CONCEPTS

The technology of 'timing'

Thomas R Cutler discusses the importance of effective scheduling in the food processing industry

In many ways food process production is similar to other industries. In the food processing industry the products must be produced on time to meet demand as production capacity is limited. Raw material purchasing and intermediate production must be coordinated as there are constraints limiting the equipment to be used for production. In addition, food process manufacturing poses a number of unique production scheduling challenges. There are spoilage concerns, cross-contamination must be avoided, cleanouts can be lengthy, intermediate storage is limited and conveyance equipment constrains material flow paths.

The benefits of effective scheduling in the food processing industry are also unique and substantial. Good schedules take more time producing and less time performing cleanouts – resulting in increased output and higher revenues. In addition, risks associated with spoilage and cross contamination are reduced as there are the costs of storing products that are produced too early or shipped late. Even transport costs can be reduced by tightly integrating shipment schedules with production.

Defining production capacity, production rates and expected yields

Production equipment in food processing is extremely expensive and therefore limited. A facility's maximum production output is constrained by physical constraints such as the following:

- The number of machines available
- The rates at which products are produced on each machine
- The time lost to yield problems, changeovers, and equipment downtime.

Capacity is lost due to 'timing constraints' – where raw materials or intermediates are not available at the right time or when equipment is not staffed and is kept offline according to the hours of operation. In these situations equipment is idle by choice or at least according to 'plan'.

Some of the physical capacity constraints are relatively static, which are ported directly into the ERP system. These constraints are as follows:

- Work centres with specific defined machines
- Expected yield rates by product
- Standard production rates by product and by work centre.

"Often the output rate and expected yield for a single product can vary depending upon the specific piece of equipment used. For example, one mixer may produce 250 gallons per batch while another produces 1,000 gallons per batch so the time to produce 'x' gallons varies based on the mixers chosen. This is handled by creating a lookup table that specifies the capacity, production rate and expected yield of each product on each machine," says Evan Garber, President of Escape Velocity Systems.

Product specific resource assignment

In any manufacturing process there are limitations regarding the capacity of machines and the kind of products that are produced by the machine. Machine 'A' may be able to produce products 'x' and 'y', while machine 'B' can produce products 'y' and 'z'. Assuming machines 'A' and 'B' are in the same work centre this can be handled by simply specifying the required work centre in the product

formula/routing for each production step. In the food processing industry this method of work assignment can be much more complex and more flexible logic might be needed.

Physical properties

In addition to work centre constraints there are often 'physical property' constraints that limit the capacity of machines to schedule specific products. For example, a situation with three meat grinders – A, B and C – where pork can only be ground on A and B, while beef can only be ground on B and C. Clearly the work centre assignment alone is insufficient since B's capability spans the kind of setup required for the 'pork grind' and 'beef grind' work centres. A product may be a beef product and so only machine B and machine C would be considered eligible since they are actually the grinders that can grind beef. These physical property capabilities can also be used to avoid allergen problems where only specific machines are defined as capable of handling products that contain the allergen.

Quantity, quality, or other assignment limitations

Mr Garber also insists, "There are situations, where the eligible machines cannot be specified by physical properties of the product alone. Some machines may only handle orders of certain quantities due to size limitations. Two orders for the same product could therefore have differing eligible machines. Orders of less than 500 pounds may be made in the small mixer while larger orders are handled in the large mixer. Alternatively, orders may be assigned based on the customer for whom the order is being manufactured."

Having examined the issues of defining production capacity, production rates and expected yields, product-specific resource assignment, physical properties, as well as quantity, quality, or other assignment limitations, a second information resource is specifically designed. This is done with the objective of exploring inventory constraints, material handling equipment constraints, prevention of cross-contamination and allergens, avoiding spoilage and the nature of batch processing.

Inventory constraints

Food production often requires a wide variety of ingredients - both raw materials and intermediates. Mr Garber says, "Ensuring that the requisite materials are available at the right time is a critical and difficult task, which can be made much easier by automatically creating schedules that are based on current on-hand inventories and projected receipts." Creating schedules that are always material feasible – a production batch is only scheduled at a time when the necessary inventory is expected to be available. The source of supply can be from on-hand stock, from a scheduled purchase order, from a scheduled intermediate batch, or based on the standard purchase lead time if no other supply is available. Garber suggests, "Since the schedule can be constrained by materials, there is clear visibility to material bottlenecks. If material is late, due to a delayed vendor delivery, the production batch can be highlighted on a Gantt chart, making it obvious that there is a material bottleneck coming. Simply pointing to the batch on the screen warns the planner which material is the problem so that the material can be expedited or produced in time. This is a far better alternative to unexpected material shortfalls discovered at the last minute."

Material handling equipment constraints

The movement of intermediate food product between operations is often done with the use of direct feed material handling equipment with no manual intervention. Moulded cheese, for example, falls directly from moulder into a transport canal where it cools while transporting to the packing workstation. This creates a scheduling constraint because the selection of machines for moulding and packaging are often interdependent. The cheese can only be packaged on a packaging line that is setup to service the particular transport canal.

There may be other packaging lines available, yet if they are not connected to the mould machine then they are not eligible to do the packing. Moving a production run to a different mould machine would automatically cause the associated pack operation to be

moved to an eligible pack line, ensuring feasibility. If more sophisticated logic is required there are often options of defining a custom constraint.

Preventing cross contamination and allergens

A common goal in food process scheduling is to avoid certain products from running in sequence on the same equipment, thus preventing allergens from cross-contaminating other products. For example, a mixture containing peanuts followed by another mixture that does not contain peanuts could lead to traces of peanuts in the second mixture. There are several strategies for avoiding this problem. They are as follows:

- **Machine assignment:** The system can be configured to only allow certain products to run on certain machines.

- **Avoid bad sequences:** If products with different allergens must run on the same machine then the system can be configured to disallow certain sequences?

- **Cross-machine contamination:** In situations where airborne particles can result in cross-contamination between machines it is necessary to prevent non-compatible products from running together on machines in the same vicinity.

Avoiding spoilage

Food spoilage typically results either from products cross contaminating each other or from products being excessively delayed in the production process or in storage. Prevention of contamination is discussed above. Mr Garber asserts that "Food Processing manufacturers can reduce the risk of spoilage due to production delays using a 'Maximum Delay' value in the routing. A maximum duration can be specified between any two operations. If this delay is violated during scheduling then details can be provided to the planner explaining that the product is being delayed beyond its 'Max Delay value'.

It is best if a reference point is given to material that has been waiting for longer periods of time, thus reducing the chance of this Max Delay being violated at all."

Batch processes

Batch processes such as blending or mixing have some special requirements. Such requirements are in terms of scheduling. These requirements are mentioned below:

- **Uninterruptible process:** Once a batch is started it can't be 'paused' at the end of the shift or for the weekend. Systems can handle this automatically to make sure the operation only schedules at a time when it can finish completely without interruption.

- **Time varies by equipment:** If 300 gallons of soup are needed and a single 300 gallon batch is scheduled on a 300 gallon blender then the time may be one hour. However, rescheduling the batch to a 100 gallon blender means rescheduling three batches of 100 gallons at the rate of 45 minutes per batch or two hours and fifteen minutes total. Mr Garber suggests that "It is critical to set up systems to dynamically calculate these times as operations are scheduled on various pieces of equipment. Of course, the calculation can be very flexibly programmed based on certain logic or pulled from lookup tables in an Excel sheet. This makes it very easy to adjust the schedules since the planner simply drags the production run to an alternate machine."

While far from an exhaustive description of the scheduling challenges faced by food processing companies, the complexities and difficulties of this type of scheduling without a system that can model the various constraints becomes very apparent.

Mr Garber concluded that "A system for food process manufacturing must make it very easy to add constraints for specific production environments. This functionality combined with predefined tools related to food process scheduling challenges, results in a technology that is rapidly implemented, easy to learn, and highly profitable to use."

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