

Kaizen Interventions: A Tool for Industrial Engineers in Continuous Improvement Activities

Wilbur L. Meier, Jr., Ph.D.
Program Manager
ABB Electric Systems Technology Institute
Raleigh, NC 27606-5202₁
and
Adrian Arbelaez, President
World Class Manufacturing Group, Inc.
Raleigh, NC 27615-6417

Abstract

Companies today are under increasing pressure to accomplish increased productivity and effectiveness in use of people, space and equipment with the same or fewer production resources. After careful evaluation of the production processes in use, companies are often turning to Kaizen rapid improvement projects in targeted, short-term improvement activities. These activities often take no more than two to four days and can result in dramatic improvements in productivity and use of resources. However, conducting such an activity and more importantly maintaining the improvements realized are often more difficult than they might first appear to be. In fact, many of these projects fail to result in lasting improvements. These approaches can be of great benefit to the industrial engineer in providing leadership for continuous improvement activities in the companies in which they work. The authors of this paper have conducted many such improvement activities in a variety of industrial settings. Companies involved have produced computer equipment, electrical hand tools, steam pressure products, electric meters, transformers, industrial actuators, automotive products, and aircraft components. This paper will briefly describe the basics of lean production and Kaizen concepts. It will then describe the process followed in conducting a Kaizen rapid improvement project, sometimes called a Kaizen blitz. Next the paper will present some of the results obtained from these activities. Most importantly, the experience of what has worked and what has not will be discussed. An assessment of reasons for success or failure will be presented. Finally, actions to ensure success and avoid failure will be presented as well.

1. Introduction

Manufacturing companies are under intense pressure today to increase the productivity and effectiveness of their production operations. Industrial engineers have traditionally been active in leading improvement activities in industry. From the early days of industrial engineering [10,1] through today, industrial engineers have focused upon methods and procedures for improving the effectiveness and efficiency of production operations.

One such approach involves the use of lean production principles and Kaizen rapid improvement practices. These approaches were developed at Toyota in the 1950's and 1960's. They were chronicled in a book resulting from research done at MIT evaluating automobile assembly throughout the world [9]. In this book, the term, lean production, was first used. It was called "lean" because the authors discovered that the processes used fewer resources whether human, machine or economic than more conventional mass production methods used in the United States and other countries. These methods were then discussed in other books, most notably the book by Imai [4]. Other books followed discussing particular approaches employed [3,7,2].

1] On Leave from North Carolina State University as Professor of Industrial Engineering

Since that time, lean production approaches have been and are being adopted by many companies as a means of survival in an increasingly competitive world as discussed in case studies [6].

The fundamentals of lean production are easy to grasp intellectually. In fact, many of these principles do not differ from basic industrial engineering principles. The fundamental basis of this approach is to attack, reduce, and eliminate “waste” in production operations. Waste as used in lean production studies is anything that adds cost without adding value. Elements of waste in production operations include over production, waiting, transportation, inventory, motion, producing defects, and over processing. In many instances, productive work is being carried out on a product less than ten percent of the total time that a product is being produced. Lean production depends upon applying such concepts as workplace organization (5S), pull production, one-piece flow, quick change, cellular production, total productive maintenance, employee empowerment, and visual management [3, 6, 7].

Although the fundamental concepts of lean production are easy to grasp, they are often difficult to put into practice because they require fundamental changes in almost everything associated with the production processes [2, 6]. Thus, while many companies have employed lean production processes, some have not succeeded because they have failed to change the functions interacting with the production operations.

Employing lean production principles can result in dramatic improvements in productivity of production operations without requiring that production associates work harder or faster. This is due to the elimination of activities that are take time and effort but do not contribute to the productivity of the process.

2. Kaizen Interventions

When employing lean production processes, some companies have successfully used the Kaizen process of rapid improvement. The word Kaizen has been loosely translated to mean “continuous improvement.” While many companies adopted the concept of continuous improvement following the publication of the first book by Masakki Imai [4], few understood that the process could be applied immediately after initial training. Much like software training needs to be reinforced immediately by use of the software for the training to be of lasting benefit, Kaizen or continuous improvement training should also be followed immediately by application to achieve maximum results. These Kaizen interventions have been called Kaizen blitzes [5] or Kaizen rapid improvement projects.

Kaizen rapid improvement projects focus upon an area or process within the manufacturing facility and involve, as part of the training in one or lean principles, the actual application of these principles within the target area or process. Kaizen interventions are therefore necessary and essential as a part of the institution of a continuous improvement change process. If a change process is to be successful, it should result in the involvement and participation of those who must effect the change. It also must demonstrate results demonstrating the success of the change process. Kaizen rapid improvement projects do incorporate both the active participation of those who will effect the change and a demonstration of the success of its use. These Kaizen events also serve to encourage further implementation of lean production principles.

3. Outline of the Application Process

To begin the application process, one must first identify a target process from a set of production operations. This process is identified after evaluating the complete production process for a particular product. One approach for accomplishing this task is called value stream mapping [8]. Using this approach, one defines the value measure such as process time that will be the focus of the improvement effort. Then the process is mapped using the measure of value as the focus of the mapping operation. Other approaches include process mapping, identification of “bottleneck” processes, or focusing upon problem areas in the production process. Once a target process has been identified, it is observed and analyzed to develop an understanding of the opportunities for improvement that exist. Detailed mapping of the target process itself and an analysis of value-added times for individual operations and overall operation time yield a better understanding of the opportunities afforded by improvement. This initial evaluation may take

one or two days depending upon the complexity of the process. It is possible to accomplish conduct a rapid improvement without this pre-event evaluation. However, the quality of the result will be enhanced by the addition of the pre-study.

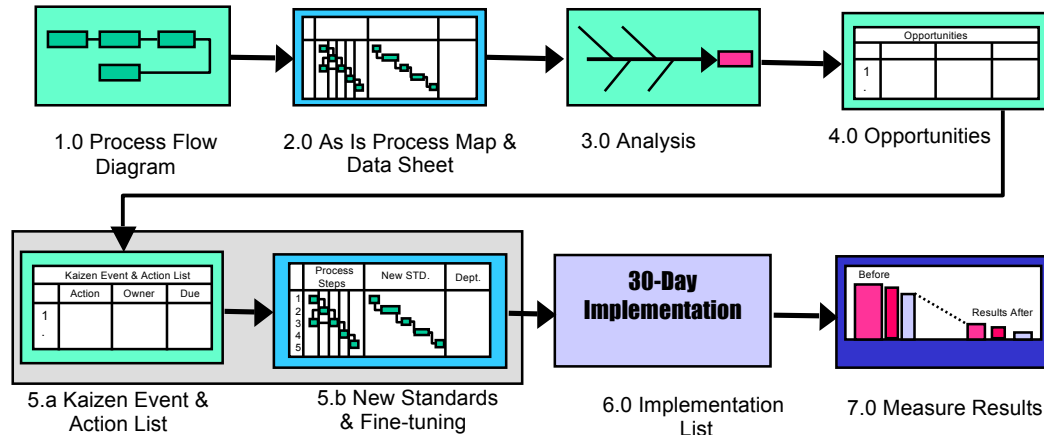


Figure 1. Kaizen Intervention Process

The Kaizen rapid improvement project itself will take two to four days to complete depending upon the complexity and extent of what is to be accomplished. The ones described in this paper all took three days. The makeup of the Kaizen team that will participate in the event is important. The team should be made up of those people with the skills necessary to make the event successful. Certainly, key members of the production associates who work in the chosen process area should be team members. The production associates chosen should represent all the shifts involved in the production operation. Other persons from the production facility needed during the Kaizen activity often supplement this team. For example, if moving machines and equipment will be undertaken, persons from plant maintenance will be involved. Other skills sometime needed include engineering and management. The active involvement in the Kaizen activity is critically important to the success of the change process. In any change process, nothing signals that the change is critical and important to the plant management like having the plant management participate in the event. Given all this, the team needs to be kept as small as possible while still providing the needed capabilities.

The first day of the Kaizen event includes an initial training session to acquaint participants with the key concepts and approaches to be followed. Here the importance of the activity to plant productivity is stressed. Also, participants learn that significant improvements in productivity will result while actually making the work processes better for the production associates. The training employed uses a production simulation exercise to demonstrate that the elimination of waste in the production process leads to improved productivity and better production processes from the associates standpoint.

Following the training session that lasts from two to four hours, the team identifies new productivity targets and performance measures. Objectives for the Kaizen project are established including targets for key performance measures. The team then proceeds in sub-teams to the production floor to observe the production operation and identify wastes and opportunities for improvement. Following this activity, the team meets together to share their observations and identify areas of opportunity. This leads to proposing actual changes in layout, process configuration, process activity, and similar changes. This usually completes the first day.

Overnight or sometimes early the next day, the changes are made and the process is again observed in operation. These changes often involve the moving of equipment and machinery and the modification of production processes. Furthermore, changes in workstations and the operations of production associates are also made. At each production run, data is taken and observations are recorded. In an iterative process,

further improvements in the process are made throughout the second day. By the end of the second day, major changes in the process have been completed and data taken on such variables as production rate, area of the operation, (WIP) work-in-process inventory levels, process times, number of people needed, and value-added and non-value-added times.

Day three concludes the activity with additional fine tuning of the processing activity, measurement of results, comparison of before and after measures, establishing of standard process activities, visual management employment, and development of a list of additional improvements needed and unable to be accomplished so far. Finally, a presentation is developed and made by the project team to the plant management.

3. What Kaizen Interventions Accomplish

You will recall that in the first section of this paper, it was noted that the Kaizen process is intellectually easy to grasp. However, it is often difficult to put into practice. One of the best ways to understand its meaning is to experience it. Thus, it is important to reinforce the training provided by immediately putting into practice the approaches that one has discussed. The following four organizations that participated in these events were amazed at the results achieved and the short amount of time it took to implement the concepts. Manufacturing companies appear unable to take advantage of this approach because their personnel are often consumed with the “fire fighting” that takes place every day in their factories. In the industry cases cited in the sections of this paper that follow, one can see that “Kaizen” can virtually be applied to any process whether in assembly, testing, fabrication, or order entry. The goal here is to identify process waste and eliminate it.

The process that was followed in each of these applications is the one described previously in this paper in Figure 1. Kaizen rapid improvement teams were identified in each case, given training in the Kaizen process of approximately two hours followed immediate application of the process in the production area. An iterative process of mapping and evaluation, analysis, identification of opportunities, moving of machines and processes, rerunning the process and reevaluation of results was followed. The teams practiced taking data, identifying and evaluating alternatives for waste elimination, testing these alternatives and continuing the process until results were obtained that met predetermined desired results.

3.1 Electric meter facility application

The first application involved using the Kaizen rapid improvement process to simplify the process of assembling an electronic meter. The meter facility is a relatively new factory, six years old, having generally mature product lines with the exception of the electronic meter products. The focus area for the Kaizen intervention was the electronic chassis assembly line. This operation employed an average of 22 employees with an approximate production rate of 700 units per a 10-hour shift. The process was composed of 20 steps in which 4 of them used tabletop presses. The work area was arranged in a straight line using a roller conveyor as the mechanism for transporting material between operations. The assembly process although simple contains repetitive motions. The assembly operators are cross-trained and are rotated among production tasks weekly.

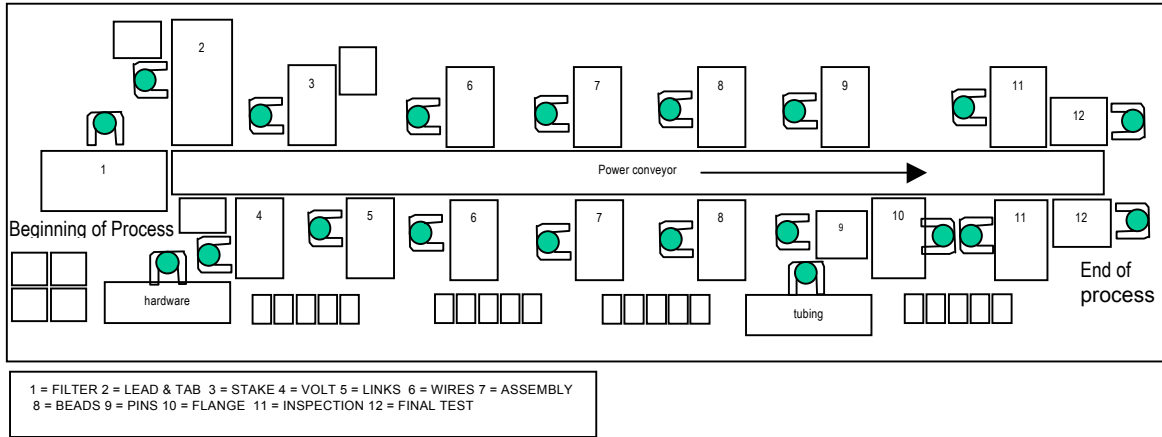


Figure 2. Layout of Meter Assembly Before Kaizen Improvement

The electronic chassis assembly was configured as a traditional batch and queue process. The material was assembled in batches with large amounts of work-in-process. This process resulted in long lead-times, and it occupied a large area. The electronic meter is a relatively new product for the plant and it has a variable demand. The typical approach to accommodating peaks in demand has been to add more associates to the line, a process that often led to slower rather than faster process times. Demand for this product has steadily increased over the last year.

At outset of the project, specific goals and performance measures were identified for the Kaizen event. The objectives were to identify non-value-added activities (waste), improve assembly flexibility (product change over), reduce cycle time, improve utilization of space, and increase throughput by at least 50 percent. The Kaizen team went observed the process, made measurements, suggested and evaluated alternatives, and, following an iterative process, tested improvements. These improvements involved simplifying the process, rearranging the layout, introducing pull production thereby eliminating most of the work-in-process inventory, and making other adjustments in the assembly processes. The following table describes the results achieved.

Table 1. Electronic Meter Results

Measure	Before	After	Change
Cycle Time	60 minutes	15 minutes	75% Decrease
Units per person	32	58	81% Increase
Space Used	1040 SQFT	720 SQFT	30% Decrease
WIP	120 units	20 units	80% Decrease

Other intangible results were achieved such as more balanced workload, less walking, reduced repetitive motion by rotating associates every 2 hours, enhanced communications, and improved team work. In general, these intangible improvements were considered very important by the production associates.

The achieved results were accomplished by implementing the following concepts:

- Cellular manufacturing
- One-piece flow
- The pull system
- Kanbans
- 5 S

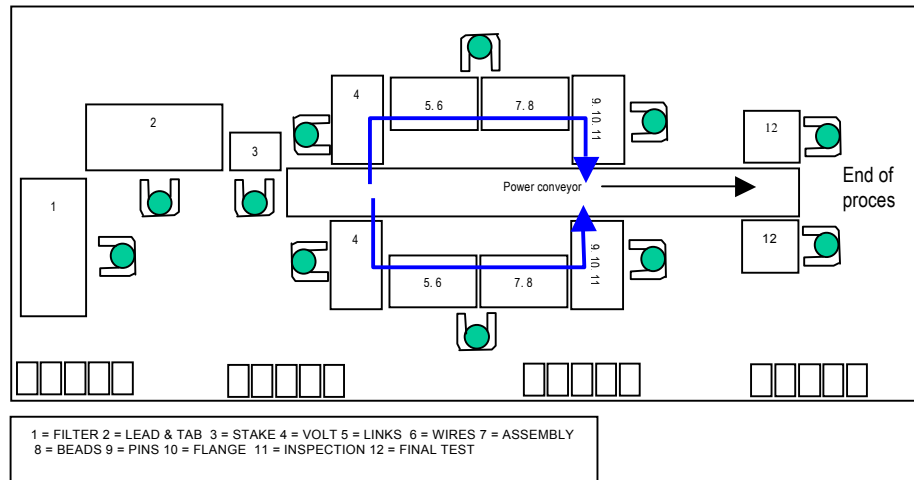


Figure 3. Layout After Kaizen Improvement

3.2 Actuator and sensor facility

The actuator and sensor facility was located in the plant of a major supplier to the automotive industry. Increased global competition and consumer expectations have forced automotive manufacturing organizations to provide improved quality products at lower costs. The actuator and sensor facility, in its efforts to improve its operations, had already begun an improvement program. The company had made improvements in its operations but was still struggling to reduce its costs and improve the effectiveness of its operations.

The organization wished to implement a Kaizen rapid improvement program to improve its production rates and improve its quality. The focus for the Kaizen intervention was a valve assembly area. This operation consisted of approximately 15 assembly and testing steps. (This varied slightly by product.) From the previous improvement efforts, some progress had been made in improving the product flow. The area layout was in a “U” shape and self-managed teams had been implemented. However, there were still opportunities to improve the operations in areas such as floor space utilization, reducing work-in-process, and increasing throughput. The main focus of this intervention was to double the current production of units per shift.

Again, a Kaizen rapid improvement team consisting of production associates, a maintenance representative, a Kaizen champion who was to carry on the process and an engineering representative was formed. After a training session, the team conducted an evaluation of the production process. From an initial assessment of the assembly area, it appeared that excessive work-in-process was clogging the ability to increase throughput. The build up of the inventory was due to the way the material was moved from machine to machine. This material was moved between processes in multiple trays that held in excess of 75 units per tray. Many of the trays were placed on short roller conveyors to facilitate the feeding of the machines. It was also observed that the supposed “U” shaped layout was more like an “S” shape. Parts were assembled and tested within the “U” shaped cell, and then boxed and packed outside the “U.”. Employees had to walk constantly in and out of the cell to complete the production process. The initial process “U” is depicted in Figure 4 below.

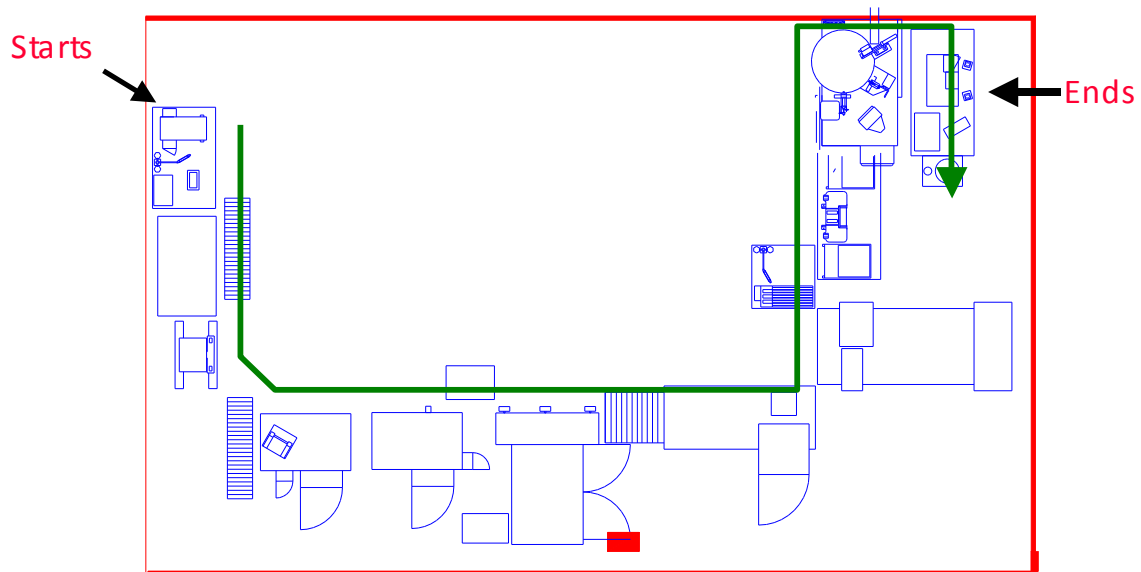


Figure 4. Layout Before Kaizen Improvement Process

The Kaizen project team focused upon layout, workplace design, operator activity, and instituting pull production. The cell itself was reduced in size, operations were rearranged, pull production reduced work-in-process levels, and the workplace was much better organized and arranged. The table below presents the results.

Table 2 Actuators and Sensors Results

Measure	Before	After	Change
Throughput	650 units/shift	910 units/shift	38% Increase
Product Change Over	8 hours	1 hour	87% Decrease
Space Used	910 SQFT	637 SQFT	30% Decrease
WIP	750 units	187 units	75% Decrease

The above results were accomplished through the implementation of the concepts below.

- Pull production
- Kanban trigger points
- One piece flow
- Cellular manufacturing
- 5's

All of the concepts were implemented in three days with only 4 hours disruption to the assembly area.

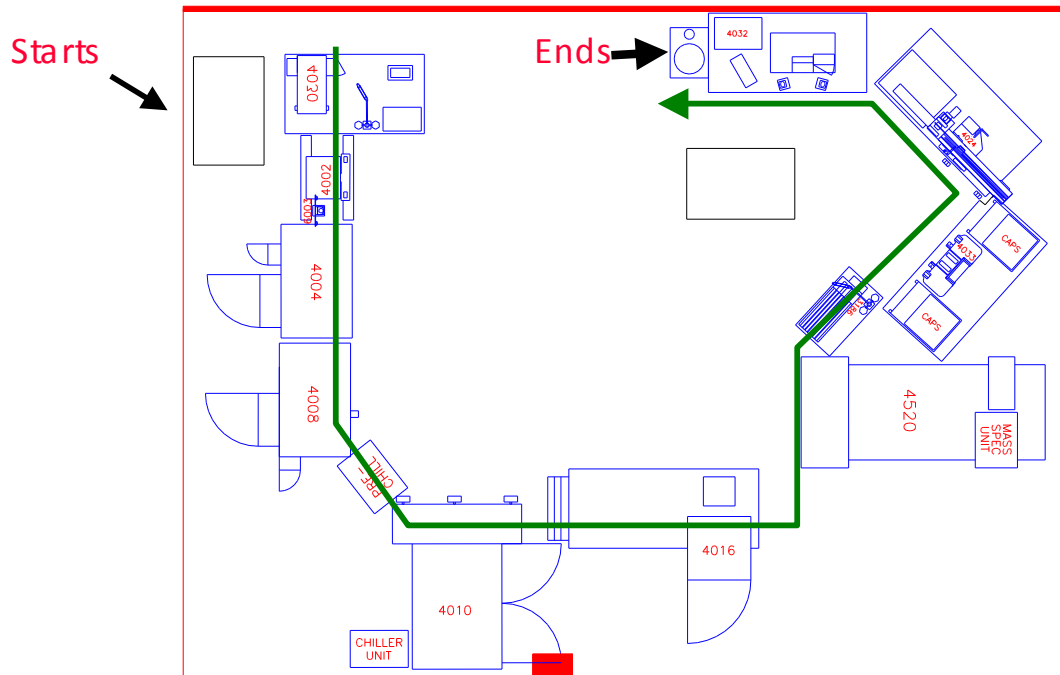


Figure 5. Layout of Valve Production After kaizen Improvement

3.3 Applying the Lean Operations approaches in order processing

This example illustrates what can be accomplished in an office area dedicated to order entry. The plant had a fairly large staff and a complex process in their customer service and sales department. The company's average cycle time for order processing ranged from 3 to 5 days. However, the existing hand-delivered, order-form process could take up to 17 days from the time a customer's order was received in the company (usually over the 'telephone or fax) to the time it actually reached the manufacturing floor. And this was for standard orders. Special order purchases (SOP) could take much longer. Not surprisingly, the company's retention of customers and growth in business was suffering.

As before a team was identified and trained in the elements of the Kaizen rapid improvement process. The team then conducted analyses, mapping the process and identifying non-value-adding activities by observing and tracking items through the process. In the original process, there were 23 employees in customer service and sales, who had something to do with the order process, including customer service, SOP, data entry, fax service, inventory, order review and supervisory personnel. The team's analysis revealed that at least eight persons touched a standard order on its long and tortuous journey through the labyrinth that the order followed. The analysis further revealed that the problems included the fact that the departmental layout was by functions, and hence the process was necessarily limited, sequential, bureaucratic, and replete with work-in-process paperwork. Also, the orders were batched at each stage. Thus, there was considerable inefficiency and high stress, customer response was long, and there was a lack of accountability. The complex process of order entry is depicted in Figure 6.

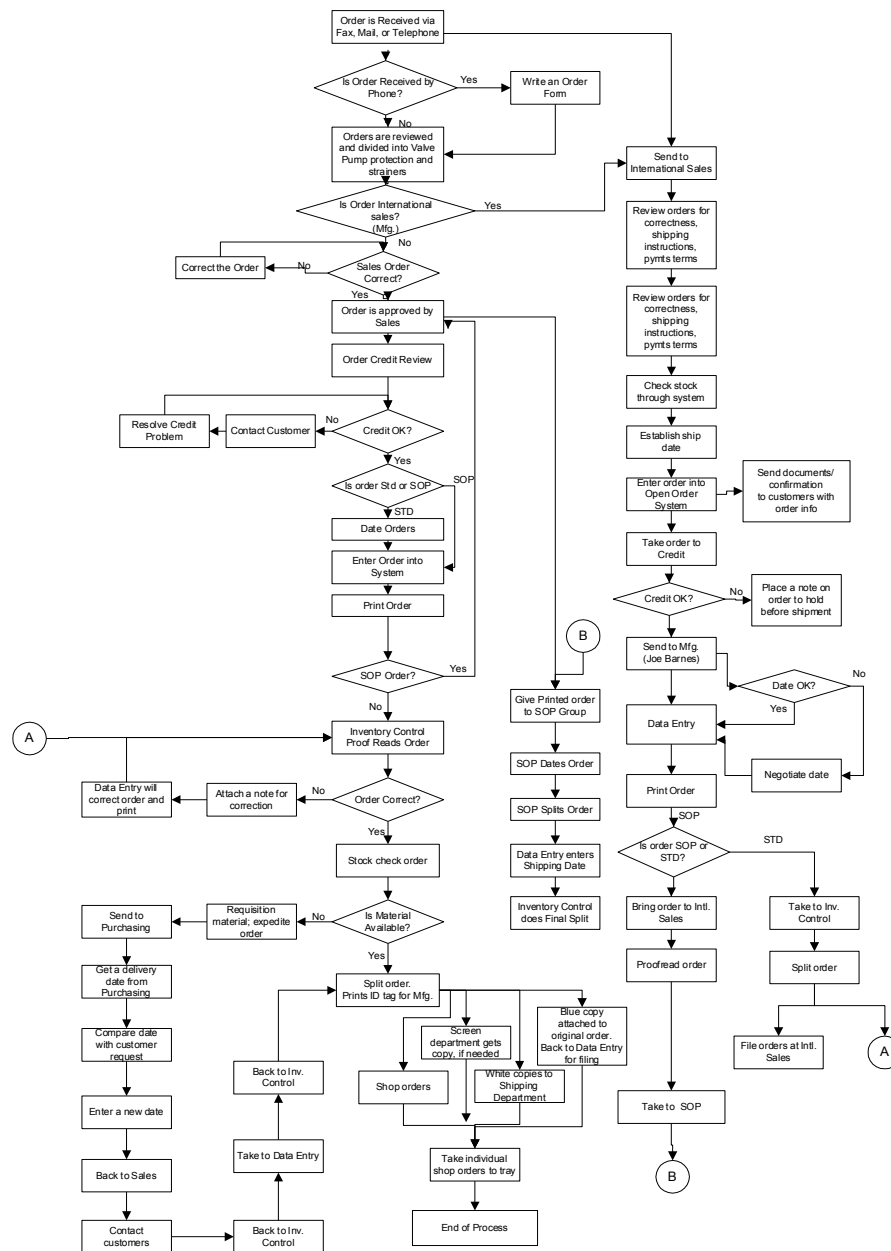


Figure 6. Order Entry Process Flow Before Kaizen Improvement

The order entry process was certainly in need of dramatic improvement. The approach to improve this area was the same as that followed in the improvement of manufacturing operations. The Kaizen team suggested and tested iteratively applying different lean production approaches to the order entry process. As a result the team introduced one-piece flow, and re-layout of the customer service and sales department into a cellular arrangement. An analysis of the orders indicated that creating processing cells based upon specifically geographical sections of the country would result in a balancing of the workload. Three cells were formed. In this arrangement, only four people now handled the order from its first receipt until it reached manufacturing. The results were forthcoming within the first month of the cells being set up. Initially, one cell was tried out for three weeks as a pilot project and found to be a resounding success. The

cellular configuration combined with one-piece flow improved productivity immediately by 75-80%. Achievements included: reduced lead time to less than the new target of 59 minutes; handling of orders was reduced by 90%; internal communication improved exponentially—well over 100%; and productivity was increased dramatically, while reducing non-value-added activities, both by 80%. This was an immediate success, apparent to all.

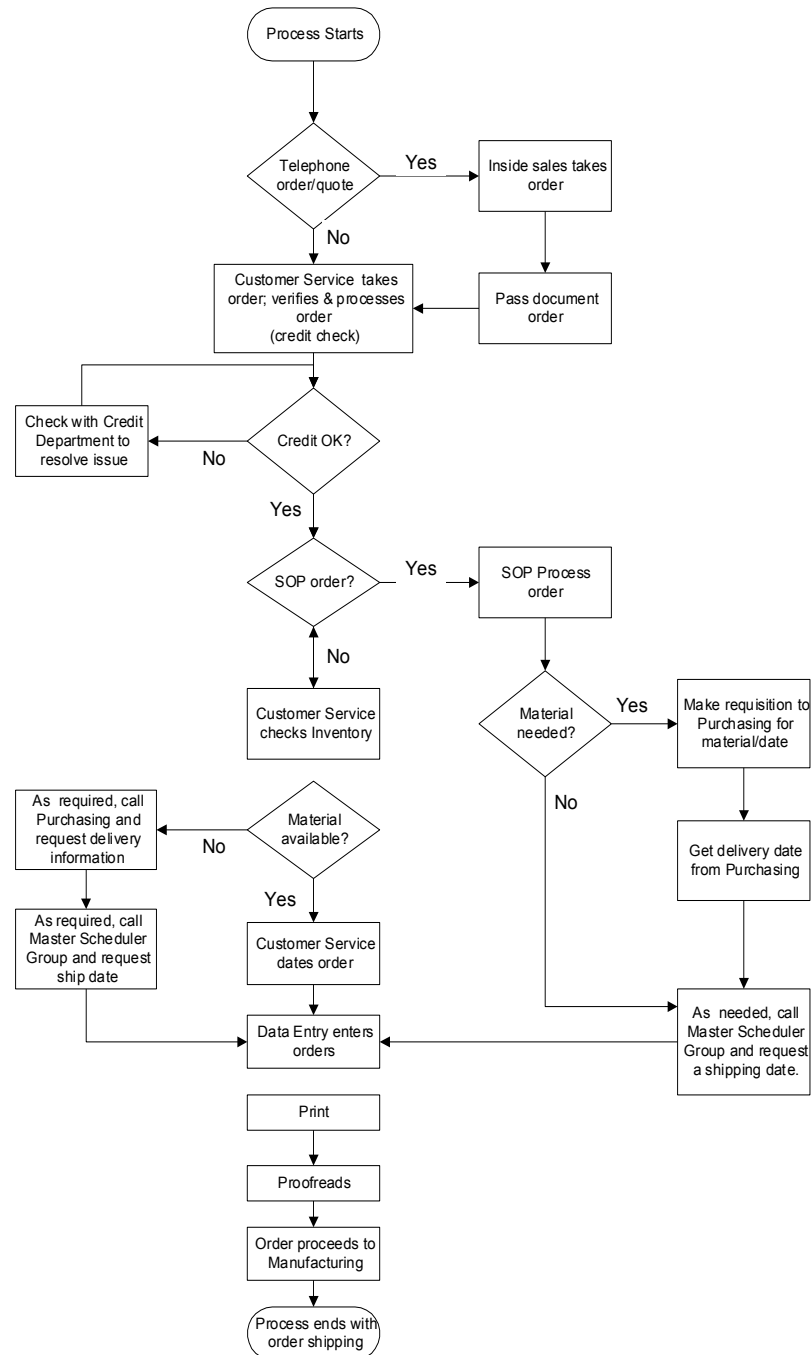


Figure 7. Simplified Order Entry Process After Kaizen Improvement

3.4 Transformer facility

The transformer facility produces small transformers encapsulated in a special polymer. The process for building this product involved several stations located in different areas of the plant. The Kaizen intervention focused on the winding and assembly operations in the production process. The layout of this product line, typical of traditional manufacturing companies, was arranged in a functionally. All low and high voltage-winding machines were clustered together, and the assembly operation was located some 50 feet away. All during the production day, one could see assembly operators walking back and forth gathering products to assemble. Due to the location of the winding machines and the assembly area, large amounts of work-in-process were present.

After initial training, the team began data collection and observation of the production process. The team observed that, in the assembly area, associates were partially assembling the units and then moving them to final assembly. It was noticed that the typical weight of a small transformer at this point was approximately 50 pounds. The assembly associates were picking up and putting down the transformers some thirty to forty times per day. This was a source of some dissatisfaction among production associates.

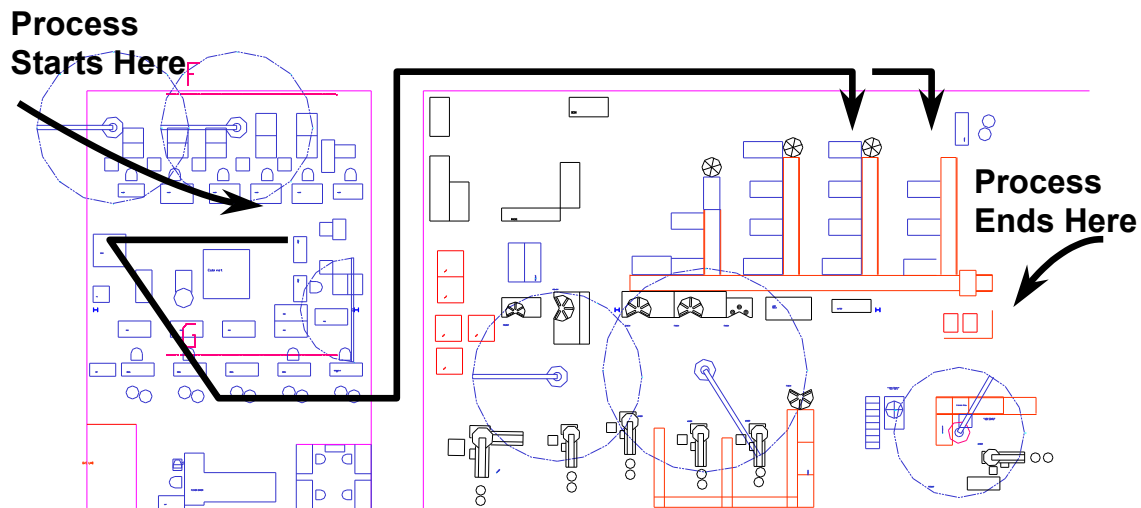


Figure 8. Transformer Winding and Assembly Layout Before kaizen Improvement

Once all the information was collected and documented, the Kaizen intervention team had as its objectives, increasing throughput, reducing cycle time, and reducing floor space. The approach taken was to use cellular manufacturing as the key concept and eliminate the non-value-adding elements that filled this process. First, the product demand was reviewed and the number of low and high voltage machines was identified. These machines and the assembly area were laid out in a “U” shaped arrangement. The entire process was set up in such way that the assembly process would trigger the winding machines to produce only in the quantities needed. This way the work-in-process was reduced to less than 20 percent of what it had been. The communication between the associates was greatly improved and walking was virtually eliminated. Again, these intangible results were extremely important to the production associates. In Table 3 below, the results achieved from this Kaizen intervention are given. The new layout is depicted in Figure 9.

Table 3 Transformers Results

Measure	Before	After	Change
Cycle Time	8:15 hours:min.	1:41 hours:min.	80% Decrease
Units per person	15	20.5	36% Increase
Space Used	1793	875	51% Decrease
WIP	140 units	29 units	79% Decrease

It is impressive to see these results after just three days. The true success in Kaizen interventions is in the sustaining of the achieved results. The initial step of implementing lean manufacturing concepts is typically the simplest and the easiest. Once the concepts are implemented, it is the organization's discipline and willingness to improve that achieves long-term success.

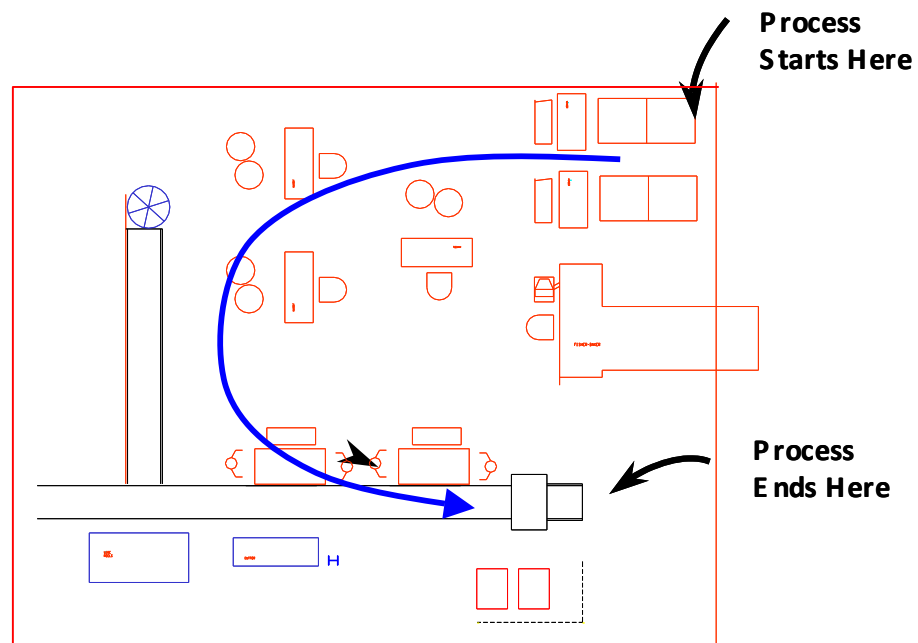


Figure 9. Transformer Winding and Assembly Layout After Kaizen Improvement

4. Some Lessons Learned

As discussed previously in this paper, implementation of lean production requires a change in the total system of production to be truly effective [2]. Kaizen rapid improvement projects are beneficial in getting started on the road to lean production. But as pointed out in other references and observed by the authors, it is difficult to “blitz” one’s way to becoming lean [6]. Kaizen interventions are very effective in preparing people to accept a lean production system. The speed of accomplishment, the reinforcement of training, and the demonstration of results are all important. However, there is a real need to apply these principles everywhere in the organization because waste abounds in every area of activity in a manufacturing facility. Changing from a mass production to a lean production operation is a difficult transition because virtually everyone and everything must change.

The leadership for this activity has to come from the top management in the plant and the corporation. Thus, when it was recommended earlier that the plant management take an active role in the Kaizen activity, it is because this very visible leadership is necessary if the change required in plant culture is to take effect. Leading by example is particularly important in signaling that business as usual is no longer acceptable.

Also, a principal advantage of a Kaizen intervention is the speed at which changes within a process take place. But anyone that has conducted a Kaizen intervention knows that in order to have successful events serious planning needs take place both prior to and after the event. A potential downfall of these quick and concentrated events lies in the implementation and follow up that must take place following an intervention. Many organizations that have adopted the Kaizen process, as a means of continuous improvement, but have difficulty with the lack of sustainability of achievements. In order to find out the reasons for the lack of sustainability, one needs to review the organization's culture and management vision for the program. In many instances, management has mixed feelings about the benefits of Kaizen interventions. Many organizations lack a well-defined strategic plan in which a clear integration of the different improvement programs. It is to management's advantage, to review and develop a focused strategic plan that incorporates a common goal with specific objectives for the different improvement programs. It has been observed during the execution of the Kaizen events that the lack of a clear vision and management plan for how improvement activities work effectively together limits the effectiveness of all of the activities.

To receive maximum benefit from reducing waste, a Kaizen team must be empowered to look at all aspects of waste. A team must be able to remove waste that is caused by the design of the product, technology inadequacies, production planning or scheduling problems, inventory, or labor. Almost always, organizations have different groups that are concerned with the same areas, but work independently of the Kaizen teams. These groups need to be interconnected, and they need to have effective communication channels in order to work towards a common goal. Kaizen teams should be composed of not just production associates, but also personnel from inventory management, product design, engineering, human resources, marketing, production planning, and purchasing. Another group that often gets overlooked is the supplier companies. It is not sensible to try to improve a process without the participation and knowledge that the supplier can offer. In many instances, the supplier is able to provide revolutionary ideas that can improve the overall quality of the product as well as a cost reduction of the product.

One of the greatest opportunities for sustainability of the improvements realized in a Kaizen event results from having a post-Kaizen event audit or follow-up. Many organizations try to conduct too many improvement activities in a given period of time. This aggressive schedule may not permit sufficient follow-up of recommendations and implementation of action items. An auditing process is an essential ingredient for successful Kaizen events. It is up to management to assign a champion that will follow-up with the complete implementation. It is recommended that someone from management assume the role of the champion. The Kaizen champion needs time to provide support to team members during the implementation phase, discuss changes with operators and make appropriate changes, review areas that are not running smoothly within the production lines, and make sure management understands and supports the changes. The power of a cohesive managerial staff with a focused positive direction is essential. Without it, the positive achievements will be short lived. The Kaizen team will view the intervention, as "just another idea that will come and go."

Using Kaizen interventions provides another opportunity for industrial engineers to promote actively continuous improvement of production and other plant operations. While this is not a panacea, it does provide industrial engineers with additional approaches that can be useful to them. Those who have not yet learned about these valuable methods should do so.

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