CAPACITY PLANNING SIMULATION OF AN OLIVE PROCESSING PLANT

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ABSTRACT

The Lindsay Olive Company is expecting a large increase in the volume required to be handled by their olive processing plant over the next few years due to increased sales. They chose to simulate the current facility in order to determine capacity planning measures to be undertaken in the near future in order to meet the increased volume. The initial simulation was designed to answer the question: "What is the capacity of the current olive processing system?" The simulation was modified to study the balance between processing and canning systems over a year. Results obtained from this simulation have enabled managers of the plant and production engineers to determine how the current system would handle future sales forecasts. It was also used to determine methods of increasing production through improved scheduling along with helping determine exactly where future capital investments should be made in the plant.

1 INTRODUCTION

Simulation modeling can be a highly effective tool for solving problems found in the food, beverage, consumer products, and pharmaceutical industries. The flow of material or fluid in these industries is often described as bulk flow, continuous, semi-continuous, or high-speed. Current literature contains many references to simulating these kind of systems such as modeling beverage processing (Harrell, 1993), simulating capacity expansion for a pistachio hulling process (Dessouky, Maggioli, and Szeflin, 1994) and simulating a high-speed process (Sturrock and Drake, 1996). All of these systems exhibit the similar characteristics of having multiple products running at high speeds through multiple pieces of equipment (usually separated into making and packing areas). Also generally, in all of these cases, the product is packed at high speeds into small containers for consumer purchase.

In this simulation study, the project manager wanted to know the capacity of the current plant and have a tool that he could use to test the effect of various changes on the plant. The model served as a vehicle for testing the impact of schedule alternatives, variations in product mix, shift and crewing policies and in identifying plant bottlenecks as well as underutilized operations.

In this paper, we will first present a brief overview of the plant operations. Then, we will present the different steps of the model-building process, identification of modeling assumptions and input data collection, actual model building, validation and verification, and analyses and results of the model.

2 OVERVIEW OF THE OLIVE PROCESSING PLANT OPERATION

The Lindsay olive processing plant produces consumer-size packages of olives. The packages are produced by the following operations: processing, pitting, sorting, filling into cans, seaming, and cooking. A flow diagram of the operation is shown at the top of the next page in Figure 1.

A unique element of the olive industry is that all olives are harvested during a six-week period in the fall, then stored until they are processed throughout the year. This makes their inventory management and scheduling a critical part of their downstream processing.

The olives move between the different operations on belt conveyors. There are a number of different varieties of olives, which are processed through the plant, and each has a different set of parameters associated with each of the pieces of processing equipment. Some varieties of olives can be pitted faster than others. Some varieties of olives have different types of defects, which are manually sorted, in the sorting area. The filling operation is of course affected by the size of the different olive varieties. Olive size creates the most significant downtime for equipment changeovers. The seaming and

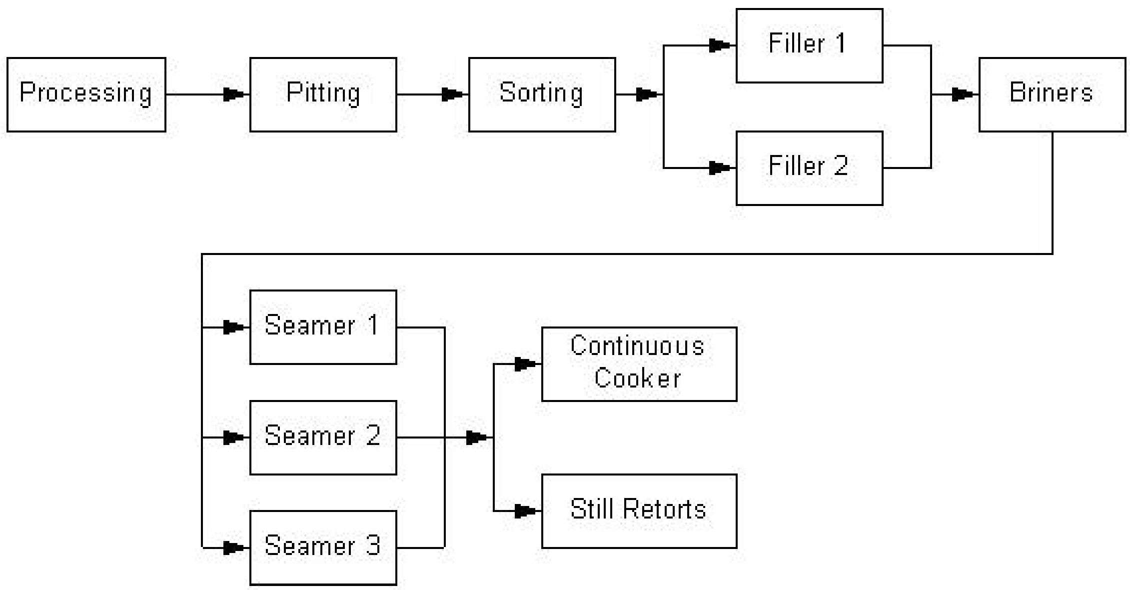


Figure 1: Olive processing plant schematic diagram

cooking processes are operated differently based on the size of the cans and the variety of the olive.

There are also numerous scheduling issues associated with the different types of olives and crewing which can significantly affect the operation of the plant. There are different shift patterns for different operations in the plant, which make the use of simulation important due to the nature of the complexity of the system.

2 MODELING ASSUMPTIONS AND DATA COLLECTION

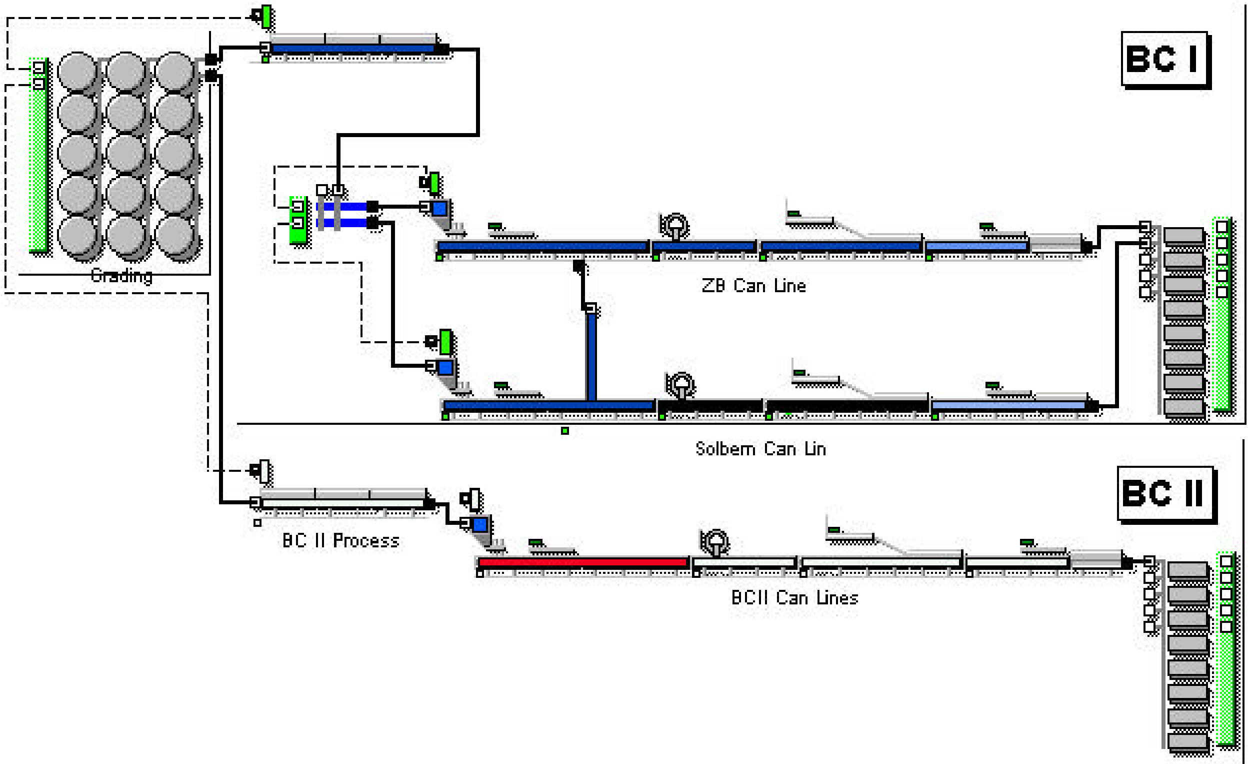
Meetings were held with Lindsay's project manager for the simulation to determine what some of the assumptions were for building the model and the data that needs to be captured for the model. As is typical in many simulation projects this process was difficult and many times leads to expanded understanding of the operation of the plant.

The project manager and the simulation builders agreed upon the following assumptions:

• Olive harvest will be modeled as a gross arrival rate of olives to the plant during a limited "harvest season" of 4-6 weeks. The harvest will be modeled as if it were stored in a single tank of infinite capacity.
• The olive sorting and grading process will be modeled as a gross sorting rate, with the olives diverted simultaneously into seven different storage bins based on their size/type. The percentage going to each storage bin will be variable about the "statistically known" percents of the harvest.
• The repeated lye process will be modeled as a delay of at least seven days between grading and pitting/slicing.
• The pitting and canning process will draw from the graded/pickled inventory a rate based on the olive size/can size being processed. This process is constrained by the cooking processes, and as such, only the details required to determine the cooking rate will be included.
• Slicing and canning also draws from the graded/pickled inventory.
• Storage of finished product, labeling, and shipping will not be included in the model.

The simulation builders worked with the project manager, plant engineers, production scheduler and director of operations to get accurate and valid logic for the model. The type of data collected and input into the model database is as follows:

• Equipment capacities including pitters, continuous cookers, and still retorts
• Yield factor for each olive variety to account for quality (based on historical data)
• Shift patterns
• Routing logic for different olive varieties and can sizes
• Changeover and downtimes for equipment
• Material specifications for different SKUs



3 BUILDING THE MODEL

As was mentioned in the Introduction, the olive processing plant exhibits a classical making/packing layout typical of food, beverage, pharmaceutical, and many other processing-type manufacturing facilities. The way in which important factors interact with each other through time in a making/packing operation makes simulation the tool of choice for evaluating problems and predicting the effect of design or reengineering decisions. In particular, simulation is well suited to study the logistical problems of these systems, such as plant configurations, scheduling, and capacity.

Unfortunately, in using simulation for logistic-related problems, practitioners have had two kinds of tools to choose from, and neither has met their need well. On one side are physical process modeling tools, which are best used to study the thermodynamic and physical properties of the material being processed (such as viscosity, compressibility, enthalpy, etc.). Physical process simulation systems address the continuous nature of the bulk flow problem, but the resolution required to capture important events results in cumbersome, inefficient, and slow-running models. This makes the use of continuous equations inappropriate for application to logistical problems.

On the other end of the spectrum are classical discrete event modeling systems, which are best used for logistical problems, but are inappropriate and slow for modeling the flow of bulk material or the high speed of packaging operations. A common approach for dealing with bulk material in a discrete event system is aggregation. This approach requires assigning a certain quantity of material to each discrete entity, and then treating each entity as a portion of flow. This leads to inaccuracy and loss of detail, and potentially slow models (Sturrock and Drake, 1996).

SDI Industry was chosen to build the simulation of the olive processing plant because of its unique architecture. SDI Industry is a graphical, interactive, industrial simulation program built on top of the popular Extend simulation package, which is developed by Imagine That, Inc. The architecture was designed specifically to model flow of materials in a rate manner rather than in the traditional item paradigm. Thus, the significant advantage of discrete-event simulation over continuous is utilized without having to aggregate and thus create slow and inaccurate models.

An overview of the olive processing plant simulation is shown at the top of this page in Figure 2. SDI Industry exploits the hierarchical nature of Extend, so that there are numerous levels within the model which represent different parts of the manufacturing process of the olives.

A part of building the model includes organizing pertinent processing data in the integrated database. The database is used to provide operating information to the simulation such as changeover times, downtime, material types (olive varieties in this case), shift scheduling etc. This information is displayed in a database table similar to the one shown below in Figure 3.

	From	To small	To medium	To large
1	small	0.00	10.00	10.00
2	medium	10.00	0.00	10.00
3	large	10.00	10.00	0.00
4	extra large	10.00	10.00	10.00
5	jumbo	10.00	10.00	10.00
6	colossal	10.00	10.00	10.00
7	super colossal	10.00	10.00	10.00
8	broken pitted	10.00	10.00	10.00
9	sliced	10.00	10.00	10.00
10	chopped	10.00	10.00	10.00
11	wedges	10.00	10.00	10.00
12	diced	10.00	10.00	10.00

Figure 3: Database Table

Lindsay was interested in analyzing annual production (due to their once a year harvest). To facilitate that objective, the model was set up to run on an annual schedule. This schedule was generated by importing data from their production schedule and generating a model run schedule. The model run schedule followed specified routing logic and production requirements. Operations in the model communicate their current status to the schedule on a continuous basis during the model run. An important output of the model run was the amount of overtime required to meet a particular schedule.

4 VERIFICATION AND VALIDATION

The model builders held numerous meetings with the plant engineers and production scheduler to verify that the model represented the processing plant accurately. The logic in the pitting area was reviewed and refined based on input. The data contained in the database was reviewed extensively. A custom report generated by the model was compared with the annual schedule to verify that the model was running as intended. The model was then run with an annual historical schedule to validate that there was enough detail in the model and that assumptions were valid.

5 RESULTS

The model confirmed bottlenecks at certain operations in the plant. It also helped Lindsay Olives understand their process better and gave them an effective tool to evaluate proposed capital expenditures and scheduling changes over short and long-term periods. The simulation offered Lindsay personnel an understandable representation of their large, complex plant. The simulation is a tool that has allowed management to evaluate critical factors about their facility while discarding irrelevant detail.

Additions are planned for the model, to incorporate capital purchases that have been approved and expand the scope of the model to include the entire operation. The expanded model will allow Lindsay personnel to further analyze their operation. The success of the model is attributed to the fact that the simulation has been used and accepted by all levels of management within the organization.

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