JIT FOR HIGH VARIETY/LOW VOLUME MANUFACTURING

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ABSTRACT

Frequently in traditional batch manufacturing organisations group technology cells are not feasible due to the high variety/low volume, (HV/LV), nature of the components being processed. Functional layouts which must then be used prevent the adoption of Just-in-Time material control techniques. It is, therefore, difficult to gain the benefits of JIT within such environments. This paper describes an alternative plant layout arrangement, (Process Sequence Cell Layouts), for such environments that enables material flow to be controlled using Kanban signals. Case studies are used to demonstrate how such layouts can be identified and descriptions offered of how materials can be controlled in such environments. The paper concludes by identifying the benefits to be gained from adopting process sequence cells.

INTRODUCTION

Functional layouts involve grouping items of processing equipment according to the types of operations or processes they perform. It is the inherent flexibility of such systems that are their major strengths in that these layouts allow organisations to change parts, processes and process sequences quickly and relatively economically. This type of layout is, therefore, extensively used in manufacturing organisations that process high varieties of components in low volumes.

However, this type of plant layout encourages the processing of large batches which consequently leads to large amounts of work-in-progress inventory and long unpredictable queues of materials awaiting processing at individual machines. Hence manufacturing lead times can be long and difficult to reliably estimate. In addition material handling can be complex and the costs involved high. Complex production control procedures are required to plan and control the flow of work through such systems.

In order to bring the benefits of flow process production methods to HV/LV environments the traditional approach has been the use of group technology, (GT), which yields advantages such as:

- low work-in-progress levels and material handling costs
- simple production control procedures required
- high throughput quantities
- ideal conditions for group working.

However, group technology is often not applicable since it is impossible to identify groups of components from which to form cells. In addition when cells can be formed, they often cannot fully process all the components assigned to them. Hence components need to leave the cell to be processed then returned to the cell for further processing. The greater the variety of part types within the system the greater is the chance of this occurring. Complex production control procedures are still required to manage these types of facilities layout.

PROCESS SEQUENCE CELLS

Essentially a process sequence cell layout, (PSCL), is made up of a number of individual cells each containing a variety of items of processing equipment. Equipment is allocated to a cell depending on its position within the processing sequence of components. Cells should be arranged on the shop floor according to the process routes of components. Hence each component would enter a cell for its first operation before being moved to the next cell in the cell sequence for its second operation. Again the component would leave this second cell and move to the next cell for its third operation. The component would move in this way through the PSCL layout until completed.

A number of methods have been identified for designing a process sequence cell layout. The actual method used would depend on the extent of the variety present in part types and process routes. The method used to identify the process sequence cell layout for case study company X was simply to list the process routes of all the components manufactured within the company as shown in Table 1. This involves placing all processing equipment required to perform the last operations on components in the end column, "last but one operation" processing equipment in the last but one column and so on until all operation routes have been dealt with.

TABLE 1

PROCESS ROUTES

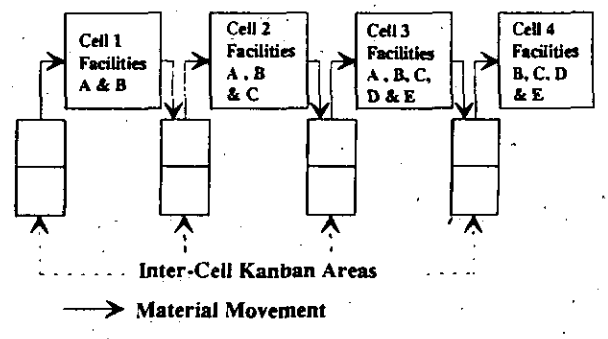
Part Code	Last but three Operation	Last but two Operation	Last but one Operation	Last Operation
P1	B	C	D	E
P2			A	D
P3			C	E
P4			B	C
P5	A	B	C	D
P6		A	E	C
P7		A	D	B

A, B, C, D and E represent equipment codes

The items of equipment required to perform specific stages in the process sequences of components can now be identified from Table 1 and a provisional layout would be as shown in Figure 1. This layout indicates that, irrespective of the component type, materials would flow from one cell to the next cell in the layout sequence. Materials would follow simple paths from one cell to the next. Kanban controls, could, therefore, be implemented to regulate the flow of work between adjacent cells.

FIGURE 1

PROCESS SEQUENCE CELL LAYOUT



CASE STUDIES

Two HV/LV companies have been examined for suitability for implementing process sequence cell layouts. Both organisations process wide varieties of parts in small to medium batch sizes, ie. as illustrated in Table 2. In addition both company's existing manufacturing layouts are function based and group technology cells were identified as being unsuitable.

TABLE 2

COMPANY INFORMATION

Company	Number of Product Types	Number of Machined Part Types	Number of Items of Processing Equipment	Average Batch Size
X	30	70	54	100
Y	34	949	42	30

For each company the process routes of components were entered into a spreadsheet package and individual operations sorted according to their position in the process sequence. This sorting process identified the items of equipment required within each cell. Listing the equipment requirements of each cell as illustrated in Table 3 enabled the feasibility of implementing individual cells to be identified, ie:

a. The majority of items of processing equipment were found to be required only at one position in the operation sequence of components. Hence the equipment required could be placed in one cell resulting in no capacity problems arising.

b. Some items of equipment were found to be required in more then one cell. However, the company possesses multiple units of this equipment and there are sufficient numbers to be allocated between the cells that require them.

c. Items of equipment were found to be required in two adjacent cells. The company could either consider purchasing additional units of such equipment or resolve the problem by:

   i. Placing the item of equipment in the succeeding cell, (of the two), in the process route. This would result in a number of components requiring two operations within the succeeding cell.

   ii. Placing the item of equipment in the preceding cell of the two and performing two operations within this preceding cell.

d. The company possesses insufficient numbers of a specific type of equipment to allocate units to each cell requiring them. As with other types of plant layout procedures, (GT or flow lines), the company may need to invest in additional items of equipment to resolve these problems. Depending on the volumes of work involved the company may be able to resolve these problems by using inter-cell sub-contracting, ie. one cell sub-contracts work to another cell.

TABLE 3

EQUIPMENT REQUIREMENTS OF CELLS - COMPANY X

Equipment Code	Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8	Cell 9	Cell 10	Cell 11
A		b								b	b
B										a	
C							a				
D			a								
E				d		d					
F									d		d
G										a	
H											a
I										c	c
J										a	
K						b	b	b	b		
L									a		
M								a			
N					a						
O								a			

See notes a, b, c and d.

Sorting the process routes of components resulted in the identification of 11 potential cells. A consideration at this point is the uneven number of component types each cell would process, eg. the final cell in the process sequence, (cell 11), would need to process all components whilst cell 11 would only process those parts requiring 11 operations, ie. 5 parts. Combining cells, (as illustrated in Table 4 for example), would increase the total number of components processed in each and hence make each cell more feasible to implement.

TABLE 4

ORIGINAL AND COMBINED CELLS - COMPANY X

Cell No.	No. of Machines	No. of Part Types	Combined Cell No.	No. of Operations
1	2	5		
2	4	14		
3	3	22	1	41
4	4	22		
5	4	28	2	50
6	2	32		
7	5	37	3	69
8	7	54	4	54
9	9	66	5	66
10	10	70	6	70
11	7	70	7	70

1. Equipment required in adjacent cells has been placed in the preceding cell.
2. In cases where there are insufficient items of processing equipment a single machine has been placed in the first cell in the sequence.

CAPACITY PLANNING

A process sequence cell layout must be designed such that there is sufficient processing capacity available within each cell for all components processed within that cell. Allocating equipment of the same type to more than one cell would result in specific cells having excess capacity whilst other cells had insufficient capacity. Currently being investigated are potential methods of overcoming these capacity imbalances, ie:

- Moving mobile equipment between cells.
- Sub-contracting work from cells with insufficient capacity to those with excess capacity.
- Use of multiple items of low volume processing equipment.
- Amalgamation of cells into larger cells which carry out more than one operation on components.
- Re-design components to remove operations, change operations or use different items of processing equipment.

CONTROLLING MATERIAL FLOWS

Within PSCL's material flows can, in JIT terms, be considered visible since materials move only between cells along a limited number of well defined paths. Kanban signals could, therefore, be used to control material movements by signalling when more materials needed to be moved to the next cell down the process sequence. Inter-cell Kanban devices could either be containers, (designed to hold a range of part types), or areas marked out on the shop floor.

Jobs would enter the PSCL based either on the planned order release schedules of an MRP/MRPII system or a manually produced production schedule. The use of MRP and MRPII to support JIT environments that contain a degree of product variety has been successfully achieved on a number of occasions, [1, 2]. Each job entered into the system would remain as an individual job through each cell. Once within the system the movement of jobs between cells would be controlled using Kanban signals. In a PSCL environment the role of the Kanban device would be modified since Kanbans would not control what materials were moved or the quantities of these materials moved. This would be impractical in such an environment in which demand for part types is highly irregular.

The MRP/MRPII system would ensure that the correct materials and components were being "pushed" [3] through the PSCL and the Kanban system would prevent excess work-in-progress building-up by limiting the number of containers or size of Kanban areas in the system.

The basic tasks required of a MRP/MRPII system would include:

- Generating works orders for components.
- Generating purchase orders to ensure material availability, ie. for items with long or irregular lead times.
- Time phasing of works order releases to the shop floor, ie. using cell lead times.
- Setting release dates for works orders onto the shop floor.
- Rough cut capacity planning if bottleneck resources were clearly identifiable.
- Detailed capacity requirements planning if bottleneck resources could not be clearly defined.

ADVANTAGES OF PSCL's

Improved control over manufacturing lead times would be possible due to the use of Kanban control procedures to promote the smooth flow of work through the system, ie. work would only be moved downstream on receipt of a Kanban signal. Kanban controls would also enable control to be exercised over work-in-progress levels and, therefore, as in traditional JIT environments inventory levels could be reduced resulting in shorter overall manufacturing lead times.

The opportunity also exists to make manufacturing lead times a focus for continuous improvement tasks. Within a traditional JIT environment operators are encouraged to take "ownership" of the product. Within a PSCL environment "ownership" would in addition need to be focused on lead times. Maintaining cell lead times could become the focus for the allocation of responsibility within individual cells, eg. operators could be given responsibility for internal cell scheduling of work to achieve lead time targets.

The materials moved between two adjacent cells as a result of one Kanban signal could be made up from a range of part types, batches or jobs. However, a regular flow of work between cells could be expected by allocating all cells a specific lead time, (time bucket), for the completion of their Kanban quantities, ie. the quantity moved as a result of one Kanban signal. Those cells not meeting their lead time cycles could then be readily identified from irregular flow of Kanban containers and the reasons for the problems identified and overcome. In this way lead times would have a direct link to those problems that resulted in throughput constraints, eg. bottlenecks would result in longer lead time cycles at the cell that contained the bottleneck. Work-in-progress would also be directly linked to manufacturing lead times.

The total manufacturing lead time for a job moving through the system would be equal to the sum of the individual cycle times for the cells visited. Time phasing of MRP planned works order schedules could be based on these cycle times resulting in reduced need to add on additional safety lead times, ie. the lead times used by the MRP system would more accurately reflect the actual times taken.

Within traditional JIT cells, emphasis is placed on the attainment of multi-skills by operators. This provides a cell with the flexibility to cope when for example machines breakdown, quality problems occur or when throughput rates need to be changed. Since each cell within a PSCL contains a range of processing equipment opportunities exist for operators to gain and use multi-skills within the cell environment. Capacity changes could also be made by varying the number of operators within a cell.

Reducing waste within a JIT environment involves removing "non-value adding" service tasks such as maintenance, quality control and work planning, ie. such tasks are made the responsibility of shop floor operators. Since within a PSCL system each cell would be a self-contained work area, cell operators could be given the responsibility and authority for all internal tasks required to convert inputs to outputs. Such tasks could include quality management and control, work planning and scheduling, routine maintenance, equipment servicing and the re-work of defective items.

Each cell would be the customer of the preceding cell and the supplier of the succeeding cell. The "quality chain" involved in total quality management would, therefore, be physically represented by the JIT links between cells.

In a traditional JIT system the Kanban controls are used to drive the cycle of continuous improvement tasks [2] by enabling inventory levels to be physically reduced and there-by forcing manufacturing problems to the surface. The Kanban controls within a PSCL environment should enable such continuous improvement exercises to be performed in exactly the same manner. For example reducing processing batch sizes will result in set-up operations becoming more frequent and reductions in the available processing time within a cell. In a PSCL environment problems with long set-up times will present themselves as an inability of a cell to maintain its lead time cycle. Hence only the set-up operations having a direct effect on manufacturing lead times could be identified and made the subject of continuous improvement exercises.

In a batch processing environment many processing events are taking place simultaneously. It is essential to record the processes begun and completed in order to maintain data from which future schedules can be generated. This tracking and progressing of works orders, therefore, requires many transactions and is frequently a major source of data inaccuracy in a MRP database. The use of Kanban controls within a PSCL environment should improve this situation by removing the need for tracking of works orders during processing. Works orders will need to be created, (and materials then issued to such orders), and released to the shop floor. From then on the Kanban system could be relied on to progress the jobs through each process sequence cell, hence avoiding the need for job tracking and progressing. Once jobs have exited the final operation cell then a works order closure transaction would be required to inform the MRP system and update inventory records.

REFERENCES

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About the Authors

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WHO MURDERED MRP?

Introduction

Geoff Relph is an industrial consultant with IBM and has had many years of practical experience implementing and optimising MRP systems. He has found that there are some very common reasons why MRP installations fail to work well and together with his co-author, freelance writer Robert Irwin, he has kindly written these for CONTROL in a light hearted 'thriller' style.

This trailer introduces the episodes which will appear in the next six issues. We would be very interested to hear readers' views on this new style of article, so why not drop a line to us.

David Angove
Editor

Meet Conrad Sultant, Private Eye. He lives in the steel-edged world of the hard-boiled detective novel. He is a smoker in a non-smoking world. He is a doer - a man of action who won't stop until he's found the answers.

In real life he is Geoff Relph, Industrial Consultant at IBM, Havant. His world of industrial detection is brought to life through the pen of Robert Irwin, a writer with a Humphrey Bogart fixation.

One morning a body turns up on the factory floor at the Acme Widget Company. It is hardly a coincidence that Acme has more than just a murder that needs solving. Their Materials Requirements Planning Systems (MRP) has broken down.

Where else could they turn, but to Conrad Sultant, Private eye?

The body on the factory floor leads our erstwhile gumshoe into the shadowy world of industrial consultancy. He follows the twisting path of clues from suspect to suspect (they all have alibis!) in search of his quarry - the MRP Killer.

Initially, in 'The Clue of Borrowed Capacity' Sultant suspects the brilliant oriental strategist behind the Acme production line, Mr. Manu Facturing. Also in this episode, he encounters for the first time the blonde bombshell, Miss Purr Chasing. As Sultant chases down leads he uncovers one reason why MRP has broken down. Mr. Manu Facturing has borrowed capacity from future weeks, ignored MRP and thrown Miss Purr Chasing a curve she cannot handle. But that's only half the mystery solved.....The MRP Killer remains at large.

Follow the investigations of Con Sultant, Private Eye, as he chases the killer in episodes that follow.

- **The Clue of Capacity Smoothing.** MRP Output is not accurate. Sultant suspects Mr. Prod Uction. He has the motive - a balanced production schedule. But did he do it?
- **The Clue of the Long Time Ago Order.** MRP installation was behind schedule. Sultant questions B. Eng - otherwise known as The Master. The clue? 'New Orders with a Start date of 1988!'. What does it mean and will it put The Master on or off the hook?
- **The Clue of the Long Overdue Order.** Sultant uncovers 3,200 overdue files. Are they the weapon that Ms. Fi Nance used to knock off MRP?
- **The Clue of the Missing Free Issue.** Finally, despite having fallen for her big time, Sultant suspects Miss Purr Chasing? Could she have done it and did she act alone? Will Sultant send her up the river to do her time?

These are but a sampling of the clues dogged down by our detective. Geoff Relph's extensive industrial experience provides a wealth of topical subjects for Con Sultant to investigate.