HARVARD | BUSINESS | SCHOOL

5-688-024
APRIL 8, 1988

TEACHING NOTE

Kristen's Cookie Company (A1) and (A2)

Synopsis

The student is put in the position of being about to open a two-person midnight cookie baking operation, operating out of their own dorm room. The case asked the students to analyze the design of this simple production process. The standard tools of the first two weeks of process analysis are used to get insight into whether the process will work, how well it will work, how much it will cost, and what improvements are possible. The production process is a very simple line flow, but with high product variety. The production technology is deliberately made very easy to understand.

The (A1) case presents the situation. It includes assignment question which ask the student to calculate relevant behavior of the production system. The (A2) case then presents the answers to the questions in the (A1) case. The (A2) case is intended to be handed out during the class; it can also be handed out the night before, provided that the assignment questions change some of the numbers in the case.

Despite their simplicity, the two cases are open-ended. If the students understand the core analytical material of the cases, they can go on to discuss issues such as:

- Labor flexibility
- The interactions of the product design with the production system
- Product positioning
- Pricing

There are several ways in which the Kristen's Cookie Company is quite different from a standard bakery, even a storefront bakery. Students will find that some of the differences seem to hurt the company, but through discussion we will begin to see the interaction of marketing and production issues. It turns out that because Kristen's Cookie Company promises fresh cookies made to order, yet with very short waiting times, a variety of trade-offs have to be made in the operating system.

This note was prepared for the sole purpose of aiding classroom instructors in the use of "Kristen's Cookie Company" (A1) and (A2), HBS Nos. 686-093 and 686-094, respectively. It provides analysis and questions that are intended to present alternative approaches to deepening students' comprehension of business issues and energizing classroom discussion. HBS cases are developed solely as the basis for class discussion. Cases are not intended to serve as endorsements, sources of primary data, or illustrations of effective or ineffective management.

Objectives

The case is intended as a fun review of the rudiments of process analysis: set-up time, run time, throughput time, cycle time, labor content, and capacity. By the end of the case, students should be completely comfortable with the analysis of simple, unbuffered deterministic systems, including the effects of order size, setups, and product diversity in cases such as Blitz. The case also introduces the use of Gantt charts to analyze sequences of steps over time.

Discussion Questions

1. Answer the key questions. Be sure to consider the effects of a second oven.

2. Answer the problems for further thought.

The (A1) case includes two sets of discussion questions. The first six are mandatory basic analysis. The last four questions are posed as problems for further thought. Since these are already included in the case, there is no need for further assignment questions. However, if the instructor wants to hand out the (A2) case with the (A1) case, you can use assignment questions to change some of the processing times in the case. This has the advantage that it gives the students a completely filled out template of how to do the analysis, but requires them still to repeat the analysis using different numbers.

Analysis

Most of the necessary analysis for the "key questions" is contained in the (A2) case. A lot of it revolves around the difference between orders for one dozen cookies and orders for two dozen or more cookies. (In this note I will assume 1 dozen = 1 tray. Point out that a partial tray saves only on the cost of ingredients, which is $.05 per cookie.) The mixing step requires a 6-minute setup for each order (i.e., for each new type of cookie). The throughput time for an order of one dozen is simply the sum of set-up and run times at all the stages. However, to calculate the throughput time for 2 dozen or more, a Gantt chart is a useful way to reduce confusion. This is provided in **Figure B**. **Figure B** can be expanded to handle sequences of orders, by using a colored pen, with a different color for each new order. The table on page 3 of the case summarizes the resulting throughput times and labor times for different order sizes. **TN-Exhibit 1** provides further information.

Capacity analysis is quite straightforward as long as there is only one oven. The cycle time of the oven is longer than the setup plus run times (8 minutes) of the mixing stage; therefore the oven is always the bottleneck, regardless of order size.

When there are two ovens, capacity analysis is more interesting. Oven capacity is 12 dozen cookies baked per hour, or 2 trays every 10 minutes. If an order for 3 dozen cookies is received, the 3 dozen will come out of the mixing stage within 6 plus (3x2) or 12 minutes. For that order size, baking is therefore still the bottleneck operation. However one-tray orders in sequence will come out of mixing every 8 minutes. Therefore mixing is their bottleneck.

Question 5 asks how many food processors and baking trays will be needed. It is easy to see that when you have only one oven, the oven will always be the bottleneck; therefore there will never be a need for a second food processor. If you have two ovens, however, a second food processor would allow you to greatly increase your capacity for orders of one or two dozen cookies at a time. In essence this will give you two complete parallel systems, each one consisting of a mixing stage and a baking stage. If you do that, the bottleneck will become total labor time, rather than any of the machine capacities.

This leads back to a discussion of labor as a capacity limiting factor. The (A2) case lays out clearly that you will have a lot of idle time in the system as it is designed now. (See **TN Exhibit 1**.) Even if you go through the case with two ovens, it turns out that labor is never the constraint; it is either mixing or the number of ovens, depending on the order size. However, this assumes complete labor flexibility. If you and your roommate are specialized, for example by a union contract, then it may well be that the system is slowed down when there are two ovens. To figure this out precisely, you would have to draw Gantt charts of various circumstances, and see whether one of you had to be in two places at once. The most likely candidate is that your roommate might have to pack one batch while another is coming out of the oven.

One point of possible confusion for students in the capacity analysis is the cooling stage. Although the stage takes 5 minutes, it is reasonable to assume an effectively infinite cooling capacity; you can simply stack trays which are cooling around the kitchen. Thus there is no need to calculate a capacity for the cooling stage; it is effectively infinite.

Question 5 also asks how many baking trays will be needed. To determine this exactly, you would again have to draw Gantt charts for various combinations of orders, with a line on each Gantt chart corresponding to when the tray is in use. See the bottom of **TN Exhibit 2**. Note that it is in use during the spooning but not mixing, during loading, baking, unloading, cooling, and packing. Thus in a deterministic world you might possibly be able to get away with three trays. However, since trays are cheap, and management time to figure out the precise number of trays needed is expensive, a good management decision would simply be to buy "a whole bunch of trays." This gives you a reserve, for example if you want to have a tray cool longer than 5 minutes.

Costs: The costs of baking in this company are the cost of materials plus the cost of labor. If this is used in a first semester course, you can have an interesting discussion of the opportunity cost of an HBS student's time at 11:00 p.m. on a week night. The (A2) case uses a value of 20 per minute, or \$12.00 per hour. Obviously this is much higher than the \$3.50 minimum wage at which you could probably hire somebody to do this job. On the other hand, if you hired somebody to do the baking, that person's time might be unusable during idle periods. Thus you would have to pay for 120 minutes of labor time each hour, even though not all of that time would be used "productively." (This is an example of how skilled and flexible labor—yourself—can actually be lower cost than unskilled but less flexible labor. It provides a rationale for the "pay for knowledge" schemes which they will have discussed in HRM.)

Tensions in the design of Kristen's Cookie Company KCC has positioned itself as providing customized cookies, completely fresh. This essentially requires a make-to-order system. On the other hand, the throughput time for the system, even when there is no other activity going on, is half an hour or more. From a marketing point of view, this will probably reduce the market considerably since impulse purchases won't be accommodated. Students can debate the marketing issues of whether anyone will be willing to stand around for half an hour; that would not be a very useful POM debate, except to point out that the costs of exiting from this business if we misjudged it are very low, since we are using completely nonspecialized resources and not hiring anyone specifically for this company. For the purposes of discussion, the case assumes that customers will be able to telephone in their order, and then show up half an hour to an hour later to pick it up.

The POM tension in the case, then, is that the operating system is being called on to provide two somewhat contradictory product characteristics: complete customization, and zero lead time. Students can push in two directions to improve this situation.

An obvious change is to store some cookies in inventory. Because of product variety, we would only want to stock the best sellers. (Use critical fractile analysis to decide how much of each flavor.) Also the product may age rapidly; customers may realize the difference. If you do follow this route, you should make to inventory early in the evening, before capacity gets tights. Then FIFO the inventory to keep it fresh.

Some students may now see the value of customizing the flavor at the end of the production process instead of at the beginning. You could stock WIP before differentiating it. (Imagine what Steve's would be like if they had to mix all the ingredients at once, *before* the ice cream machine.)

A second solution is to improve the technology. To get below 27 minutes, you can use common sense and Pareto analysis to suggest tackling the three big time users: mixing, baking, and cooling. With some experimentation, the five minutes of cooling can probably be cut down to one or two. For example, a fan can be used or some kind of method of using refrigeration or a water cooled pad to immediately chill the baking tray. (If you remove cookies from a baking tray before they are cool, they will become wrinkled and distorted.)

The mixing stage can probably be sped up considerably by speeding up the measuring of ingredients. Providing pre-sized and even pre-filled containers for all the ingredients; premixing the dry ingredients of the various cookie doughs; and even premixing the wet and dry ingredients and putting them in the refrigerator, are all useful suggestions. If the wet and dry ingredients have been mixed and refrigerated, a logical way to do it is to store them in one dozen cookie quantities. When an order comes in, you just grab the right number of dozen dough batches from the refrigerator and throw them in the mixer, than add the measured spoonfuls of the mix-ins. This can easily cut 4 minutes off of the 6-minute mixing time.

Reducing the 10-minute baking time requires more willingness to try exotic solutions. Preheating the trays and preheating the dough in a microwave oven are both possible. This raises issues which will be important later in the course, of controlling quality, and of using experimentation to develop entirely new production methods.

A third solution comes from the insight that most of the waiting time under real operating conditions will probably be queue time, i.e., waiting for orders ahead of you to get finished. Adding more oven capacity and possibly even another mixer will have a dramatic effect on the queue time. However, that will not reduce it below 27 minutes.

From the point of view of the course, the details of various innovations are not particularly important. However, the case should drive home the lesson that a knowledgeable manager who is not afraid of experimenting with the technology can probably make a variety of improvements in any production system, no matter how simple or how complex. It also raises the issues of how to manage experimentation and learning processes. These will return with a vengeance in the Kristen's Cookie Company (B) case.

What is the Value of a Second Oven? We are now in the position to see the value of a second oven. In a deterministic system, we could simply calculate that it would raise the capacity by a given amount, therefore increasing the contribution correspondingly. To know the exact amount would require knowing the mixture of orders coming in 1 dozen, 2 dozen and 3 dozen cookie sizes.

For example, if all orders were for 1 dozen cookies, capacity would rise from 6 dozen per hour to 7.5 dozen per hour. Value would be:

(Hours per night) x 1.5 x (Selling price - variable cost).

Then sum this over a year and make the appropriate NPV adjustments.

In fact, because we are a make-to-order system and cannot buffer the arrival of orders, the exact effect of a second oven is more complex. It depends on the probability that the second oven will allow us to serve either an additional order, or an order faster, than would have been possible without it. An easy although approximate way to figure this out once the single oven production system is running, is to keep a tally of how often orders arrive that you would have put through a second oven if it had been available. In other words, whenever a dozen of cookies has to wait to go into the oven, write down the number of minutes that it is delayed. If the delay is between 1 minute and 10 minutes, it would have been reduced to 0 by the arrival of a second oven. If the delay is 11 minutes or more, it would have been shortened by 10 minutes. In this way, over the course of a week you can get a sense of how often the second oven would have been useful. This trick of using a "phantom oven" to evaluate possible capacity additions or contractions is useful for things like a second Green pantograph, or reducing the number of fuel oil trucks in the FBO case. This approach emphasizes observation and experimentation, compared with detailed analysis.

TN Exhibit 1 Summary of Times for Large Orders (Minutes)

Order Size (trays)	TPT	Labor Time	Idle Time (per10 minute cycle)	Bottleneck Time*	Variable Cost per Dozen+
1	26	12	8 in 1 cycle	10	$3.10
2	36	17	23 in 2 cycles	20	$2.05
3	46	22	38 in 3 cycles	30	$1.70
4	56	33	47 in 4 cycles	40	$1.83
n	16+n	(5n) +10 +10xINT(n÷3)	----	10n	

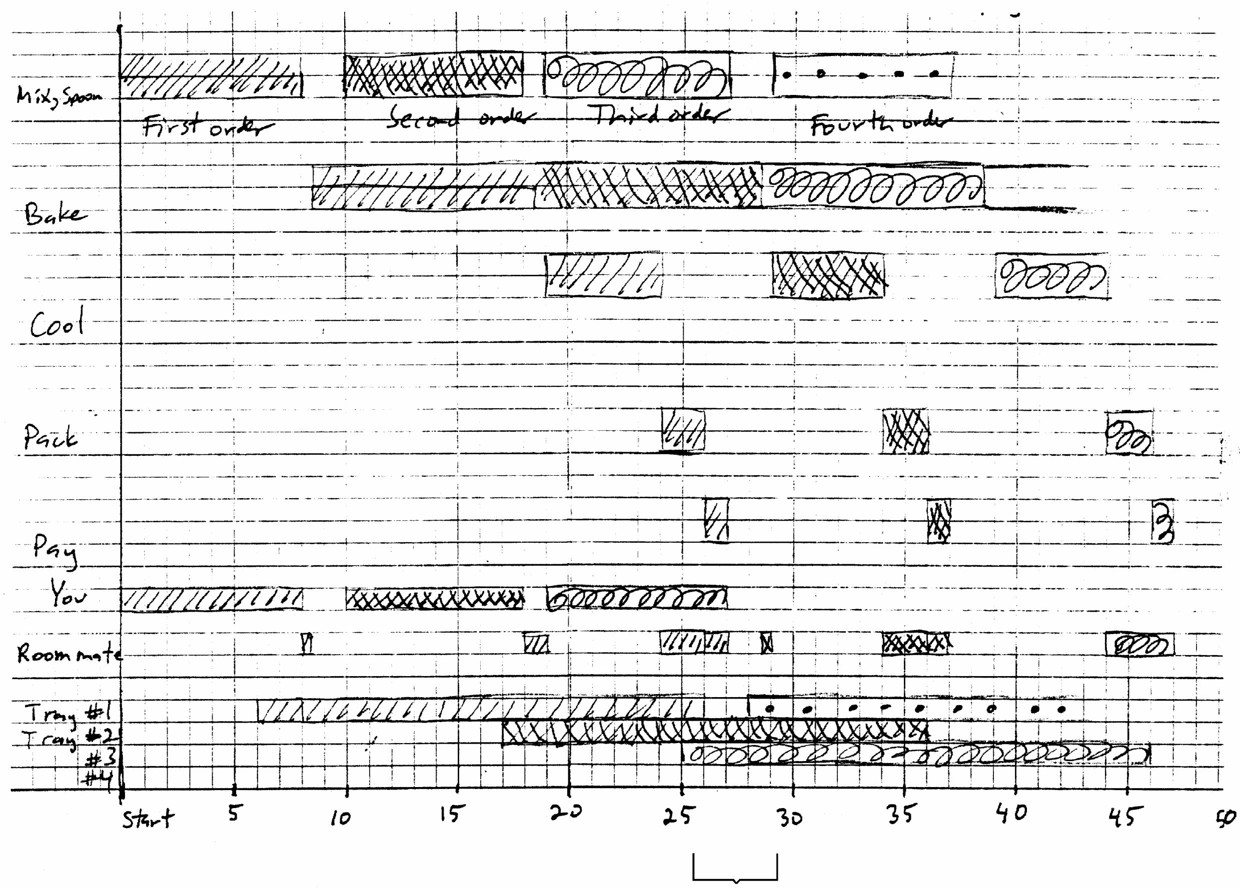
* Bottleneck time: The amount of time for which the order is using scarce capacity (i.e., oven capacity, since the oven is the bottleneck). If demand exceeds supply,

production "cost" = (Labor time) x (Labor rate)
for order of size n + Materials cost
+ (Bottleneck time) x Opportunity cost of bottleneck

\+ Assumes:
Labor cost = $12/hour or $.20/minute
Material cost = $.70/dozen assuming each dozen requires a separate box.

Overhead = 0
Labor is completely flexible; you pay only for what is actually needed.

TN Exhibit 2 A Stream of Consecutive Orders for 1 Dozen Each



Conflict here, if only have one person

Labor time (Summary)

Your labor each cycle = 6 + 2 = 8

Roomate	1 + 2 + 1 = 4
Total	12 minutes

TN Appendix 1 Second Half: Teaching Suggestions

Suggested Class Sequence:

1. Motivation. What are the key characteristics of the situation and the product, which drive the production process? (Can look back at end: which ones were really key)

   Out of this come the POM issues to analyze: costs, capacity, throughput time, how to improve system.

2. Do capacity and bottleneck analysis. By size of order. Discuss impact of setup time compared with run time. Do this discussion using a conventional process flow diagram. Ask why the 5 minute cooling time is not relevant to capacity. What if it were 15 minutes?

3. Do throughput time. (Why do we care?) Use this to introduce the Gantt chart. To introduce the Gantt chart, re-draw the process flow with the length of each box proportional to the time taken. Draw it in such a way that it becomes a Gantt chart. Instructor does the one tray case; then ask about multiple tray case and have a student do it.

4. Use the Gantt chart. Discuss the difference between capacity and TPT. (Refer back to Cranberry case, where this is very confusing for students.) Show how some changes will affect TPT without increasing capacity, while a second oven will increase capacity, but not improve TPT except for large orders.

   To drive home the Gantt chart, it is useful to tackle supplemental question 3: How soon can you promise delivery? E.g., if a one-tray order arrives just when another tray has gone into the oven. Draw the rectangles for mixing and baking "as soon as there is an opening" in the respective lines. What if the preceding order is on the first tray of a 3-tray order? (Soon find that minimum delivery time = (setup + running time) of all higher precedence orders, *in the bottleneck operation,* plus the TPT for the one order. Non bottleneck times don't matter.

   What about sequences of orders, such as 1 tray, 3 tray, 1 tray?

   All of this is pretty clear on the Gantt charts. It *can* be done without the Gantt chart.

5. Queuing discussion: So far we have assumed orders come in evenly through the night. Of course they won't. Since we have chosen not to use inventory to buffer between production and orders, this means that even if we appear to have enough capacity for the night, we will likely delay some orders due to capacity constraints. In fact at the peak time, we may fall quite far behind. This discussion foreshadows later queuing cases. You may not want to give the punch line, which is "In situations where you cannot stockpile finished goods (or nearly finished goods), aim for a capacity significantly above 100 percent of average demand."

6. Cost analysis. (This discussion could come earlier, even before throughput time.) Run through basic accounting to decide the relevant categories. Derive labor times from the Gantt chart or the process flow. (This distinguishes *machine* time from labor time.

Cooling and baking use machine time but not much labor time.) Determine the cost per dozen for each order size, assuming 100 percent yield.

Discuss whether the correct measure of labor cost is labor time required, or elapsed time (4 hours per night). Labor as a variable cost or an overhead item. This discussion can have two possible punch lines:

a. Expensive but flexible labor may be cheaper than inexpensive but less skilled or less flexible labor.

b. If you view labor as a fixed cost (4 hours every night, regardless of demand), you can get radically different pricing results. You would be willing to sell down to material costs, on slow nights of the week; then make it up with high prices on busy nights. (Or seasons.) Discuss the application to Japanese auto and semiconductor prices in a recession.

7. Now ask what happens on nights when your roommate is sick or studying. Looking at the capacity calculations, you see there are more than 10 minutes of labor time for each order. You can build a table of labor capacities for different order sizes, and find out where labor would be the bottleneck. Good students will point out that the labor constraint is not going to be a problem very often, since it is a binding constraint only when you have a backlog of one-tray orders. So if demand is slightly less than capacity for the night, or has a few large tray orders, you would seem to be OK.

   But that's only part of the story, since TPT may also change. Go back to the Gantt chart and draw a line for you and one for your roommate. (See the (A2) case.) The general rule in drawing Gantt charts *is one row for each operation and one row for each common scarce resource*. (Such as food processors and people.) Wherever the two lines overlap, you would have to slow down with only one person.

8. Now summarize what we have learned. We have investigated in detail the costs and effectiveness of the system as it is now designed. We have looked at several contingencies: a sick roommate, a bunch of orders at once, rush orders, yields less than 100 percent. We have considered a few possible improvements, including more capacity, and simple changes in the technology.

   We have also gotten a better sense of the answers to topic 1 in this sequence, namely the key characteristics of the situation. Simple capacity was important, but throughput time was an equally important goal of the system.

9. From here it's logical to tackle the marketing/POM/strategy interface. Central to the design of KCC is its customization strategy; customers can have whatever strange combination of flavors they want. (Peanut butter oatmeal cookie with almonds and M&Ms.) No one else can offer this, because of the problems of stocking every conceivable combination. On the other hand this customization strategy has also forced you into some relatively unfavorable trade-off situations, such as the half hour waiting time (minimum), and the susceptibility to peak demands. Here you can lead into the analysis of this tension, and how to improve the terms of trade-off.

   If you can keep this discussion off of the pure marketing issues (predicting consumer demand), this should be a fun discussion. One way to defuse the marketing argument is to discuss the need for flexibility and an open minded approach in the first month of operation. Ask students what they would do with the operation design, after start-up, *if* customers seem indifferent to freshness. What if only 10 percent of the flavors account for 80 percent of demand? What if a few customers seem willing to pay a huge premium for exotic and fresh cookies, but are willing to wait? Most likely, what if some subset of customers fall into all these categories? Can you design an operating system which will be competitive in all of these segments at once? (Back to the focus discussion in Blitz.) Are there any decisions we should make *now* to give us faster response and more flexibility later? Probably yes: another oven should be ordered, with the option to cancel the order.) What milestones will you set for yourself to decide whether and when to alter the production system?