BREATHE NEW LIFE INTO YOUR MRP SYSTEM

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This short article argues that an effective manufacturing control system will contain a realistic finite capacity scheduler, and that the finite capacity scheduler and its related functions can be effectively located on separate hardware systems. However they will share common data but will recognise the master elements and where these belong.

I offer practical advice to those contemplating the introduction of a capacity scheduler and I will highlight the pitfalls to be avoided. However this will not be a definitive statement but will provide useful guidelines. The practical (and successful) application of finite capacity scheduling requires a flexible and adaptive approach which recognises the prevailing operating constraints.

Why a Distributed System?

Many companies now operate computer-based MRP and MRP-II. Typically this will contain the following:-

- Master Routes (process plans) with operation times
- Bills of Materials
- Product Costs

Together with the individual requirements of the order book. This information will be used by most departments in the company and is what I term corporate data. The multi-user aspects of this common shared data resource makes this corporate information ideally suited to a mainframe application.

Such corporate data will contain the master plan or requirement to satisfy customer orders; the actual accomplishment of this plan is ideally suited to delegation within subservient systems. I call this a bottom up approach.

I believe that corporate data belongs to corporate mainframe based computer systems; mini and micro computer based systems within a distributed co-ordinated computer network can provide economic local computing power and provide responsive resources where they are needed.

For example a multi-user minicomputer might be used to hold a total factory work-in-progress requirement against which orders are tracked, perhaps this performing a scheduling function for the total factory against the outstanding order requirement, linked both ways with the corporate MRP database to post movements to and receive orders from. The minicomputer will offer sufficient resource to allow total order rescheduling, perhaps overnight, for companies with say 20,000 — 100,000 outstanding WIP operations.

If the minicomputer contains the total factory WIP requirements then this may be split into smaller independent units to reflect individual areas constituting the factory. This may comprise breaking down a precalculated work-to-list onto shop floor micros which then issue work tickets and collect movements and shop floor incidents, or individual micros which are then used to perform their own scheduling functions on their own WIP files. Either way the users in those areas must be responsible for their own resource information.

The above illustration indicates three elements of the distributed computer system, mainframe, mini, micro. However in many applications it will be possible to eliminate one constituent provided a local reactive computing resource is maintained. This is ideally suited to cellular manufacturing. Obviously timely communication must exist between each level such that each is kept in step.

Elements of the Distributed System

MRP Systems have long been criticised (by me) for their inability to perform detailed control of shopfloor activities. I believe that successful manufacturing control requires elements of traditional MRP together with realistic control of performance. I propose that any manufacturing control system will be incomplete without a detailed finite capacity based system, the type of manufacturing (eg make to stock, make to order) determining whether the MRP plan (infinite capacity based) or the finite capacity driven plan should be the master.

WHAT FUNCTION WILL EACH ELEMENT PERFORM

Infinite Capacity Scheduling from MRP

Most MRP systems include modules for Capacity Requirements Planning (CRP) and Master Production Scheduling (MPS). I define master scheduling as the process that calculates operational due dates for each job or route, back scheduling to set stage due dates, maybe also including recognition of bills of materials structures. When bills of materials (or product structures) are present two major techniques are used. The most common method is to use fixed lead times based on procurement times for each item at each level. Alternatively these lead times can be similarly back scheduled as with higher level product. Generally these lead times are not updated by the system and therefore will not reflect current operating constraints eg. bottleneck at section X. Having thus set operational requirements then these will result in generated load requirements for each period for each resource. Master Scheduling sets and reports these requirements.

Capacity Requirements Planning then becomes the representation of the above load requirements into time buckets (usually a daily or weekly slot). CRP will present those requirements against some notion of capacity for each resource or resource grouping against time. MRP usually does not concern itself with what happens should the due dates be missed or should conflicts arise due to resource shortages. The rationale in MRP is that due dates are sacrosanct and must be met otherwise revised. Some MRP systems have finite capacity modules which attempt to resolve those conflicts. Usually those are single resource eg. machine or person based, not both.

Finite Capacity Scheduling

Finite Capacity Scheduling (FCS) will resolve resource conflicts and identify and closely control production bottlenecks. FCS recognises that due date achievement may fail and indeed may allow redundant due dates in its order book.

FCS systems use a number of techniques to resolve resource conflicts, for example using operational due dates, critical ratio, and so on. Proponents of pure MRP infinite scheduling may argue that due dates must be accomplished or revised; FCS takes the pragmatic approach. However FCS attempts to control the most complex and transient part of a company, the shop floor.

For FCS to work then it must be realistic. If it is realistic then the shop floor (supervisors and operatives) will see benefit from co-operation. To be realistic then there are a number of requirements. Providing realistic schedules is examined in detail later. Let me first describe what FCS is

trying to control, that is work queues, cause and effect.

Effect of Queues on Lead Times

For example a company might hold WIP valued at £5 million cost. On average this company may plan one week per operation, each product averaging ten operations. Therefore in this case the plan will be to achieve on average a lead time of ten weeks. If the average process time per operation is four hours, in a single shift company working 40 hours per week the following is planned:

10 Operations, total processing time 40 hours in 400 available hours (ten weeks).

Queuing time planned therefore is (400–40) hours ie. time waiting for a resource.

$$\frac{\text{Queue}}{\text{Process}} = \frac{9}{1}$$

If the aim is to reduce lead times to eight weeks this could be achieved through queue reductions rather than in making resources more productive.

In this case the Queue/Process ratio will become 7/1, that is still allowing seven times the processing time for queuing. The result of achieving this will reduce WIP value to £4 million. Cash flow is also improved as products will be turned into revenue in these shorter lead times.

The above is a simple illustration. In practise the queue/process ratio at the bottleneck will directly control WIP and throughput levels. Maximising the throughput at the bottleneck will maximise total output. Gearing the feed of work to the bottleneck such that it is at the rate that the bottleneck can accommodate will provide the means to minimise WIP. In financial terms the effect on the bottom line will be enormous.

Reducing work queues reduces choice. High WIP means more choice from the work queue and therefore more batching; high work queues mean there is a greater chance of picking the wrong job next. Work-to-Lists help to ensure that given a choice the correct job is done next. FCS is a tool to produce the work-to-lists initially, and then to control issuing of new work and therefore WIP. *Controlled WIP will reduce the available choice and thus* the chance of picking up the wrong job — the factory will start to schedule itself.

Reduced WIP means lower obsolescence, less damage and losses to work lying around, as well as obvious improvements to lead times and the cash position of the company.

The relationship between high WIP and long lead times becomes a self fulfilling prophecy. For example, if the plan is to achieve a ten week lead time and it actually takes 12, this may tempt the company to start manufacture two weeks early next time to allow enough time — this will inflate WIP, 12 will become 14 and so on — a catch 22 situation.

Musts From The Finite Capacity Scheduler

For FCS to be credible and realistic I have identified five major requirements.

Data
Modelling
Speed
Bottleneck Control
Issue Control

Data

Firstly accurate data is required about the factory. By this I mean:

Job Position
Routes and Bills of Materials
Time Estimates (subservient to routes)

The ownership of this data must be defined, which in practise is a complex interaction bringing together industrial engineers, production engineers, shopfloor supervision and operatives. The timing of posting job movements is crucial such that rescheduling is from the latest position ie. right now. The accuracy of this core *order and position data is likely to be suspect if shop floor* scheduling is not in use.

The requirement to satisfy this data is likely to strengthen any argument for data collection.

FCS will not work without formal data collection, whether this is through bar codes or the physical presence of some manual/electronic collection medium. It will provide the perfect tool to:

i) Establish routes where they do not already exist or verify existing routes.
ii) Establish/verify operation times and their variance.
iii) Provide utilisation data about primary resources (operatives and machining processes).

Modelling

This is the most important feature of FCS and it is on this that it stands or falls. FCS requires an accurate resource scheduler, capable of simulating what actually happens on the shopfloor. The resource schedule is sometimes called the factory modeller or simulator.

Speed

FCS must be flexible and fast. It should accept external factors relevant to the business of the user. The requirement for detailed modelling and its impact on computer run times may seem contrary to requirements for rapid response. However the problem can be simplified. The fragmentation of the factory into individual segments, each with its own hardware, will reduce complexity of assessment in the modeller and thus improve responsiveness. This will be especially important where a critical resource has failed and there is an urgent need for a dynamic reschedule, without waiting for a full factory reschedule. This task will be ideally suited to a dedicated PC within the area or cell.

Bottleneck Control

FCS must be able to quantify bottlenecks, where, when and by how much. It should then allow close control of those bottlenecks to ensure maximum throughput and delivery of required jobs. FCS must allow What If? around the bottleneck such that proposed courses of action (eg. *extra machine, overtime, new tooling) can be tested prior* to adoption.

This bottleneck control will be required on the total factory order book scheduled across the resources of production. That is all cells/areas. This is suited to the minicomputer approach to determine the impact between different areas and will probably to beyond the scope of a PC. This process will probably entail overnight batch runs.

Issue Control

Techniques must be provided which allow work to be released to or held from scheduling.

Jobs require a hold mechanism such that once work has been started it can be removed from selection in a work-to-list. This could be due to unresolved technical reasons or external factors in the case of a held job.

Control of issuing, especially the release of new orders such that they can be selected into work-to-lists, is a key functional area of WIP management. This is because once a job is available through release it will eventually be manufactured, whether or not it is required. Effective bottleneck management will require control of work

release to prevent work being called forward to fill capacity of non bottleneck sections.

Forward release of work must be avoided if WIP is to be controlled.

Desirable Features within FCS

Further to the mandatory elements of a successful finite capacity scheduler, there are a number of desirable functions.

Multiple Resource

Facilities should be provided to allow multiple resource allocation to operations. This will allow the allocation of primary resources such as machines and people to operations, and preferably secondary resources such as tools and special equipment.

Factory Flexibilities/Constraints

The inclusion of multiple resource allocation will allow machine-operation, machine-person and person-operation relationships to be defined where appropriate. This will then provide for the assessment of operator skills plus machine capabilities within the simulation, building the foreman's knowledge into the scheduling process and giving greater realism in the process. This is shown diagrammatically in Figure 1.

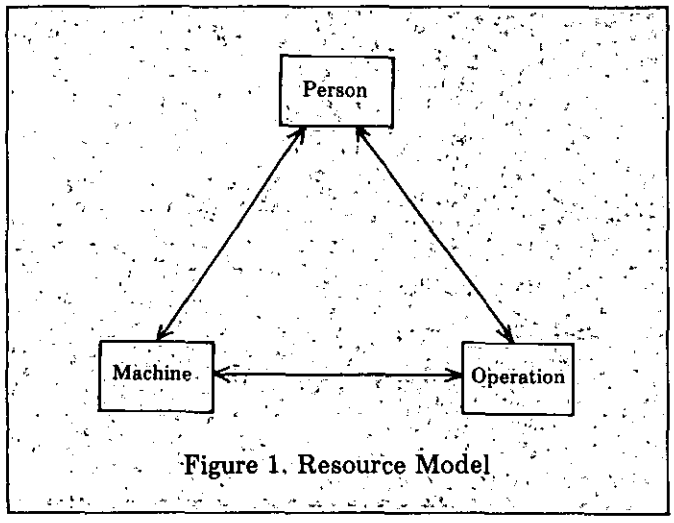

Figure 1. Resource Model

By building such resource modelling into the simulation prevents the allocation of operation-dependent resources when one is missing.

Periodic and Real Time Scheduling

Different elements of a manufacturing business may require differing scheduling periods. This might be to cover a shift or a day. Other parts of the business may be more dynamic and require rapid response. Real time scheduling will allow the rapid provision of reactive work-to-lists. This will be important in the event of critical resource failure where the periodic schedule becomes delinquent and the refresh rate is too slow for the needs of the area. Again these can be regenerated from the master system above, from which they receive orders, and to which they post movements.

Figure 2 shows the data flow for periodic scheduling, driven by orders from MRP, but holding its own resource relationships. Periodic scheduling here will be run on either a minicomputer or PC dependent on data volumes, response required and level of complexity.

Figure 3 indicates a simple schematic for real time scheduling. This is subservient to either periodic scheduling or MRP, from which either can receive orders. Real time scheduling is an optional extra from FCS, periodic

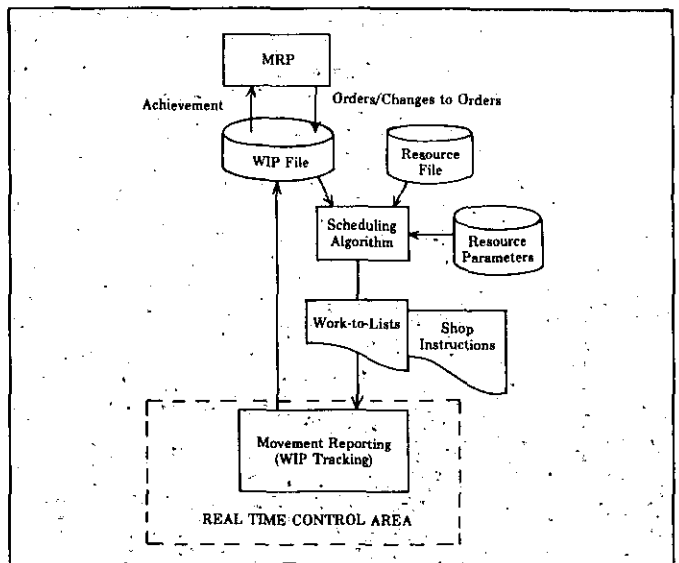

Figure 2.
Schematic for Short Term Periodic Scheduling

scheduling is mandatory.

Benefits/Motivating Factors for Users

The success of a FCS system lies in its realism which influences its acceptance on the shop floor. The requirement to communicate data from operatives and supervision is fundamental.

I will summarise under user headings.

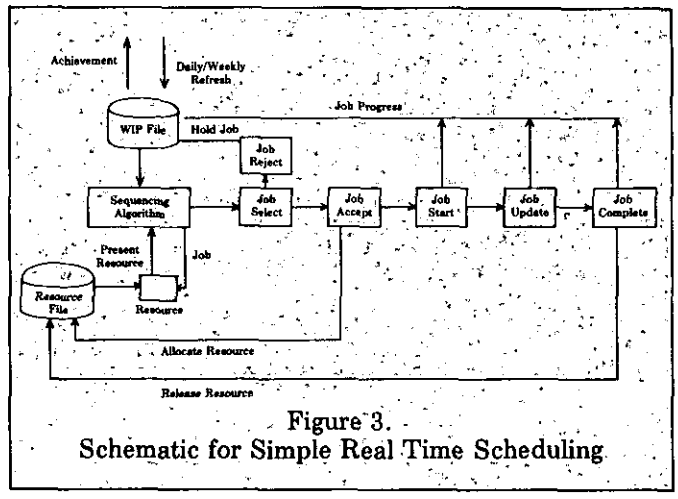

Figure 3.
Schematic for Simple Real Time Scheduling

Shop Floor Operatives

What will motivate the operative to use the FCS system? Links to payroll from data collection will obviously motivate but may not encourage positive collaboration.

Better planning of work will inspire confidence and belief that the management of the business does know what it is doing.

Shop Supervisor

Effective scheduling will allow the supervisor to manage workers, ensure correct skills are available and contribute to the success of the business, rather than being tied up with paperwork, administration and firefighting.

Shop Manager

The shop manager will be given the ability to forward plan resourcing and put into place the necessary flexibilities to beat the bottleneck. Emphasis must be to anticipate situations rather than managing by the seat-of-the-pants.

Production Controller

The major impact of FCS will provide the production

controller with the means to control WIP, predict deliveries and identify and resource bottlenecks.

Works Manager

The works manager will be able to plan medium/long term resourcing policies eg. How many people are required? What should the plant purchasing policy contain?

Commercial

The effect of FCS on many businesses can be quantified in financial terms. However, in reality the commercial benefits that will accrue from confidence in delivery dates, and the ability to warn customers in advance of late deliveries will generate goodwill and repeat orders.

Production people will have the ability to communicate the consequences of pulling orders forward, that is the effect on existing commitments.

Managing Director

The MD will be able to manage the business rather than the current situation — to point direction rather than follow the course.

What are Problems People Face?

Installing detailed shop floor scheduling is a difficult process and must be planned properly. It is likely that many prevailing customs and practises will be uncovered and may cause conflict with the disciplines required if the scheduling is to work effectively. This will examine and question existing procedures. For this reason the realism of the scheduling model and data will need to stand up to close scrutiny from the doubters who may attempt to resist change. This realism is by far the single most important feature of FCS.

Jobs

There are a number of practical problems that will be faced at the operational level. From my work in this area the single most common difficulty lies in the accuracy of job routes. The existence of a routing within an MRP system is no guarantee of its integrity. It is only when detailed shop scheduling is used that routes are verified. As creation of the route file is a substantial element of preparation then its quality should be evaluated and any remedial action taken before implementing scheduling — there will be plenty of other problems to overcome. Additionally the scheduling system may require detail which is not already resident in other computer or manual systems.

In order to schedule the multiple level impact of subsidiary items then Bills of Materials will need verifying, especially when items may be kitted or unkitted.

Standard times, although important, are subservient to routes and bills and can be collected in the scheduling process once correct location has been established.

FCS should allow accommodation of urgent requests, new orders and modifications to existing order instructions in order that these changes can be reflected immediately into the scheduling environment. Every job must be booked through the system and there cannot be any informal systems. FCS must be allowed to consolidate all requirements.

Resources

The derivation of the factory model, against which the finite capacity assessments will be made, will require detailed evaluation of the method of actual operation. This will require detailed information regarding the relationships between different resources in order that the prevailing constraints and flexibilities are correctly applied.

Resource definitions will include elements such as the capabilities of machines/processes, skills of the workforce, and contingency factors. It might be desirable to link into Time and Attendance.

These elements will include detailed shop floor knowledge which will probably not be in the domain of production/industrial engineers, rather with the foreman and operatives.

Movements

Status reporting will keep FCS up-to-date. The primary elements will be booking on and off jobs and therefore the incentive for the operator should be examined. The method of notifying movements must be as simple as possible which might vary from simple printing of job tickets through to full shop floor data collection and machine/process monitoring.

Collection and processing movements at the right time will enable FCS to lead and not follow production. Don't forget the shop floor is a complex and transient place, the means to communicate this both ways is mandatory. These movements may be of crucial importance, all must be reported, and the shop floor have to be motivated to enable such collection.

Once FCS is working then the use of it makes the system self-auditing.

Parts of the Jigsaw

I summarise the following elements of hardware/software:

1) Mainframe — Supermini

Use for large scale MRP/rescheduling where total impact is required. This will typically comprise an overnight run to set medium/long term objectives.

2) Minicomputer — Supermicro

Use for finite capacity rescheduling of a complete factory. This will provide daily/weekly work-to-lists. It will not include dynamic nor real time scheduling.

This environment may be utilised to finite capacity schedule a number of cells/work centres/shops and will provide a backup facility for individual PC's within the factory.

Simulating the complete factory at this level will provide information about inter-area influences. It is at this level that it will be possible to identify bottlenecks and therefore from where the release of new work will be controlled.

3) PC

PC's provide economic means for dynamic (real time) rescheduling and will be used where the computing resource is unshared and local. This will be confirmed to discrete areas to optimise on local conditions, where perhaps a key resource has become unavailable and a new fit of orders to resources is required quickly.

The shop/cell manager will be in control of this process but will not be aware of resources in other areas. Identification and resolution of bottlenecks will not be performed at this level.

Each individual area will only be aware of the orders released to it from the higher level.

Conclusions

I offer the following guidelines:

1. Finite capacity scheduling is the heart of an OPT system. FCS will allow the identification and quantification of the true bottleneck and not the apparent one. Attacking where the largest current queues are on the shop floor will not necessarily cure the bottleneck; it may make the bottleneck appear quicker. FCS coupled with What If? will allow remedial actions to be simulated to test effect. This will show for example what type of resources are required enabling concentration on maximum return for minimum effort.

2. Do not use touch management, there is no need, chase exceptions only.
3. Make foremen/operatives part of the system. Their knowledge is invaluable.
4. Every area should be scheduled, so that there are no black holes.
5. Use appropriate hardware for each element of the manufacturing system.
6. Make sure that the parameters of the system eg. WIP controlling factors are fully understood and used properly.
7. Educate all.
8. Do not underestimate the size of the task. FCS will control the life blood of any company and its implementation must be conducted properly. Employ the expert because the cost of failure will be high. Conduct a proper evaluation of available solutions.
9. Finally, remember that the cost of consultancy may be the largest investment to make FCS, and therefore the company, work properly. Do not justify the system on the basis of clerical savings, reductions in overtime and so on. It will take time to set up properly and the success must not be jeopardised for the sake of minor economies. The real savings will be on the bottom line.

About the Author

Nick Norton is a 1976 graduate in Mechanical Engineering from Salford University. He holds a Diploma in Management Studies, is a Chartered Production Engineer, and a corporate member of BPICS.

He has spent the last 11 years heavily involved in developing and implementing finite capacity scheduling systems, initially with Metal Box. In 1982 he joined W W Computing as Manufacturing Systems Consultant and was appointed Director in 1984.

Since 1987 Mr Norton has been an independent freelance consultant specialising in finite capacity scheduling. He has successfully designed and implemented realistic scheduling systems for numerous major organisations.

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