PROPOSED CHANGE OF WORK IN PROCESS (WIP)
INVENTORY FOR THE POLISHING DEPARTMENT AT APN,
INCORPORATED

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ABSTRACT

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PROPOSED CHANGE IN WORK IN PROCESS (WIP)
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The purpose of the study is to research new and effective methods of changing WIP inventories with the objective to provide a competitive advantage in improving manufacturing lead times for APN, Incorporated. Currently APN is using a batch processing system where product is transformed into finished goods dependent on customer requirements. Product is also made to stock, or finished goods inventory to accommodate customers requiring quick deliveries. Due to increased global competition, customers are requiring increasingly short lead times for these products. Current lead times at APN are at times longer than is acceptable to the customer. As a result, customers sometimes decide to choose from competitors of APN. In addition to lead-time requirements, some competitors of APN are capable of lowering their prices on products due to lower operating expenses, mainly in labor cost reductions. APN carries inventory in finished goods in efforts to provide the company flexibility in delivery.

A study will be conducted comparing both conventional and experimental methods by changing WIP inventory quantities. Further, the study will determine whether a change in WIP inventory will be beneficial to the performance of APN. Depending on the outcome of the study, a particular training program will be developed for the APN management team that will provide polishing operators hands on experience that can stimulate employee involvement and innovation. Results of conventional and experimental methods will determine methods of training. Results will focus mainly on lead time changes to finished goods.

ACKNOWLEDGMENTS

There are many individuals throughout the course of my field problem to whom I wish to thank.

This research paper is dedicated to many people in my life. To my loving wife, Amy Wink, and children, Ryan and Andrea, who provided me encouragement throughout the research process, and who stood behind me throughout times of challenge. Special thanks to my father, Donald R. Wink, for providing me skills and tools in life as a leader, manager, and metal worker. A stainless steel fabricator for 31 years, he taught me the importance of leadership, quality, and process improvement years before any book was put into my hands. To my mother, who always seemed to make things seem good, even in most trying situations. To employees at APN, for providing support throughout the research process, and for keeping an open mind toward new approaches in manufacturing. Most importantly, to the Plant Manager and Owner of APN, for their continued support and determination throughout this project. I also dedicate this paper partially to my deceased brother, Gregory Scott Wink, to whom I have always admired as an academic scholar and role model. Throughout this research paper, he was looked upon in mind and spirit.

Last, I thank God for the many ways for which He has touched my life through this research project. I give credit to my personal faith and also to two special friends, Hermann Butting, and Terry Breunig, for their special prayers and guidance both in faith and profession.

TABLE OF CONTENTS

LIST OF TABLES

Table

CHAPTER 1

INTRODUCTION

APN is a small, privately owned stainless steel manufacturer of fittings for sanitary and biopharmaceutical (BPE) industries. In efforts of determining potential for performance improvement at APN, a foundation of research on the hand-polishing process will be compiled. Due to process complexity, the study will be conducted and limited to training hand-polishing operators and related operations on optimal WIP inventories at APN.

Increased global competition from manufacturers around the world has presented an urgent need for APN to improve its manufacturing strategies in efforts to maintain and gain market share in sanitary fittings and special fabrication markets. APN has been utilizing the Theory of Constraints (TOC) to some degree in providing a foundation of continuous improvement for the organization since 1999. In 1999, a group of consultants provided training for the entire organization, and in 2000, implementation was well under way (Hansen & Associates. Aug. 1999). One of the consultants was hired on by APN, and provided significant leadership in improving overall performance at APN. In late 2001, the leader of the implementation program resigned. Methods of manufacturing soon returned to conventional methods of manufacturing; using batch processing coupled with make-to-order methods.

Since the transformation back to conventional manufacturing methods, a new management team was hired, including a private consultant that has provided training on TOC. The private consultant and the APN team also have made several improvements to the shop floor. Cellular manufacturing layouts were put in place to minimize movement of product. A constraint has been assigned for optimizing throughput of product through the manufacturing process.

Training was provided on TOC providing previously trained operators a review, and also introducing new operators to philosophies of TOC. A review was provided by the sales manager of new competitive strategies that APN distributors have taken the past two years, and also explained market share loss due to these new strategies.

There is a need to continue providing operators information on new methods of manufacturing related to TOC, and a better understanding of how it works. For example, new employees are not trained on TOC as an orientation requirement.

Work in process inventories remain at times high, especially when demand increases and greater than normal work orders are issued to the shop floor. This can affect outcomes of how quickly products get through the process. This in turn can affect lead times and customer delivery.

Statement of the Problem

The researcher proposes comparing conventional manufacturing transfer quantities of product that is released from a temporary stock in the process known as buffer to experimental manufacturing transfer quantities from the buffer.

In this case, when customer demand or anticipated customer demands are recognized, a work order is developed and released to pull from buffer and work through a set of operations that ends either at the customer, or finished goods (see Appendix A). The buffer was established to shorten lead times to customers upon confirmation. Often times orders are released to build a quantity of product to finished goods inventory in anticipation that a customer may seek demand in the near future. Due to extended lead times, products requiring hand-polishing operations are typically stocked in finished goods to avoid extended waiting times from buffer.

Comparing results of conventional methods for hand-polished parts from buffer to finished goods with experimental methods involving the reduction of WIP inventories will determine if a change can improve lead times. Results will be used to train hand-polishing operators.

Sub-problems

The first sub-problem. The first sub-problem is to compare conventional methods of manufacturing with experimental methods related to WIP inventories in hand-polishing.

The second sub-problem. The second sub-problem is to realize any performance improvements from the comparison between conventional and experimental methods, and develop surveys for both before and after training to measure knowledge growth from operators.

The third sub-problem. The third sub-problem is to develop a method of training to operators for personal and organizational growth, and assist in providing involvement in the training program.

Assumptions

The first assumption. The first assumption is insuring individuals involved in the comparison experiment with WIP inventories will provide accurate data in an ethical and honest manner.

The second assumption. The researcher will assume operators in the hand-polishing department will provide fair and honest answers to questions provided on surveys.

The third assumption. Based on results from research compiled by performing experiments in the hand-polishing department at APN, training procedures will be effective in improving lead times.

The fourth assumption. Operators and management will be cooperative in providing accurate information, and will keep an open mind on results from the study.

The fifth assumption. Training will be provided not only to assist in learning new methods, but also to build ownership and involvement to any new process improvements developed.

Delimitations

This study will not analyze gender or age as a method of evaluation.

The study will be limited to management, the supervisor of the department, and operators involved in hand-polishing operations at APN.

Operators and/or management will not be evaluated based on knowledge, skills, or abilities of polishing prior to training.

Definition of Terms

Theory of Constraints (TOC): A continuous improvement manufacturing philosophy designed to optimize the business process. The goal of the philosophy is to make money by focusing on areas in the process which increases throughputs, reduces operating expenses, and reduces inventories.

Work in process (WIP) inventory: Any product in the manufacturing process that has begun transforming from raw materials.

Make-to-order: Parts are manufactured only when customers require them. Minimal if any inventory is stocked for anticipated demand.

Biopharmaceutical (BPE): Drug-related industry that requires various specifications.

Raw Materials: Material that is purchased and has not begun any transformation from its shipped stage.

Finished Goods: Storage area prior to shipping. Parts that customers require on quick notice usually are stored in finished goods. Parts at this point are in the completed state.

Lead Time: Time it may take for parts to be transformed into finished goods and shipped to the customer.

Customer Demand: Demand may be a confirmed customer requirement, or an anticipated requirement from APN management.

Purchase Order: Confirmation that the customer will be purchasing parts. Quantities and required delivery dates are commonly documented.

Work Order: Paper that is released to manufacturing that provides instructions on how to make the part, quantities to build, materials, and machine settings.

Constraint: Anything that limits the system from attaining its goal. Constraints may be categorized as behavioral, managerial, capacity, market, and logistical. System constraints determine the total system throughput.

Operator: Individuals involved in providing the hand-polishing operation are known as operators. Squaring and Sizing operators are also considered operators unless otherwise specified.

Conference Room: The training facility at APN where classroom training will be performed.

Learner: Operators will be classified as learners through the training program.

Sizing: Operations required between rough polishing and squaring operations that were necessary to be studied for the outcome to reach its potential.

Squaring: Operations required after sizing and finish polishing operations that were necessary to be included for the outcome to reach its potential.

Simulation: A hands-on exercise that will be utilized which allows the learner to understand by using similar techniques as their operations require to show methods of manufacturing.

Buffer: In the situation at APN, buffer is a storage area after a long operation where WIP is staged as a midpoint through the process. Upon confirmation of demand, the parts are then released from buffer and transformed to customer or finished goods requirements.

Transfer Quantities: The amount of product going from one operation to another. It is sometimes typical in conventional methods to produce the entire work order quantity at one operation and then move the product to the next proceeding operation. In this case, the work order quantity is considered the transfer quantity.

Process Interdependence: Relying on another person or machine to produce work for the proceeding or preceding operation.

Assignable Causes: Any problems in the process that may have caused differentiation or lack of validity in results of the outcome.

Performance Improvement: The achievement of results; the outcomes (ends) to which purposeful activities (means) are directed to increase efficiency and/or effectiveness.

Value-Added Time: Time added to the product which will provide some means of tangibility for the end user.

Non-Value Added Time: Time added to the product that does not provide any tangible result to the product or its end user.

Changeover: An operation performed by operators which allows them to change from one size product to another.

Batch Processing: Method of running a quantity of parts at one operation before moving them to proceeding operations.

Pitting: A process issue in welding that may be caused by several variables in the manufacturing process.

Protective capacity: Capacity to protect against system disruptions.

Reject: Part that does not conform to manufacturing or customer requirements.

Abbreviations

1. WIP: Work in process
2. BPE: Biopharmaceutical
3. APN: Austin-Paasch-Neumann (partnership and name of company)
4. TOC: Theory of Constraints
5. ID: Inside Diameter
6. OD: Outside Diameter

Importance of the Study

The importance of the study is a key requirement to benchmark lead times due to increased global competition. Offshore competitors are putting severe pricing pressures on the industry of APN. APN is receiving less market share due to global competition, so to better leverage the business, there may be a serious need to change from conventional strategies. Lead time can be a strength APN can provide over some competition due to demographic reasons.

A series of experiments will be performed and studied to understand lead times and benchmark improvement potential. By running an experiment comparing the two methods, the researcher will be capable of better understanding lead times to finished goods. The training program will allow operators to better understand different methods of processes and also provide them a foundation for being involved. Training on effects of WIP inventory can assist management in making a smoother transition to new manufacturing methods. One of these important objectives of the training program is to introduce interdependence in the process as an essential tool in performance improvement.

CHAPTER 2

REVIEW OF LITERATURE

Introduction

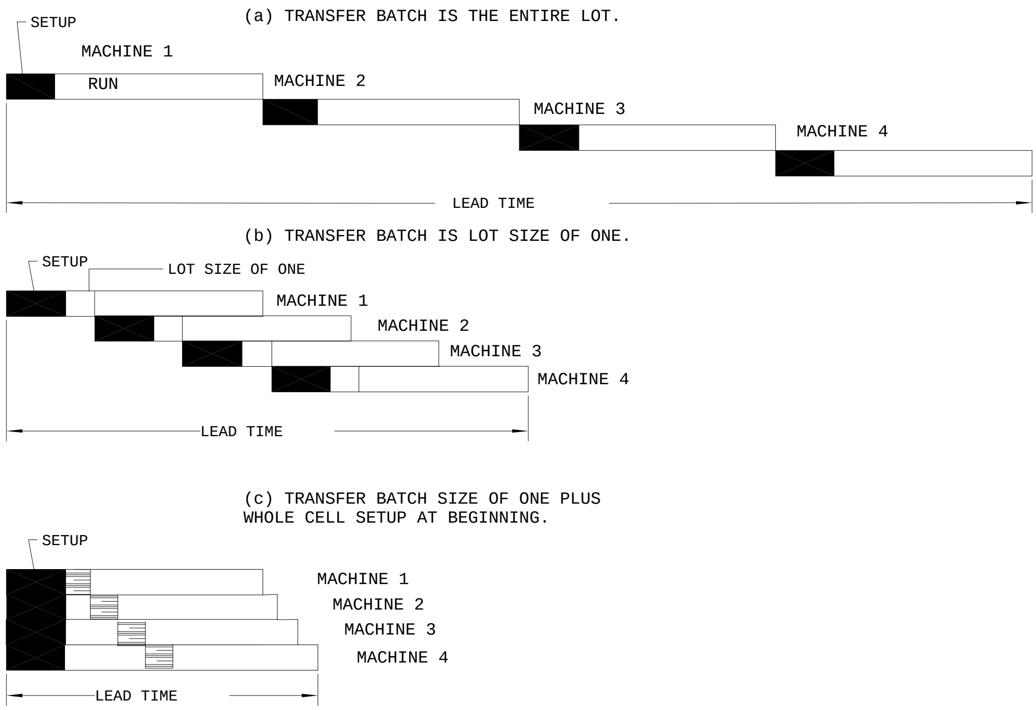
The review of literature will include three key areas: (1) assessing conventional and experimental manufacturing processes through experimentation to provide information on amount of lead time required from buffer to finished goods, (2) evaluating results from pre and post-training surveys that are to be completed by the learner, and (3) implementing a training program based on results from the comparison experiment, and (4) expression of results from the experiment, surveys, and simulation.

Conventional methods of manufacturing refers to methods that have been commonly used in manufacturing organizations. One characteristic of conventional manufacturing is associated with taking time away from the task of producing (making parts, components, and finished units) in order to train, communicate, and physically change the plant (Davis, 1999, p. 44). Some conventional characteristics of manufacturing may lack interdependence of operations, as shown in Table 1 (a) below (Suri, 1998, p. 179). As shown, Machine 1 processes all parts through its machine before moving to Machine 2. The entire lot is transferred as it is completed, then sent to the next operation.

Experimental methods of manufacturing will focus on a scenario similar to Table 1 (c), where setups of all machines will be completed at the start of production. As compared to Table 1 (a), there is a significant reduction in lead-time.

Table 1

Transfer Quantities



The researcher will base the experiments on similar production situations being experienced in the hand-polishing department at APN. Work-in-process inventories include several topics of study. Elimination of waste focuses on all inventory; raw material, WIP, and finished goods. The researcher will be conducting research exclusively on the effects of WIP inventories in the polishing department. There will be five process principles of improvement the researcher will follow in gaining a better understanding of the hand polishing process and in using the findings of these topics to determine a need to improve lead times and reduce WIP inventories (Goldratt, 1990):

1. Identify the system's constraints.
2. Decide how to exploit the system's constraints.
3. Subordinate everything else to the above decision.
4. Elevate the system's constraints.
5. If in the previous steps a constraint has been broken, go back to step 1, but do not allow inertia to cause a system constraint.

These five principles will be the foundation of all study. They will be followed in identifying the constraint in the hand polishing process when the experiments take place. The simulation will follow these principles in identifying the constraint, and if possible, elevating the constraint. Reducing WIP inventories, reducing operating expenses, and increasing throughput are the three measurements that organizations need to follow in order to continuously improve.

Experiments will be completed in an ethical manner to promote involvement, honesty, and respect toward potential improvement. The researcher will place great emphasis on communicating to operators prior with explanations to the study.

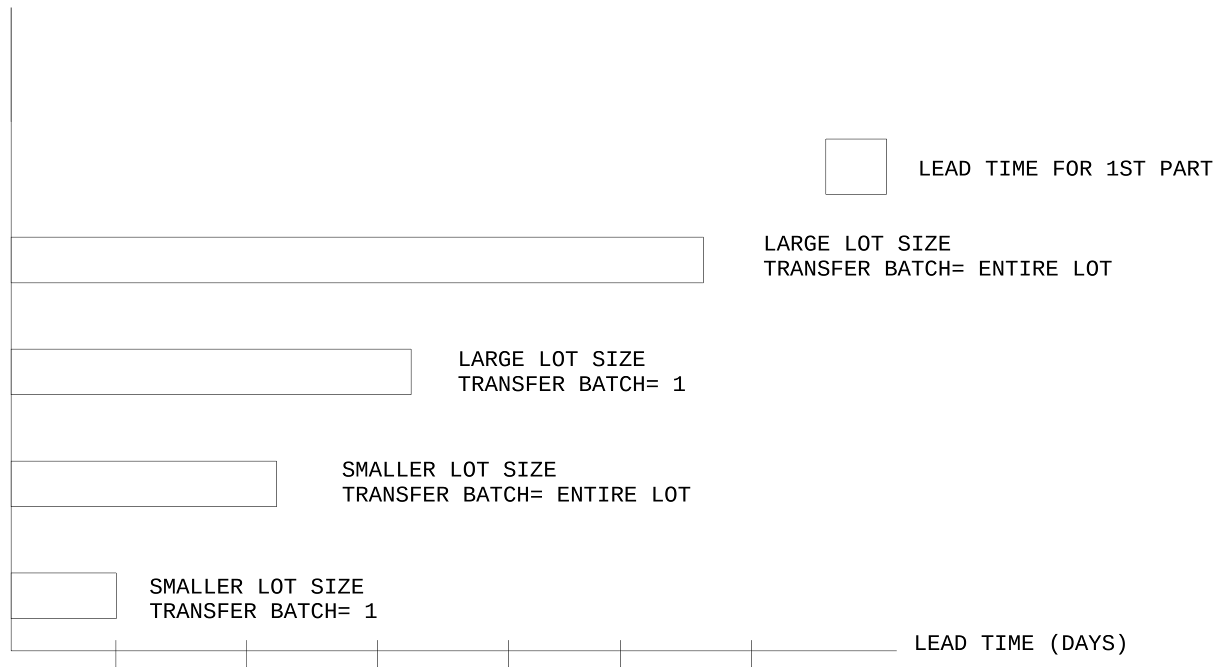
Simulation as an aid in training provides a real-time situation incorporating hands-on experience in a simplistic form to operators to mirror results similar to the experiments. A partial fulfillment of the training program is to encourage operator involvement. Training is absolutely critical to process buy-in and continuous improvement, especially for those manufacturing firms who have for years operated under batch mode of operation (Davis, 1999, p. 248).

The researcher will be performing research based on WIP inventories, analysis of experiments and findings, and effective involvement with operators to encourage performance improvement. A process has been designed so operators understand potential improvements to the point where they may use this approach to processes at APN.

Table 2 on the following page shows results of a practical application that will be used in determination of lot sizes for both the experiments and the simulation (Suri, 1998, p. 180) which is similar to the hand polishing process. The model is based on a cell in an aerospace company that custom machines hubs for engines. When lots are large with the transfer batch the entire lot (30 to 44 parts), lead times show well over twenty five days. As lot sizes become smaller, lead times become shorter, as shown with a smaller lot size, and a transfer batch of one. The reason for this is, the large lot size with the entire lot transfer batch is a conventional method of transferring quantities. The reason for the entire lot is because conventional processes were mostly departmentalized. This means that Machine A may have been on one end of the plant, while Machine B may have been on the other end, forcing product to be batched.

Table 2

Lot Size/Transfer Batch



APN has somewhat of a cell layout, which will be helpful to reduce WIP inventories. Without a cell layout, it would have been extremely difficult to perform due to material handling. As mentioned earlier, the cell layout has significantly improved the visibility of product and to some extent the movement of product through the process.

Upper Management Requirements

Commitment from upper management is critical. The decision to move forward with implementation after completion of the training program is the plant manager's responsibility.

The researcher will provide detailed information to the plant manager and the supervisor prior to the training program. All resolutions to training program procedures will be made at this time to make intervention between operators and the researcher more valuable during the training program.

Supervisor Training

Prior to training hand-polishing operators on any new changes in the process, the supervisor will first be involved and given the opportunity to review the process change. Buy-in must be attained by the supervisor before the training program moves forth. Because the supervisor acts as leader and decision-maker for the department, his/her role may include facilitating methods in the process should implementation occur.

Lack of Evidence

There are several sources available that incorporate philosophies to improve manufacturing performance. However, there is a lack of evidence that any particular philosophy matches APN production systems. APN is a small stainless steel fabrication job shop. Although small, APN retains over 3500 active part numbers. In addition, customers sometimes require same day shipments or will otherwise go elsewhere. Therefore, there is a need to stock items which APN anticipates are needed by customers on a moments notice. Though any inventory is wasteful other than protective capacity, according to TOC (McMullen, Jr., 1998), it is also necessary for APN to retain customers if correct parts are stocked and frequently shipped to customers. In conclusion, the researcher will only base the study on lead time improvement based on WIP inventories. Finished goods inventories will not be investigated, only analyzed by the affects of WIP inventories that may cause an affect.

CHAPTER 3

METHODOLOGY

Introduction

This study is used to compare experimental methods of manufacturing to conventional methods, and determine a conclusion for providing APN with a procedure of implementing change through organizational involvement and training. To complete the training program for hand-polishing, the researcher shall gather data and evidence to be used in the training program. Surveys, the simulation, and comparable experiments will provide evidence of which method is most effective. The simulation will be used as an aid in allowing operators to view and experience involvement, improvement potential, and overall interdependence.

Design of Comparison Methods

To make valid comparisons between conventional methods and experimental methods of manufacturing, work orders will first be released as a normal production run. Operators will document by operation the start time, end time, name, and any assignable causes that may have occurred throughout the production run. Names will only be used in the retrieval of information should an issue come up that may bias or skew evidence. This spreadsheet will be attached to the original work order. The first work order will be released as a conventional work order. No changes will be made with exception to operators logging operation times. Work order quantities used in the experiment are usually used as transfer quantity also. The researcher decided not to dictate transfer quantities to retain normalcy. Another work order will be released with the same spreadsheet using the experimental method. Setups on various machines will be completed prior to reaching the operation, creating interdependence to the process. Transfer quantities will be determined by both the researcher and operators of specific operations to determine effective transfer quantities. The researcher will document typical transfer quantities. If requirements are necessary in providing validity toward the comparison, additional work orders will be released and used by following methods described above. Upon completion of these work orders, the researcher will document results related to lead times, assignable causes, and overall results. Results from the comparison will be used as a prerequisite to the simulation project in training.

Design of Surveys

Prior to the training program, each operator will be assigned to complete a pre-training survey which will include a series of questions related to conventional fallacies of efficient processes (Suri, 1998). Surveys will take into consideration and be evaluated for purposes of understanding individual operator thoughts on what may be required to improve process performance, and also to aid the researcher and management in gaining a better understanding of operator knowledge about performance improvement. A post-training survey will be given to operators at the completion of training to be evaluated in providing the researcher a result of what operators learned in the training program. Questions will be explained from surveys upon completion of the training program if necessary.

Design of the Training Program

The training program design will be administered in a manner which everyone will be treated in an ethical and appropriate manner. Because new operators may not have any training on process improvement programs, the researcher will develop a program which is both simplistic, yet effective in providing the beginning and advanced operator with an opportunity to stimulate personal growth. Results from experiments will be used to show results performed by polishing. Results and findings will be discussed. The intent of showing results is to facilitate continuous improvement. Due to the fact that several operators have been trained on some process improvement programs before, whether at APN or elsewhere, the use of the simulation will be new for all operators. This method was developed to provide a sense of comfort, and to welcome involvement from those that have not been involved in any process improvement programs in the past, while providing a new method of communicating to existing operators with previous training.

Simulation

The simulation will be divided into two teams, Team A and Team B. Legos will be used as components to assemble space cruisers (See Appendix B, C, & D). Each team will have three operators and a customer. Both teams will assemble the same product in a line. Operators will be given 4 minutes to complete 30 parts, which is the customer requirement for each team. Customers will be asked by the researcher to act out emotions such as frustration due to waiting for product, or happiness, due to on-time shipments. The researcher will post results of quantity produced, defects, and WIP inventory for every team simulation.

Team A

Team A will use conventional methods of manufacturing. The purpose is to simulate methods currently used in the polishing department. Operator 1 of the process will perform assembly requirements for 25 before moving them to the next operation. This will simulate large lot sizes as was performed in Experiment 1. Operators 2 and 3 will use these same rules as units are completed.

Team B

Team B will be using experimental techniques. Operator 1 of the process will perform assembly requirements for 5 before moving them to the next operation, similar to lot sizes performed in Experiment 2. Operators 2 and 3 will use these same rules as units are completed.

Instrumentation

The training program requires use of a computer, overhead projector, Microsoft Powerpoint, legos, a blackboard, and operators. The researcher has been granted one hour for training. The employee conference room will be utilized for the training location. Training contents will be dependent on results from experiment comparisons and surveys.

CHAPTER 4

RESULTS

Results of Experiment 1

As shown in Table 3 below, Experiment 1 went as the researcher expected. Parts were moved from buffer to the first operation. The entire work order was batch processed. Without interdependent operations, the work order was slowly worked through the process based on operator and machine resources. As operators found time to work on the work order, they would complete an operation.

Table 3

Conventional Methods

Experiment 1 (2" Polished Weld Tee)			
Method-Conventional	***Time Started***	***Time Ended***	***Date***
Start Time from Buffer	7:00 a.m.	7:05 a.m.	4/7/03
Rough Polish O.D.	10:00 a.m.	12:00 p.m.	4/7/03
Rough Polish I.D.	7:30 a.m.	9:30 a.m.	4/7/03
Size	12:30 p.m.	2:15 p.m.	4/8/03
Square length	7:30 a.m.	9:00 a.m.	4/9/03
Finish polish O.D.	6:00 a.m.	7:15 a.m.	4/11/03
Scotchbrite O.D.	7:15 a.m.	9:00 a.m.	4/11/03
Finish Polish I.D.	10:40 a.m.	1:00 p.m.**	4/14/03
	Total Value Added Operational Time		**12 hours 5 minutes**
	Total Non-Value Added Operational time		**185 hours 30 minutes**
	Throughput Time		**197 hours 5 minutes**
** 1/2 hour lunch deducted		Total Time (days)	***8.4 days***

Results of Experiment 2

Table 4 on the following page shows the work order by changing transfer quantities, or reducing WIP. Operators were asked by the researcher to produce 5-10 parts at one operation before moving them to the next operation. sizing and squaring were set up together to provide a smooth flow through the two operations, quickly circulating parts back to polishing for finish polishing operations. As sizing completed 5-10 parts, squaring then pulled parts from sizing and began production. This is also known as a pull system (Davis, 1999) due to interdependence regulating the process. When one operator gets ahead, the previous operator stops or slows operations to keep minimal WIP inventories. Parts seemed to make it through the process much more quickly, and with less material handling in large totes.

One problem did occur during this process. An operator from another department approached sizing to see if there was capacity for some urgent parts that another customer wanted quickly. This presented a problem because the operator of the sizing machine set up for experiment 2 was not the size in question. The researcher took note of the issue and presented it to the plant manager. The response from the plant manager to perform another experiment due to the nature of the problem was requested. The request was to flow material similarly to experiment 2 with the exception of batch processing the entire work order in front of Sizing so if an operator required to use the size that was set up, then the operation would not require changeover.

Table 4

WIP Reduction

Method-WIP Reduction	Time Started	Time Ended	Date
Experiment 2 (2" Polished Weld Tee)			
Start Time from Buffer	10:15 a.m.	10:18 a.m.	4/15/03
Rough Polish O.D.	11:30 a.m.	1:30 p.m.**	4/15/03
Rough Polish I.D.	11:25 a.m.	1:45 p.m.**	4/15/03
Size	12:45 p.m.	2:20 p.m.	4/15/03
Square length	1:15 p.m.	2:30 p.m.	4/15/03
Finish polish O.D.	1:15 p.m.	2:30 p.m.	4/15/03
Scotchbrite O.D.	6:00 a.m.	7:45 a.m.	4/16/03
Finish Polish I.D.	8:30 a.m.	10:00 a.m.	4/16/03
		Total Value Added Operational Time	**10 hours 40 minutes**
		Total Non-Value Added Operational time	**12 hours 5 minutes**
		Throughput Time	**23 hours 45 minutes**
		Total Time (days)	***.989 days***
**1/2 hour lunch deducted		Time saved vs. Conventional	***7.411 days***

Experiment 3

This experiment was performed by request from the plant manager to batch process at sizing to prevent sizing from being set up too long on one size. Although results are much more impressive than Experiment 1, results of this experiment shows to be less effective as Experiment 2. The problem did not exist with set up, however batch processing caused the process to split. Operations such as Rough Polish O.D. and Rough Polish I.D. went smooth, although, once parts reached sizing, there no longer was interdependence in the process. Once sizing set up for processing parts, squaring also set up, which allowed operations from sizing to Finished Goods to be processed interdependently. As shown in Table 5, process lead times more than doubled as compared to results shown in Table 4. Increase in lead time is due to batch processing and loss of total interdependence.

Table 5

WIP Reduction-Revised

	Experiment 3 (2" Polished Weld Tee)		
Method-WIP Reduction-Revised	***Time Started***	***Time Ended***	***Date***
Start Time from Buffer	6:00 a.m.	6:10 a.m.	4/28/03
Rough Polish O.D.	6:10 a.m.	8:45 a.m.	4/28/03
Rough Polish I.D.	6:10 a.m.	8:15 a.m.	4/28/03
Size	8:00 a.m.	10:05 a.m.	4/28/03
Square length	8:55 a.m.	11 a.m.**	4/28/03
Finish polish O.D.	11:00 a.m.	12:45 a.m.**	4/29/03
Scotchbrite O.D.	6:00 a.m.	7:45 a.m.	4/30/03
Finish Polish I.D.	6:00 a.m.	7:40 a.m.	4/30/03
	Total Value Added Operational Time		**12 hours 55 minutes**
	Total Non-Value Added Operational time		**35 hours 45 minutes**
	Throughput time		**48 hours 40 minutes**
Note: Lot size split at Sizing		Time (days)	**2.07 days**
**1/2 hour lunch deducted		Time saved vs. Conventional	***6.33 days***

Summary of Experiments

Comparisons provided the researcher with valid information that performance improvement is attainable not by necessarily working harder, faster, or longer hours, but by working more effectively (Suri, 1998). Experiment 2 issue was not a process problem. That is, the reason operators were not able to process customer parts was not due to the Sizing being set up for Experiment 2, but due to a lack of effective scheduling and communication. Because Experiment 2 work order was going to finished goods, and not to the customer, it should not have been worked on until more urgent work orders were completed, such as expedited parts that caused concern. As shown in Table 4, the sizing operation was utilized for 1 hour 35 minutes. Table 3, which is conventional methods of processing parts, shows times at Sizing of 1 hour 45 minutes (Table 1, sizing), which is very comparable. Had the operator decided to break into the process during Experiment 3, and the machine was not set up for the correct size, the urgent order would have had to wait 2 hours 5 minutes (See Table 5, sizing). This scenario is similar to Table 1 (b). Setups for squaring and sizing were not set up in sequence with the remainder of the process, resulting in longer lead times and more WIP inventory.

Table 6 shows the 3 experiments and their respective times of completion. There is an obvious lead time improvement associated to changing WIP inventories.

Table 6

Summary of Experiments

Experiment	***Value Added Time (Operations)***	***Non-Value Added***	***Throughput Time***
Experiment #1 (Conventional)	**12 hrs. 5 min.**	**185 hrs. 30 min.**	***8.4 days***
Experiment #2 (Reduced WIP)	**10 hrs. 40 min.**	**12 hrs. 5 min.**	***.989 days***
Experiment #3 (Reduced WIP-Revised)	**12 hrs. 55 min.**	**35 hrs. 45 min.**	**2.07 days**

Notice the significant changes in time that is considered non-value added time. In Experiment 1, there is a noticeable amount of time that parts are being kept in queue before they are processed further through the process.

Results of Pre-Training Surveys

Results of pre-training surveys showed indications in operator knowledge of problems present in the current process, and also a need for training on performance improvement. Operators also gave inputs toward problems associated to what was hindering outputs.

Question number 6 results of the pre-training survey showed operators were well aware of parts that are frequently expedited. One hundred percent of the learners responded that when other urgent customer orders need to be completed, then it is typical for them to stop working on an order to perform operations on urgent work orders to complete them on time (See Appendix F, number 6). Learners explained that orders are sometimes dropped because an urgent job comes through. This phenomenon is typical to manufacturing in a batch processing system. These urgent work orders are unscheduled jobs being put into the factory at shorter than normal lead times, thus needing to be expedited. Work orders crowd out scheduled jobs, which experience many delays, leading to even longer delivery times than originally planned (Suri, pg. 60).

Another indication that operators were aware of problems in the polishing process was because 80% of learners answered that parts would be received in shipping more quickly if parts were processed through sizing, squaring, and welding more quickly (See Appendix F, number 7).

Because parts are batch processed through sizing, squaring, and welding with relatively large lot sizes, parts completed with rough polishing operations can typically wait a period of time before being processed at sizing, squaring, or welding. This is caused by lack of interdependence (See Table 3, sizing).

Results from the pre-training survey also showed indications that additional training is necessary toward involvement and participation in performance improvement. Eighty percent of operators felt in order to get jobs out fast, they would need to keep machines and people busy all the time. The purpose of this question was to gain an understanding in TOC from the learner. Results of this question will be explained in training program results.

Results from questions on the survey showed several indications that operators had an understanding of problems that existed in hand polishing. Operations that are relied upon by polishing, such as sizing, squaring, and welding, were hindering throughput due to lack of interdependence in the process. Operators also realized that work orders were set aside to work on more urgent work orders, hindering on-time delivery on work orders set aside.

Results of the Training Program

The researcher was pleased with the training program outcome. All learners were present at 12:30 p.m. on July 24, 2003, including the plant manager and supervisor of the polishing department. Initial portions of the training program consisted of discussing experiment results. The researcher described experiments 1-3 in detail to show how changes in WIP inventories affected product outputs. Involvement was minimal through the discussion, which was expected.

Team A Performance

Team A performed operations as explained. Due to the significant wait time from operators 2 and 3, they decided to line up parts in front of them to get set up for when parts were to be delivered to them (non-value added).Upon completion of the time period, operators had not fulfilled customer requirements (see Table 7). Viewing the process, operators noted that several parts were partially complete, but not ready to ship to the customer. More WIP inventory would have been present, however, the researcher neglected to communicate for operator 1 to continue with second lot of twenty five.

Table 7

Team A Results

Team A	
Parts shipped to customer	9
Operator 1 WIP	0**
Operator 2 WIP	16
Operator 3 WIP	16
Rejects	0

**Operator was not told to continue after completion of first 25.

Team B Performance

The same method was used with Team B as Team A, with exception to lot size reduction from 25 to 5. Results from the simulation went well. Operators remarked how smooth and quickly product moved through the process. Although customer requirements still were not completely achieved (see Table 8), there was performance improvement from Team A results.

Table 8

Team B Results

Team B	
Parts shipped to customer	20
Operator 1 WIP	9
Operator 2 WIP	7
Operator 3 WIP	9
Rejects	0

Concluding results from Team B, the researcher then asked if there were any improvements that can be made. Operators identified Operator 2 being the constraint. The researcher then asked how they could optimize the constraint operation. Responses were to have Operator 1 provide assistance with a part that Operator 2 performed. The rule was for Operator 1 to only perform the added operation only when there was protective capacity between operations 1 and 2. At this point, the researcher realized time existed to perform a third simulation with this method of potentially improving the process.

Team B Optimized Performance Results

Outputs for this simulation resulted in reaching customer requirements. Operator responses were positive toward the performance improvement. Seeing such a positive result was exciting for the team, as shown in Table 9. Active involvement was key in the process improvement and provided a sense of satisfaction.

Table 9

Team B Optimized Results

Team B-Optimized	
Parts shipped to customer	37
Operator 1 WIP	0
Operator 2 WIP	2
Operator 3 WIP	7
Rejects	0

Summary of the Simulation

Active involvement from operators was a major link in providing significant performance improvement results. Actions were taken to continuously improve the process, and several discussions surfaced regarding the importance of reducing WIP inventories. A main point in the training program was the realization by operators of WIP inventory effects associated in performance improvements. Results from the three simulations show how WIP inventories were reduced as outputs increased. An operator emphasized the benefits of reducing WIP inventories affecting quality.

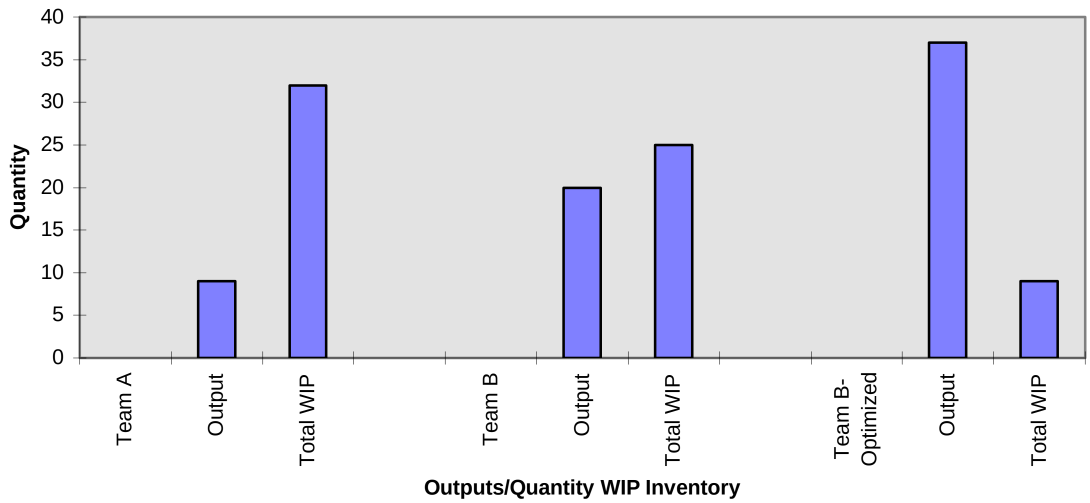
Although no rejects occurred in any of the three simulations, if one had, reduced inventory may reduce the amount of rejects associated with the work order. Team A Operator 1 performed assembly requirements for 25 parts before passing them on to the next operation. If those parts had quality issues, then operator 2 would have received 25 reject parts. In relation to Team B, if Operator 1 performed assembly requirements for 5 parts and moved them to the next operation, had there been any quality issues, Operator 2 would only have 5 reject parts. Operators realized this in polishing due to the amount of process problems that exist prior to polishing that have already been completed in polishing.

Simulation results showed that as WIP inventories were decreased through smaller lot sizes, outputs to finished goods increased as shown in Table 10 on the following page. The ratio of the simulation shows that as WIP inventories are reduced, the quantity of completed parts increases.

Operators also discussed impacts that large WIP inventories may have on volumes of finished goods inventory. The explanation was made that as WIP inventories decrease and lead times decrease, overall finished goods can be decreased also. As lead times decrease, there exists the opportunity of lowering inventory levels due to more achievable on-time delivery success. The reason this opportunity exists is because of significantly improved lead times.

Table 10

Simulation Summary-Results



Unanticipated Findings

An operator brought up a good point during the simulation. The question was asked how several jobs due on the same day use this type of method. The question was referring to the simulation being only one product being processed through the polishing department. The position the researcher took on this question was that if all work orders were run in this manner, results showed that work orders would reach finished goods more quickly dependent on scheduling and reducing work order lot size. For example, if six work orders of 100 different products were scheduled to move through the polishing department, can production scheduling release work orders in twelve orders of 50? In this case, if there were 6 customers requiring these parts, then by splitting them into 12 work orders of 50 would yield faster partial delivery to customers. The customer is assumed to have a job that requires these parts very quickly. Shipping 50 instead of 100 will cut the lead time basically in half, allowing the customer to start the project twice as fast versus waiting twice as long and possibly canceling the work order and going to a competitor.

After performing the simulation, this partially proved that smaller WIP inventories will yield shorter lead times on all product. Further experimentation to scheduling would have been necessary due to the fact this was more of a scheduling requirement, which was not studied.

Because the researcher did not anticipate performing the Team B-Optimized simulation, operators were not able to complete the Post-Training Surveys within the hour time frame. The simulation was not anticipated, however, the results were significant and operators showed great involvement and curiosity toward the outcomes. Therefore, no Post-Training results were able to be reviewed in the study.

CHAPTER 5

DISCUSSION

Summary

Overall effectiveness of the research project was favorable in both providing effective methods of implementing a change of this magnitude, while informing and providing active involvement for those operators performing the operations. Although some situations were not anticipated, further analysis was continued in retaining valid evidence.

Results showed significant improvement in reducing WIP inventories, and also providing on-time deliveries. Operators involved voiced their opinions in a constructive manner so knowledge was gained in providing a comfortable, communicative atmosphere. Because the experiments defined the method of preparing the simulation, it was interesting and exciting to see such improved results from conventional methods of processing parts, and also to witness curiosity from a group of individuals that take so much pride in their careers.

Conclusion

The researcher realizes the purpose of this research was only the beginning of the continuous improvement process. The simulation showed how processes can be improved continuously. Awareness of identifying where to concentrate efforts in the process was realized, and results made operators aware that processes need to be refined continuously. Operators were able to see immediate results, a key point the researcher wanted to convey in the training process. Results of the study also showed smaller WIP inventories to be more effective in shortening lead times to customers than with larger WIP inventories. The researcher feels that evidence of the experiments, simulations, and overall training program showed this was a positive change.

Recommendations

During the study, the researcher analyzed another opportunity that may continuously improve the polishing process. Although cell layouts were put into place in the recent past, an opportunity exists to possibly move sizing and squaring operations into the polishing department, as shown in Appendix G. Reasons the researcher feels confident this opportunity exists is because there are two sizing machines and two squaring machines. Utilization would not change if moved into the polishing department because other parts that do not require polishing will still be capable of using the machines in polishing. Although no research was concluded in plant layout, the researcher feels confident a change of this magnitude would provide many similar benefits as shown in this study to optimize performance.

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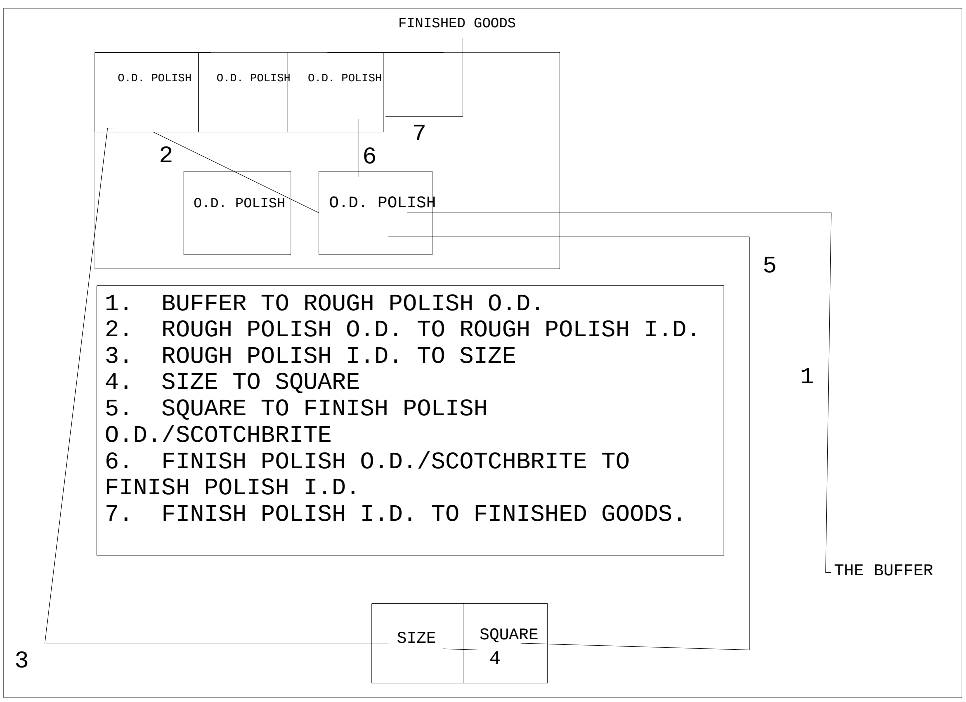
Appendix A

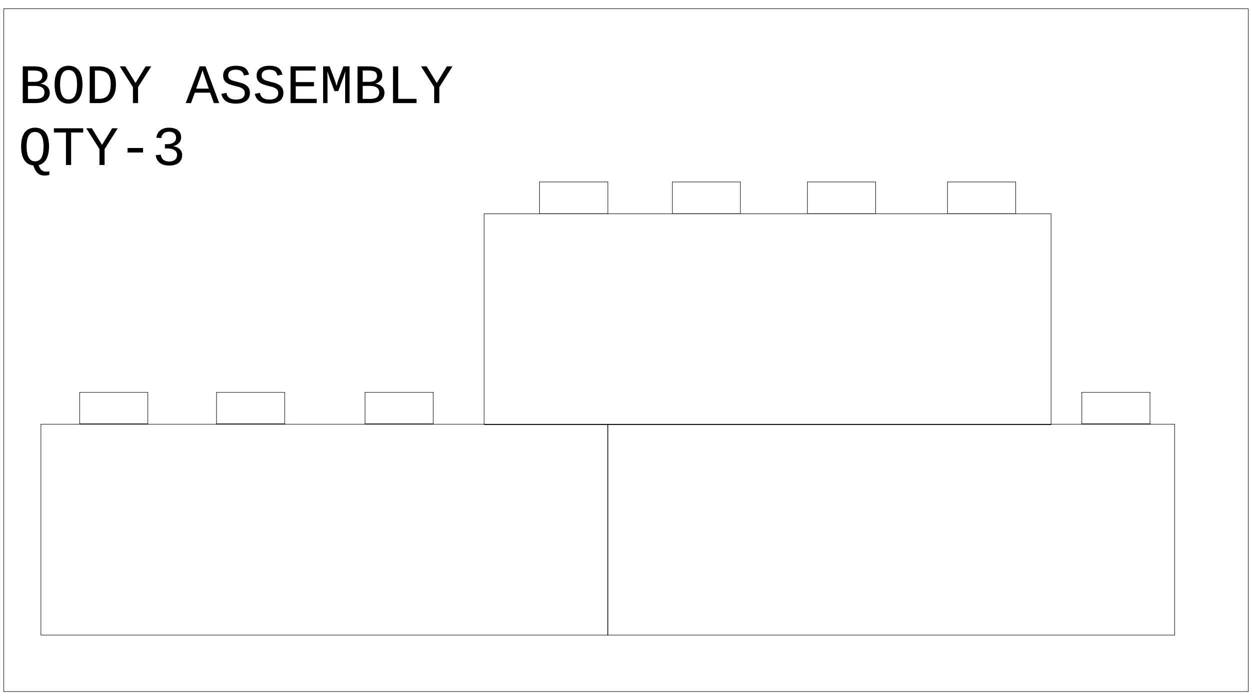
Polishing Layout and Flow



Appendix B

Operator 1 Assembly Drawing

OPERATOR 1 ASSEMBLY INSTRUCTIONS

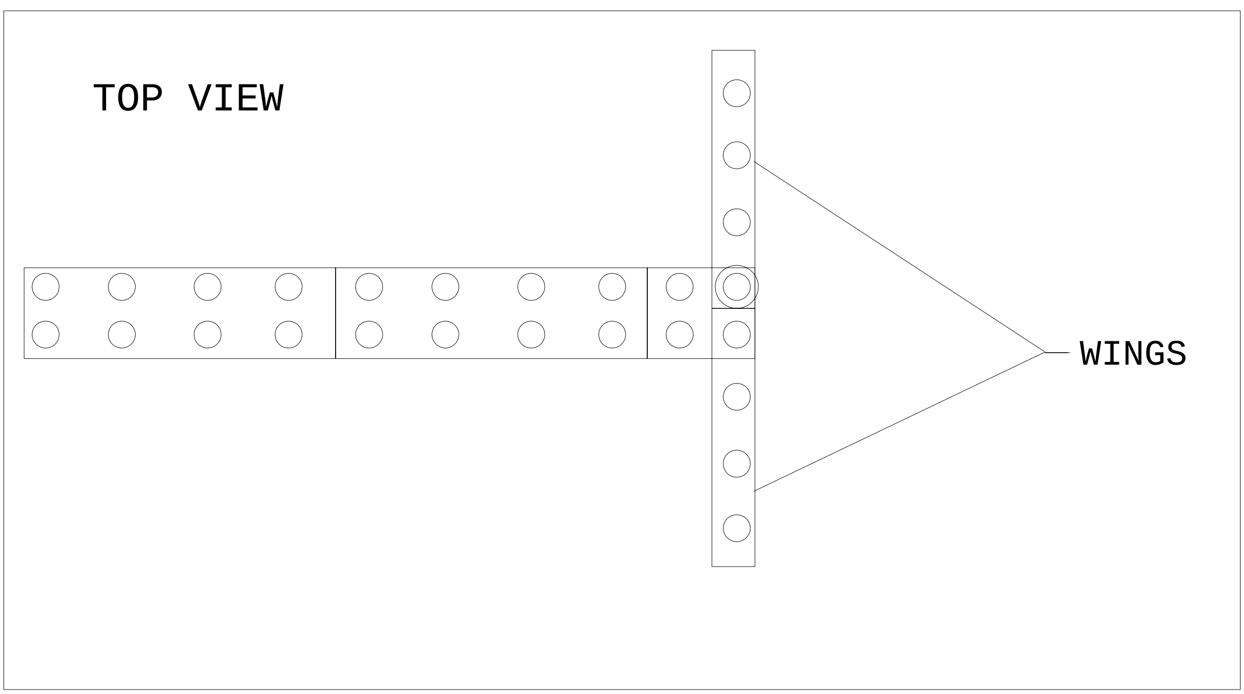


Appendix C

Operator 2 Assembly Drawing

OPERATOR 2 ASSEMBLY INSTRUCTIONS

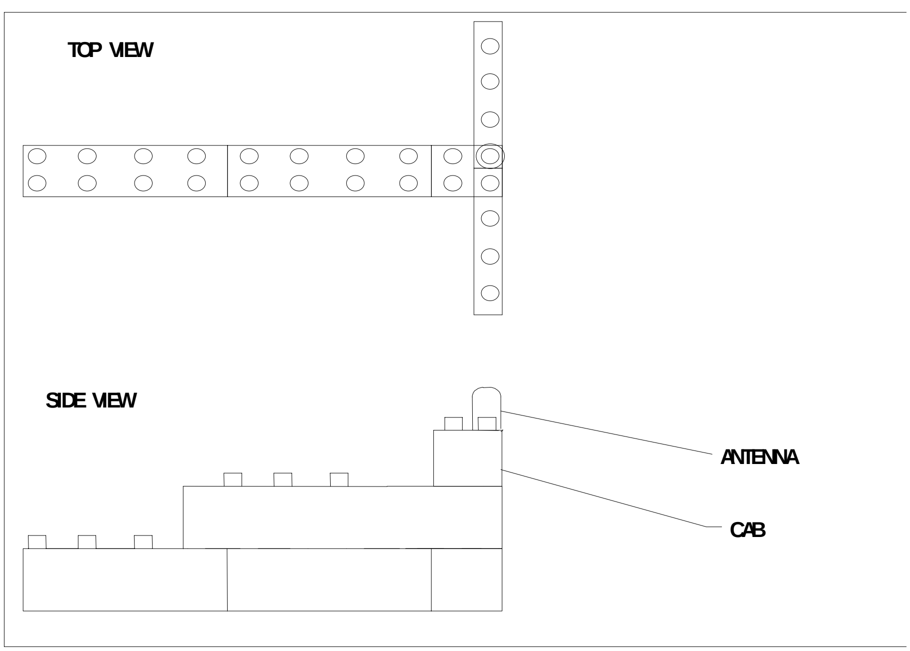
WINGS (2)



Appendix D

Operator 3 Assembly Drawing

CAB AND ANTENNA
CAB (1)
ANTENNA (1)



Appendix E

Pre-Training Survey Questions

1. In order to become more competitive at APN, Inc., everyone will have to work harder, faster, and longer hours in order to get jobs completed in less time.
2. To get jobs out fast, we must keep our machines and people busy all the time.
3. In order to reduce our time to customers, we have to improve our efficiencies.
4. We can implement Theory of Constraints (TOC) in the polishing department by forming a team in polishing alone.
5. In most cases, what takes the most time to get APN products through the polishing department?
6. If a work order is urgent, is it typical to stop performing other customer work orders to get more urgent work orders completed?
7. If parts were processed through sizing, squaring, and welding based on when parts were completed in polishing, would operators in polishing be able to get the work order to shipping more quickly?

Appendix F

Post-Training Survey Questions

1. How do you feel about creating an interdependent process from buffer?
2. Do you agree results from the experiments gave you a better understanding of how change can get work orders through operations more quickly?
3. In order to become more competitive at APN, Inc., everyone will have to work harder, faster, and longer hours to get jobs done in less time.
4. To get jobs out fast, we must keep our machines and people busy all the time.
5. In order to reduce our lead times, we have to improve our efficiencies.
6. We can implement Theory of Constraints in the polishing department by forming a team in polishing alone.
7. In most cases, what takes the most time to get APN products through the polishing department?
8. If work orders can get from buffer to shipping more quickly, there is less of a need to carry inventory in finished goods as long as the customer required parts are held in buffer.
9. If everyone worked together on one work order and got it through operations together, there would be more of a need to schedule based on due dates versus current methods.

10. If parts were processed through sizing, squaring, and welding based on when parts were completed in polishing, would operators in polishing be able to get the work order to shipping more quickly?
11. Did the simulation during training provide a better understanding of achieving effective results from being more dependent on one another?

Appendix G

Recommended Plant Layout Change