An Integrated Approach to Process Design and Continuous Improvement of a Food Processing Facility

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This paper describes the physical activities involved in the operation of a meat processing facility and the methodologies deployed to enhance the efficiency of these processes. The objective of the efforts discussed was to utilize an integrated approach to reach corporate profitability goals. This approach established a sound foundation of contemporary business practices and procedures within the facility and put in place a continuous improvement system.

The process setting of the meat processing facility involved operations that ranged from blending to final packaging of ham and sausage product lines. With a greatly reduced salaried staff, the answers to profitability lay hidden somewhere in the plant's operations. The preliminary process gap analysis revealed improvement opportunities in the procedures and process flows. Further investigation led to specific improvements within the processes of blending, filling, cooking, chilling, and packing.

The core of this paper concentrates on specific elements of integrated manufacturing that were analyzed in order to improve the effectiveness of production processes. These elements included layout redesign, constraint management, capital expenditure analysis, line balancing, employee utilization, reporting system design, standards development, performance metrics introduction, scheduling, and manpower allocation.

The integrated approach also led to the implementation of specific process improvements. These resulted in substantial improvements in productivity and profitability. More than one million dollars of continual improvement ideas were generated and implementation initiated. Throughput from meat blending through meat packing was increased by as much as 40 percent on particular unit items. Direct labor utilization and efficiency realized 28 to 50 percent gains in the three main departments that were addressed. These findings, combined with scheduling and constraint management techniques, led to a very significant reduction in overtime expenditures, along with a decrease in the total work force, that could be applied in other functions throughout the facility.

Background

This paper describes the production process and the integrated manufacturing efforts to improve the operational effectiveness of these processes at a satellite plant of a meat processor. The story is not unusual: A company buys a competitor; the acquired plant doesn't turn immediate profit; cost savings are garnered through corporate staff reductions and attrition; some unit volume is moved to the parent plant where money is being made; and as a result, questions arise as to whether the new facility has a long term value in the corporate strategic plan.

The bad news for the new facility and its operations manager was that they didn't know where they were losing money. With a greatly reduced corporate staff that was concentrating on "fighting fires", the answers to profitability lay hidden somewhere in the operational areas of blending, filling, cooking, chilling, and packing meat. Costly and wasteful overtime became the panacea for most production ills. Historical data and manufacturing standards were almost non-existent. There were few tools for decision making, continual improvement, or cost effectiveness.

A decision was reached to begin an integrated manufacturing approach to solve this dilemma. The project would begin with a two prong focus: begin observation and data gathering efforts, while simultaneously developing the enabling technologies to improve manufacturing operations and incorporating team building. This development would stretch the previously rigid culture that had existed. Managers and supervisors would be introduced to consensus building and modern manufacturing concepts.

Process Flow Analysis

The plant has two main departments – Cooked Ham and Smoked Meats. It was decided to begin the project in Cooked Ham since there were fewer products involved, and in turn, would be less complicated and results could be achieved more quickly. The initial step was to map, as shown in Figure 1, the process. This would allow everyone to gain familiarity with the product flow and have a common agreed to point of reference.

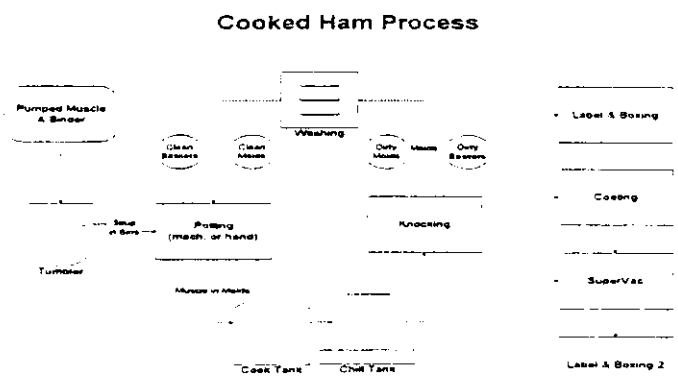

Figure 1. Cooked Ham Process

Integrated Process Improvement Methodology:

The approach for improving the process and system performance can be described as deploying the enabling tools and techniques in an integrated approach that fosters continuous improvement. For the manufacturing operation under discussion, the first step was to gain and document an "as-is" understanding of what currently existed. The definition of the current environment created a full understanding of the processes at work and led to proper future evaluation of continual improvements. At the initial stage of the project, processes were documented by gathering relevant data to provide benchmarks and to establish a database for the manufacturing activities and their relationship to each other. From this "as-is" data; non-value added element elimination, direct labor line balancing, cost effective crew sizing, standard rate development, and ultimately, alternative idea generation would occur.

The second phase of the project correlated the base data with product volumes, process capabilities, and employee availability. This effort introduced enabling techniques involving constraint management, employee utilization, product scheduling, and manpower allocation to the facility.

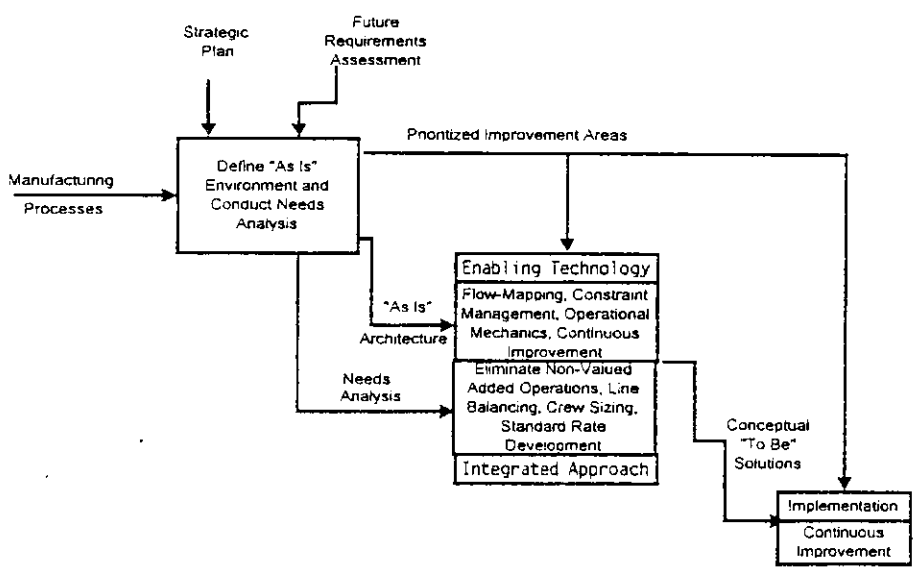

Figure 2. Integrated Process Improvement Methodology

The third phase resulted in continual improvement action items: Cost savings analysis, action plan recommendations, layout design, capital expenditure analysis, performance metric documentation, and reporting systems development.

1. Process Mapping and Data Analysis

The Cooked Ham Department consisted of six distinctly different operations where product was manufactured and product flowed in a production line shaped as a rectangular loop. The operations are Tumbling, Potting, Cooking, Chilling, Knocking,

and Pot Washing. These operations while dependent on each other for product flow, are not "in-line", and product must be transported between operations.

The operations in the Cooked Ham Department are either man-man or man-machine operations and are labor intensive. Some operations required only one person, while others required a crew. Analyzing these types of operations required extensive elemental time studies. This was essential in appropriately understanding each operation and ultimately being able to improve it. The resultant knowledge that was gained answered the following questions:

1. What were the current and appropriate crew sizes?
2. What were the current and appropriate production rates?
3. What non-value added elements could be eliminated?
4. How could the work duties within crews or between operations be re-balanced to improve individual utilization or increase throughput?
5. What potential process changes could occur to reduce cost, increase throughput, upgrade quality, or enhance customer service?

2. Volume and Utilization

After the processes were mapped and analyzed, the volume forecast was used to develop a line utilization for each operation of the cooked ham line, as shown in Figure 3.

	Tumbler	Potting	Cooker		Chiller		Knocking
Item #	Percentage used	Percentage used	Percentage used in bulk production	Percentage used in batch production	Percentage used in bulk production	Percentage used in batch production	Percentage used
	82%	72.4%	110.2%	121%	160.2%	175.6%	75.8%

Figure 3. Utilization rates of the operations in the cooked ham line

3. Scheduling and Constraints

The forecasted volumes required 37 baskets of potted hams to be produced per day. Since there was no scheduling person dedicated to this function, the production manager scheduled work and people in addition to his other duties. As a result, poor scheduling produced unnecessary amounts of overtime. It is estimated that more than two hundred thousand dollars was saved by project end.

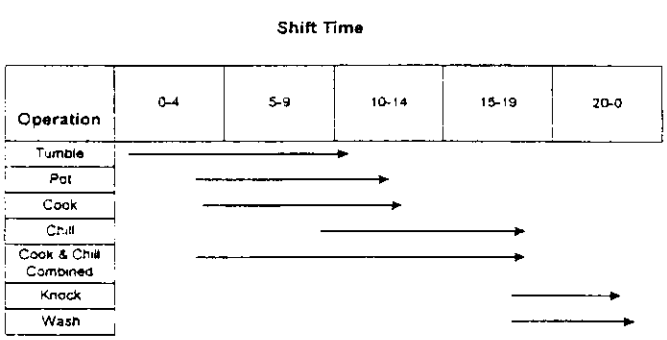

Figure 4. Shift Schedules for the Cooked Ham Line Operations

To improve on this non-engineered approach, time study data from each operation, as shown in Figure 4, was used to establish a continuous operation to produce the volume of 37 baskets per day. The resulting staggered shift allowed for the entire process to run a 37 basket cycle in 25 hours instead of the 42 hour cycle indicated by the 175% utilization of the chiller operation scene in Figure 3 above. This new scheduling nearly eliminated normal overtime, greatly reduced inefficiencies, showed that chilling and eventually cooking are constraints, and eliminated the need for a second shift crew. Since the chill time required having to run on more than one shift, the old process of four hours / basket in the chill tank was reduced to two hours in the tank and 4 hours in the cold storage room. The chill tank capacity was now equal to that of the cooking tanks, refer to Figure 5. There was now a smooth flow through these two process steps, and reduced queuing problems in front of the cooker.

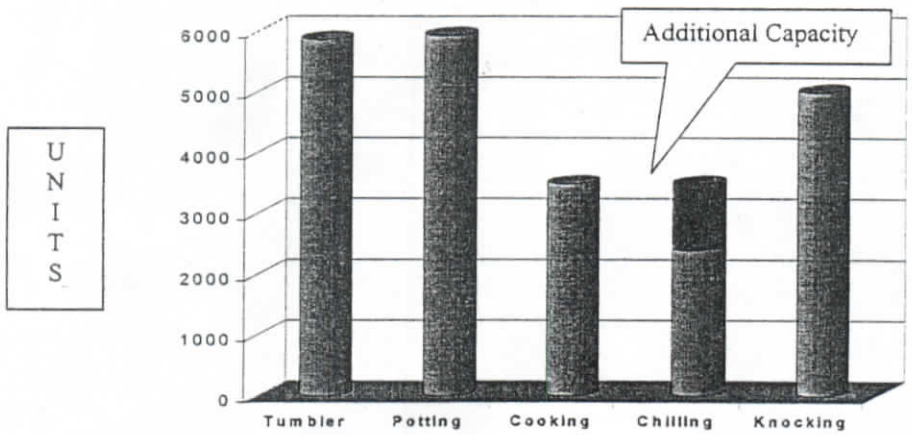

Figure 5. Operational Capacities of the Cooked Ham Line

The facility did not have a daily production reporting system which could capture employee hours and production quantities, or allow a review of production line utilization and production labor efficiencies. The inefficiencies that were obvious in the potting and knocking areas could not be addressed in a timely manner due to the information lag with their monthly report. Prior calculations indicated that only three quarters of a shift per day were needed to handle the sales volume. This meant significant inefficiencies were occurring. Using data from the studies of the cooked ham line operations, production performance metrics were generated. This is shown in Figure 6.

Supervisors filled out record sheets. The data was entered into a personal computer, and the Production Manager had the data the next day. The supervisors now could monitor the operation during the course of each shift by viewing the record sheet. As a result, they could deal with problems immediately. The daily reporting encouraged proactive, timely investigation into production variances.

DATE	Shift	Item #	Time Start	Time end	Prod.	Time	Production per Hour	Efficiency		
5/1/97	1	2284	5:30	12:00	1944	6.50	299.08	92%	Total Production =	31.891
5/1/97	1	6248	12:00	13:45	366	1.75	209.14	101%		
5/2/97	1	2284	5:45	9:45	1176	4.00	294.00	90%	Available Production=	37.744
5/2/97	1	6204	9:45	14:00	1512	4.25	355.76	109%		
5/5/97	1	6206	5:45	14:00	2422	8.25	293.58	90%	Efficiency=	84%
5/6/97	1	6206	5:30	9:00	996	3.50	284.57	87%		
5/6/97	1	6204	9:00	11:30	684	2.50	273.60	84%	Total Hours=	116.92
5/6/97	1	6248	12:00	13:15	424	1.25	339.20	164%		
5/6/97	1	2284	13:15	13:30	88	0.25	352.00	108%	setup hours=	32.50
5/7/97	1	6211	5:30	11:15	1611	5.75	280.17	86%		
5/7/97	1	2284	11:15	13:20	588	2.08	282.24	87%	setup/production=	28%

Figure 6. A Section of the Potting Report

Results:

1. **Tumbling:** The improvements in the tumbling operation allowed supervision to schedule the tumbler operator 4 hours before the potting operation began. This enabled him to mix and blend 2 batches before potting start-up. Now both tumbling and potting would be timed appropriately to reduce non-value added process flow interruptions. The time studies also showed that the tumbler operator is under utilized, and could aid in material handling.

2. **Potting:** This operation consisted of a crew of six or seven. Process analysis, as shown in Figure 7, showed a 17.4 second machine potting cycle to fill two hams. However, by shifting work elements to balance the line stations, the potting machine could now be run at 15 second cycles with a crew of 5.

Production Standard Sheet								
Old Production Rate / 8 hrs.	New Production Rate / 8 hrs.	Old Crew	New Crew	Old Direct Labor Cost	New Direct Labor Cost			
2607	3024	6	5	$.3093	$.2222			
Potting Ham – Automatic						Operation (minutes)	Persons	Minutes/ Person
Operation #1	Pioneer Machine Speed 17.4 seconds / cycle - 2 up				old	.145		.145
	" " " 15 " " "				new	.133		.133
Operation #2	Load ham into pot				old	.139	1.0	.139
	[new-leave 25% flap untracked]				new	.125	1.0	.125
Operation #3	Close lid on ham filled pot				old	.100	1.0	.100
	[new-do 25% tucked flap]				new	.114	1.0	.114
Operation #4	Apply springs & tighten lid onto potted ham				same	.178	2.0	.089
Operation #5	Machine Attendant				same		1.0	
Operation #6	Supervisor / Material Handler				Reassign		0.0	

Figure 7. Elemental Operation Times of Pioneer Potting Square Pots

A standard rate with direct labor efficiency and line usage was also developed at this time. Analysis showed that production levels through potting were only at 51%

efficient. After the implementation of improvements, efficiency is now near 100%. This productivity increase is worth $230K in annual direct labor reduction and improved profitability.

3. **Cooking and Chilling:** As stated previously, reducing the constraint in chilling allowed for more production to run through the plant. It was also discovered that the cook-chill operator was under 50% utilized allowing him to be used for material handling duties at the potting operation.

4. **Knocking:** After the hams are chilled, they are taken from the cold storage room to the knocking operation. Similar to potting, time study revealed that the nine person crew could be reduced, and the historical efficiency of the operation was only 79%.

   It was decided that through a minimum of capital expenditure, the crew could be reduced to 6 operators. This re-balancing would allow for the reassignment of the crew leader, the labeler, and the ham blower operator to other operations in the plant. An ROI was then conducted on the feasibility of making these changes.

   Once the ROI confirmed that the capital expenditure for the knocking line was warranted, a new layout design was developed. The revised operation benefited the process by [1] utilizing the space better, [2] incorporating a new automatic labeler, [3] creating more buffer area with automation between stations, [4] and development and implementation of a new spring knocker.

   The new equipment also included two pallet lifts to reduce the ergonomic hazard of excessive bending and lifting. Cost savings from the crew reduction and efficiency improvements yielded 150K annually.

5. **Smoked Meats:** As a direct result of the lessons learned in the Cooked Ham Department, similar improvement efforts were conducted in Smoked Meats. In this area, where hot dogs and sausage are produced, the oven was found to be a constraint for a group of labor intensive operations that involved 20 employees. Through the reduction in cooking time and a subsequent increase of volume through the oven, $250K in additional direct labor cost savings was realized.

Conclusion:

The improvements and gains on this project were not reached in one step. Nor are the challenging situations in which companies find themselves, born overnight. The most important question to be answered by manufacturing management should be, "What is actually going on here?" Too many manufacturing companies, in the absence of data, make rough estimates of what is happening based on judgments. This approach unfortunately often falls short. Using appropriate integrated improvement tools provides a strong basis for sound evaluations. From this base, managers can make appropriate manufacturing and economic decisions to continually upgrade processes and design.

The improvement process discussed in this paper succeeded when an integrated process of engineered evaluations, standards, and documentation was conducted and implemented. The results for this company were dramatic and gave them a solid and profitable base for future decision-making.

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