RATE-BASED SCHEDULING AT OPW FUELING COMPONENTS

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Any product that is sold or used somewhat repeatedly is a candidate for rate-based production, which means scheduling the same quantity at regular intervals (see, for example [2]). Rate-based production is also referred to as leveled or "levelized" production, which is a less precise term that could mean level as to capacity but consisting of an uneven mixture of products, quantities, and intervals.

Scheduling to a rate simplifies planning and tightly synchronizes multi-stage production. The rate may cascade down through several bill-of-material levels, thus unifying the schedules of components and parent items. The quantity and interval can range from thousands per hour or per day (e.g., a certain model of inoculation syringe at Becton Dickinson) to one every few days or weeks (e.g., a Boeing 737 airplane).

BACKING AWAY FROM BATCHES

A rate-based system replaces the usual pattern of irregular batches and work orders. Conventionally, each batch is separately planned, scheduled, and controlled, which usually requires dozens of computer transactions including assigning labor, tooling, and equipment; collecting costs; and accounting for work-in-process handling and storage. The irregularity of batching passes backward through component and purchasing stages and forward through distribution channels. This generates costly yo-yo demands on capacity at each stage of the supply and customer chains.

Converting to a rate reduces administrative overheads and quiets demands on capacity. It can become as simple as issuing a single work order per month, expressed as a quantity per day; then, during the month, instead of transactions, production associates work off a fixed package of planning documents and capacity elements situated at the work sites. While the conventional system is usually driven by an uneven master schedule and material requirements planning (MRP)-generated work orders, the rate-based system can be run manually or off a simple PC routine. However, today's MRP systems often allow the option of running either to work orders or to a stable rate. This option may apply to a single component or to a group of related components spanning several stages of a product structure. The benefits of rate-based production are summarized in the following scenario in the form of a hypothetical conversation between an advocate and a reluctant plant manager.

BUT OUR GOAL IS MAKE-TO-ORDER

Advocate: Do you have any parts on rate-based schedules?

Plant Manager: No, our main JIT goal is make-to-order production—essentially zero finished goods.

Advocate: But you have a few standard "commodity" items. For them, you should think in terms of making to a smoothed representation of the actual spikey customer demand pattern; in other words, make to a rate—the drumbeat of demand. Then pass that rate back through to components and even to purchased parts. Get it all synchronized to a rate, and you cut out intermediate work in process and eliminate the need for work orders, move tickets, and many other production control costs.

Plant Manager: I suppose we could do that on some items. But most of our products are configurable to customer order.

Advocate: Yes, that's where make-to-order makes sense—but just in final assembly, where model variety cannot be known in advance. As for the feeder processes—the subassemblies—put most of them on daily rates. And pass that rate back through component fabrication and many of the purchased materials.

Plant Manager: (Long pause. But finally . . .) I see your point. But wouldn't we have to maintain buffer stocks at the subassembly level in order to cover peak demands in final assembly? Our JIT goal is still elimination of stocks.

Advocate: Yes, you would need buffer stocks of subassemblies. It might amount to a few days' worth. You would gain that back, and more, by eliminating buffer stocks backward through the supply chain. No need for intermediate buffers when a process and its supplier are both making, say, a hundred units per shift, day after day.

Plant Manager: What about costs?

Advocate: You would spend more for carrying buffer stock at the high end. That may seem to violate the old principle of delayed differentiation (keep inventory in its least valued-added state). However, rate-based production can eliminate *most* of the overhead costs at component levels—and overheads are the dominant component of your cost structure. Overall reductions in unit costs are the main advantage of rate-based production, along with high levels of predictability. You and your customers will share the bounty.

Despite the benefits noted in the scenario, relatively few companies appear to have adopted rate-based production. In fact, in my experience involving hundreds of manufacturers over the past 15 years, of all the practices closely associated with Just-in-Time production (JIT), scheduling to a rate is the one that companies seem most hesitant to undertake. One reason may be that managers' JIT attentions are focused mainly on the direct production benefits (shortened cycle times, removal of excess stocks, stock-handling apparatus, etc.) and direct customer-service benefits (quick response and make-anything-to-order flexibility). Cutting the complexity and cost of production support (capacity planning and scheduling) is less visible. Furthermore, since many manufacturers have spent enormous sums getting their batch system software into good working order, there may be some hesitation to revisit the system in order to simplify it.

Whatever their reasons, even best-in-class manufacturers usually have herky-jerky schedules, which raise havoc back through supply chains and forward through customer chains in the form of high capacity-management costs, excess inventories everywhere, and other ills.

The purpose of this article is to demonstrate, via a case study, that gaining the benefits of rate-based production need not require a traumatic multi-month system redesign. For the subject of the case-study, the OPW Fueling Components subsidiary of Dover Corp., the analysis and much of the planning for implementation took only a few hours; the plan was up and running shortly thereafter. Cincinnati-based OPW's primary product line is the hand-held nozzle assemblies that go on the end of a fuel hose at gas stations. They also produce fuel vapor recovery apparatus and valves and fittings for overfill and spill containment. The case study presents OPW as a company well on the world-class pathway prior to this implementation, which made the effort a natural fit. The quick implementation method may be called "on-the-fly" consulting (see [3] for more on this method).

RATE-BASED PRODUCTION: PREPARATION AND IMPLEMENTATION

Scheduling to a rate initiates changes that ripple from the shop floor back through production control, material control, purchasing, and demand management. Since conversion to a rate has such far-reaching effects, seemingly requiring a complete system overhaul, it may be surprising that planning for this method of scheduling could be largely done on the fly in a day or less. Yet it can be done, particularly if the company has already removed many of the trappings of the batch system. As we see next, OPW had done so.

Already on the Path to World Class

The plant had begun conversion to machining and assembly cells in the mid-1980s, and currently has 24 cells. Cellular manufacturing had reduced or eliminated many of the non-value-adding wastes associated with the batch system, yielding various savings:

- Some of the savings were direct. Since each cell processes a family of similar items, changeovers were simpler and each item was run more frequently in smaller lot sizes. Work-in-process (WIP) inventory was reduced to the point that WIP stockrooms had been eliminated; each cell has its own inventory. Less stock, in turn, means less to rework and scrap. And within the cells, material handling, queuing delays, and travel distances were slashed.
- Other savings were indirect: reductions in overhead and managerial support. These savings accrued from reductions in move tickets, simplified shop floor control and priority management, and more natural process-to-process communication among cell-team members.
- Since the product families made in the cells own the resources of the cell—including equipment, operators, supervision, material management, utilities, supplies—OPW accountants could more easily and accurately determine product and component costs. In effect, for purposes of assigning direct and overhead costs, a cell becomes a *cost-containment center*.
- Process control charts had recently been put to use in a few areas. Benefits included cutting scrap and rework and associated delays and rescheduling,

TABLE 1: Demand of #12 Spill Container

	Model D	Model E	Totals
Model ratio last year	70%	30%	= 100%
Planned rates (per day)	126	54	= 180

late-delivery problems affecting multiple operations, and related overhead and managerial support.

- Piece-work incentives were eliminated, and labor classifications were reduced from 32 to just two in the late 1980s. These changes cut costly wastes in industrial engineering (time standards), accounting (monitoring and paying incentives), and human resource management (complex wage and classification, job bidding and bumping). These changes, in turn, set the stage for higher levels of employee involvement.
- Several suppliers had been certified. For those suppliers, receiving associates green tag incoming materials and send the items onward without inspection. That reduced inspection activities and associated costs, including several inspection-related documents per order; storage resources and inventories of items awaiting inspection; and delays in getting purchased materials to using work centers.

Implementation—On the Fly

The aforementioned improvements eased the transition to rate-based production. My own involvement in this transition was in connection with a visit to the company to conduct a seminar. A plant tour the previous day revealed a situation ripe for conversion to rates. The next day the general manager, the heads of materials and production, plus other key associates and I spent a few hours in a meeting room mapping out the plan. Our tools were pencils, paper, calculators, and hastily assembled demand records. The following description of our group's efforts uses disguised but representative names and data.

We selected two good-selling products for conversion—#12 spill container in two models and #9 swivel in four models. Both sold in erratic quantities per month (e.g., 100 one month, 600 the next), but since some were sold nearly every day, we considered them suitable for rate-based scheduling.

In working the data, we found it practical to schedule both models of spill container to daily rates. The swivel, however, required a less-than-daily rate because of a long setup time on a key component; we settled on a once-a-week production rate for the four models of that product. In both cases, rates would be reviewed monthly and would be raised or lowered only if the level of demand had clearly changed. The recent average demand of #12 spill container was 180 units per day, broken down into models D and E as shown in Table 1.

The planned daily rates would become the schedule in boxing, testing, assembly, and the purchase of all parts except metal lids. There are numerous options for breaking this schedule down within the day. At one extreme is making all 126 Ds followed by all 54 Es each day; that schedule minimizes setups (just two per day) but creates "mini-batches" (lumpy demands passed back through the product structure). At the other extreme is the "pure" JIT schedule of making a repeating minimum ratio of models. In this (simplified) case it would be 7 Ds and 3 Es 18 times during the day, totaling 180 units. While the 7 D-3 E schedule is the ideal, to be worked toward as setup and process variation problems are ironed out, a larger-lot schedule was a more practical one with which to begin. The details could be ironed out by trial and error on the shop floor.

Lids for the #12 spill container are of two types, one of cast iron and the other of aluminum. The customer may order either type for either model of spill container, which means that the spill container schedule simply becomes the purchasing schedule for the lids. The new schedule for lids would still total 180 units per day—same as the parent spill containers. However, those 180 units would split between cast iron and aluminum, each to its own historical usage rate.

While the lids, and all other purchased parts, would be scheduled to daily rates, transport economics would dictate that most of them be delivered to a multiple of the rate, such as 360 units every two days

TABLE 2: Demand of #9 Swivel

	Model Q	Model R	Model S	Model T	Totals
Model ratio last year	60%	21%	4%	15%	= 100%
Planned rates (per day)	180	63	12	45	= 300

TABLE 3: Schedule for #9 Swivel

Monday, Tuesday, and Wednesday	60 per day of Model Q
Thursday	63 of Model R
Friday	12 of Model S, followed by 45 of Model T

or 900 units once a week. Boxes and certain packing materials—bulky and from a local supplier—would be most suitable for daily deliveries. The recent average demand of #9 swivel is 300 per day, broken down into models Q, R, S, and T as shown in Table 2.

A key component of the #9 swivel is a swivel connector, which is machined from purchased castings to different dimensions for each of the four models. This machining is done on dedicated equipment, that is, on a machine that currently makes only the four models of swivel connector—no other parts. On this equipment, changeover time from one model to the next is six to eight hours. For that reason, machining the connectors for all four models every day is impractical, which makes assembly, testing, and boxing to a *daily* rate much less attractive. While it might be economical to schedule to a twice-weekly rate, we decided on a once-a-week rate with which to start. The schedule—same rate for boxing, testing, assembly, machining, and receiving purchased parts—is as shown in Table 3. Equipment changeover for each model of swivel connector would take place off shift.

Since the structure of the rate-based scheduling plan had been developed by a cross-functional group of managers, their commitment was assured. For this fast-track plan, commitment of the cell teams would need to be addressed quickly, starting with a showing of the 28-minute Britannica videotape, entitled "Just-in-Time/Just-in-Case [2]." While the tape does not specifically address scheduling to a rate, it convincingly details the advantages of JIT over batch manufacturing. Within about a week, the plan we had worked out in a few hours had been implemented.

RESULTS AND AFTERTHOUGHTS

Checking back with the general manager some months later, I learned that the rate-based system was doing well and had been extended to seven additional cells. Within the rate-based cells, a sense of operator ownership and involvement had visibly improved. The cell coordinators (non-supervisory lead persons) have assumed the job of faxing orders for materials directly to suppliers.

There had been no increase in finished goods inventory, as was feared, and on-time performance had significantly improved. Most gratifying of all, the customer service level had risen about 40%. No one had analyzed the savings accruing from reduced scheduling activity and computer transactions, smoothed demands on capacity, and more dependability backward through the supply chain. Those savings being obvious, there seems little point in proving them via a cost study.

A missing ingredient in our on-the-fly implementation was early front-line associate involvement—for example, in selection of the products for conversion and calculation of the rate-based plan. However, there were plenty of details remaining to be worked out on the floor by the cell teams, and more products and cells as future targets for conversion to rates.

Overall, the OPW experience indicates that system changes of a fairly radical nature can sometimes be planned with just-in-time speed—the kaizen "blitz" approach [1]. An outside authority figure may act as catalyst, helping to break down normal fears of change and go-slow inertia. Availability of case-study evidence such as that presented herein, however, may convince other companies that they can run the show themselves.

REFERENCES

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