Optimization of Production Equipment Layout Based on Fuzzy Decision and Evolutionary Algorithm

Wenfang Chen, Hunan International Economics University, Hunan, China

ABSTRACT

A method of optimizing equipment layout is proposed in production equipment layout of a complex manufacturing system, using fuzzy decisions combined with evolutionary algorithms. First, the optimization model is improved, the total cost is minimized, while the requirements of adjacent equipment and the space utilization are maximized; the material handling cost, the resetting cost, the loss of production costs are considered in the total cost objective. Second, this method takes into account the ambiguity of the satisfaction and priority of users such as cost, utilization and proximity requirements, based on the fuzzy decision theory, the multi-objective optimization model is fuzzified, and the fuzzy fitness function is designed to evaluate the pareto solution set according to the user’s priority relation. Based on the characteristics of the solution model, the chromosomal coding method of multi-objective evolutionary algorithms and the genetic operation mode are improved, and the practicability and efficiency of the model is improved. Finally, the effectiveness of the method is proved by the optimization of the practical case.

KEYWORDS

Evolutionary Algorithm, Fuzzy Decision-Making, Evolutionary, Fuzzy Fitness Function, Layout Optimization, Multi-Objective Optimization

1. INTRODUCTION

Optimization of equipment layout is one of the core contents of production system design. The optimization of equipment layout is divided into static optimization and dynamic optimization. Static optimization is assuming that the production equipment is fixed in different production cycles, the equipment is optimized according to the process, type and quantity of the product, the production logistics costs are minimized. However, due to the rapid changes in market competition, the traditional static optimization are both enterprises in the new workshop, or transformation and restructuring, etc., it cannot meet the requirements of enterprises quickly, promptly and reasonably determine the manufacturing system layout program needs. Gupta and Seifoddini (1990) pointed out that more than one-third of companies in the United States have to reset or adjust the equipment on average every two years. Balakrishnan (1993) pointed out that US companies spend more than $250 billion a year on production plant design or retrofit optimization, and that costs are increasing year by year. Similarly, in China, many large and medium-sized state-owned enterprises production equipment need to be updated, transformation and restructuring from time to time, a large number of production equipment need to re-layout. Therefore, the layout of the production equipment is
optimized, it can reduce the number of equipment adjustments, the logistics costs are reduced, it is a matter of great concern to enterprises.

Dynamic Plant Layout Problem (DPLP) is based on static optimization. The factors are considered such as product process change, variety change, design update and change equipment change, update and reorganization of production mode in different production cycles, these are a typical combinatorial optimization problem, they can be expressed as: for the system within the different manufacturing cycle of the dynamic changes in the product, a reasonable equipment layout program is selected, the equipment re-layout is to meet the smooth production at the same time, it can also ensure that the total manufacturing cost is minimal. Kulturel (2007) analyzed the influence of logistics constant, randomness and equipment size on DPLP, and he pointed out that DPLP occupies a very important position in manufacturing system in the 21st century. Moslemipour (2012) studied the common solution method of DPLP problem, analyzed the advantages and disadvantages of deterministic method, heuristic method and intelligent algorithm, and pointed out that the deterministic method or heuristic method can only be used to solve the small DPLP. For large DPLP problem, only the intelligent algorithm can get the desired solution.

A hotspot in the DPLP problem is how to build an exact solution algorithm. Genetic algorithm (GA) has a wide range of combinatorial optimization problems in solving the nonlinear or nonconvex problem, and it is no relation to the properties of the required objective function. The performance of GA is directly related to the expression and parameter setting of genetic individuals. Therefore, when solving DPLP problem with GA, the research focus on how to improve genetic algorithm, Balakrishnan and other (2000) proposed CONGA algorithm and NLGA algorithm, the core is chromosome coding way to be improved, that is, a real number encoded by the device number. Chang (2002) proposed a multi-population co-evolutionary approach, the population is decomposed into multiple subpopulations, and each subgroup independently evolves and updates the shared information. Dunker (2005) designed hybrid algorithm, it combines dynamic programming and genetic search. Simulated Annealing (SA) has a high efficiency in solving the known optimization problem of data structure. Baykasoglu (2001) had achieved good results with simulated annealing algorithm in solving large-scale DPLP problems. McKendall (2006) designed a forward and backward two-stage SA algorithm to solve DPLP problem; Dong (2009) put the device layout problem, and the SA algorithm is used to obtain the satisfactory solution. In the optimization of DPLP problem, Şahin (2010) considered the constraint of budget cost and improved the SA.

In addition to GA and SA, the construction, improvement of other intelligent algorithms and improvement of the problem model is also the focus of the DPLP problem researchers. For example, Rosenblatt (1986) constructed a DPLP mathematical model, it contains logistics costs and equipment replacement costs, and the corresponding branch-bound method is designed to solve. McKendall (2012) designed a three-layer topological search method, the first layer is to take a relatively simple heuristic approach, a variety and intensive strategy is added in the second layer, and a probability of topology search method is used in the third layer. Erel (2003) proposed a three-stage heuristic algorithm. First, according to the different data flow in the optimization period, different weight coefficients are assigned, and the preliminary optimal layout scheme is obtained, and then the dynamic programming method is used to obtain the satisfactory solution of the problem from the known optimal solution. Finally, the stochastic descending order pairing strategy is used to improve the satisfactory solution to get the final optimization. Hosseini-Nasab (2013) proposed a hybrid particle swarm optimization algorithm (HPSO) to solve, they designed a special application in the DPLP coding and decoding methods, so that the discrete solution space in the DPLP problem is one to one correspondence with the continuous solution space in PSO.

Although the results of the mentioned various solutions in the above studies have achieved good results, the discussion of the cost structure is less discussed in the DPLP multi-objective optimization model. Most of them only consider the material handling fees, and discuss the equipment moving costs. There are few studies on the cost of equipment replacement and resettlement losses. In
15 more pages are available in the full version of this document, which may be purchased using the "Add to Cart" button on the product's webpage:

www.igi-global.com/article/optimization-of-production-equipment-layout-based-on-fuzzy-decision-and-evolutionary-algorithm/230314?camid=4v1


www.igi-global.com/e-resources/library-recommendation/?id=2

Related Content

Mapping the Critical Links between Supply Chain Evaluation System and Supply Chain Integration Sustainability: An Empirical Study

www.igi-global.com/article/mapping-critical-links-between-supply/53024?camid=4v1a
Ordering Policy in a Two-Warehouse Environment for Deteriorating Items with Shortages under Inflationary Conditions
[www.igi-global.com/article/ordering-policy-two-warehouse-environment/78360?camid=4v1a](www.igi-global.com/article/ordering-policy-two-warehouse-environment/78360?camid=4v1a)

Context in Decision Support Systems Development
[www.igi-global.com/chapter/context-decision-support-systems-development/11244?camid=4v1a](www.igi-global.com/chapter/context-decision-support-systems-development/11244?camid=4v1a)

A New Multi-Objective Model for R&D Project Portfolio Selection Considering Potential Repetitive Projects and Sanction Impacts