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DEVELOPMENT OF A PATH LAYOUT OPTIMIZATION MODEL FOR AGV IN FLEXIBLE MANUFACTURING SYSTEM USING PARTICLE SWARM OPTIMIZATION (PSO) APPROACH

Dr. Surinder Kumar[1] and Prof. Tilak Raj[2]

[1]Department of Mechanical Engineering, Shri Ram College of Engineering and Management, Palwal, Haryana,
[2]Department of Mechanical Engineering, J.C. Bose University of Science and Technology YMCA, Faridabad, Haryana,
Email:[1]Skumar.srcem@gmail.com,[2] skumar.apj@gmail.com

Abstract

Industry path layout arrangement of a flexible manufacturing system (FMS) has an important role in achieving high productivity and quality product at a competitive cost and time. Layout deals with the selection of machines, path of material movement and material handling devices involved in manufacturing a product. In this paper path layout optimization model has been proposed for FMS environment. The key purpose of this layout problem is to get the sequence of machines in the order by using Particle Swarm Optimization (PSO) approach for random generation, and automated guided vehicle (AGV) path minimization. This idea has been developed to select the best FMS layout and bi directional movement of an AGV just about the loop type layout. The spaces among the machines have also been considered in this loop layout design for a FMS environment to achieve the optimized and better results.

Keywords: *Automated Guided Vehicle, FMS, Java programming, PSO and loop layout*

Introduction:

In the present scenario manufacturing concerns are adopting flexible manufacturing systems to avoid facing competition in technology at global level due to shortened product life cycles and highly quality demand by the customers at lowest price. Because it is quite difficult to survive for manufacturing concerns without using advance and optimize manufacturing techniques in combination with advanced material handling systems for developing countries. Only FMS can be used to fill up the gap between the traditional job shop and advance automated transfer lines. According to Ponnambalam and kiat (2008) about 15–70% of the manufacturing costs are raised due to material handling only. Materials handling must be performed effectively (the right materials in the right amount to the right location at right time in right condition with a right manner) without damage. Scheduling of material handling systems in FMS are equally responsible as machines for actual time evaluation so a good path layout design is more effective in cost and time reduction. Fauadi and Murata, (2010) have suggested that a best layout design is also a most an important issue and it must be resolved in initial phase of the FMS. Material handling devices are generally used to determine the machine layout so that raw materials, finished goods and tools can move from one location to another to facilitate the overall operations of manufacturing.

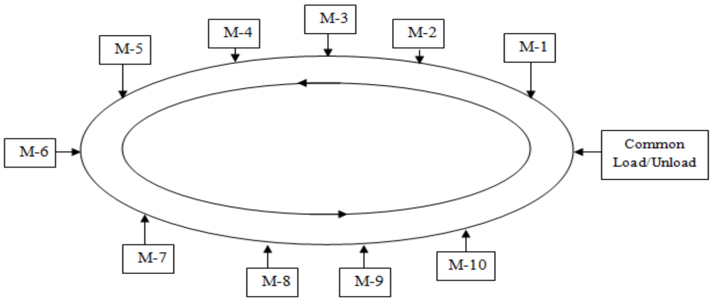

Figure 1 Machines loop layout

2 Literature Survey

Literature indicates that plant layout is an important factor of a production system that minimizes the movement of material between the machines and processing time for production by proper utilization of resources and AGVs etc. According to Kumara et al., (2008), PSO heuristics may be a solution option for unidirectional loop layout problem in flexible manufacturing system. Muhammad Hafidz, et al., (2010) have also suggested that Binary Particle Swarm Optimization is a best technique for synchronized machines and AGVs path scheduling minimization. Bansal and Darbari (2012) suggested an outline in which machine scheduling can be achieved intelligently by using MCDM and DRSA techniques. Mallikarjuna et al., (2013) suggested an optimal solution of a loop layout problem for FMS environment which can be solved by using Genetic algorithm (GA), because it provides more accurate result then Simulated Annealing (SA). Nanvala and Awari, (2011) proposed a review on Swarm intelligence method for solving the scheduling problem of FMS. Shivhare and Bansal (2014) also proposed a layout optimization method for FMS by using Mat lab. In this paper, PSO approach has been proposed for obtaining the minimum total distance travelled by AGV between machines (i.e. optimal sequence selection). This sequence has been selected by computation method for optimal path layout selection by using Java programming and based on this a model has been proposed. Scheduling of automated guided vehicle in different flexible manufacturing system environment, the simultaneous scheduling of machines and AGVs in FMS are addressed using GA for the minimization of makespan (Vasava, 2014). The FMS layouts can also be solved by the genetic algorithm. Various authors such as Kouvelis and Chiang (1992), Heragu and Alfa, (1992) have used single row machine layouts for FMSs. Similarly, Solimanpur et al., (2005) used an ant colony optimization, and Kumar et al., (2008) have used the scatter search method to resolve the machine layout problems for FMS. Chen et al. (2016) used PSO for routing pickup and delivery of multiple products with material handling in multiple cross-docks. Hamed, et al., (2018) utilized improved Particle Swarm Optimization for a Class of Capacitated Vehicle Routing Problems.

3 Problem Description

We have selected a loop layout for 10 numbers of machines in Flexible manufacturing system (FMS) environment. These machines have been organized in a loop layout and materials are moved by the single AGV in bidirectional manner. Designing of loop transportation system is also an essential step for finding the relative order of machines in the bidirectional loop to minimize the transportation cost, time and number of backtracking if any occurs in the loop layout.

4 Particle Swarm Optimization

Particle swarm optimization (PSO) is a computation base technique used for search algorithm from a population. Basically this technique is inspired by the behavior of bird flocking and fish schooling.

It is a set of rules which performs optimization of a non-linear and multidimensional problem to provide excellent solutions while requiring minimal parameterization. This wonderful technique was designed and initiated by Kennedy and Eberhart (1995). PSO is similar to many other non-traditional techniques such as Genetic Algorithms (GA). However this technique does not have evolution operators like crossover and mutation used in (GA). Under this technique, every particle is having synchronization to the solution space which offers best result for the particle under consideration. The outcome of this result value is called personal best (pbest). PSO tracks another best value known as global best (gbest) in the locality of the considered particle. The basic working of the PSO algorithm has been illustrated in Figure 2.

In PSO each particle has a position (1) and a velocity (2) which are calculated as follows:

$X_{i,d}(it + 1) = x_{i,d}(it) + v_{i,d}(it + 1)$ ---- (1)

$V_{i,d}(it + 1) = v_{i,d}(it) + C1 * Rnd(0, 1)*[pb_{i},(it) * x_{i,d}(it)] + C2 * Rnd(0, 1) *[gb_{d}(t) * x_{i,d}(it)]$ ---- (2)

PSO can be implemented by adjusting the few parameters only. This technique also has been applied in many different areas like artificial neural network, function optimization, fuzzy system control, study in social behaviors and many more. Particle swarm optimization has numerous advantages like: simple, easy to implement, proficiency in computation and good base for artificial life.

Application of PSO approach**:** PSO can be used in various diverse domains such as artificial neural network training, Biomedical, Communication Networks, Clustering and Classification, Combinatorial Optimization, Design, Engines and

Motors, Entertainment, Prediction and Forecasting Robotics, Security and Military, Sensor Networks, Signal Processing, fuzzy system control and other areas where GA can be applied.

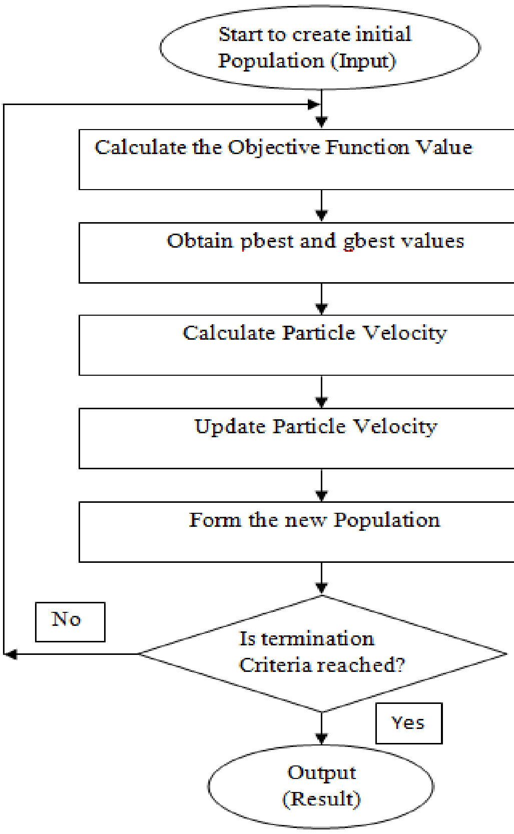

Figure 2 Flow chart of PSO Algorithm

5 PSO Algorithms

The step wise procedure involved in PSO algorithm is as follows:

- Create a population of n particles arbitrarily.
- Compute fitness value of every particle. Also, at this point, compare fitness value with pbest value. If it is batter, then set this fitness value as new pbest.
- Select particle having best fitness value (gbest) for all the particles.
- Compute particle velocity every particle using the following equation.

V [ ] = V [ ] + C1*rand ( ) *(Pbest [ ] – Present [ ]) + C2 *rand ( ) * (gbest [ ] – Present [ ])

Where, Present [ ] = present [ ] + V [ ].

V [ ] = particle velocity, Present [ ] = current particle (solution), rand ( ) = random number among (0, 1), C1, C2 = acceleration factors (Range between 1 and 4)

- Clamp particle velocities for each dimension to the maximum velocity (V max).
- Stop after reaching maximum iterations quantity.

If not, go away to Step 2.

6 JAVA Programming

Java is a programming language and it is used for numerical computation and programming purpose. This can be used to develop algorithms, models and applications from C and C++.

Java applications usually runs on any Java Virtual Machine (JVM). Currently Java is best one for programming languages work. Java programming for Particle swarm optimization (PSO) is as follows:

public void initialize Swarm( ) {

Particle p;

For (int i=0; i<swarm size; i++) {

p = new Particle ( );

// randomize location inside a space defined in Problem Set double [ ] loc = new double [problem_dimension];

loc[0] = ProblemSet.loc_x_low + generator.nextDouble( ) * (ProblemSet.loc_x_high - problemset.loc_x_low);

loc[1] = ProblemSet.loc_y_low + generator.nextDouble( ) * (ProblemSet.loc_y_high - ProblemSet.loc_y_low);

Location location = new Location (loc);

```
// randomize velocity in the range defined in
Problem Set double [ ] vel = new double
[problem_dimension];

vel [0] = ProblemSet.vel_low +
generator.nextDouble ( ) * (ProblemSet.vel_high -
ProblemSet.vel_low);

vel [1] = Problem Set.vel_low +
generator.nextDouble ( ) * (ProblemSet.vel_high -
ProblemSet.vel_low);

Velocity velocity = new Velocity (vel);

p.setLocation (location);

p.setVelocity (velocity);

swarm. Add (p);

                    }

          }
```

7 Generation of new sequence

First, initial population is created arbitrarily and its objective function value (OFV) is computed. Then, new sequence is generated for the next iteration. Table 1 shows the java programming output for new sequence generation. Similarly for all remaining present particles, new particles are generated and the OFV is calculated. This process is achieved for the desired iterations for obtaining the optimal value.

Table 1 Snapshot of Java programming Output for generation of new sequence (Sample for S. No 4. of Table 2)

Result 4					
3	3.929667	0.724118	2.85	13.12	4.61E+00
8	2.976976	0.494058	1.47	13.12	8.92E+00
7	3.001283	0.500583	1.50	13.12	8.73E+00
2	3	0.5	1.50	13.12	8.75E+00
9	2.996979	0.503456	1.51	13.12	8.70E+00
10	3.047998	0.505857	1.54	13.12	8.51E+00
1	2.987524	0.499834	1.49	13.12	8.79E+00
4	3.25651	0.558327	1.82	13.12	7.22E+00
6	2.987524	0.499834	1.49	13.12	8.79E+00
5	3.113001	0.532218	1.66	13.12	7.92E+00
Sequence	PBEST	GBEST	Updated Velocity	Distance	optimal Value 80.89

8 Assumptions used for layout optimization

- All tools used are new at the initial stage.
- Machines or material handling systems are free from breakdowns.
- A particular tool and operation is allocated to a specific machine.
- Distances between machines are same.
- Machines are not identical.
- Setup costs vary with shape and size of component.

9 Optimize Path Layout

Now in this proposed optimized path layout the movement of an AGV has been changed to bidirectional movement from the unidirectional movement in this layout. In this optimized path layout one common delivery post is considered having unloading equipments like robots etc. similarly every machine having separate loading station equipped with loading arrangement. The main aim of this proposed optimized path layout is to improve in productivity enhancement, total distance moved by AGV within the minimum time frame, minimization in backtracking of the AGV and reduction in the floor space requirement. Figure.2 shows the new proposed path layout. Best machine sequence for the selected FMS path layout is 3 8 7 2 9 10 1 4 6 5 based on PSO method. AGV travels 40 m distance or 131.2 feet per cycle. Here, no backtracking has been taken in account. The optimized machine path layout with proper sequence has been illustrated in Fig.3. There is 10 numbers of optimal orders from 100 iterations obtained from the computation and objective function values have been selected as shown in the Table.2.

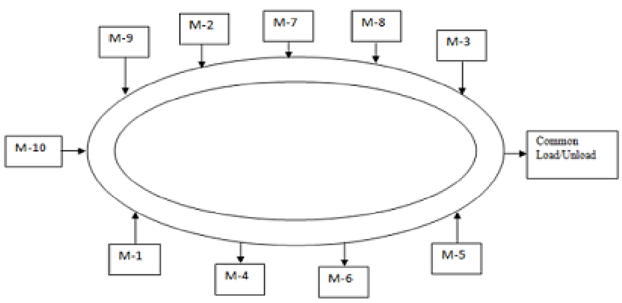

Figure 3 Proposed path layout

S.No	Sequence	Objective Function Value
1	9 8 5 7 1 6 2 10 3 4	87.05
2	10 4 5 2 8 1 3 7 6 9	94.1
3	8 10 6 9 3 4 1 7 5 2	82.7
4	3 8 7 2 9 10 1 4 6 5	80.9 - Min
5	8 5 9 4 2 1 10 6 3 7	87.0
6	9 5 7 3 4 6 8 2 1 10	91.0
7	5 3 6 4 8 7 10 1 2 9	86.2
8	7 4 2 10 6 8 5 9 1 3	85.7
9	9 5 8 6 4 7 3 1 10 2	86.6
10.	4 3 8 7 10 9 5 6 2 1	85.7

Details of the proposed Optimized plant layout are as follows:-

- Number of machines = 10
- Total distance travelled by AGV =40 m or 131.2 Feet
- Number of AGV = 01 (for bidirectional movement)
- Distance among the machines = 4m (Not same for all provided machines)
- Optimal machine sequence = 3 8 7 2 9 10 1 4 6 5
- Number of backtracking = Nil

The proposed optimized path layout consists of ten machines and is arranged on the basis of optimal sequence as shown in fig. 3.

10 Layout optimization

Objective function for loop layout optimization can be illustrated as

X = A1*P + A2*Q

Where,

A1, A2 is the normalized weight i.e. 0.9, 0.4

P – Distance moved by AGV for one complete cycle.

Q – No. of back tracking in one cycle, if any.

11 Results and Discussion

The suggested path layout, machines are positioned in an appropriate location in such a way that distance travelled by AGV is minimum which results in reduction of idle time of AGV. The best machine sequence for the considered FMS layout is 3 8 7 2 9 10 1 4 6 5. AGV travels distance 40 m per rotation and no backtracking occurs in each cycle. Now, some of the optimal sequences derived from the computation are shown below in the Table 2.

Table 2 Optimal Sequence

12 Conclusion

In the present research work, proposed Particle Swarm Optimization (PSO) algorithm which is also known as a non-traditional optimization algorithm has been used for obtaining the best possible solution of bidirectional loop layout problem. The main motive of this research is to reduce the total time consumed and distance moved by AGV between the machines to reduce the number of backtracking per cycle if any. This algorithm has been used to provide a best solution for loop layout problem. A java programming has been used for 100 generations by 10 test runs for every occurrence in a problem. For a proposed objective function, optimum sequence of machines can also be found out for the proposed layout of a FMS. The optimum numbers of sequences in a Loop layout model can be found for a given optimum layout in FMS. The model is not limited up to a single solution only, but it also suggested a range of good solutions which may be different. From the result it has been concluded that this proposed approach regarding path layout is improved optimization approach like Simulated Annealing (SA) and Genetic Algorithm (GA). This approach can also be further extended to solve the loop layout and bidirectional loop problems based on MIN_MAX objective.

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