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Kaizen: An Essential Tool for Inclusion in Industrial Technology Curricula

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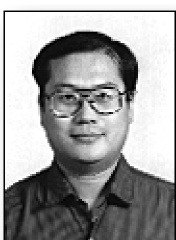

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Although industrial technology (I.T.) programs cover a wide range of curricula, such as construction, communications, power and energy, and manufacturing, a review of the 1999 National Association of Industrial Technology Baccalaureate Program Directory indicates that the largest portion of the programs operate under the manufacturing umbrella. At least one recent article (Dugger & Teegarden, 1997) has called for a stronger emphasis on manufacturing, along with the creation of a separate manufacturing division that supports a journal focusing on manufacturing topics. The call for the formation of a separate manufacturing division within the association became so strong during the 1998 National Association of Industrial Technology (NAIT) conference that several division organizing sessions were conducted. The outcome of these sessions was that the Executive Board of NAIT, soon after the 1998 conference, approved a separate manufacturing division to be fully implemented during the 1999 NAIT Annual meeting.

One of the primary objectives of manufacturing technology programs is to teach students how to create and improve manufacturing systems by reducing costs, improving quality and decreasing cycle time. Much emphasis has been placed on CAD/CAM, CNC, visual electronics, Programmable Logic Controllers, and robotics to solve problems in the manufacturing environment. However, Ashley (1997) reports that more employers are demanding that graduates have further experience in TQM (Total Quality Management), SQC (Statistical Quality Control), and Kaizen, the Japanese philosophy of continuous improvement.

With the wide range of programs that have been available, such as QC (Quality Control), SQC (Statistical Quality Control), and TQC (Total Quality Control), it is easy to become confused and lump Kaizen with the other "quality"-focused programs. According to Imai (1986), Kaizen means "continuous improvement". Not just a philosophy of the workplace, it means continually improving in every facet of life, including business, industry, commerce, government, and diplomacy, among others. In full implementation, it becomes the foundation of all activities. In the production activities within organizations, utilization of the Kaizen philosophy addresses continuous improvement not only in management, but also in the general workforce. Womack and Jones (1996) refer to Kaizen as *Lean Thinking* and lay out a systematic approach to helping organizations systematically reduce waste, or *Muda*. This approach is described in the next section.

Overview of Kaizen Philosophy

Many of the "quality" programs have called for benchmarking competitors and establishing measures for the industry. Womack and Jones (1996) wrote:

Our earnest advice to lean firms today is simple: To hell with your competitors; compete against perfection by identifying all activities that are muda and eliminating them. This is an absolute rather than a relative standard which can provide the essential North Star for any organization. (p.49)

Kaizen training has focused on both philosophical and cultural concepts and is based on the belief that the development of an individual's skill benefits both the company and that individual, and that people constantly aim for self-improvement (Imai, 1986). This declaration contains elements of the famous motivational theories developed by Abraham Maslow (Chester, 1994).

Womack and Jones (1996) describe Muda as any human activity that absorbs resources but creates or adds no value to the process. Most employees could identify several different types of *muda* in their workplace, but unfortunately the waste that they identify is only the tip of the iceberg. The authors continue by stating that until these employees have been taught the essentials of *lean thinking,* they are unable to perceive but a few types of the waste actually present in their environment.

The Kaizen or Lean Thinking approach begins with "…a conscious attempt to precisely define value in terms of specific products with specific capabilities offered at specific prices through a dialog with specific customers." (Womack & Jones, 1996). Many steps, such as attaching a wheel to a frame or moving a case of product from one location to another where the product is in demand, will clearly add value to the product. Some will not add value but will remain necessary under current conditions, and these include testing the installed wheel or packaging the product prior to shipment. A second type of *muda* adds no value and could be eliminated immediately since it is not necessary.

Once the value stream has been identified, the next step in lean thinking is to address flow. This requires a dramatic change in the way the problems to be undertaken are structured. Womack and Jones (1996) provided an example involving preparing a newsletter for mailing. Most of us would tackle the problem after the printing has been completed by folding all copies of the newsletter, placing stamps on the envelopes, then inserting the folded newsletter into an envelop and, finally, sealing all of the envelopes. When examining this process, it is not readily apparent to the observer that the newsletter is picked up four times. We compartmentalize and attempt to group tasks without looking at the flow. It would reduce *muda* if the newsletter were folded, inserted into the envelope, stamped, and stacked. When explained, this opens up a new world of operation to those studying manufacturing processes. The Kaizen process carries many other benefits as well.

Purpose

An example of a systematic process utilizing the Kaizen approach would be helpful to I.T. instruction. The following case study provides a description of the steps used to implement lean thinking in a typical Midwestern company. The benefits of undertaking this process are also discussed.

Company Background

The study was undertaken in what shall be referred to as "Company A", a small Iowa manufacturer, at the beginning of a new era in the field of concrete reinforcement. Today, steel is about the only available concrete-reinforcing material. Steel has an average to above-average tensile and sheer strength, correlatively weak thermal properties, and a rapid corrosion rate. What Company A has attempted is to invent a structural reinforcement for concrete that carries all the strengths of steel while eliminating the problems associated with its weak corrosive and thermal characteristics. What they have developed is a dynamic tri-resin fiberglass rod. This rod has about 120,000-lbs/inch^2 tensile strength, which is about 100 times that of steel. But what makes their product so ingenious is that it is resistant to chemicals and almost 100% non-corrosive. It also has low heat conductivity (2.1 BTU/ft^2/hr/F/in).

To allow the product to serve more customers, Company A has designed a wall system using precast or pours instead of concrete walls. They work closely with a chemical company (Company B) and use Styrofoam along with their own connectors to make a sandwich-type wall. Company A's connectors hold the foam in place and work together to produce a wall with four times the normal R-value of a typical insulated concrete building. Tremendous success with this product has created a need to expand and increase production in their Ames facility.

Kaizen Procedure

Depending on the objectives of the improvement, there are many ways to implement the Kaizen procedure. The flow chart, shown in Figure 1 (page 4), demonstrates the Kaizen procedure taught at one Midwestern university.

Step 1. Form the team and gather information

According to Shores (1994), the productivity of most processes tends to increase. The process of improvement, then, begins with forming a Kaizen team that is responsible for the product, while also carrying responsibilities for the consideration of the process. In this step, the facts of the process and the direction for improvement are examined. This information will be used in the next step, the current process, to gather information about the process.

Step 2. Description of the process used by Company A

The first step of the current process is to load spools of glass fiber to be fed into the pull-truder. These long glass fibers are run through a trough of heated resin as a series of heated molds. Each mold breaks through the resin at a different (controlled) temperature, and these specific temperatures force the resin to solidify to a desired hardness. After the product passes through the heated molds, it goes to the painting machine, which prints a code on each of the three rods extracted from the pull-truder, which ejects three rods at a time at the slow rate of three and a half inches per minute. After the painting, the rods are directed through a hole in the wall and are driven through the hole until they reach the desired length of 107 feet (321 linear feet), in about 35 minutes.

At this point, a hand grinder cuts the rods and the three separate, 107-foot lengths are massed on the floor. An employee then feeds six of the long rods slowly into the cutting machine. The rods are bent, and wound around two barrels to conserve space. They are then fed through six pipes, which line the pieces up. Of each 107-foot piece, 7 feet are wasted in this process due to the design of the cutoff machine.

The cut rods are boxed by hand and taken to the injection molders where they are fitted with plastic collars. After the rods are fitted with the collars, they are packaged according to the consumer's desire and shipped out. Figure 2 shows the flow of the current process. Utilizing the Kaizen methodology, the team will select the aspect of the process most in need of improvement.

Step 3. Decide goal of the team

After gathering detailed information about the current process, the Kaizen team identified the goal, which took into consideration the directions of the management group. In this case study, the team decided to focus on improving the method of storing the rods due to the excessive waste generated by the normative process. This improvement was expected to reduce more than 50% of the waste of that process. This reduction of waste was, in turn, expected to reduce the total cost of production.

Step 4. Alternative Storage Method

Following the Kaizen methodology, the Kaizen team developed seven ideas to improve the storage of the rods after they are ejected from the pull-truder. Below are the seven alternatives and some advantages and disadvantages of each. Figure 3 demonstrates these seven alternatives at a glance.

1. Stay with current method: Cut the rods to 107¢ lengths, storing them on the floor
   Advantage: no changes are necessary, no equipment needs to be moved, and workers need no training in the new storage methods.
   Disadvantage: The forklift runs over rods as they exit pull-truder, thereby generating excessive waste at the cutoff machine.
2. Bend the rods around three large spools
   Advantage: an entire day of pull-truder production can be stored on these spools, very little waste is generated, and less space is consumed.

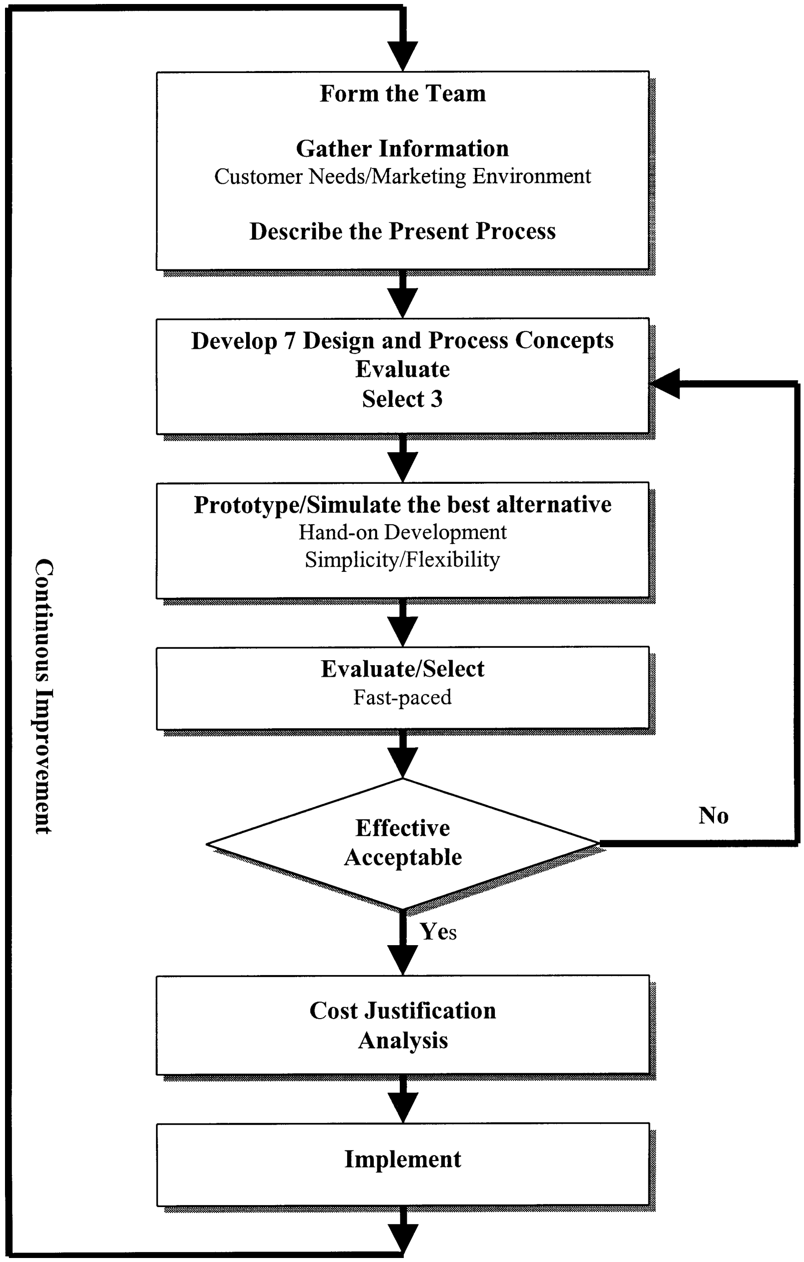


Figure 1. Flow chart of Kaizen procedure

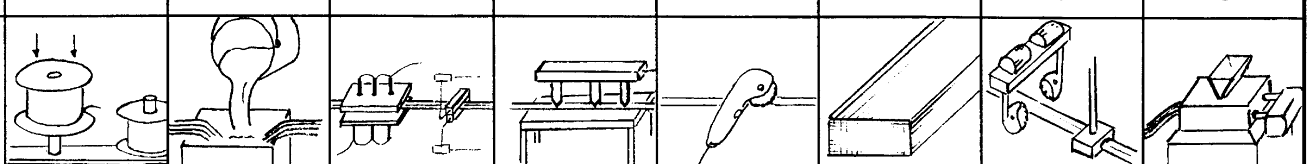
Process Number	1	2	3	4	5	6	7	8
Process Sketch								
Operation	Load Gass Spools	Dump in Resin	Pull Truder	Ink Machine	Hand Cutoff	Storage (WIP)	Cutoff Machine	Injection Molder

Figure 2. Current process at a glance.

Disadvantage: the spools are very bulky and very heavy.

3. Run rods directly into the cutoff machine
   Advantage: excess consumption of storage-space is essentially eliminated, very little waste is created.
   Disadvantage: the cutoff machine runs faster than the pull-truder, and equipment relocation is required.
4. Cutoff at building-length and store overhead
   Advantage: less waste is created than with the current method.
   Disadvantage: very awkward to carry out, overhead racks must be constructed over the entire length of the building.
5. Cutoff at short lengths and store in bins for transport to the cutoff machine
   Advantage: easy handling of materials, no forklift is required.
   Disadvantage: the cutoff machine requires longer pieces to work efficiently, so more waste is created.
6. Feed rods into a tube leading to the cutoff machine
   Advantage: this is a continuous process with no cutoff required.
   Disadvantage: the pull-truder speed does not match the speed of the cutoff machine, and the tube system must also be constructed.
7. Fold as needed (like an accordion)and store overhead
   Advantage: longer rods are generated so there is less waste.
   Disadvantage: guides must be built, still need to backtrack to cutoff machine

Weighing the advantages and disadvantages of each of these seven methods, our group developed three that we thought were the most viable options. Alternatives 3 and 4 both involve matching the pull-truder speed to that of the cutoff machine, and the group felt that this would be neither efficient nor effective. Therefore, the group accepted alternative two (Figure 4), to use the large spools as a new storage method.

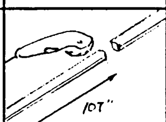
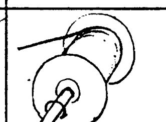
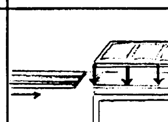
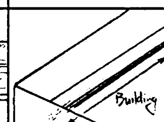
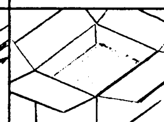
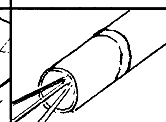
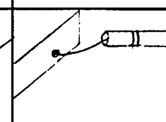
Proposed Process Number	1	2	3	4	5	6	7	8
Process Sketch								
Operation	Cut off at 107' lengths and Store on floor	Store on a spool	Run directly into Cut off Machine	Cut off at building length and Store overhead	Cut off at shorter lengths and box it	Feed into tube-System that will Automatically feed to cutoff machine	Folds as needed and store overhead	
Measuring Gage	Measuring Tape mark on floor	meter	not needed	Measuring Tape	Measuring Tape or Mark gage	not needed	calculation	
Tool	hand handle cut off saw (electric)	hand handle cutoff saw (electric)	none	hand handle Cut off saw (electric)	chop saw (electric)	none	hand handle cutoff saw (electric)	
Jig or Fixture	none	supports for 3 reels	none	none	stop block	none	guides	

Figure 3. Seven alternatives

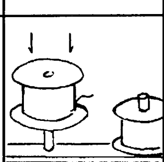
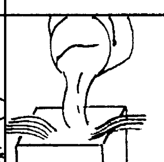
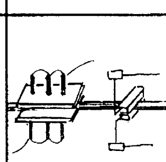
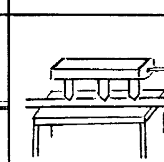
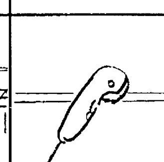
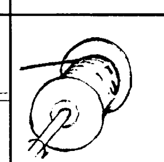
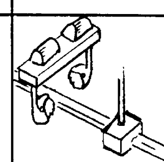
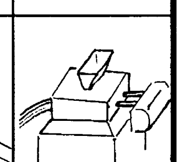
Process Number	1	2	3	4	5	6	7	8
Process Sketch								
Operation	Load Glass Spools	Dump in Resin	Pull Truder	Ink Machine	Hand Cutoff	Storage (WIP)	Cutoff Machine	Injection Molder

Figure 4. Process at a glance for the best alternative

Step 5. Evaluate and select the best solution

The best of these solutions for the storage of the material is the spool system, alternative number two. Three rods are extruded from the pull-truder. Using this alternative, each rod is wound on a spool two feet wide having a six-foot center diameter. The rods are 3/8ths of an inch wide, so each layer of the spool would hold 64 wraps of the rod. With a 6-foot center diameter, each turn around the spool would hold 37.7 feet of rod. 64 turns around the spool would hold 2412.74 feet of rod. The pull-truder extrudes the rod at a rate of 3.5 inches per minute, 24 hours a day. Three spools winding rods for a period of 24 hours would accumulate 15,120 feet of rod.

After the rod is produced, it is transported to the cut-off saw, which cuts notches in the rod and then cuts it to a specified length. The cut-off machine usually runs for 2 shifts a day, for a total of 15 hours. In those 15 hours, the cut-off machine can run 28,290 feet of rod through it, six rods at a time. In the current process, these rods are 107 feet long. Each time a rod is loaded and fed far enough into the cut-off machine, an average of about 7 feet of each rod is wasted. The cut-off is capable of running 270 rods per day. A waste of seven feet from each of 270 rods forms a total waste of approximately 1900 feet per day, approximately 6.5% of the total product.

Using the spool system, the cut-off machine is loaded only once a day. Each spool would still create 7 feet of waste, but this waste is incurred only when the spools are changed, rather than in every cutting, as was the case with the previous process. If spools are changed only once per day, only 42 feet (7 feet of waste ´ 6 rods) of waste is created per day, or 0.15% of the total product. This is an improvement of about 97.7%.

Step 6. Simulation and evaluation

Simulation is well recognized as a very useful technique for designing and evaluating manufacturing facilities (Chan and Smith, 1994). To confirm the possibility of implementing the alternative method abstracted by the Kaizen team, a simulation was undertaken. The team decided to see if it was possible to reduce the number of employees required to run the injection molder without a significant loss of output. To do this, the team used ProModel, one of the most powerful simulators with the animation function and an easy-to-use interface. The process and its results are shown in Table 1. If the results of the simulation are positive, cost justification of the new method is needed for presenting the financial goals of the top managers or vice-presidents.

Step 7. Cost justification and accomplishments

Table 2 (page 7) shows the cost justification. As is obvious, a large reduction in cost is expected by implementing this procedure.

Step 8. Results and analysis

Company A is a growing company, and because of this they need to find a means to improve their current process. Anyone can simply add more equipment and personnel, but a special effort is required on all levels of production to decipher where the problems are and how to fix them. A major advantage to fixing these problems is that it almost always results in a more refined and efficient process, thus increasing profits and outputs without incurring the significant cost of buying new machinery.

As stated earlier in the paper, one area of the plant needed immediate attention, and that was the cutoff process. Currently, Company A stores a large amount of 107-foot rods. By implementing the reel system, a reduction in space used in the building, material-handling costs, and also lower scrap rates can be expected. The reel system is something that can be made in-house or purchased from an outside vendor. It was proposed that at least two sets of reels be implemented, allowing plenty of storage room in case the cutoff machine breaks down in the setup procedure.

Conclusion

From this case study, it is apparent that Company A can benefit from lean thinking. It is also apparent that many organizations could gain from utilizing the lean thinking approach. However, the major components of Kaizen are the use of teams, the use of problem-solving tools, and an orientation to the lean thinking philosophy to reduce *muda*. Exercises such as the one described in this paper could be used within existing courses in all manufacturing-focused industrial technology programs to assure that graduates are sufficiently familiar with this important thrust.

It is the authors' belief that the inclusion of the Kaizen approach in Industrial Technology curricula could not only benefit our graduates in future

Table 1. Compare of the ProModel results of original and new methods

	Current Layout (4 Machines and 4 Workers)	New Layout (4 Machines and 2 Workers)
Simulation Time	7 Hours 30 Minutes	
Average Percentage in Use of Workers	15.14	29.57
Average Percentage of Idle of Workers	67.35	37.34
Average Percentage of Travel of Workers	17.52	33.10
Average Percentage of Use of Molders	67.80	69.41
Average Seconds per Entry of Input	1,314	1,438
Total Output	8,744	8,490

employment, but it could also improve the understanding of this technique in manufacturing settings across the United States. As cooperation between industries and educational institutions increases, this type of instruction could also further reduce the gap between educational practice and industrial need

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Table 2. Cost Justification

Saving for Work In-Process Improvement			
1	Loss of rod for cut off setup ever 107 ft		7 ft/rod
2	Amount of rods per day		270 rod/day
3	Loss of rod per spool (Initial setup cutt off)		7 ft/spool
4	Amount of spools per day		6 spool
5	Rod saving per day	1*2 - 3*4	1,848 $/day
6	Material cost per feet		0.192 $/ft
7	Saving per day	5*6	354.816 $/day
8	Working days per year		250 days
9	Saving per year	7*8	88,704 $
Cost for Implement of Reel System			
10	Setup cost per reel system		1,000 $/system
11	Minimum requirement in setup		12 system
12	Minimum setup cost for reel system	10*11	12,000 $
Saving For Changing Injection Molders to Two-Operators			
13	Salary per hour for one worker		8.00 $/hour
14	Working hour per day		
15	Number of changed workers		2 worker
16	Saving per year	8*13*14*15	32,000 $
Cost due to Small Loss in Productivity			
17	Difference of output of 4 worker 4 machine and 2 worker 4 machine system		254 shift
18	Amount of rods for connector		0.5 ft/cont.
19	Amount of connectors per day		254 cont./day
20	Lost rods per day	18*19	127 ft/day
21	Cost for lost rods per day	6*20	24.384 $/day
22	Cost for lost rods per year	8*21	6,096 $
Total			
23	Saving for Work In-Process Improvement	9	88,704 $
24	Cost for Implement of Reel System	12	12,000 $
25	Saving For Changing Injection Molders to Two-Operators	16	32,000 $
26	Cost due to Small Loss in Productivity	22	6,096 $
27	Total Saving for First Year	23 - 24 + 25 - 26	102,608 $
28	Total Saving for Following Year	23+25-26	114,608 $