A Case Study on Hybrid Cellular Layouts

Introduction

This case study discusses the theoretical background of hybrid cellular layouts in the factory. Traditionally either a Functional or Cellular layout has been recommended for a jobshop. The Functional layout has advantages such as high machine utilization at workcenters and high flexibility in allocating operations to several alternative machines in a workcenter. However, it has disadvantages such as high throughput times and high WIP levels. In direct contrast, the Cellular layout has advantages such as, low throughput times and low WIP levels. However, high machine utilization is not guaranteed in all cells. Also, the absence of intercell flows limits flexibility in case of machine breakdowns and changes in demand or product mix.

This case study describes a variety of Hybrid Cellular Layouts (HCLs) that attempt to avoid the physical separation of identical machines in several cells without destroying the original cell composition. All of these layouts are developed from the initial machine-part grouping analysis used to design independent cells. However, during the layout phase, creative layout strategies are used to place the shared machines as if they had been retained in functional sections. Instead of a pure Cellular or Functional layout for a jobshop, these layouts represent a novel fusion of partial conversion to a Cellular layout, functional grouping of several shared machine types, limited physical duplication of shared machines and intercell flows.

ISBN 978-93-83302-14-7

sdmimd

The case writer(s) Jaideep Gupte, Assistant Professor - Operations, may be reached at jgupte@sdmimd.ac.in

Hybrid Cellular Layouts: Integration of Functional and Cellular Layouts

Table 1 shows the routing of each product in a hypothetical facility that consists of 12 machines and produces 19 products. Figures 1 and 2 show a Functional layout and a Cellular layout with three cells generated for the sample of parts in Table 1, respectively. With reference to the cells shown in Figure 2, machine types 1, 6, 7, 9 and 10 have been physically duplicated among the cells. This physical duplication of identical machines into cells destroys the flexibility obtained by having all machines of a shared type in a functional section. To avoid physical machine duplication, we suggest the following hybrid cellular layouts.

Table 1 :

Operation Sequences of Products Produced in the Facility

Product #	Sequence	Production Quantity
1	1→4→8→9	2
2	1→4→7→4→8→7	3
3	1→2→4→7→8→9	1
4	1→4→7→9	3
5	1→6→10→7→9	2
6	6→10→7→8→9	1
7	6→4→8→9	2
8	3→5→2→6→4→8→9	1
9	3→5→6→4→8→9	1
10	4→7→4→8	2
11	6	3
12	11→7→12	1
13	11→12	1
14	11→7→10	3
15	1→7→11→10→11→12	1
16	1→7→11→10→11→12	2
17	11→7→12	1
18	6→7→10	3
19	12	2

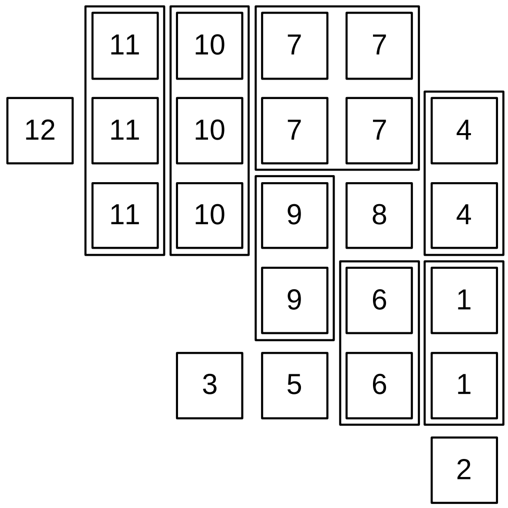


Figure 1: Functional Layout

Cellular Layout with Reorientation of Cells (Figure 3): Here, by a simple 90-degree rotation of Cell 2, all machines of types 1 and 7 are located physically adjacent to each other, as if in a Functional layout, even as the original allocation of machines to cells is retained. Hence, in case of machine breakdowns or demand changes, parts could still be transferred among machines of the same type.

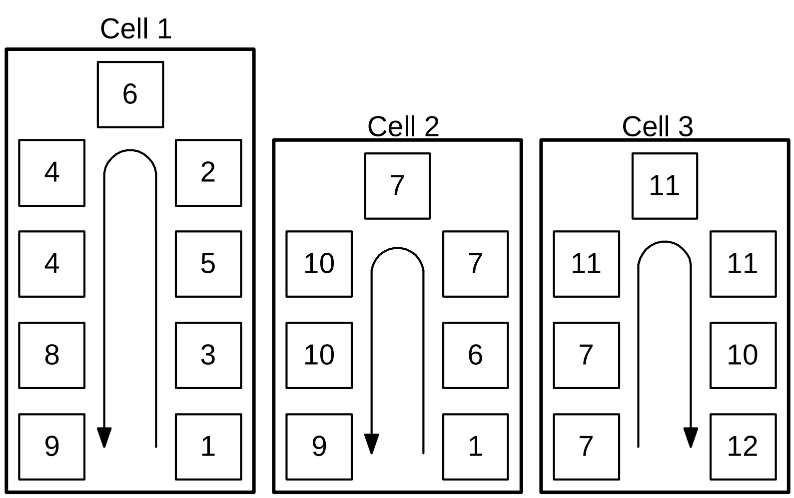


Figure 2 : Cellular Layout with Three Cells

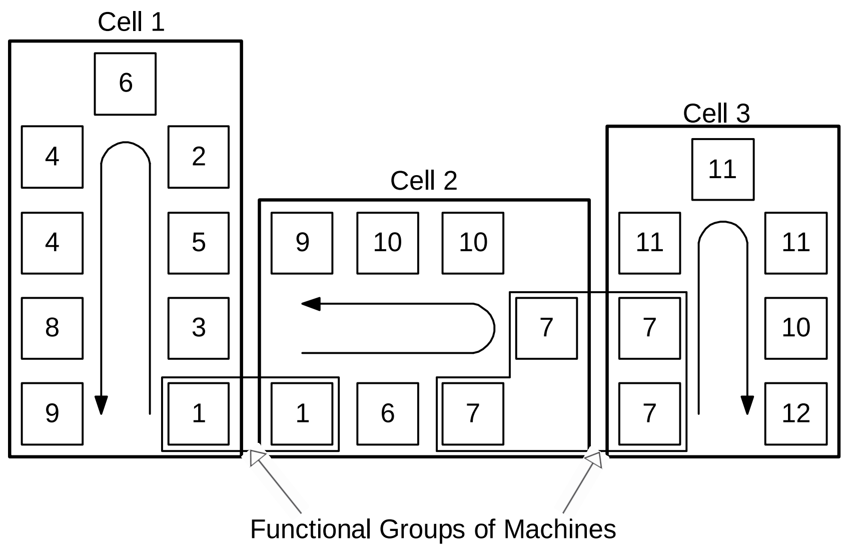


Figure 3 : Cellular Layout with Reorientation of Cells

Cellular Layout with Reorientation and Reshaping of Cells (Figure 4): This is a more complicated case of a hybrid cellular layout since it was generated by a reorientation as well as change of shape of one or more cells. Instead of retaining the U (or rectangular) shape for all cells, cells are allowed to have L (or S) shapes, which allows more machine types distributed among the cells to remain grouped in functional groups .GupteJ.S(2005) discussed the application of facility layout to high variety and high volume jobs in manufacturing systems

Cellular Layout with S-shaped Flowlines (Figure 5a): This layout for embedding functional groups in a pure Cellular layout is similar to Figure 3. A Flowline layout was developed for each of the cells. Next, the cells were arranged in parallel to minimize intercell flows. Subsequently, their linear shapes were modified into S-shapes to group identical machines into functional sections. Figure 5(b) shows a Hybrid Flowshop Layout. In this layout, the machines are allocated into several groups of machines and the groups are arranged in a sequence. However, unlike a traditional manufacturing cell, each group of machines does not process a family of parts. Rather, it can perform one or more consecutive operations occurring in the operation sequence of almost every part. In a pure flowshop, the routing of every product is identical to the sequence of machines that comprises the linear layout of the flowshop. In this hybrid cellular layouts, only the pair of operations – 7 ® 4 – in the routings of parts 2 and 10 cause flow backtracking in the layout. Otherwise, if every part routing in Table 1 is mapped onto the flowshop layout shown in Figure 5(b), then the moves for all pairs of consecutive operations will be in-sequence or forward bypass moves between any two processing stages in the flowshop. If an additional machine of type 4 could have been purchased and allocated to the fourth cell in Figure 5(b), then no backtracking would have existed in this hybrid cellular layouts. These layouts have been addressed in GupteJ.S(2005) in the technical report prepared on application of qualitative and quantitative models applied for Layouts.

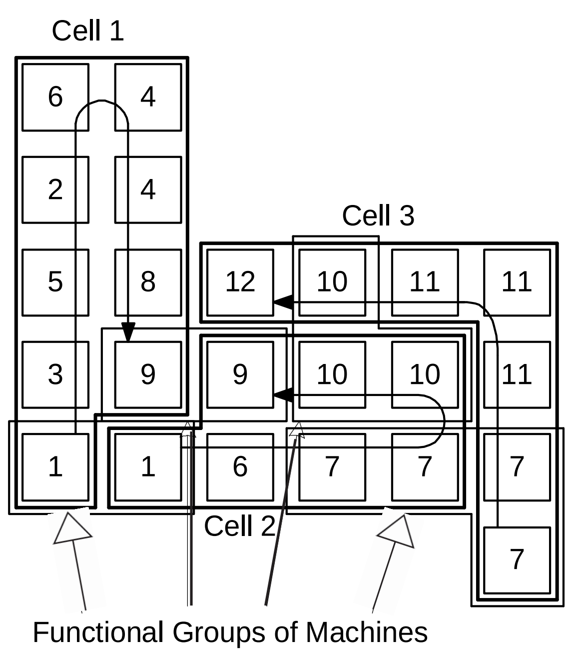


Figure 4 : Cellular Layout with Reorientation and Reshaping of Cells

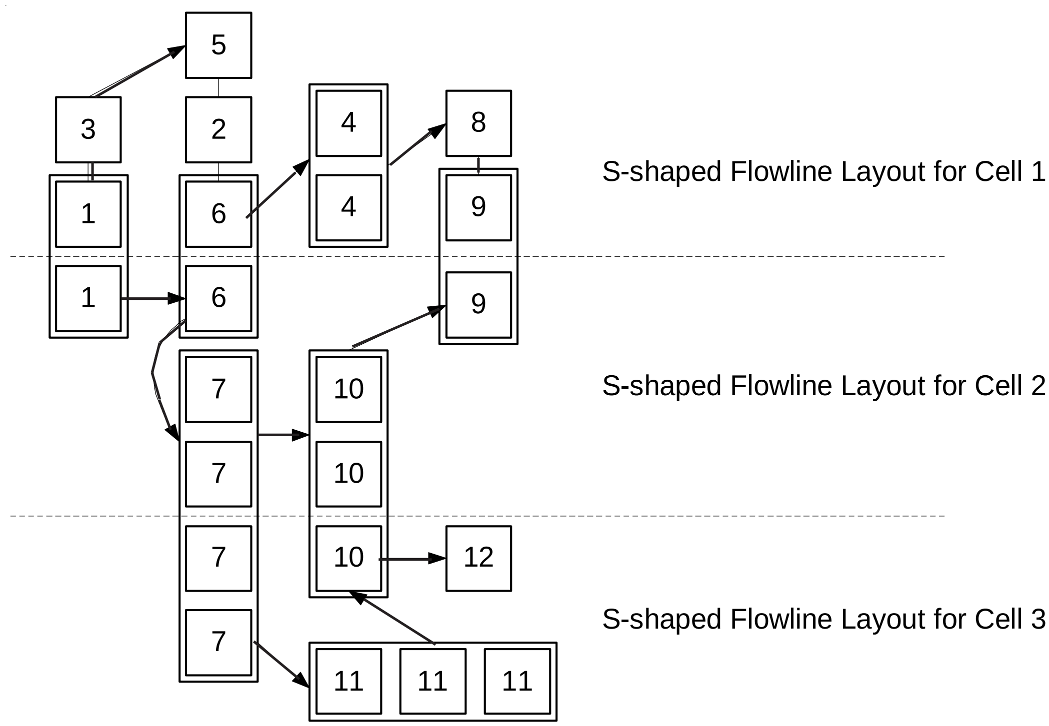


Figure 5(a) : Cellular Layout with S-shaped Flowlines in Parallel

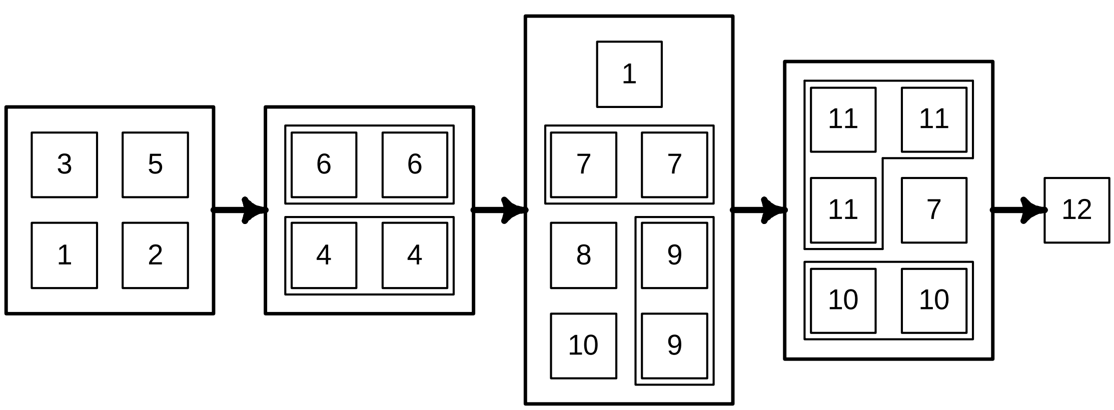


Figure 5(b) : Hybrid Flowshop Layout

Virtual Cellular Layout (Figure 6): The layouts in Figures 3, 4 and 5 demonstrate the basic objective of hybrid cellular layouts to minimize the number of machine types that cannot be retained in functional sections within a pure Cellular layout. Even though the shared machine types are located in functional sections, they can remain dedicated to a particular cell and a family of parts routed to the cell. Furthermore, this "virtual focus" could also be obtained without creating a Cellular layout by dedicating a particular handling device to move all parts belonging to a particular family among the necessary machines. In the Virtual Cellular Layout, machines shared by several cells are assumed retained in functional sections if these cells can be located adjacent to each other. This adjacency of the cells allows the machine groups based on the part families to be virtual, i.e. a particular handling system links machines in adjacent cells that are required by a part family without necessitating rigid physical co-location of the machines in a cell .This layout has been suggested by Irani et. al(1993) in the thesis prepared on layouts.

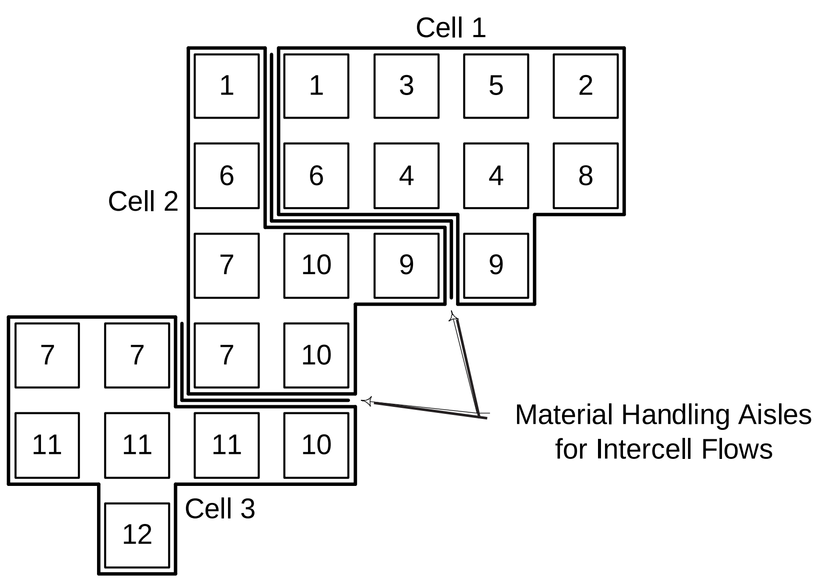


Figure 6 : Virtual Cellular Layout

Cellular Layout with a Remainder Cell (Figure 7): This layout eliminates the machine duplication problem experienced with a pure Cellular layout. One or more shared machine types are retained in a Remainder Cell reachable by all the cells among which these machines are shared. The original compositions of Cells 1 and 2 were relaxed to facilitate flows of parts through the Remainder Cell. Machines in the Remainder Cell were arranged using standard methods for design of a Functional layout.

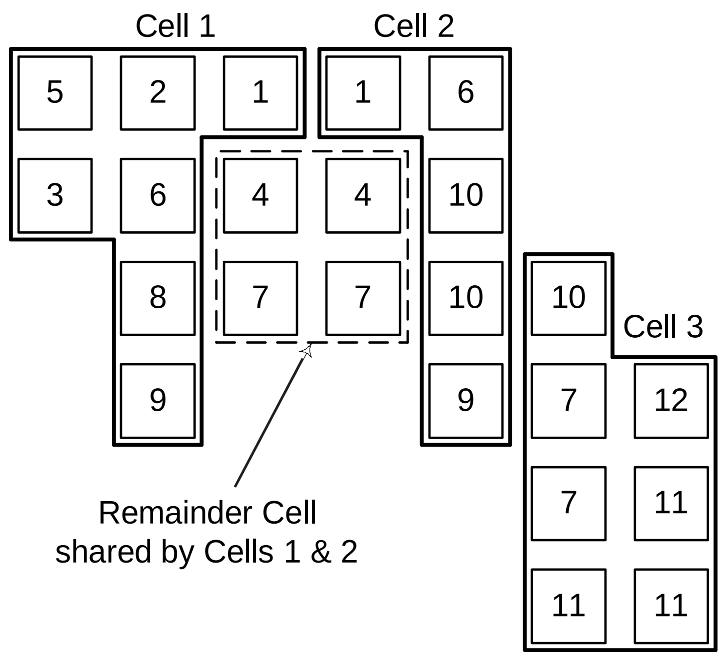
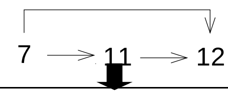
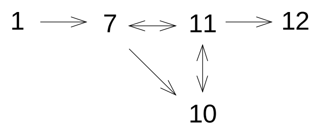
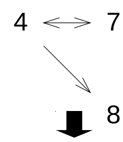
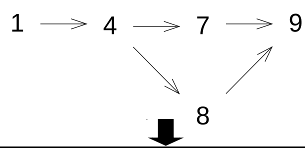
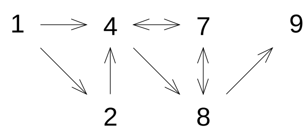
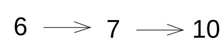
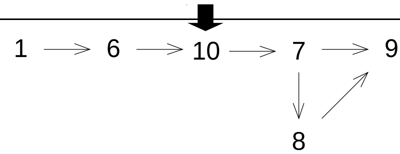
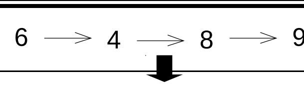
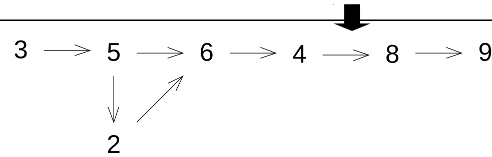


Figure 7 : Cellular Layout with a Remainder Cell

Cascading Cells (Table 2): This layout depends on the routing similarity between parts. The cells are designed such that simple parts are allocated to small cells and complex parts get routed to larger cells. There is no intercell movement for any part i.e. every part gets processed in at most one cell. Significant machine duplication is required to implement this layout.

Table 2 :
Cascading Cells

Part Numbers	Cell Composition
12, 13, 17, 19	
14, 15, 16	
10	
1, 4	
2, 3	
18	
5, 6	
7, 11	
8, 9	

⬇ shows the cascading of a simple cell into a more complex cell

Conclusion

This case study introduced several Hybrid Cellular Layouts that modify a standard Cellular layout in order to group all shared machines into functional groups, as far as possible. Each hybrid cellular layout has a different degree of grouping of dissimilar machines and similar machines into cells and functional groups, respectively. The development of hybrid cellular layouts reduces machine duplication and minimized queuing delays in the factory. The work in process inventory was significantly reduced. The cycle time taken to manufacture one unit of product was reduced and the overall throughput was increased. The intercellular traffic of jobs was significantly reduced. The crisscrossing of material flows is reduced considerably. The planarity of graph structure in the factory is maximized and this helps in achieving a high productivity in the factory. The planar graph ensures that there is no criss-crossing of material flow lines in the factory. The layouts of different orientation were considered and they incorporate distinct features of product , process and cellular layouts thus resulting into a hybrid layout.

References

Irani, S. A, Cavalier, T.M & Cohen, P.H. (1993). Virtual Manufacturing Cells: Using Layout Design and Intercell Flows for the Machine Sharing Problem. International Journal of Production Research, 31(4), 792-810

Irani, S. A, Cohen, P.H. & Cavalier, T.M. (1992). Design of Cellular Manufacturing Systems. Transactions of the ASME, 114(3), 352-361

Shukla, J. (1995). Hybrid and Progressive Cellular Layouts for Jobshops. Master of Science thesis, Department of Mechanical Engineering, University of Minnesota, Minneapolis, MN

Gupte J.S (2005) Revisionist Theory on Facility Layouts, Technical Report, Ohio State University.

Heragu (2003) Design of Facility Layouts. Technical Report.

Muther(2003) Facilities Layout & Planning. Technical Report.