

A DYNAMIC PART ASSIGNMENT PROCEDURE IN MACHINE CELL FORMATION

Hamid Seifoddini
Associate Professor
Industrial and Systems Engineering Department
University of Wisconsin-Milwaukee

Manoocher Djassemi
and PhD Candidate
Industrial Systems Engineering Department
University of Wisconsin-Milwaukee

ABSTRACT

A major contributing factor to the under utilization of machines in cellular manufacturing is the development of long queues in front of some machines in machine cells. This paper presents a procedure which identifies such machines and redistributes their loads to alternative machines whenever feasible.

INTRODUCTION

Cellular manufacturing is one of innovative modern manufacturing techniques which has emerged as a solution to the problem of inefficiencies in batch-type manufacturing. It is based on the formation of dedicated machine cells each capable of processing one or more part-families (groups of parts with similar machining requirements) for their entire operations. Cellular manufacturing overcomes some of major problems of batch-type manufacturing including frequent setups, long throughput times, and excessive in-process inventories [2,9].

A number of studies indicate that in some cases, the full benefits of cellular manufacturing cannot be realized unless some deviation from the original structure of the cellular manufacturing system is tolerated [1,3,8]. One important deviation from pure cellular manufacturing is the transfer of parts between machine cells. The part transfer between machine cells in cellular manufacturing creates intercellular material handling which is disruptive to achieving the maximum productivity potential of cellular manufacturing systems. In spite of this in many cases such a practice is necessary to balance the workload among the machines in different machine cells. A survey of manufacturing companies using cellular manufacturing shows that 20% of companies with manned and 14% of companies with unmanned cells have part transfer between machine cells [1,10]. Furthermore, the survey indicates that on the average, 20% of processing time of parts occur outside of their original machine cells.

In this paper a dynamic part assignment (DPA) procedure is presented to deal with the problem of imbalanced work load on machines in machine cells.

Dynamic Part Assignment (DPA) Procedure

The existing part assignment procedures in cellular manufacturing are static in nature. That means they determine in advance, the primary machine cell in which a part-family should be processed. They allow part transfer between machine cells when exceptional parts (parts which require operations in more than one machine cell) exist. These procedures cannot deal with the needed adjustments due to continuous changes in the status of machine cells during operation. DPA is developed to overcome the problems associated with the existing part assignment procedures.

In DPA, the status of machine cells is continuously monitored and as soon as a machine is over loaded, alternative machines in other machine cells are checked for possible rerouting of parts that can be fully processed in the alternative machine cell. There are two main requirements for the implementation of DPA:

1. Parts in the part-families should have alternative routings that can be used to reassign them to an alternative machine cell.
2. There should be a dynamic cell monitoring system which detects the overloading of machines and identifies alternative machines and machine cells.

These requirements call for a dynamic cell control system which is becoming an important feature of modern manufacturing systems. The flow chart of the DPA procedure is given in Figure 1. In the following pages, the effectiveness of DPA will be demonstrated through the application of a numerical example.

Numerical Example

A manufacturing system with 15 machines and 18 parts is used to compare the performance of a conventional job shop manufacturing system with the corresponding cellular manufacturing system when DPA is employed. The machine-component chart representing the machining requirement of parts is generated and given in Figure 2. The presence or absence of a "one" entry in row i and column j

COMPONENTS

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|----|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|
| L1 | 1 | 1 | | 1 | | | | | | | | 1 | | | | | | |
| L2 | | | 1 | | | 1 | | 1 | | | | | | | | | | |
| M1 | | 1 | | 1 | | | | | 1 | | | 1 | | | | | | |
| M2 | | | 1 | | 1 | 1 | | | | | | | | | | | 1 | |
| M3 | | | | | | | 1 | | | | | | | | | | | 1 |
| G1 | 1 | 1 | | | | | | | 1 | | | 1 | | | | | | |
| G2 | | | 1 | | | 1 | | 1 | | | | | | | | | | |
| G3 | | | | | | | | | | 1 | 1 | | 1 | | 1 | | | |
| G4 | | | | | | | 1 | | | | | | | 1 | | 1 | 1 | |
| D1 | | 1 | | 1 | | | | | 1 | | | 1 | | | | | | |
| D2 | | | | | 1 | | | | | | | | | | | | | |
| D3 | | | | | | | | | | 1 | 1 | | 1 | | 1 | | | |
| D4 | | | | | | | | | | | | | | 1 | | 1 | 1 | 1 |
| S1 | 1 | 1 | | | | | | | 1 | | | 1 | | | | | | |
| S2 | | | 1 | | 1 | 1 | | 1 | | | | | | | | | | |

Figure 2. The initial machine-component chart

COMPONENTS

| | 4 | 2 | 1 | 9 | 12 | 3 | 8 | 5 | 6 | 10 | 15 | 13 | 11 | 18 | 14 | 17 | 16 | 7 |
|-----|---|---|---|---|----|---|---|---|---|----|----|----|----|----|----|----|----|---|
| L1 | 1 | 1 | 1 | | 1 | | | | | | | | | | | | | |
| M3 | 1 | 1 | | 1 | 1 | | | | | | | | | | | | | |
| G6 | | 1 | 1 | 1 | 1 | | | | | | | | | | | | | |
| D10 | 1 | 1 | | 1 | 1 | | | | | | | | | | | | | |
| S14 | | 1 | 1 | 1 | 1 | | | | | | | | | | | | | |
| M2 | | | | | | 1 | | 1 | 1 | | | | | | | | | |
| L2 | | | | | | 1 | 1 | | 1 | | | | | | | | | |
| D2 | | | | | | | | 1 | | | | | | | | | | |
| S15 | | | | | | 1 | 1 | 1 | 1 | | | | | | | | | |
| G7 | | | | | | 1 | 1 | | 1 | | | | | | | | | |
| D12 | | | | | | | | | | 1 | 1 | 1 | 1 | | | | | |
| G8 | | | | | | | | | | 1 | 1 | 1 | 1 | | | | | |
| M5 | | | | | | | | | | | | | | 1 | | 1 | | 1 |
| G9 | | | | | | | | | | | | | | | 1 | 1 | 1 | 1 |
| D13 | | | | | | | | | | | | | | 1 | 1 | 1 | 1 | |

Figure 3. Machine-component groups

indicates the presence or absence of operation j on machine i [8].

One of the existing machine-component grouping algorithms such as the similarity coefficient method can be used to form the machine cells and part-families [7,8]. The machine component groups for this example is given in Figure 3. There are four machine cells with the size ranging between 2 to 5 machines.

Solution Methodology

The performance of manufacturing system under job shop and cellular manufacturing is evaluated using simulation modeling. SIMLAN language is selected due to its flexibility in modeling material handling systems [4,5,6]. The production volume for each part is assumed to be exponential with the expected daily volume of 70 parts. The processing time of each operation is also exponential with the average of one hour. Further more, it is assumed that the area of each cell is proportional to the number of machines in that cell (one unit area for each machine).

In cellular manufacturing, no intercellular move is allowed. When DPA is employed parts having operations on the most overloaded machine are reassigned to an alternative machine cell where they can be processed for all their operations.

Simulation Results

The cellular manufacturing system and the corresponding job shop system were simulate for 20 days beyond the warm up period. The results are summarized in Table 1.

As results in Table 2. indicate, the performance of the cellular manufacturing system is superior to the corresponding job shop manufacturing when DPA is employed. In the pure cellular manufacturing the steady state is not achievable due to accumulation of parts in the front of bottleneck machines.

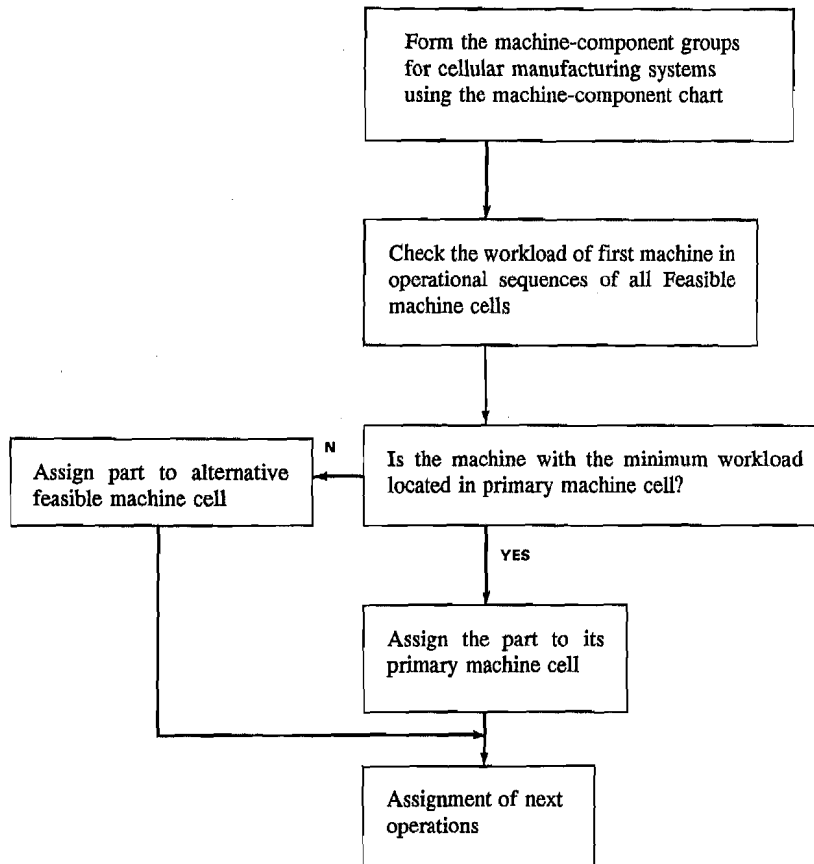


Figure 1. Flow chart for dynamic part assignment procedure.

TABLE 1. Simulation Results

| Type | Average Throughput Time | Average In-process Inventories | Average Machine Utilization | Average Distance Travelled |
|---------------------------|-------------------------|--------------------------------|-----------------------------|----------------------------|
| Cellular Manufacturing CM | NA* | NA | NA | NA |
| CM with DPA | 19.3 | 0.62 | 44 % | 26.6 |
| Job Shop | 28.6 | 0.95 | 45 % | 128 |

*Model did not reach steady-state

CONCLUSION

In this paper a DPA procedure was presented. The simulation results indicate that DPA can substantially improve the performance of a cellular manufacturing system. When Cellular manufacturing and DPA are used together the performance of the corresponding job shop manufacturing system is improved.

REFERENCES

1. Ang, C. P., Willey, P. C., "A Comparative Study of the Performance of Pure and Hybrid Group Technology Manufacturing Systems Using Computer Simulation Techniques," International Journal of Production Research, IJPR, 1984, Vol. 22, No. 2, pp. 193-233.
2. Ballakur, A. and Steudel, H., "Cellular Manufacturing Systems," International Journal of Production Research, IJPR, 1987, Vol. 25, No. 5, pp. 639-665.
3. Flynn, B. B. and Jacobs, F. R., "A Simulation Comparison Group Technology with Traditional Job Shop Manufacturing," International Journal of Production Research, IJPR, 1986, Vol. 24, No. 5 pp. 1171-1192.
4. Law, A. M. and Kelton, W. D., "Simulation Modeling and Analysis," McGraw-Holt, New York, Second Edition, 1991.
5. Pegden, C. D., Shanon, R. E., and Sadowski, R. P., "Introduction to Simulation Using SIMAN," McGraw Hill, New York, 1990.
6. Priksker, A. B., "Introduction to Simulation and SLAM II," John Wiley, New York, 1986.
7. Seifoddini, H. and Wolfe, M. P., "Application of the Similarity Coefficient Method in Machine Cell Formation in Group Technology," Institute of Industrial Engineering (IIE).
8. Seifoddini, H., "Performance Evaluation of Hybrid Cells in Cellular Manufacturing," Institute of Industrial Engineering (IIE) Transactions, 1992, Vol. 24, No. 1, pp. 84-88.
9. Welke, H. A. and Overbracke, J., "Cellular Manufacturing: A Good Technique for Implementing Just-in-Time and Total Quality Control," Journal of Industrial Engineering, 1986, Vol. 20, No. 11, pp. 36-41.
10. Wemmerlov, U. and Hyder, L., "Cellular Manufacturing in the U. S. Industry: A Survey of Users," International Journal of Production Research, IJPR, 1989, Vol. 21, No. 9, pp. 1511-1530.