REENGINEERING THE PROCESS OF MANUFACTURING

THERMAL-CRYOGENICS TANKS

By

Luis O. Lozada

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Tom Lacksonen
Research Advisor

The Graduate School
University of Wisconsin-Stout

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The Graduate School
University of Wisconsin-Stout
Menomonie, WI 54751

ABSTRACT

(Writer)	Lozada (Last Name)	Luis (First)	O (Initial)

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This research study takes place at Chart Industries/Storages System Division in New Prague, Minnesota. The researcher employs the concepts of batches, line balancing, and layouts to help CHART Industries to increase production in the “Locator Tanks” line. This research examines the current production process and to discover and reduce non-value added activities and another alternatives to improve the process through reduction of the work-in-process inventory (WIP), reduction of the set-up times, and reorganizing the work area in a more efficient way.

This research benefits any manufacturing company considering increase throughput through reducing batch sizes, line balancing, and developing a more efficient process layout. Some of the benefits achieved through the implementation of this study are an 80% reduction in labor, an increase of 320% in production, and a cleaner and safer work area due to the elimination of excessive WIP.

Table of Content

List of Figures

List of Tables

Chapter One: Introduction

Background of the problem

This field project was completed at Chart Industries - System Storage Division, a manufacturing company located in New Prague, MN, that produces pressured vessels and vacuum isolated tanks for the cryogenic industry. The pressured vessels or Bulk Tanks are produced for welding and laser applications, and consist of one tank inside another. The inner vessel is wrapped in aluminum foil and the space between the inner and outer vessels is vacuumed, all to avoid heat transfer to the inside of the tank. These tanks are built to store up to 15000 gallons of cryogenic fluids at a pressure up to 500 psi (see Appendix 1).

On the other hand, the vacuum isolated tanks (manufactured in the Artificial Insemination Building) are also one tank inside another. They are not pressurized; and their purpose is to keep specifics products or substances like animal sperm for the breeding industry or human parts for medical purposes. The intention is to keep or preserve all these components at low temperatures. These tanks are built in sizes of 10 liters or less (see Appendix 2). These tanks are classified as seasonal products, for the breeding season that goes from most part of the spring until fall. The production of these tanks represents for the company about 15% of sales. Although the company's main business right now is Bulk Tanks, everything started with the manufacturing of these small tanks.

Statement of the problem

The Bulk Tanks are built to order, but all the products made at the AI (Artificial Insemination) building are produced in batches that depend of the size of the work order. There are two production lines in the AI building. One is called the "Main Line" with a production average of 90 tanks per day. The other process is the "Locators Line", the focus of this study, with an average production of 10 tanks per day.

The company is interested in increasing production and lowering costs in this line.

Objective of this study

The objective of this study is to find procedures, or methods, to increase the profitability in the Locators' production line. The tasks of this project were:

- Batch size reduction,
- Process layout redesign, and
- Line balancing

Limitations of this study

This study focuses in the production area of the Locators; all the suggestions and changes will be restricted to the manufacturing process.

Inventory policies and forecasting methods are not the focus of this study. The company made very clear that there is no intention, at this time, to invest in new equipment for this production line. The company keeps the final decision regarding the full or partial implementation of the recommendations of this study. Findings are limited and applicable only to processed and converted Locators at Chart Industries – System Storage Division in New Prague, MN. Results cannot be generalized beyond this scope.

Overview of this thesis

Chapter One states the introduction to the thesis. It has the background, the problem statement, the objective, and limitations. Chapter Two is the review and critique of part of the literature currently available. Chapter Three outlines in detail the research methods used in this study. In Chapter Four are the results obtained in this project. Chapter five analyzes the study and draws conclusions and recommendations for future research.

Chapter Two: Literature Review

The purpose of this project was to increase production and lower operational costs of a specific line inside a manufacturing company. The following sections provide an example in how to implement a process change from the perspective of management, and from the perspective of supervisors and line-workers employees.

Just-in-Time (JIT).

In today's environment, it is well known that shortest time to introduce a product into the market place is a competitive advantage (Blackburn, 1991). Companies that have been able in the past to redesign their process to compress time and improve performance achieved higher productivity, increased market share, charged premium prices, reduced risk, and improved customer service (Blackburn, 1991; Schmenner, 1991; Stalk and Hout, 1990).

During the 80s and 90s, Japanese automakers implemented Just-in-time (JIT) philosophies to increment production capacity in the United Sates, but they went beyond JIT and then included all aspects of time-based manufacturing (Liker and Wu, 2000). JIT can be defined as the management that focuses the organization on continuously identifying and removing sources of waste so that processes are continuously improved (Nicholas, 1998, pp. 5).

Although JIT's main purpose is cost reduction, and is an internally focused production system that produces parts on demand eliminating unnecessary elements in production (Monden, 1983), JIT is also recognized as the origin of time compression (Blackburn, 1991). According to Abegglen and Stalk (1985) some JIT innovators became the first time-based competitors as their emphasis on speed propelled their skills in time reduction throughout the value-delivery system. In other words, time reduction was an indirect benefit of JIT. But, there is another view that affirms that seeing JIT just as a method to reduce batch and inventory sizes is a misconception, and that time compression is one of its main virtues (Blackburn, 1991).

JIT also focuses in time compression, but with a different objective than time-based manufacturing. JIT's mainly objective is cost reduction while time-based manufacturing is a production system that focuses on quick response to changing customers needs, and its primary purpose is to reduce end-to-end time in manufacturing (Blackburn, 1991).

The process of implementing a continuous flow system (or non-batch situation) is according to Fleming (2000) "anything but easy"; but in the other hand, does not necessarily require a large investment in capital or a large team of manufacturing engineers (Heard and Heard, 1991). Stedman (1998) does not agree with the small investment requirements when he affirms that in the case of NACCO Materials Handling Group the project of getting each plant up to speed on flow “is a huge effort but the lack of inventory goes right to the bottom line”. In the other hand, what the process does require is a permanent re-evaluation and commitment to eliminate old practices.

In most cases the process involves three phases: preparation, execution, and perpetuation (Chaneski, 2000; Fleming, 2000; Heard and Heard, 1991). Each phase is dependent and related with the previous one, making these three different phases a whole system (Allen, 2000).

The first phase, preparation, introduces management and line workers to the process, and establishes the commitment for everybody in the company with the transformation process. It is typical when management or line supervisor want to improve efficiency and production without stopping the process. Here is where the level of commitment of all the people involved in the process will be tested. In this phase, one of the main objectives is to inform the line workers why the company is trying to implement a new process (change the way they have been doing the work for many years) and explain them the benefits of this change. Benefits may include reduced cycle time, work-in-process inventory, and set-up times. These may not make too much sense for the line workers and in their opinion those improvements do not justify the change.

It is very important to keep the employees informed; extensive sharing of information throughout the organization is one of the seven practices of successful organizations (Pfeffer, 1998, pp. 65). In the end, the employees working in the line are the ones that are going to make the new system succeed; but for this to be accomplished, the organization and line workers must be on the same page and go in the same direction.

The second phase, execution, is the implementation of the new system, and involves making work all that was discussed in the previous stage. New problems and new solutions can emerge in this phase. Perpetuation, the third phase, is the one that tries to avoid coming back to old practices when a crisis occurs. Rewarding change and continuous improvement (Carpenter, 1995; Lippman, 2000; Story, 1995) will make this new system last. The universal leadership principle "you get more of the behavior that gets rewarded," supports this affirmation.

Batch Size Reduction.

The manufacturing method of working in batches has been criticized for its inconvenient results, such as large work-in-process (WIP) inventories, big lead times, and large floor-area requirements (Nicholas, 1998, pp. 155; Stedman, 1998). This production system is called also "push system", and is characterized, among other things, by scheduling production according to forecast by a central staff. Usually the size of the batch is the same as the customer order without taking into consideration whether a customer really needs those products (Liker, 2000; Nicholas, 1998, pp. 256).

According to Liker et al. (2000), in small batch production systems the costs of inventory are lower, and suppliers can respond quickly to changes in customer demand. Defects in products are easily identified, which means less defective parts that need to be sorted and reworked; this also can be interpreted as if fewer workers are needed to perform non-value-added activities, such as moving large batches of inventory from place to place in the plant, productivity rises.

Layout Redesign.

The objective is to come up with a more efficient layout. The general criteria is that the actual layout is almost impossible to improve, and sometimes these layouts are so old that employees working in the line are the ones that opposed more even when they are the ones who would benefit from a layout that would mean less travel distance for the product, and walking distance for the employees. For the company this would mean a reduction in non-value-added activities, a reduction in the cycle time, and a more efficient management of the floor area.

Frequently, this stage includes new plant or process layouts, according to Stedman (1998); plant layouts usually need to be redesigned for demand-driven flow systems. A well-redesigned new process layout, one that would among different issues reduces travel distance and time, and represents a more efficient distribution of the space, will help the employees to accept the change.

Line Balancing.

Line balancing is the procedure of adjusting the times at work centers to conform as much as possible to the required (Nicholas, 1998, pp. 619). If a process layout is going to be changed, the travel times and distances may change, and a new distribution of the work load between the operators would be required.

The basic aspects of line balancing according to Nicholas (1998, pp. 620) include:

- ≡ The Cycle Time (the time between when units are completed in a process) of the combined workstations satisfies the required cycle time.
- ≡ The tasks are assigned in the right order.
- ≡ The assignment is as efficient as possible.

The first point insures, that the new system is capable of meeting the demand; and for this to happen the cycle time of the bottleneck must not exceed the required cycle time. The second point implies that the new arrangement must meet precedence requirements. The third point finally asks for a minimum number of workstations.

Chapter Three: Research Methods

Introduction.

The purpose of this study was to increase the profitability in the Locators line process at Chart Industries - System Storage Division. The main objectives were to eliminate non-value-added activities and increase profitability either increasing production or reducing costs.

The methods and procedures used to identify ways to meet the objectives are described below under the headings of: Data Collection Techniques, Procedures Followed, and Method of Analysis.

Collection of Background Information.

The company initiated its activities producing cryogenics tanks or thermos to keep substances like animal sperm at low temperatures.

In the Locators Line, 8 different models are built; all of them but the Cryoshipers follow the same manufacturing procedure.

The data needed for each objective (batch size reduction, layout redesign, and line balancing) was collected through participant observation; several hours were spent watching and asking the employees performing the work. Information was gathered also from current procedures manuals, process layout plans, policy manuals, and forecasting projections from various sources within the company. Time and distances studies were made with the Locator 4, which has the highest production lf all models. It is a medium size tank, so it is a very good and average representation of all the tanks built in the line.

Analysis Method.

The data collected during the process was analyzed in order to determine the extent in which a raise in the profit through increased production or reduced operational costs could be done. The results obtained for the Organization were determined through a combination of company knowledge, collection of data, and engineering experience.

Productivity changes will be measured according the followings criteria:

≡ Batch size reduction: comparisons will be hold against a batch size reference of 10 tanks, and the distance that a single unit travels in each of the methods. The two main results will be the time to get the first tank from both methods, and the total time needed to finish 10 tanks.

≡ Layout redesign: the travel distance required for the proposed layout must be lower than the current one; the new layout also should be logic in the sequence to follow, comfortable for the operators, use existing equipment, and consistent with company's safety policies.

≡ Line balancing: all three operators must have close to the same workload.

Chapter Four: Results

This project was proposed after the Locators' line supervisor noticed that the work area wasn't large enough to store the work-in-process inventory they thought they needed to perform the job. The work area is small and the operators frequently had to push the WIP inventory somewhere else. Figures 1 through 4 show the current situation.

The size of the batch depended of the dimensions of the tanks, if the dimensions were too big, then the batch would be smaller, and if the dimensions of the tanks were small, then the batch would be bigger. Usually the batch's size varies from six for the Locator 6000 to ten for the rest of the models built in the line.

Figure 1. WIP location by the
Auto-welder (I).

Figure 2. WIP location by the Roller.

Figure 3. Several WIP locations.

Figure 4. WIP location by the Auto-
welder, aisle and water fountain.

Batch Size Reduction.

Although one of the benefits of JIT is a gain in floor space, increase the batch's size to use this new area available is not one of the objectives of this project. The current flow-process was obtained in order to become familiar with the process. The time study and a product travel study were performed to determine how much a single tank moves during the process.

The current flow process with its travel distances between workstation is shown in Figures 5 and 6. The numbers indicate each workstation, and tanks shown represent a batch of production, number of tank vary depending on model and amount of tanks to be built. There is only one batch that is moved through all the workstations and no other lot is started to be worked until the previous is finished, or like in most cases when the batch reaches the last workstation.

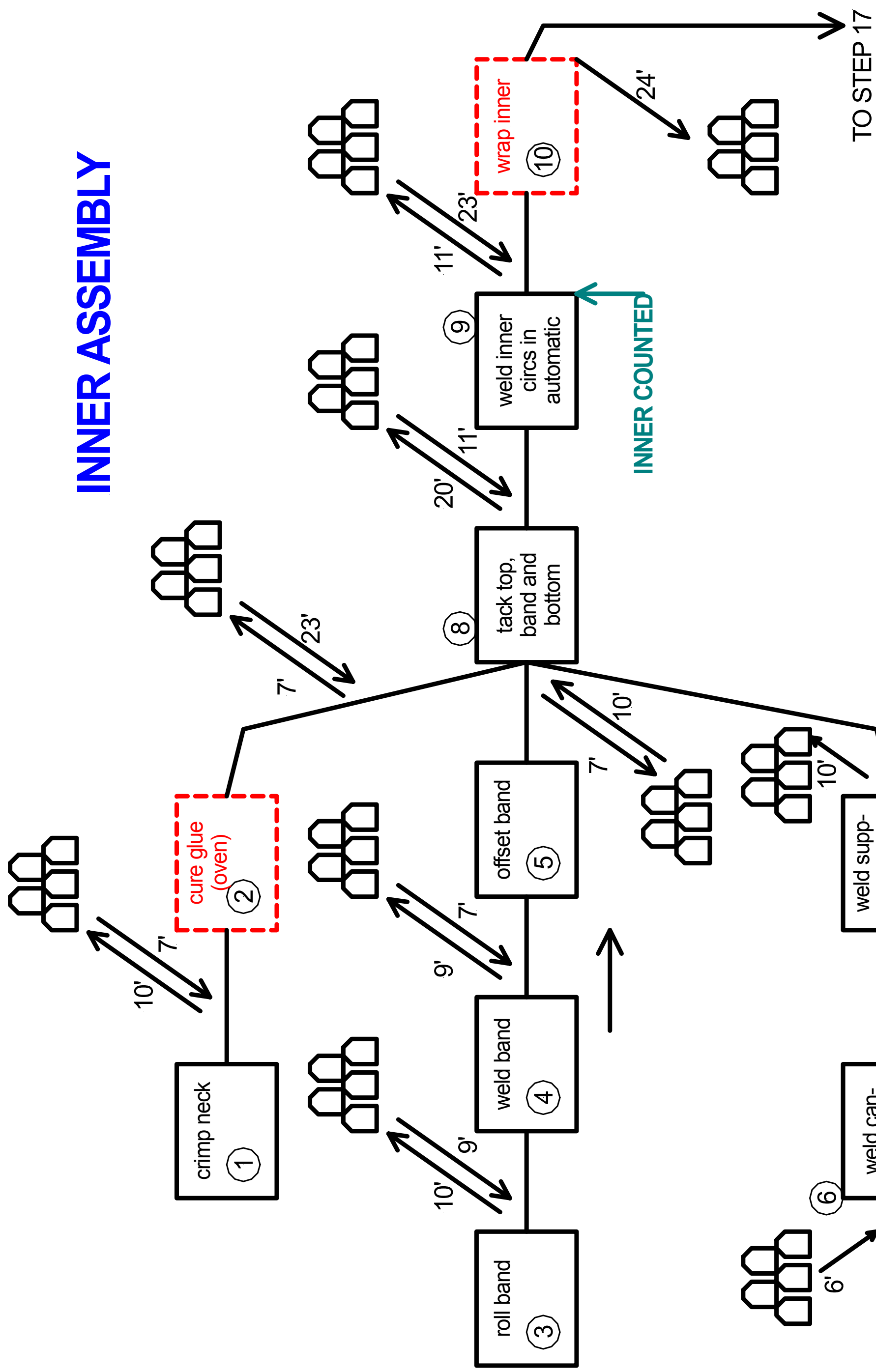

Figure 5.
Inners' assembly process.

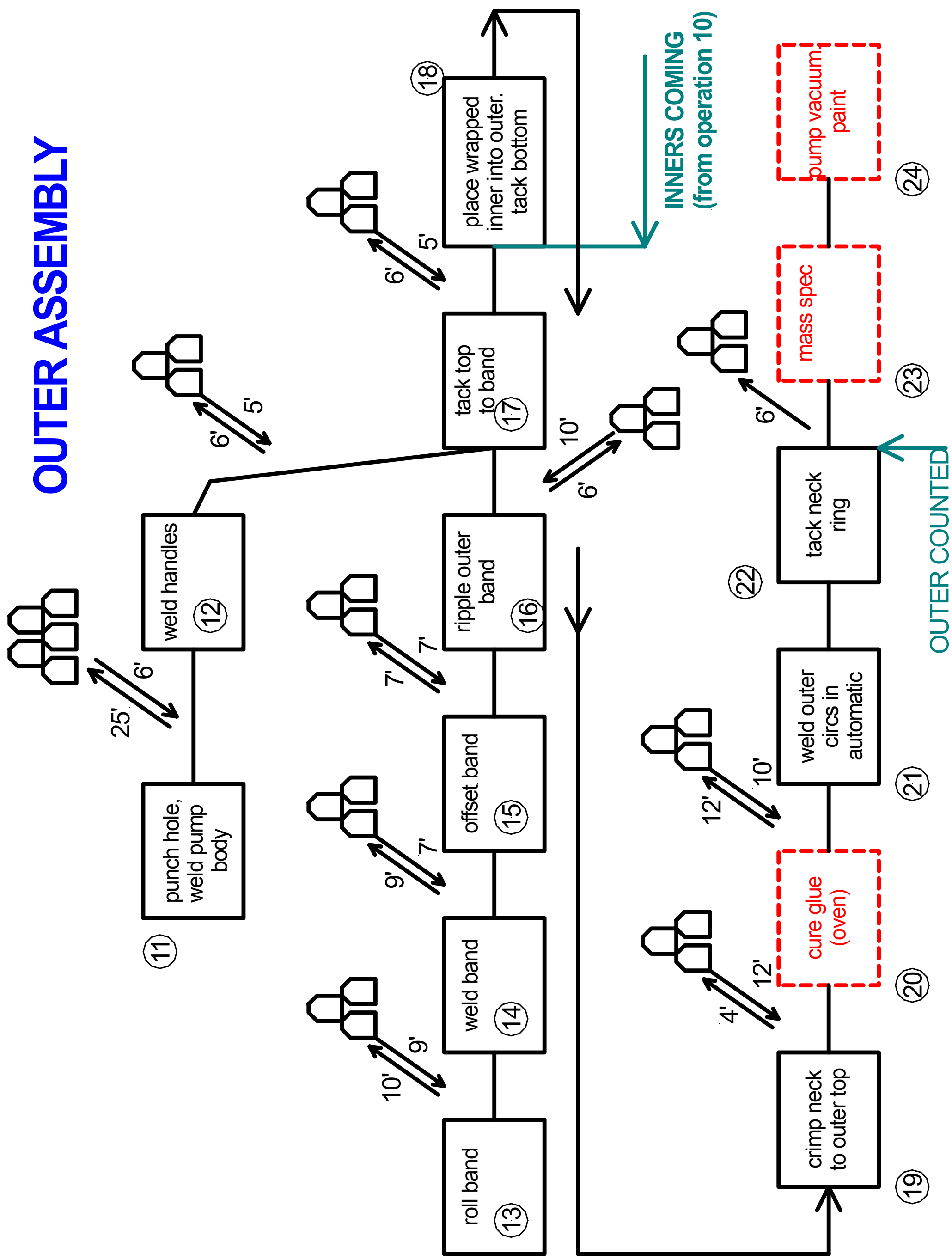

Figure 6.
Outers' assembly process

In this process, there are three full time operators in the line, and one more that help wrapping the inners, an operation that can't be done in the line. One of the full time operators spends the day assigned to the automatic welder, while the other two work on the others steps of the process.

The current cycle time for the Locator 4 (the model selected for the study) in a batch of 10 tanks is shown in Table 1.

Locators 4 (02/02/01) Current process			
Size of the batch= 10. Three operators	Date	Time	Total time
1st inner activity: gluing and crimping the neck	fri 2-2	1:30pm	0
1st outer activity: roll outer band	mon 2-5	9:00am	4h45m
1st outer coming out of the auto-welder	tue 2-6	8:35am	12h
Last outer coming out of the auto-welder	tue 2-6	1:15pm	15h45m

Table 1. Current cycle time.

As shown in the table, it takes 12 hours to get the first tank counted as ready (after the automatic welder and before mass spec), and 15 3/4 hours to have the 10 tanks of the batch ready. Appendix 3 shows data collected in another opportunity.

A test was conducted to evaluate the viability of a batch reduction to a one tank at a time. The basic idea is that one operator will perform all the steps for the inner vessel and the other will do the operations for the outer vessel, while the third worker is trying to keep working the automatic welder.

In a regular day, two operators are moving the batch through all the workstations in the process but the two times they go to the automatic welder, where the third operator is waiting for the batch or, working in the previous batch.

For this day one of the operators was out for the day, so the remaining two would perform all the operations included the ones in the automatic welder. The division of the workload was decided as follows: with a batch size of one, one operator would take one part through all the operations, and then he/she would get the next part. This is for both inners and outers, except the rolling the outer band that will be rolled in batches of ten.

The results of the first test are shown in Table 2.

Locators 4 (02/16/01) experiment day			
Size of the batch= 10. Two operators	Date	Time	Total time
1st inner activity: gluing and crimping the neck	fri 2-16	4:45am	0
1st outer activity: roll outer band	fri 2-16	4:45am	0
1st outer coming out of the auto-welder	fri 2-16	11:55am	**6h40m**
Last outer coming out of the auto-welder	mon 2-19	7:30am	**10h30m**

Table 2. Experiment day

Ten tanks are finished in 10.5 hours, a little over five (5) hours less than the current system, and the first tank is counted as ready in 6 hours 40 minutes, almost the half of the time or 5 1/3 hours less than the current system.

A set unique affected the outcome of this test. The first one is that one of the three operators was out that day, they would be slower and the daily production was going to be affected anyway. This also means that these results obtained were with one operator less. The second situation was that the outer bands were already passed through the roller as the last operation on the previous day. Inner and outer bands are same material but different thickness, meaning that the roller must be reset for each type of band. The roller's set-up process is a trial-and-error one what means that it is impossible to roll an inner and then an outer.

Line Balancing.

The time required for each operation for an inner and an outer were collected during the study (allowances included), and are shown in Table 3:

INNER

Operation	Time [min]
1	1.00
2	0.75
3	0.87
4	4.25
5	1.43
6	0.58
7	0.58
8	1.50
9	15.00
10	6.00
	31.96

OUTER

Operation	Time [min]
11	2.00
12	2.58
13	0.87
14	2.00
15	1.87
16	1.25
17	1.00
18	1.00
19	0.67
20	0.77
21	15.00
22	0.50
	30.18

Table 3.
Total operation time.

Now, operations 2, 9, and 10 (glue curing, wrapping, and auto welder) are not performed by operator working with inners. Operations 20, 21, and 22 are not performed for the operator assigned to the assembling of the outer vessels. These operations are performed at the "Main Line" (the other line in the building).

The time required to complete the operations assigned to each operator without the ones mentioned above, are shown in the following Table 4:

INNER

Operation	Time [min]
1	1.00
3	0.87
4	4.25
5	1.43
6	0.58
7	0.58
8	1.50
18	1.00
19	0.67
	11.88

OUTER

Operation	Time [min]
11	2.00
12	2.58
13	0.87
14	2.00
15	1.87
16	1.25
17	1.00
18	1.00
19	0.67
	13.24

Table 4.
Final operation time.

Both inner and outer operations are less than half of the time that the welder requires to close a tank (30.5 minutes), but if we make one operator work in both vessels the times are almost evened, this is shown in Table 5:

INNER/OUTER	
Operation	Time [min]
1	1.00
3	0.87
4	4.25
5	1.43
6	0.58
7	0.58
8	1.50
11	2.00
12	2.58
13	0.87
14	2.00
15	1.87
16	1.25
17	1.00
18	1.00
19	0.67
	25.45

WELDER	
Operation	Time [min]
9	15.00
21	15.00
22	0.50
18-19*	-
	30.50

Table 5. Proposed Line Balancing.

The welder would still help the other operator with operations 18 and 19, but it will not have an impact in the time because he can do it while the welder is running, that is why there is no time in Table 5 for these two operations. The five minutes of difference will be spent looking for the material in the warehouse, cleaning equipment and work area (currently is done on a daily basis), and any other activity.

For this method to succeed a small batch of parts is needed before the wrapper. Currently it is a policy that every tank wrapped must be closed in the same day, eliminating big batches at the end of the wrapper, but in the other hand does not allowing an inner wrapped at the beginning of the day. In order to close an outer the operator needs a wrapped inner. The proposal is that there will be one inner vessel of the most common models already wrapped, so the operator working with the outer vessel can start immediately and won't have to wait. The operator working wrapping will see the level of the inventory that will be two tanks, and when it goes down to one she will wrap a new tank.

Layout Redesign.

It has been established in the literature review that a more efficient product layout and a more efficient use of the floor area can help to reduce cycle time. For this project it will help also increasing safety in the work area. Currently due to space requirements, WIP is placed sometimes in aisles and/or in front of machines. Figure 7 shows the current process layout, while Figures 8 and 9 show the circuit followed for an inner vessel and an outer vessel respectively.

The distance (for both vessels) between each workstation and the place where the WIP is placed is shown in Table 6.

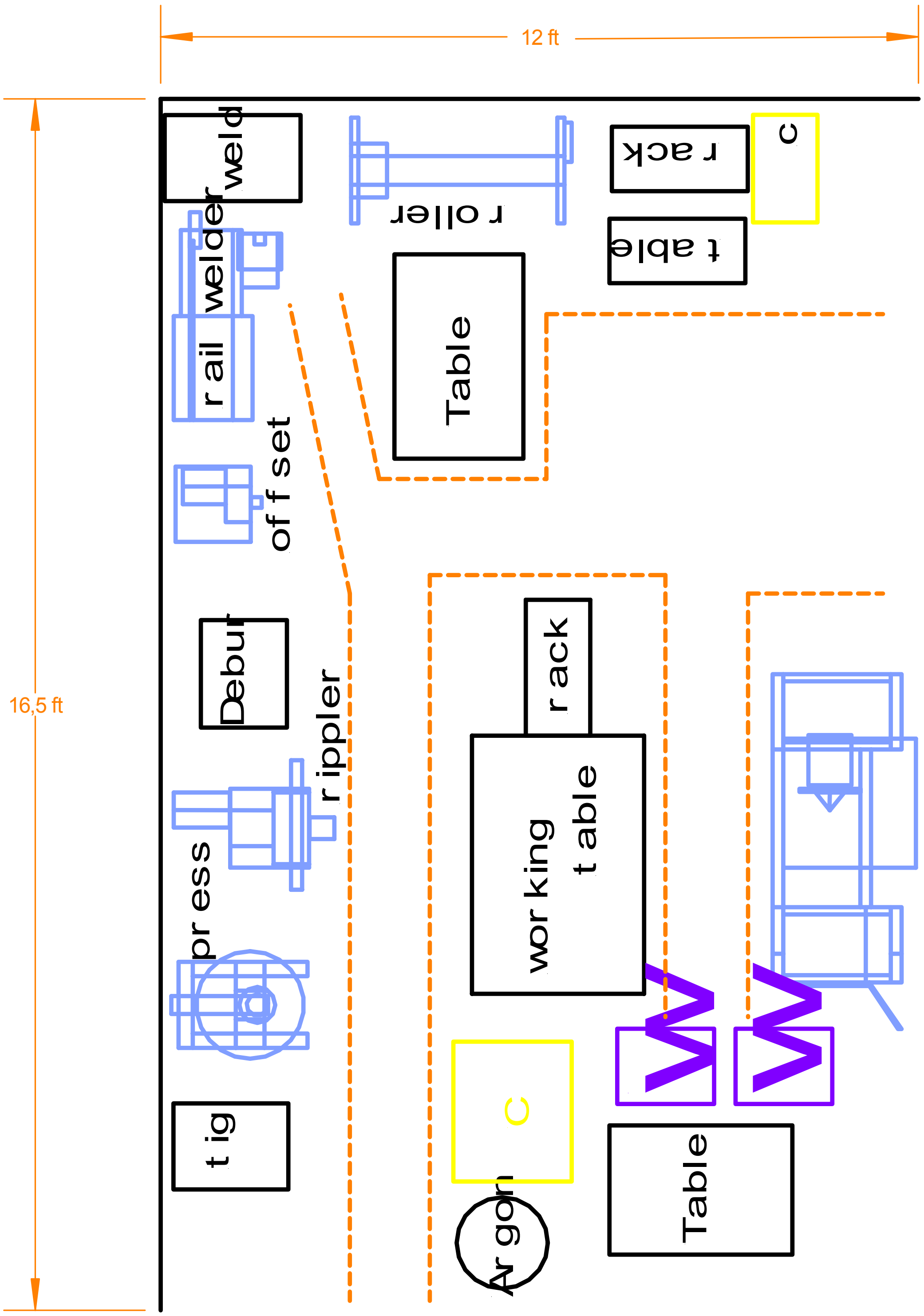

Figure 7.
Current process layout

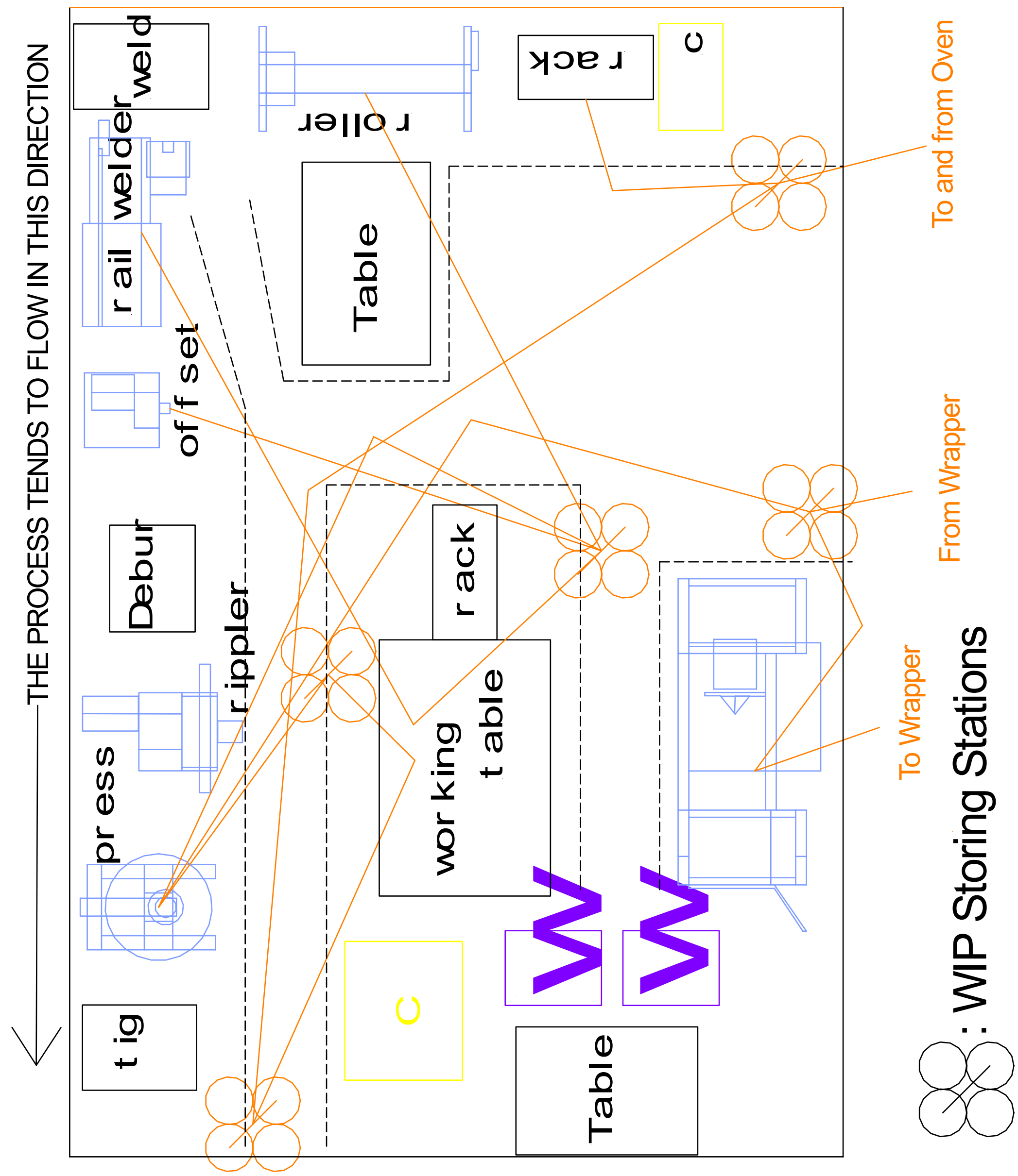

Figure 8.
Circuit followed for an inner

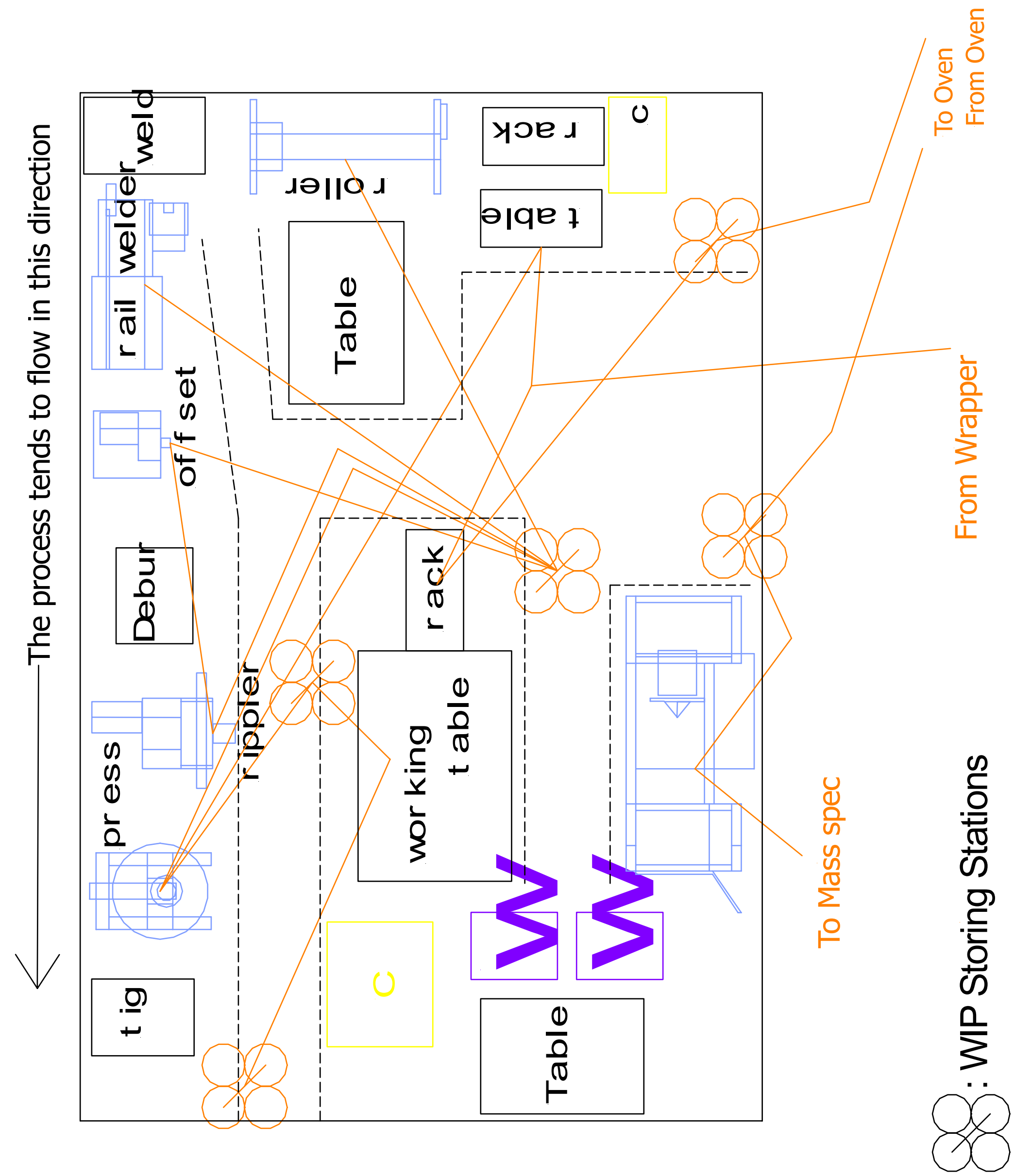

Figure 9.
Circuit followed for an outer

In this process the whole batch is processed in one station, when the batch is finished there, then the operator goes to the next step in the process, so each unit after being worked is placed in the storing location. The operator then, will take another unit from the storing station from the previous operation, will processes it and store it. In conclusion, at every station in the process, the operator walks from a storing station to the workstation and then back to a storing station, this with each unit in the batch. Table 6 shows the distance a tank travels through each circuit, and the distances from each operation to a WIP storing station.

INNER ASSEMBLY			OUTER ASSEMBLY		
Operation	To WIP station	To next workstation	Operation	To WIP station	To next workstation
1	10	7	11	25	6
2	7	23	12	6	5
3	10	9	13	10	9
4	9	7	14	9	7
5	7	10	15	7	7
6-7	6	10	16	6	10
8	20	11	17	6	5
9	11	23	18-19	4	12
10	24	24	20	12	10
			21-22	6	-
			23*	-	-
			24*	-	-

*: Operation performed out of the work area

Table 6.
Travel distances

Currently an inner vessel travels a total of 252’ from operation 1 to 10, an outer vessel travels 146’, for a total of 398’ (121.3 m). Working on one tank at a time as proposed before the travel distances change to 125’ for the inner, and 80’ for the outer, to make a total of 205’ (62.5 m). Just reducing the batch size to one tank at a time in most operations means a savings of 193’ (59 m) in each tank.

The tests performed for batch reduction were with the current arrangement, but instead going to the storing stations any time an operation is performed, the operator would take the same unit to the next station and perform the following operation, the results are as follow:

- ≡ Current flow distance for one tank working in batches (not counting distance from storage to work area, and from mass spec to painting):
  - Inners= 252'
  - Outers= 146'
  - Total= 398' (121.3 m)
- ≡ Flow distance for one tank working one tank at a time (not counting distance from storage to work area, and from mass spec to painting):
  - Inners= 125'
  - Outers= 80'
  - Total= 205' (62.5 m)

The savings in travel distance comes from not walking again and again to the WIP stations. Now, as seeing in Figures 8 and 9, the flow process tends to move to the left or the bottom of the page; for both vessels most of the operations start in the roller, they move to the other side of the area to then come back to almost the same point where they started; from this point they go (depending of the situation) to the wrapper, the oven, or the auto welder, most of the outlets of the process (oven, auto-welder, wrapper) are in the same side of the starting point, by the automatic welder. In this order, a new arrangement of the work area was proposed; basically it consists in placing the starting point (the band roller) in the opposite side of the area. Figure 10 shows the proposed layout.

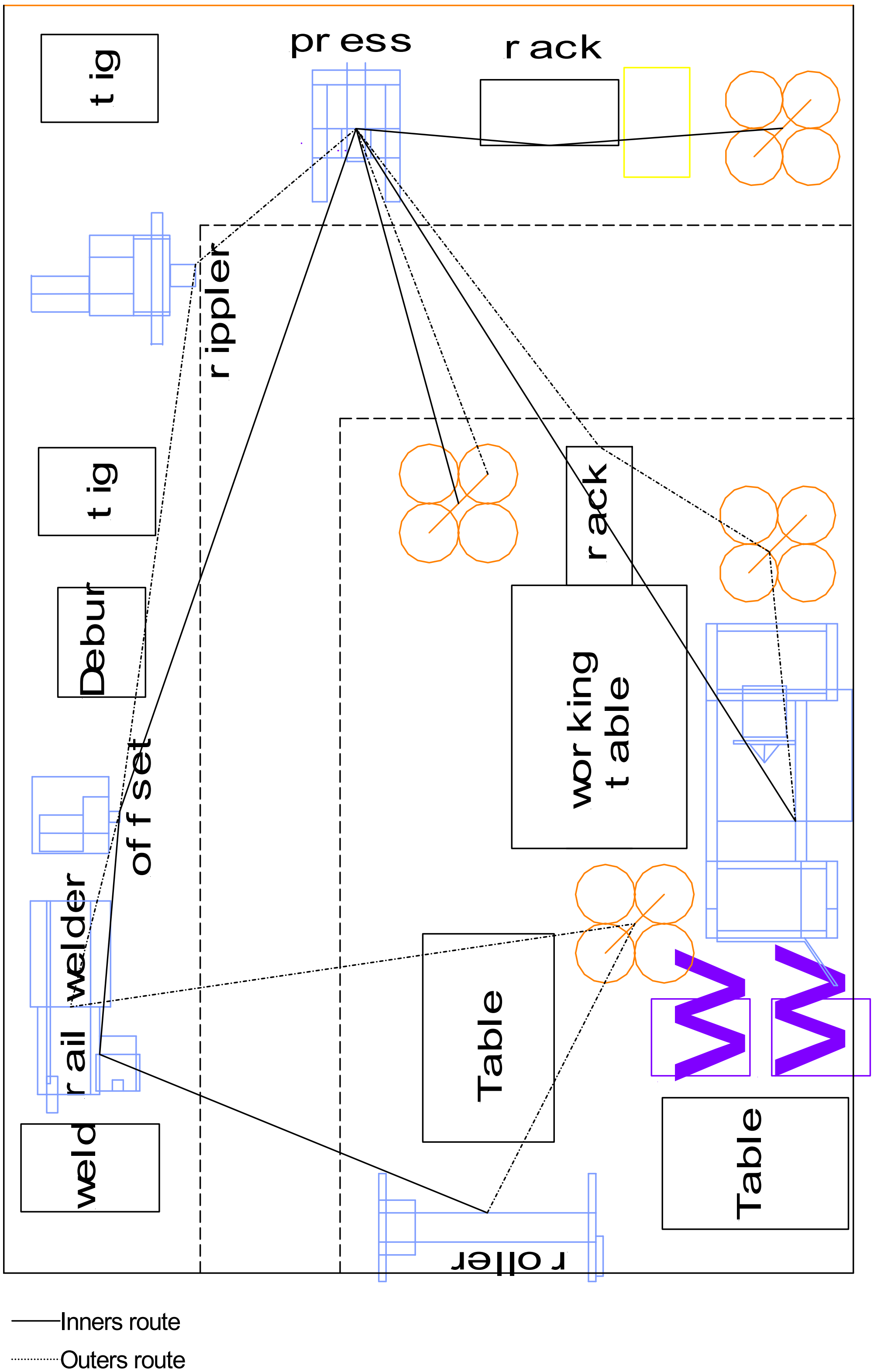

Figure 10.
Proposed Layout

The new travel distances for the proposed layout are shown in Table 7:

Operations	Dist. (ft)	Operations	Dist. (ft)
1-2	15	11-12	21
2-8	12	12-17	8
3-4	3	13-14	3
4-5	3	14-15	3
5-8	12	15-16	8
6-7-8	8	16-17-18-19	6
8-9	14	19-20	10
9-10	11	20-21	13
10-17	18	21-22-23	6
		Total=	174

Table 7.
Proposed layout distances

A comparison of the travel distances between the current process in a batch situation, in a one tank at a time situation, and with the new layout is showed in Table 8.

	Travel distances [ft]		
	Inners	Outers	Total
Current process-Batch	252	146	398
Current process-Non-batch	125	80	205
Proposed layout	174		174

Table 8.
Travel Distances

The interesting point is that all these savings in time and distances were made with minimum changes and just eliminating non-value-added activities, the core assembly process remains the same as before, this means that neither new or redesign equipments, nor different methods (besides working in one tank at a time) were used.

Savings.

≡ Currently three operators are needed to finish a batch of ten units in 16 hours, or 48 hours of labor combined (4.8 hours/unit). Also if 10 units are finished in 16 hours, this means an average of 5 units/day using one shift.

≡ The experiment realized with two operators finished the same ten units in 12 hours, or 24 hours of labor combined (2.4 hours/unit); what translates in 7.57 units/day.

≡ Ideally with the current layout and one operator performing all the operations and a second in the auto-welder as proposed in Table 5, the rate would be 2 people per tank in 30 minutes, or one hour of combined labor per unit; which means 16 units per day.

≡ Labor improves almost 80% from 4.8 hours/unit to 1 hour/unit.

≡ Production increases 320% from 5 units/day to 16 units day.

≡ The results showed above will improve when the process is performed with the proposed layout. As shown in Table 8 the distances will be shorter and then the time to go from one operation to another.

Chapter Five: Conclusions & Recommendations

This study was performed in the Locators Line at CHART Industries - Storage Systems Division. The results obtained through this work are specific for this line and company, but as stated in the review of literature, the concepts of batches, line balancing, and layout should generate similar savings and outcomes in other lines as well and in other companies.

Conclusions

≡ **Batch Size**: The material will be released to the floor the same way, the difference will be that instead taking all the units to a workstation before going to the next station, one unit (inner or outer, depending on the case) will be taken through all the workstations before starting to work in a second unit. Based on this, the time to finish a batch of 10 tanks was reduced 50%, from 12 hours to 6 hours.

≡ **Line balancing**: the new process needs one operator working in both inners and outers, and a second one in the automatic welder.

≡ **Layout redesign**: Basically, instead going anti-clockwise, all equipment was reorganized, and now operators will move clockwise. The band roller was moved to the opposite side of the work area, and all the other equipment was relocated based on this movement.

≡ The “one tank at a time” test was performed, due to time constraints, with the current layout. The Cycle Time is expected to reduce even more after the implementation of the proposed layout. Line balance is not expected to change due that basically the difference between the two methods is the elimination of non-value-added activities like pushing the WIP around the floor, and walking back and forward to WIP locations.

≡ Travel Distance was reduced 56% from 398 feet with the current layout and working in batches of 10 units to 174 feet with the proposed layout and working in one unit at a time.

≡ The informative meeting at the beginning of the project is a must; operators (as done in this study) have to be informed about what is going to happen.

≡ Small achievements made the change process easier, as was the case of the new process layout. The implementation and success of the new layout made the operators feel comfortable and confident with the project.

≡ All savings in time and travel distances, and gains in floor area were accomplished without any investment on equipment, and in the same work area used before the start of the project.

≡ The material will be released to the work area in the same way, as done before; this is the equivalent of ten (10) units. However, the difference will be that the operators will be working in one vessel at a time.

≡ There was a policy that every tank wrapped will be closed in the same day, no tank will wait wrapped overnight until the next day. Now this has changed and a stock of one unit of the most common models (locator 4, locator jr, locator 6000) will be kept unwrapped before the wrapper, so the operator working in the outer vessel won't have to wait over a half an hour (as done before) until an inner is closed and then wrapped.

≡ Labor costs were reduced in 80%.

≡ Production per day was increased 320%.

Recommendations

≡ A second automatic welder should be added to the system, this would reduce the setup time and production would be increased, a third worker would be needed to operate it.

≡ Due to the impossibility to roll an inner band and an outer band alternately, it was recommended that at the beginning of the batch all outer vessels were rolled. This will keep number of setups in the roller in two, same as before.

≡ When asked why inners and outers band have different thickness, neither operators and the supervisor, nor management knew the answer, although inner vessel are exposed to higher pressure that the outer vessel, but maybe the savings in set-up time worth paying the extra (if any) in material. It was recommended therefore, a study to determine the feasibility of having the same thickness for inner and outer vessels.

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Appendix

Appendix 1. Bulk Tanks

VS High Pressure Tank

Laser-Cyl Series

Appendix 2. Artificial Insemination Tanks

Cryoshipers

Appendix 3. Current cycle time.

Data collection #2.

Locators 4 (02/05/01) Current process			
Size of the batch= 10	Date	Time	Acum. Std
1st inner activity: gluing and crimping the neck	Wed 1-31	12:35pm	0
1st outer activity: roll outer band	Thu 2-1	6:20am	3h15m
1st outer coming out of the auto-welder	Thu 2-1	12:00pm	12h10m
Last outer coming out of the auto-welder	Fri 2-2	8:50am	15h25m