Expansion of an Agricultural Products Formulation Plant Using BATCHES.

Mike Liguori, Project Manager
Rhone-Poulenc, Inc.
Cranbury, New Jersey

Abstract:

A dedicated agricultural products formulation plant was slated for a 25% increase in capacity. The processing steps are characterized by variability in cycle times, failure of equipment and shared resources, generation and user of recycle material and synchronization of equipment to ensure smooth operation. The BATCHES simulator was used to accurately model the underlying process. Prior to the simulation study, several alternatives were suggested based on experience and "gut feel". The simulation model quantified all alternatives. The best process modifications, resulting in the desired increase in capacity, when compared to the "gut feel" modifications reduced the pay back period by 15 months.

OBJECTIVE

Rhone-Poulenc identified the need to increase the capacity of their agricultural products formulation plant in southern Georgia by 25%. A team was assembled to determine the most cost effective modifications to accomplish this objective.

PROCESS DESCRIPTION

The schematic diagram of the process is shown in Figure 1.

A batch of material is prepared in a hopper by mixing fresh raw material with recycled material from the **UNDERS** storage tank. A batch from the hopper is mixed in one of the formulators with recycled material from the **OVERS** storage tank and solvents from the **SOLVENT** storage tank. The **OVERS** material brought into the process varies from zero to an upper threshold called for by the recipe. Chemical reactions and solvent recovery, involving heating and drying, take place during the formulation step. The formulation material is moved to two mixers where the material is cooled and more raw materials are added. A screening process then recycles oversized material to the **OVERS** storage tank, and sends the product to either the **PROD1** or the **PROD2** storage to await packaging.

Fresh raw materials are staged into storage facilities such that they never drop below a specific threshold. Filling operations are scheduled as needed to fill the raw material storage vessels.

Some of the key operating characteristics, which made this process difficult to analyze with traditional methods, are explained below.

Cycle Time Variation:

The cycle times of all the processing steps fluctuated randomly. The plant data were accurately characterized by truncated normal distributions.

Conveyor Breakdowns:

Conveyor systems are used for the following material transfers: Raw material to the supply storage tank, supply storage tank to the hopper, formulators to mixers, mixers to the screen, and product storage tanks to the packaging line. All conveyor systems experience random breakdowns with characteristic frequencies and repair times.

Utility Breakdown:

Steam is consumed by the formulators during the drying and solvent recovery steps. Like the conveyors, the boiler plant experiences random breakdown. Depending on the status of the drying and solvent recovery at the time of the failure, the formulation operation is either started over, or continued without interruption.

Recycling of Material:

The screening step after the mixing tanks generates oversized material, while the packaging step generates undersized material. The undersized and oversized materials are recycled to the respective storage tanks. The amount of the oversize material varies randomly from one batch to the next, while a fixed percentage of undersize material is generated for each batch. The process variability causes wide swings in the availability of the recycle materials.

Mixer Constraints:

A formulation batch is split into two and sent to the downstream mixers. As an operating policy, material transfer between a formulator and mixers is not initiated until both mixers become available at the same time.

Packaging Line Schedule:

The packaging line is operated only on six days of a week, with each day following a different operating pattern. The total operation time per day may vary from 7 to 15 hours. This results in wide swings in the product storage tank levels.

SIMULATION MODEL

The BATCHES model was generated jointly by Rhone-Poulenc and Batch Process Technologies. The recipe network consisted of 26 tasks (processing steps) and 58 subtasks (elementary processing steps).

Varying cycle times, equipment breakdown and repair times were implemented using sampled distribution functions. User Logic was used to determine the generation of **OVERS** recycle material with variation in each batch and to establish the packaging availability.

The main performance measure for a simulation run was the total amount of material produced in a period of one month.

As a first step, the model was verified against previous production runs. The comparison showed that the model was within 0.5% of the plant data.

After verifying the model, several alternatives were evaluated for plant expansion, each scenario representing a specific combination of process changes.

SIMULATION STUDY

After model verification, several scenarios were run, each reflecting changes proposed by the project team. The preliminary scope of the project, determined through empirical evaluation of plant operating and maintenance data, was evaluated using the BATCHES simulation model. Our hope was to verify the original scope of the project and insure that secondary bottlenecks were not overlooked.

Some scenarios were pre-selected and some were determined based on the analysis of the previous simulation runs. In all, six major scenarios plus the initial verification runs were made. The various scenarios reflected changes in vessel sizes, packaging schedule, and flow rates. The key scenario parameters and results are summarized below. The simulation time of 720 hours was used in all simulation runs.

Base Case:

The total monthly production for the base case under the current mode of operation was 5.122 million pounds, within 0.5% of the actual production from the plant history data.

Case 1:

For this simulation run, the formulation batch size was increased by 30% without changing the flow rates into and out of the formulators. Thus, the overall cycle time of the formulator and hopper operations also increased. The total monthly production for this case was 5.390 million pounds.

Case 2:

This simulation run is the same as Case 1. Additionally, the flow rates of **UNDERS** to the hopper and solvent to formulators were increased, reducing the times for the corresponding steps in the hopper and formulation operations. The total monthly production for this case was 5.878 million pounds.

Case 3:

This simulation run is the same as Case 2. Additionally, the cycle times for the two formulators were made identical. The total monthly production for this case was 5.869 million pounds.

Case 4:

This simulation run is the same as Case 3. Additionally, the total available product storage capacity was increased by 90,000 pounds. The total monthly production for this case was 6.282 million pounds.

Case 5:

This simulation run is the same as Case 4. Additionally, the available time for the packaging line was increased. The total monthly production for this case was 6.657 million pounds.

FINDINGS

Although Rhone-Poulenc had used BATCHES for other processes, our experience using batch simulation was limited. The simulation study results were both favorable and surprising. Four specific results of the simulation study were:

1. The amount of equipment required to meet the increased capacity was less than anticipated
2. It was not necessary to replace several equipment items with larger units as proposed prior to the simulation study
3. Numerous smaller changes were identified that were not previously included in the project scope
4. Operating parameter changes were identified that would yield immediate results.

BENEFITS

The simulation modeling project required approximately two man weeks of engineering time using BATCHES plus an equivalent amount of time gathering data to describe the process, operating policies, and analyzing simulation results. The benefits of this investment were dramatic. The immediate benefit to the plant was the identification of operating parameter changes that resulted in a capacity increase of 8% without capital investment. In a sold out position, this means a potential addition of $300,000 in profits to the company, and the ability to better meet market demands. The model also provides a tool for operations that allows them to evaluate how a change to each variable affects plant production. This is useful in optimizing the operating parameters for various production rates.

The benefits to the capital project were the reduction in scope, schedule, and difficulty. Perhaps the greatest benefit, however, was that it helped ensure that the modifications that will be installed will produce the desired and needed results.

Overall, it helped Rhone-Poulenc's engineers add value to the company by providing the best, most cost effective solution to a business need.

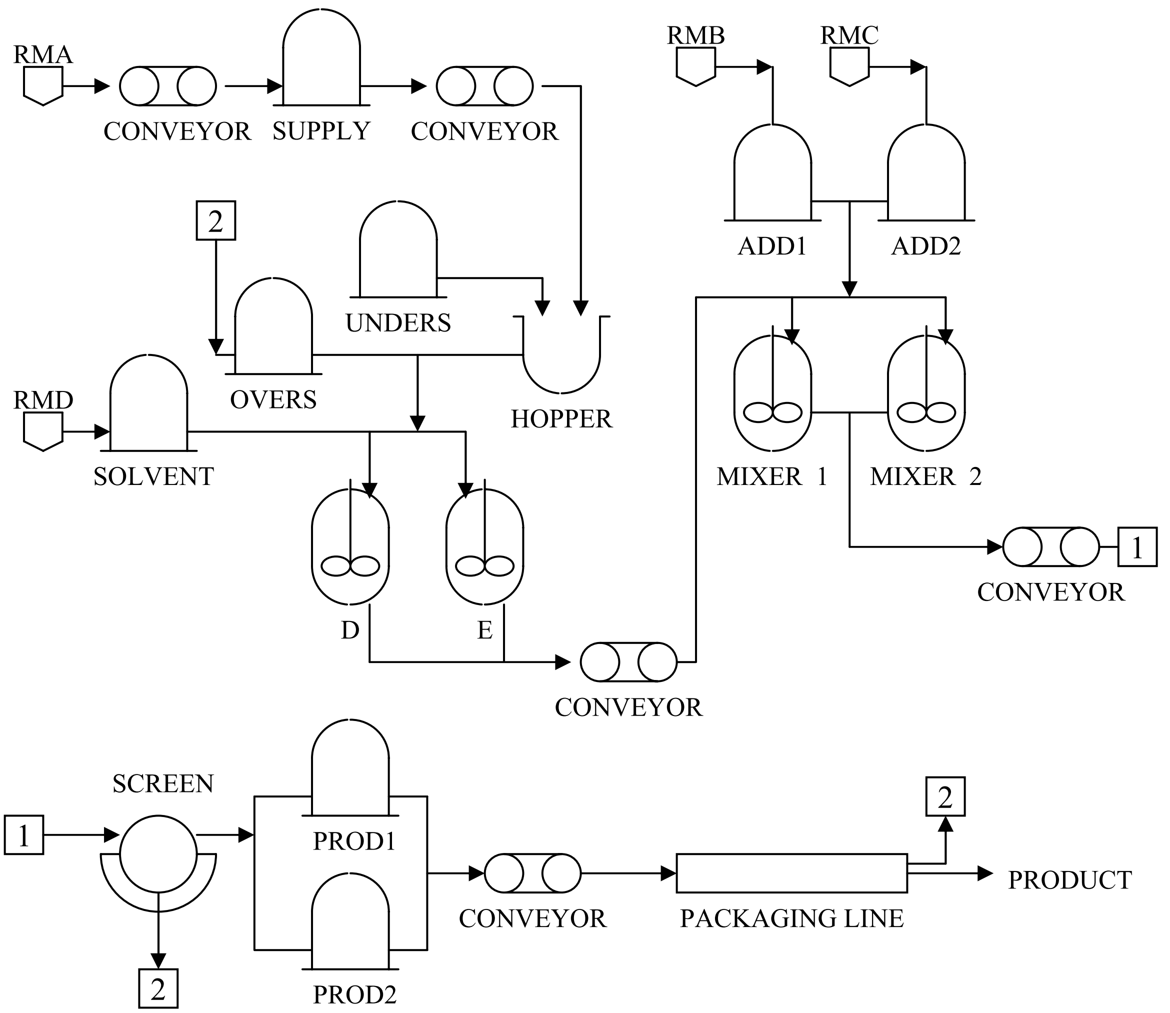

Figure 1: Equipment network for the agricultural products formulation plant.