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# Planning and Optimization Using of Flexible Manufactruing System With Petrinet to Hybrid Algorithm

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**Abstract: The design of an adaptable assembling framework (FMS) includes circulating various assets for accomplishing most extreme effectiveness. To give an assortment of items to clients the FMS has made a noteworthy arrangement of operational changes. Among this, format arranging is progressively significant in accomplishing profitability of FMS. The issue of this sort is combinatorial in nature and observed to be Non-deterministic Polynomial (NP) complete. This paper centers the circle design arranging of a FMS with the point of limiting the transportation remove and the backtracking separations of the Automated Guided Vehicles (AGV) utilizing the half breed Scatter Search - Particle Swarm Optimization calculation (SS-PSO). Since the Loop format has moderately low beginning expenses and contains couple of material taking care of connections with higher adaptability. SS-PSO works on binding together standards dependent on vital structures contrasted with other metaheuristic calculations, for example, GA, PSO and so forth. Half breed SS-PSO approach is connected to seven and nine machines circle format issue. It is discovered that the proposed calculation furnishes a superior arrangement with quick union rate contrasted and other metaheuristic calculations.**

**Keywords: Flexible manufacturing system, Hybrid algorithm, Particle swarm optimization, Scatter search algorithm.**

## I. Introduction

The reasonable perception of constant changes in the items has done to change over to Flexible Manufacturing System (FMS) rather than customary assembling frameworks. 15-70% of assessed assembling cost because of material dealing with. There is a probability of diminishing the assembling cost by 10-30% through legitimate arranging of design. In this way structuring the format is the significant issue and that must be settled in the arranging of the FMS. Better answer for design issue is vital for powerful usage of the assets and direct to an outrageous decrease of material dealing with costs [20].

Format of a FMS is generally dictated by the sort of material taking care of gadgets, for example, robots, AGVs, gantry cranes and so forth. Practically speaking, the most widely recognized formats are 1) Circle Type 2) Dynamic or Line Type 3) Stepping stool Type 4) Open field type 5) Robot focused sort. Among this, the circle design was observed to be appropriate, since it has moderately low introductory expenses and high adaptability in material handling practical perception of continuous changes in the items has done to change over to Flexible Manufacturing System (FMS) rather than traditional assembling frameworks.

## II. Literature Review

Amine Drira *et al.,* [1] proposed the need of business programming apparatus to aid the structure of assembling frameworks. Daniel Scholz *et al.,* [4] proposed a Tabu look calculation for the huge size issue occasion of the office format issue. Fred Glover *et al.,* [5] portrayed the idea of Scatter Search and re-connected for various application. Liang *et al.,* [12] proposed Tabu Search calculation and an ideal format was gotten. Ignacio Castillo *et al.,* [6] showed a demonstrating structure to set up the ideal answer for format plan issue. Dissipate Search (SS) is connected for the stage stream shop, adaptable assembling framework planning issue and the ideal calendar is gotten by Saravanan *et al.,* [16, 17]. A Genetic calculation is proposed to locate the most ideal arrangement and inferred this was increasingly reasonable to get a worldwide ideal procedure plan by Li *et al.,* [11]. Singh *et al.,* [20] checked on the metaheuristic methodologies, for example, SA, GA and Tabu Search to tackle enormous office design issue and proposed the ideal arrangement got is relies upon the underlying arrangement expected. Udhayakumar and Kumanan proposed and created Ant settlement streamlining and Particle

swarm improvement calculation to assess the target capacity of minimization of the separation voyaged and least number of backtrackings for an AGV. This investigation uncovers that, the need of a calculation which assemblies rapidly with less cycle. Kemal Alaykyran *et al.,* [8] proposed an altered Ant Colony Optimization for stream shop issue. Half breed and parallel application uncovers the better outcomes. Likewise, it is joined with other metaheuristics. Satheesh Kumar *et al.,* [19] built up the Scatter Search calculation to comprehend single line unequal territory office format issue. It is essential that the proposed SS calculation yields better answers for the huge size examples. Additionally proposed by the creators to utilize multi-column and circle format issue in FMS. Satheesh Kumar *et al.,* [18] showed PSO in unidirectional circle format structure issue with least traffic blockage. It might be stretched out to take care of bidirectional circle format issue. Jerald *et al.,* [7] executed four metaheuristic approaches for taking care of the booking streamlining issue of FMS. The molecule swarm calculation is observed to be predominant and gives the base consolidated target work. Numerous analysts are working the region of discovering vigorous timetable strategy for the material taking care of framework yet least intrigue appeared to limit the separation of backtracking. The writing obviously underpins the proposition of an effective heuristic to this issue. The utilization of developmental calculations for coordinated planning issue of FMS needs consideration. Other than that, the support to embrace developmental calculations, for example, a molecule swarm streamlining calculation is for the most part because of its exhibition in taking care of booking issues. Up until this point, half breed of Scatter Search with Particle Swarm Optimization has not been attempted to take care of the format structure issue. In this paper, Hybrid SS-PSO has been proposed to tackle the FMS bidirectional circle format issue. Albeit numerous analysts have been focused on plan and operational issues of adaptable assembling frameworks and the quantity of issues stay unsolved.

## III. Problem Description

A common format in FMS is the circle design in which the machines are masterminded in a circle and materials are transported in bidirectional. Requesting of the machines on top of it is a significant advance in structuring the bidirectional. A circle format configuration can be described as a blend of machines (m1, m2...mn) with a prefix of the stacking / emptying station. In FMS, AGVs are utilized to execute the undertakings for transporting the parts between the stations. A lot of M machines and P parts.

The objective function is stated as in the equation,
Minimize $Z = W_1D + W_2B$

$$D = \sum_{i=1}^{P}\sum_{j=1}^{M}\sum_{k=1}^{M} d_{ijk} \quad ; d_{ijk} = 0;\ if\ \ j = k$$

$$B = \sum_{i=1}^{P}\sum_{j=1}^{M}\sum_{k=1}^{M} b_{ijk} \quad ; b_{ijk} = \begin{cases} 1; & if\ \ j > k \\ 0; & \text{otherwise} \end{cases}$$

Let,

$d_{ijk}$ - Distance gone by AGV in moving part P from machine j to k.

$b_{ijk}$ - Backtracking separation by AGV in moving part P from machine j to k.

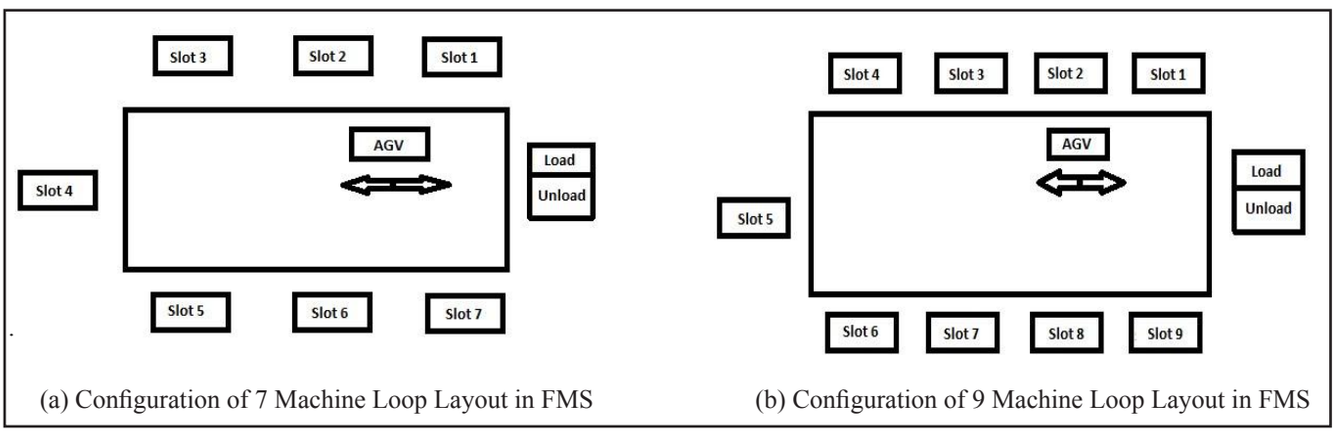
D - Total separation gone by AGV in moving all parts P.

A - Backtracking separation of an AGV in moving parts P.

W1, W2 - The loads allotted to every goal.

## IV. Problem Environment and Assumptions

The Fig. 1(a) and Fig. 1(b) demonstrates the circle design FMS issue for 7 and 9 machine which was taken from the writing, which demonstrates the heap / empty stations and there is the single AGV which is bidirectional and the seven machines are masterminded in the shut circle.




(a) Configuration of 7 Machine Loop Layout in FMS (b) Configuration of 9 Machine Loop Layout in FMS

Fig. 1

The following assumptions are made in this study:

- Jobs are independent and no priorities are assigned to any job type.
- Job pre-emption or cancellation is not allowed.
- Processing time and sequences of the jobs are known.
- Loading and unloading time of the jobs is neglected.
- Machine cell and duplication of tool is neglected.

## V. Proposed Methodology

The proposed half and half SS-PSO calculation is figured by combining two developmental heuristic inquiry calculations. The half breed calculation is appeared in Fig. 2. The proposed calculation is tried against benchmark issues.

### *A. Scatter Search (SS)*

Glover presented SS as a heuristic for tackling Integer Programming Problems. SS has a place with a transformative calculation family as they fabricate, continue and advancement a populace of answers to create new preliminary arrangements [5]. In SS, the underlying populace is made with great and expanded arrangements. At that point a reference set (RefSet) is created from an underlying populace of arrangements. Size of the RefSet in SS is moderately little when contrasted with the populace size of other transformative calculations. In other developmental calculations like GA, propagation depends on probabilistic choice of guardians, while in the SS, it depends on deterministic choice of reference arrangements. For consolidating the arrangements, SS works on binding together standards dependent on strategic structures, where different methodologies drives randomization.

### *B. Particle Swarm Optimization (PSO)*

Swarm-based insight is a computerized reasoning procedure dependent on the investigation of aggregate conduct in self-sorting out frameworks. Swarm-based frameworks are commonly made from populace out of people, which takes the discussion among them and condition. An individual could convey legitimately or through affecting in environment.

### *C. Hybrid Algorithm*

Half and half calculation is defined with the accompanying advances,

Step 1: The target capacity is being acquired from the underlying arrangement by utilizing the combinatorial streamlining.

Step 2: The addition heuristics are being finished with the underlying answer for create the new broadened arrangement.

Step 3: The proposed strategy for hybridization by applying the molecule swarm advancement procedure all together for the new grouping age by, for example New grouping = Present arrangement + Velocity.

Step 4: Reference set development is being done to locate the best and most pessimistic scenarios of the arrangement.

Step 5: The blend strategy is being done up to four component subset where the quantity of successions is acquired.

Step 6: New successions are being sifted and update the reference set.

Step 7: Based on the improvement with the reference set go to stage 5.

Step 8: If there is no improvement and n number of cycles are being performed until end criteria came to.

Step 9: If end criteria achieved stop the procedure.

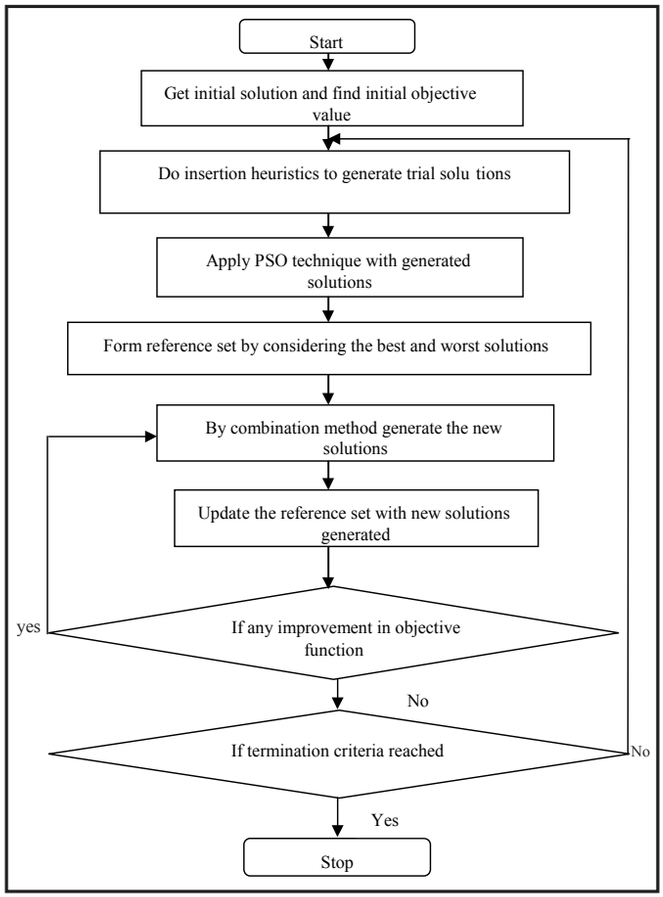



Fig. 2: Flow Chart for the Hybrid SS-PSO

## VI. Case Studies

Benchmark issues are browsed the writing, where there are two contextual analyses in which the setup of FMS is appeared in Tables I and V, section machine openings

occurrence framework is appeared in Tables II and VI. The Distance between the Machine spaces is appeared in Tables III and VII. The heap / empty Distance Matrix is appeared in Tables IV and VIII and the proposed calculation is tried for the predetermined number of cycles and the outcomes are dissected.

Table I: Arrangement of FMS - Case Study 1

| Layout | No. of Machines | No. of Jobs | Load / Unload Stations | No. of AGV |
|---|---|---|---|---|
| U-loop | 8 | 3 | 1 Each | 2 |

Table II: Part Machine Incidence Matrix

| Job | Process Sequence in Machines | | | |
|---|---|---|---|---|
| J1 | 1 | 5 | 3 | 8 |
| J2 | 1 | 7 | 4 | 5 |
| J3 | 2 | 7 | 4 | 6 |
| J4 | 3 | 5 | 3 | 8 |

Table III: The Distance Matrix Between the Machine Slots

| Slots | S1 | S2 | S3 | S4 | S5 | S6 | S7 |
|---|---|---|---|---|---|---|---|
| S1 | 0 | 2 | 4 | 8 | 12 | 12 | 10 |
| S2 | 2 | 0 | 2 | 6 | 10 | 12 | 12 |
| S3 | 4 | 2 | 0 | 4 | 8 | 10 | 12 |
| S4 | 8 | 6 | 4 | 0 | 4 | 6 | 8 |
| S5 | 12 | 10 | 8 | 4 | 0 | 2 | 4 |
| S6 | 12 | 12 | 10 | 6 | 2 | 0 | 2 |
| S7 | 10 | 12 | 12 | 8 | 4 | 2 | 0 |

Table IV: Load / Unload Distance Matrix Between Slots

| Slots | S1 | S2 | S3 | S4 | S5 | S6 | S7 |
|---|---|---|---|---|---|---|---|
| Load | 4 | 6 | 8 | 12 | 10 | 8 | 6 |
| Unload | 6 | 8 | 10 | 12 | 8 | 6 | 4 |

Table V: Arrangement of FMS - Case Study 2

| Layout | No. of Machines | No. of Jobs | Load / Unload Stations | No. of AGV |
|---|---|---|---|---|
| U-loop | 10 | 3 | 1 Each | 2 |

Table VI: The Part Machine Sequence Matrix

| Jobs | Process Sequence in Machines | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| J1 | 3 | 6 | 4 | 2 | 9 | 5 | 7 | 10 | 7 |
| J2 | 7 | 10 | 6 | 4 | 2 | 5 | 8 | 9 | 2 |

Table VII: The Distance Matrix Between the Machine Slots

| Slots | S1 | S2 | S3 | S4 | S5 | S6 | S7 | $S_8$ | $S_9$ |
|---|---|---|---|---|---|---|---|---|---|
| S1 | 0 | 6 | 8 | 12 | 14 | 14 | 12 | 8 | 6 |
| S2 | 6 | 0 | 6 | 10 | 12 | 14 | 12 | 10 | 8 |
| S3 | 8 | 6 | 0 | 8 | 10 | 12 | 10 | 9 | 7 |
| S4 | 12 | 10 | 8 | 0 | 8 | 11 | 12 | 9 | 10 |
| S5 | 14 | 12 | 10 | 8 | 0 | 7 | 9 | 12 | 6 |
| S6 | 14 | 14 | 12 | 11 | 7 | 0 | 12 | 14 | 12 |
| S7 | 12 | 12 | 10 | 12 | 9 | 12 | 0 | 4 | 6 |
| $S_8$ | 8 | 10 | 9 | 9 | 12 | 14 | 4 | 0 | 4 |
| $S_9$ | 6 | 8 | 7 | 10 | 6 | 12 | 6 | 4 | 0 |

TABLE VIII: THE LOAD / UNLOAD DISTANCE MATRIX BETWEEN SLOTS

| Slots | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 | S9 |
|---|---|---|---|---|---|---|---|---|---|
| Load | 3 | 5 | 7 | 8 | 13 | 13 | 13 | 12 | 15 |
| Unload | 4 | 5 | 8 | 9 | 14 | 15 | 11 | 16 | 17 |

To outline the exhibition of proposed calculation a 7 machine 4 occupation and 9 machine 2 employment circle design FMS is considered. The FMS comprise of single bidirectional material dealing with framework i.e., Automated Guided Vehicle (AGV) and stacking and emptying stations one each. Machines are accepted as novel in nature and the machining arrangements are known.

## VII. RESULTS AND DISCUSSION

The created metaheuristics is assessed on a similar standard arrangement of test issues accessible in the writing [14]. The proposed mixture calculation is contrasted and the current calculations, for example, GA, SS and Hybrid SSA-SAT. After effects of SS-PSO for contextual investigation 1 is given in Table IX. Target work by the proposed developmental calculations for contextual analysis 1 is given in Fig. 3. The use of half and half calculation has enriched with proof as the ideal estimation of the target work with the current calculations. Table X demonstrates the after effects of created calculation for contextual analysis 2. The target capacity esteem for the contextual analysis 2 is given in Fig. 4.

TABLE IX: CORRELATION OF SS, PSO AND THE HALF AND HALF SS-PSO CONSEQUENCES OF CONTEXTUAL ANALYSIS I

| No. of Iteration | SS [9] | | | PSO | | | Hybrid SS-PSO | | |
|---|---|---|---|---|---|---|---|---|---|
| | B | D | Z | B | D | Z | B | D | Z |
| 1 | 167 | 5 | 101.8 | 163 | 4 | 93.2 | 109 | 1 | 69 |
| 100 | 149 | 4 | 90.6 | 143 | 4 | 85.6 | 109 | 1 | 69 |
| 200 | 141 | 4 | 85.8 | 134 | 4 | 81.8 | 109 | 1 | 69 |
| 300 | 135 | 6 | 83 | 128 | 3 | 78.2 | 109 | 1 | 69 |

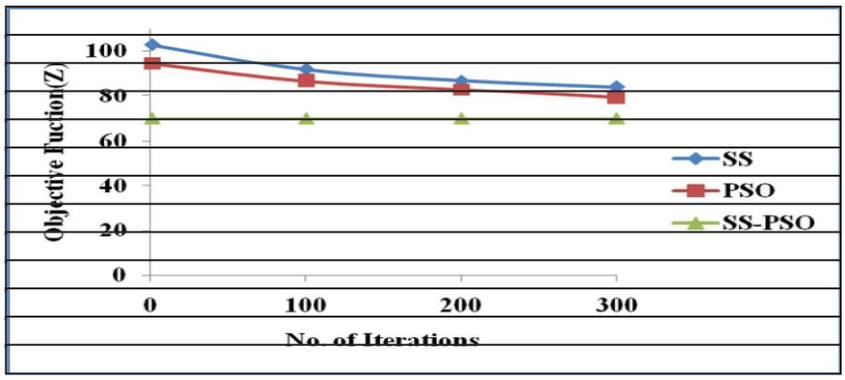



Fig. 3: Performance of the Hybrid SS-PSO for Case Study 1

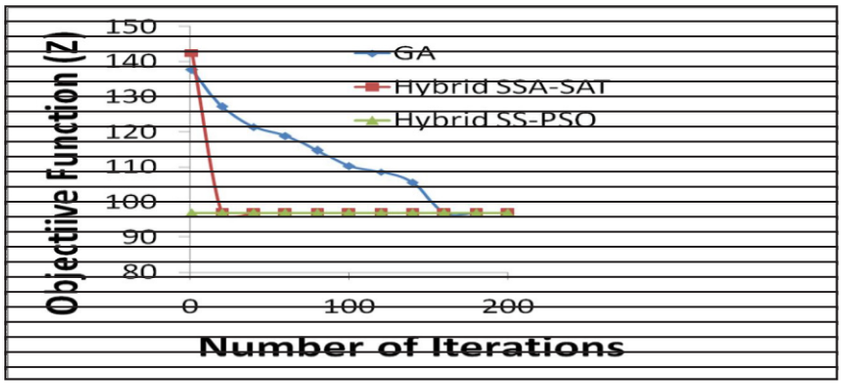



Fig. 4: Execution of the Cross Breed SS-PSO for Contextual Analysis 2

This comparative system was connected to a 9 machine 2 work issue for finding the ideal arrangement. The outcomes got were accounted for in the Table X. The proposed calculation additionally created an ideal estimation of target work. It might because of the union of worldwide optima. The comparable outcomes were additionally revealed in the writing [14].

TABLE X: COMPARISON OF GA, THE HYBRID SSA-SAT AND THE HYBRID SS-PSO RESULTS OF CASE STUDY 2

| No. of Iteration | Objective Function (Z) | | |
|---|---|---|---|
| | GA [14] | Hybrid SSA-SAT [10] | Hybrid SS-PSO |
| 1 | 136.6 | 141.39 | 96 |
| 20 | 126.2 | 96 | 96 |
| 40 | 120.4 | 96 | 96 |
| 60 | 117.9 | 96 | 96 |
| 80 | 113.8 | 96 | 96 |
| 100 | 109.4 | 96 | 96 |
| 120 | 107.6 | 96 | 96 |
| 140 | 104.6 | 96 | 96 |
| 160 | 95.99 | 96 | 96 |
| 180 | 95.99 | 96 | 96 |
| 200 | 95.99 | 96 | 96 |

## VIII. CONCLUSION

The half breed SS-PSO is able in discovering better answer for bidirectional circle format structure issues with less endeavor. The SS-PSO calculation is connected to m x n issue for the limiting the separation gone by AGV and the backtracking separation. The outcomes acquired were contrasted and other metaheuristic calculations like SS, PSO, and ACO and so forth. The ideal estimation of target capacity was improved by 11.67% for a seven machine issue and acquired the comparable outcomes in the writing for nine machine issue with moderately less calculation time. In future, this proposed developmental cross breed calculation might be connected for frameworks with more AGVs, different formats and the outcomes are thought about in all cases.

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