

MANUFACTURING CELLS DESIGN IN JOB SHOP PRODUCTION SYSTEMS USING A P-MEDIAN MODEL AND A GENETIC ALGORITHM

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Abstract

Manufacturing cell design in job shop production systems is a challenging problem that directly affects production efficiency, material handling costs, and shop floor organization. This paper proposes a mathematical optimization model to support the formation of manufacturing cells by partitioning a production system into smaller and more manageable subsystems. The model is based on a p-median formulation that assigns machines and parts to manufacturing cells while minimizing the number of intercell part movements and respecting constraints on cell sizes. This paper makes two main contributions. First, it develops a p-median-based formulation for the manufacturing cell formation problem that explicitly incorporates constraints on cell sizes. Second, it proposes a practical solution approach that combines a genetic algorithm with spreadsheet-based optimization tools, facilitating implementation in industrial environments.

The approach is evaluated through a real-world case study from a manufacturer of agricultural machinery and implements that exports its products to several countries in the Caribbean, Africa, and South America. The production system manufactures approximately 3,500 parts using 96 machines belonging to 43 different machine types, which are subsequently assembled into final products.

Because the resulting optimization problem can become computationally intensive for large instances, a genetic algorithm is developed to efficiently obtain high-quality solutions. For small instances, optimal solutions are obtained using the Microsoft Excel Solver, while larger instances are solved using OpenSolver.

In the case study, the number of movements between cells obtained with both the genetic algorithm and OpenSolver was 314, which is a very high value. Eight machines, for which there is only one unit available on the factory floor, are responsible for 241 of these movements. Since no alternative machines exist for these operations, these movements cannot be eliminated through reassignment within the current system. The computation time required to solve the case study instance on a microcomputer (Intel i7 processor, 2.30 GHz, 8 GB RAM) was 4 seconds and 18 seconds for OpenSolver and the genetic algorithm, respectively.

Additional computational experiments show that the proposed model effectively groups machines and parts into manufacturing cells while substantially reducing the number of intercell movements. The analysis of the resulting solution also identifies critical machine bottlenecks and suggests system improvements, including the acquisition of additional machines to increase the operational independence of manufacturing cells. Moreover, since the proposed approach can be implemented using spreadsheets, one of the most widely used tools in industrial environments, it can be readily adopted by managers, technicians, and manufacturing engineers.