Simultaneous Tactical Planning and Production Scheduling of Batch Operated Reactors

Background

The traditional approach used to plan and manage the production of a suite of products at geographically distributed production sites, for geographically distributed customers, relies on a two step process involving long range (12 months) production planning across all assets and short term (1 week to 1 month) local production scheduling. The goal of the production plan is to assign production quantities for each asset while taking into account asset capacities, recipe unit ratios, raw material and transportation costs and product prices. The goal of the production schedule is to determine the timing of and the material produced by each batch run on a reactor, as well as cleaning tasks, while taking into account inventory replenishment needs and inventory capacities.

Because of sequence dependent product change-over costs, the short term product schedule for a given asset can have a significant impact on its capacity and therefore the long range production plan. However the production plan does not directly account for change-over costs but instead uses discounted capacities for each asset. Likewise the production plan does not consider inventory constraints.

A related issue is the assignment of the limited number storage tanks at a site to particular materials. Generally a tank can store any material produced at a site, but due to the costs associated with setting up an inventory tank for a particular material a tank cannot be arbitrarily switched between products month to month but must be assigned a product for at least 6 months.

We want to investigate and demonstrate how the planning and scheduling can be combined to determine:

1. The value that can be generated from such an approach
2. The feasibility of developing a useful tool for the business
**Problem Statement**

The problem to be solved can be stated as follows:

A business has a set of:

**Production Sites**, each with a unique set of:
- Raw material costs ($/lb)
- Raw material availability (lbs/mth)
- Storage tanks with associated capacity
- Transportation costs to each customer ($/lb)
- Reactors with associated
  - Materials it can produce
  - Batch sizes (lbs) for each material it can produce
  - Batch times (hrs) for each material it can produce
  - Operating costs ($/hr) for each material
  - Clean out times (hrs per transition for each material pair)
  - Time the reactor is available during a given month (hrs)

**Customers**, each with a unique set of:
- Demand for desired products (lbs/mth)
- Price paid for each product ($/lb)

**Materials produced**, classified as:
- Raw materials
- In process intermediates with
  - Unit ratios (lbs of needed material per lb of material produced)
- Finished products with
  - Unit ratios (lbs of needed material per lb of material produced)
  - Price by customer ($/lb)

The problem is to determine the monthly production quantities for each reactor and the assignment of materials to storage tanks such that the profit to the business is maximized.