table>

The figure 4 shows the machine number in X-axis and Y-axis machine utilization as mentioned in the above table

The results for each case study by using dispatching rules are given below.

Result for case study-I

The Table 12 shows the machine number and their machine utilization in terms of percentage by using dispatching rules.

<table>
<thead>
<tr>
<th>Machines</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>M7</th>
<th>M8</th>
<th>M9</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPT</td>
<td>55.5</td>
<td>60.5</td>
<td>91.3</td>
<td>70.5</td>
<td>68.4</td>
<td>90.3</td>
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</tr>
<tr>
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<td>49.5</td>
<td>93.9</td>
<td>72.4</td>
<td>84.2</td>
<td>91.1</td>
<td>28.5</td>
<td>44.1</td>
<td>33.6</td>
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<tr>
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<td>51.7</td>
<td>55.1</td>
<td>90.6</td>
<td>71</td>
<td>73.7</td>
<td>87</td>
<td>36.3</td>
<td>22.3</td>
<td>30.1</td>
</tr>
<tr>
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<td>54.5</td>
<td>61.2</td>
<td>93.7</td>
<td>54.9</td>
<td>74.6</td>
<td>92.2</td>
<td>19</td>
<td>34.3</td>
<td>21.5</td>
</tr>
</tbody>
</table>
The figure 12 shows the performance of different dispatching rules keeping X-axis as machine number and Y-axis as machine utilization.

**Result for case study-II**

The Table 13 shows the machine number and their machine utilization in terms of percentage by using dispatching rules.

**Table 13** Machine utilization for Case Study-II in different dispatching rules

<table>
<thead>
<tr>
<th>Machine</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>M7</th>
<th>M8</th>
<th>M9</th>
<th>M10</th>
<th>M11</th>
<th>M12</th>
<th>M13</th>
<th>M14</th>
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<td>96.6</td>
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<td>74.8</td>
<td>63.6</td>
<td>41</td>
<td>30.9</td>
<td>24.8</td>
<td>59.8</td>
<td>57</td>
<td>14.3</td>
<td>20.9</td>
<td>5</td>
</tr>
<tr>
<td>LPT</td>
<td>49.8</td>
<td>93.6</td>
<td>96.6</td>
<td>97.4</td>
<td>74.6</td>
<td>63.4</td>
<td>41</td>
<td>30.9</td>
<td>24.8</td>
<td>59.8</td>
<td>57</td>
<td>14.3</td>
<td>20.9</td>
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<td>97.4</td>
<td>75</td>
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<tr>
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</table>

**CONCLUSION**

This paper includes on MATLAB petrinet, Scatter Search calculation and dispatching rules. To concentrate the execution of the given FMS, the Petrinet indicates ideal machine usage than Scatter Search result and determined dispatching rules from the watched three contextual analyses. In future work, the MATLAB petrinet approaches have various particular ramifications for the objective of planning enhanced streamlining techniques. To comprehend these suggestions, it is valuable to consider certain complexities exceptionally exploitable importance of "arrangement blend" and assessing the MATLAB petrinet with various demonstrating and to give an examination between them.

**REFERENCES**