Lean at a Local Safety Spectacles Manufacturer

What Went Wrong?

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1 Introduction

In February of 2005, a four day kaizen event was held at a local maker of safety wear, in its single lens safety spectacle assembly area. Single lens denotes a one-piece lens covering both eyes with integrated sideshields.

The purpose of this paper is to examine this kaizen event for applicability within the framework of lean manufacturing. The before and proposed conditions of the assembly area will be detailed and the current post-kaizen state will be described. Also, the people/cultural aspects of the kaizen event will be examined. In the end, suggestions for improvement of future kaizen events will be detailed from the standpoint of better adherence to the principles of lean manufacturing.

2 The Kaizen Event

The kaizen effort at the company consisted of three teams, each with 3 members. The teams were composed of, although it varied slightly from team to team, one engineer, one production floor operator from the area being kaizened, and one production floor operator from an unrelated area.

The teams were trained on topics such as spaghetti charting, one-piece flow, and cycle/takt time calculation in a 5-hour crash course on the first afternoon of the kaizen. After this training session, and for the subsequent 3 days, the kaizen teams are let loose upon the assembly area with the goal of increasing part output and making other improvements in the areas of safety and ergonomics.

The goals are communicated to the team captains [usually the aforementioned engineer] only via a project overview sheet that is handed out on the day preceding the event start. Takt times for each product line were also provided to the teams for the various single lens models.

The kaizen teams are directed to do certain activities at certain times throughout the course of the event. Status reporting by team captains each evening was required on the prescribed activities. These activities are: baseline the existing process, brainstorm improvement ideas, simulate the improvement ideas, collect comparison data on the improved process, and make some safety and ergonomic suggestions.

The first activity undertaken by the kaizen team, as prescribed by the kaizen facilitators, was to time the existing operations' work elements and cycle times. This timing activity was carried out using multiple passes through the process for which an average time for each work element was generated. This activity eats up most of the first day of the kaizen event. The large time commitment of the baselining activity was chiefly due to the fact that the shop-floor kaizen members, none of whom had ever been in a kaizen before, were not comfortable with techniques as trained to perform the study. In this case, the brunt of the work fell to the team captains (engineers) to perform the time studies. The other activity that took a lot of time in the event was the creation of spaghetti charts for the walking distances of the operators to get their parts from the stocking areas into production.

Next, brainstorming for improvement ideas occurs on the end of the first and most of the second day of the event. This activity occurred on the shop floor, as the meeting area for the event was at the other end of the building. The noise level of the shop floor made having meaningful discussions difficult, but not fruitless. Due to the pressure of producing results, coupled with the limited resources allocated to the kaizen team, most of the brainstormed ideas were truncated in scope to "what we can do with our own hands in the next day or two."

It should be noted that the safety and ergonomic suggestions do not really get any timeslot of their own during events. Whenever there was downtime, or not enough immediate activity for all team members, that team member would go off and complete some observations about the safety issues in the production area.

By the end of the second day and for most of the third, the kaizen team was directed to simulate the changes needed to realize the improvements. This proved to be difficult, as many ideas required something to be built or installed at the production line. Mocking up the ideas (for part chutes, for example) out of cardboard was possible and popular with the team.

By the end of the third day, the “after” picture was to be quantified, and the teams were tasked with preparing for the final presentation the morning of the fourth day.

The goals of the kaizen team were to reduce wasted motion, increase output, eliminate waste, and decrease work content per product produced. Moreover, the team’s objective was to reduce any ergonomic or safety hazards in the area.

3 The Product

This paper is about the kaizen effort undertaken in the assembly area for a safety spectacle product family called SafeT (name changed), shown in Figure 1.

Figure 1: SafeT Line of Safety Spectacles

The SafeT product family consists of various assemblies all utilizing the same polycarbonate molded lenses. The model variations are all for aesthetic purposes only, and no model offers any more protection than the others. The components used to build a SafeT spectacle are the lens, the browbar, the nosepads, and the temple subassembly. The temple subassembly consists of an endpiece, a link, a temple, and a pin. The pin forms the hinge that allows for folding the spectacles up, just like a normal pair of glasses. All other parts are injection molded plastic.

In order to assemble the spectacles, the steps are as follows:

- Assemble the nosepads to the browbar.
- Assemble the temple to the link.
- Assemble the endpiece to the link.
- Pin the endpiece to the link.
- Attach the browbar to the lens.
- Attach the temple subassembly to the browbar and bag.

The parts that are fed into the assembly area are of two types, purchased and injection-molded in house. The purchased components include the browbars and the pins. The pins are bought in bulk from the fabricator. The browbars are bi-component [two shot] molded plastic. The second material is a rubber that pads any areas of the brow that would come into contact with the wearer. This part is purchased from a vendor that has two-shot capability, as the company does not possess the technology. The other pieces, the temples, links, and nosepads, are molded in house.

The molding operation at the company is a separate production area that does all the injection molding for the entire facility. The facility includes spectacle assembly areas, respiratory product assembly areas, and hearing protection assembly areas. All molding machines are placed together in one section of the plant, and are scheduled by a dedicated planner using kanban in conjunction with an MRP system.

The molding operation at the company is a batch process that utilizes a kanban system. The kanban system is used for most of the small spectacle components at the company. Kanban cards are placed with shop orders in racks in the scheduling room, sorted by injection molding machine in the order in which they are to run. The set-up personnel, (who do all mold, color, and material changes) take the next shop order in the rack at the time of order completion at any given machine. These orders are then brought to the machine, and if necessary, the tools or materials are changed over. A typical kanban quantity of molded components is 3000-5000 parts. This size is largely dictated by the size of the reusable plastic totes that comprise the kanban containers. Once molded, material handlers move the parts to the designated rack space, which is denoted on the kanban card.

Molding kanban improvement was beyond the scope of the kaizen event, by rule, and the teams were directed to focus on improving the operations in the single lens assembly area.

The existing process for assembling the SafeT spectacle consists of 3 operators collectively performing 4 activities. Operator 1 makes 2 different subassemblies, the nosepad-browbar, and the temple-link. Operator 2 takes the temple and link subassemblies from Operator 1, attaches the endpieces, and pinns the hinge. Operator 3 takes the nosepad-browbar subassembly from Operator 1 and the pinned temple-link-endpiece subassembly, and attaches them to the each other and the lens. Operator 3 then bags each pair of spectacles individually with a bagging machine.

The assembly area was arranged in an island configuration with a triangular flow as shown in Figure 2. At the point [top] of the triangle, was Operator 1, who fed Operator 2 temple-link subassemblies and Operator 3 nosepad-browbar subassemblies. Operator 2 then fed Operator 3 the pinned temples. Operator 3 then performs a series of pivoting motions to assemble the lens and temples to the browbar and bag the pieces.

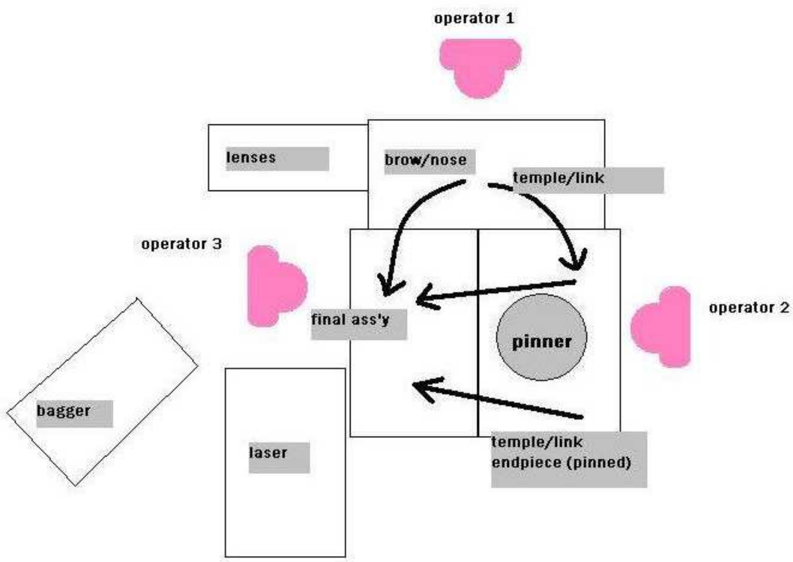

Figure 2: Product Flow Prior to Lean Implementation

4 Results of the Lean Effort

Day One:

At the start of the event, the SafeT team focused on the measurement of the "before" condition of the assembly process. Items to be reviewed included walking distances, cycle times, and unnecessary motions. Also to be noted was the current level of material waste.

The results of the first day's activities were quantification of the current cycle time, and various other observations about pinner downtime and wasted material (pins falling on the floor).

The observed cycle times for each of the operations to assemble the SafeT lens can be seen in Table 1 (all times are for one pair of spectacles).

	Time (seconds)
Operator 1:	
Assemble the nosepads to the browbar	8
Assemble the temple to the link	6
TOTAL	**14**
Operator 2:	
Assemble the endpiece to the link plus pin the endpiece to the link	**8**
Operator 3:	
Attach browbar to lens plus attach temple subassembly to browbar and bag	**10**

Table 1: Observed Cycle Times Prior to Lean Implementation

It could be said then that the process produces a part [if using one piece flow] every 14 seconds. During the total productive time on a shift of 450 minutes, this was a theoretical 1930 pieces per shift with this process. This required 3 operators, making approximately [fully loaded] $20 per hour, for approximately $0.23 per pair of spectacles (labor only).

Days Two and Three:

The team wished to reduce the labor content per piece. Looking at the cycle times, it was theorized that the process could be performed with two operators as shown in Table 2.

In theory, because only 2 operators were needed, and the new process would produce a part every 18 seconds, the output would drop to 1500 pieces per shift, but the cost would drop to $0.20 per pair of spectacles.

Since the volume of the product was low enough, it was deemed that going to a shift and a half (second shift being somewhat light during the evening) would be attractive.

In practice, upon simulation, operator 1 in the new process found the addition of new work elements cumbersome. The new motions added actually changed the nature of the work. As seen

	Time (seconds)
Operator 1:	
Assemble the temple to the link	6
Assemble the endpiece to the link plus pin the endpiece to the link	8
TOTAL	**14**
Operator 2:	
Assemble the nosepads to the browbar	8
Attach browbar to lens plus attach temple subassembly to browbar and bag	10
TOTAL	**18**

Table 2: Theoretical Cycle Times After Lean Implementation

	Time (seconds)
Operator 1:	
Assemble the temple to the link	
Assemble the endpiece to the link plus pin the endpiece to the link	
TOTAL	**21**
Operator 2:	
Assemble the nosepads to the browbar	8
Attach browbar to lens plus attach temple subassembly to browbar and bag	10
TOTAL	**18**

Table 3: Observed Cycle Times After Lean Implementation

in Table 3, the actual observed cycle time for operator 1 in the new process was 21 seconds, not 14 seconds.

Carrying the same labor cost analysis through with a 21 second cycle yields a shift output of only 1286 pieces, at a labor cost of the original $0.23 per pair.

These changes were deemed undesirable in the face of meeting customer demand. The Takt time for this variety of SafeT lens was, in fact, 14 seconds, using one shift as the available time (450 minutes).

No other major process-related changes were attempted by the SafeT team, as the brainstorming and simulation activities had eaten up most of the event's remaining time.

The next area of focus for the SafeT team was to improve the ability of the operators to perform the work elements in the existing process flow. The only improvement feasible was to provide operator 3 with a work flow requiring less motion.

In order to reduce the motions needed by the operator, the SafeT team provided part delivery chutes from each of the other assembly operators to operator 3. The chutes negated the need of the operator to reach (in one case, through a rats nest of tangled power cords) for the parts needed to finish assemblies. The new chutes did manage to shave about 1 second off of operator 3's cycle time, but did little to the overall bottleneck at operator 2's station.

Another effort to reduce unnecessary motion by the operator is shown in Figure 3. By removing the laser unit, which is only used for a couple of hours a week, the motion is reduced. The result was a cycle time improvement of roughly 1.5 seconds per piece. This was also viewed as an ergonomic improvement since much twisting was eliminated from the process. Laser movement for low volume work was removed.

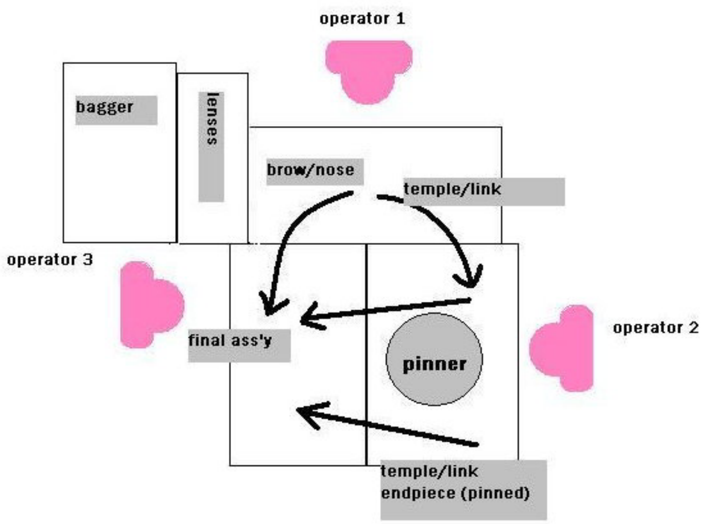

Figure 3: Product Flow After Removing Laser Unit

One of the largest sources of waste found during the event was the downtime associated with the pinner machines, shown in Figure 4. Roughly 14% of productive time was spent un-jamming the clogged pinner lines. The team estimated that the effect of this lost time was in excess $6,000 per year, based on fully-loaded labor at $20/hr. Switching to air fed pinners like other lines had, which did not jam once during the kaizen event, was an investment of $10,000.

The other big find during the event was the amount of pins wasted. The convention was that pins hitting the floor were unusable due to contamination, which causes further jamming of the equipment. Most of the pins that ended up on the floor were there as a result of the un-jamming process, which caused them to spill. The un-jamming process involves hitting the feeding tubes on the side of the bench. Catching the pins is almost impossible to do. The cost of the pins, being about one cent each, results in a cost of wasted pins due to machine jam clearing of roughly $50,000 per year. This number was arrived at based on counting the pins on the floor over the course of a 4-hour period and extrapolating the data.

Day Four:

Presentations are made to the engineers and managers. Everyone must present.

Day Five:

The same presentations are made to the people in the areas affected to further reinforce the external changes.

Epilogue:

By day 7, the changes implemented were unmade by the workers in the SafeT area, and the equipment was placed back where it was 2 weeks prior.

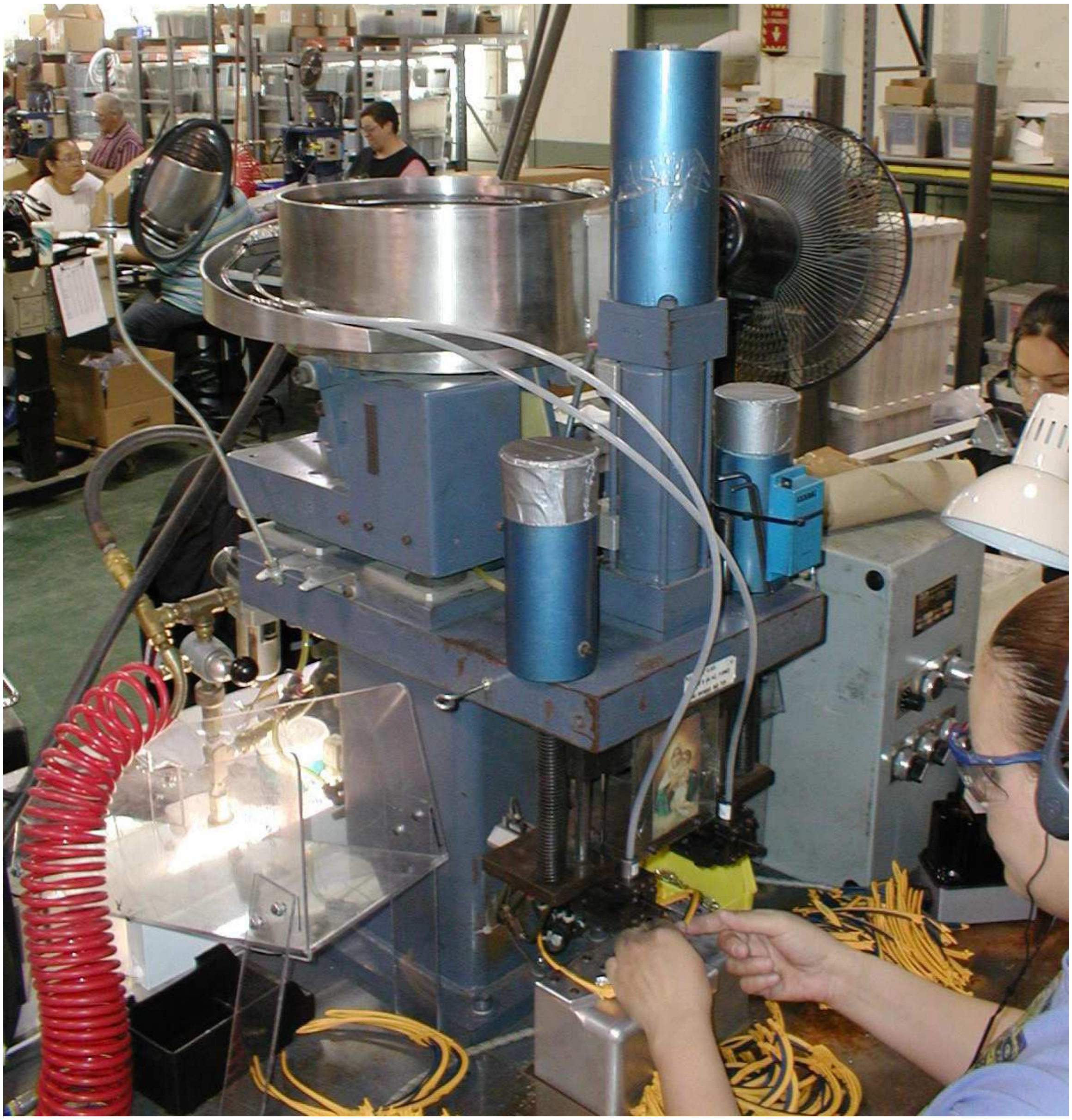

Figure 4: Older Gravity Fed Pinner Machine

5 What Went Wrong?

The major problem at the company is that the lean effort seems to be haphazard and the motions are gone through without any real desire to implement lean thinking. There is no reason or driving force for attempting lean techniques, other than for the sake of giving it a try. There is no single change agent, responsible for guiding the whole lean implementation process. A couple of corporate employees assist in putting on the "lean show", but merely act as cheerleaders without getting into the nitty gritty details. This results in a sort of "lean hodgepodge". Several specific problems that occurred during this kaizen event are highlighted in this section.

Upper management is very hands-off, trying to dip only their toes into the "lean pool" without fully committing to the effort. Before the kaizen event has begun, it seems that a final desired result is determined, such that the lean effort is more about figuring out the easiest path to that result, as opposed to actually trying to make significant changes. Since management is so hands-off, people involved in the event are able to tweak certain numbers and results in an attempt to **just finish** the desired task.

A major problem is that the kaizen event training is lacking. It is only a 5-hour crash course, led by a corporate employee with certain slides presented by other employees, often about material outside of their specialty. The material includes content on creating spaghetti charts, one-piece flow, and cycle/takt time calculations. One entire hour is dedicated to the concept of benchmarking with breakpoints (that is, in microsteps). Employees were confused by much of the material and felt uncomfortable making use of several of the techniques. The task of timing operations often fell to the engineer member of the kaizen team because the others felt incapable to complete it. Further, the training mixes terminology creating even more confusion. The term "5S + 2E" is used twice: once in the traditional lean 5S sense, plus ergonomic and environmental considerations (2E), but also when requiring kaizen teams to produce 5 safety improvement observations (5S) including ergonomic and environmental considerations. So when someone mentions something about "5S + 2E" a subsequent qualifying explanation is required in order to clarify which "5S + 2E" is intended.

Another significant problem is the lack of overall dedication to the kaizen event. This presents itself in a couple fashions. First, there are very limited resources made available to the kaizen teams. There is little or no money available in order to implement changes. Additionally, there is no dedicated maintenance support made available. So several teams are forced to use cardboard mockups, since no fabrication resources are made available, and to narrow the scope of the teams' efforts to what they can accomplish with their own hands in the next couple of days. Furthermore, the people involved in the kaizen event, including team members, are often required to not only participate in the event, but also to complete their usual duties. Upper management seems to have a cavalier attitude with regard to just how much effort and dedication is required to realize actual results.

The frequent jamming of the older gravity fed pinner machines results in a loss of approximately $50,000 per year, as described in Section 3. The dusty and dirty nature of the facility is a major cause for the jamming. Also, since there is no air conditioning installed, employees often open the windows allowing outside contaminants (dirt, dust, pollen, etc.) to enter the factory further contributing to the jamming. (As a side note, such contaminants can produce negative results in plastic molding facilities such as those present at the company.) The pins that fall on the floor as a result of clearing the jammed machine are considered contaminated and are thrown away. They are not reused because of the fact that the dirt they've been exposed to would only cause the machines to jam again.

6 What Changes Could be Made in the Future?

Despite the outcome of the kaizen event at the company and the problems mentioned in Section 5 there are several improvements that can be made in the future. Some of them require attitudinal and goals adjustments, while others require training modifications, and some actually require engineering solutions. This section discusses some potential improvements.

A "change agent", or someone who is involved in all aspects of the lean transformation, should be present at all kaizen events. This person should either be an experienced outside consultant or someone from within the company who is properly trained and qualified. The presence of such a change agent will eliminate the lean hodgepodge approach currently found at the company. It will also help with communication between all levels of employees and management, since a single person will be informed on all aspects of the lean implementation. The ability to "fudge" the results in an attempt to **just finish** will also be eliminated for the same reason.

An area that needs major improvement is the training portion of the kaizen event. Participants should only be trained in basic concepts, and only those pertinent to their event goals. This will help to alleviate confusion and employee resistance due to lack of understanding. Terminology needs to be ironed out such that it is kept simple and each term refers to only one thing. There is no problem with employee involvement in the actual training, however their participation should be tailored to their specialties. This should result in those employees feeling more vested in the event and should maintain their interest while maximizing training efficiency.

One of the most significant problems plaguing the success of lean at the company is the lack of overall dedication. Upper management needs to take lean thinking seriously and the company as a whole needs to dedicate itself 100% to a lean initiative. Any resources required by kaizen teams need to be made available. This includes fabrication and maintenance staff so that equipment may be moved and enhancements can be made to the production line. This will prevent teams from becoming discouraged and settling for only what they can accomplish with their own hands in a couple of days. Additionally, the team members involved in the kaizen event should be participating fulltime without any other work commitments. This allows them to focus their efforts and take the event seriously. There also needs to be more involvement of the employees who actually do the work which will increase the chances that they are happy with and are willing to maintain the changes. The current tendency is to stand back and let the engineers do their magic.

A problem requiring an engineering solution is that of the frequent jamming of the older gravity fed pinner machines. First, the whole facility needs to be 5Sed. Also, if air conditioning is installed then the windows will no longer need to be opened preventing outside contaminants from entering the facility. Less dirt, dust, and other contaminants should help to reduce the frequency of the jamming. Other methods of clearing jams need to be investigated. The current method wastes too many pins, which end up on the floor. Perhaps developing a method of reclaiming the pins such that they can be cleaned and reused would be appropriate. The pins can only be cleaned up with sweeping because they are non-magnetic. Changing materials to a magnetic material could help with picking up the pins without contaminating them. Methods of cleaning the contaminated pins could be implemented. Another possible solution is the investment in a newer, pneumatic pinner machine which eliminates the jamming problem, and therefore the $50,000 in wasted pins each year, but costs approximately $10,000. The company has apparently already ordered a new pinner machine to replace one of the eight older machines currently being used.

In summary, the company needs to be serious about implementing lean and achieving results. Kaizen events in the future need to be less contrived and orchestrated. An experienced and well-qualified change agent needs to lead the changes. The scope of each event should be focused so that each team can realize an implementable result by the end of the kaizen event. Better team forming and more involvement of floor workers should not only produce better suggestions for improvement but also aid in the sustaining of the changes post-kaizen event. The potential improvements for future kaizen events mentioned in this section should provide a good start to better lean implementation. However, since lean thinking requires a constant strive for perfection, these changes can only provide a starting point and should not be considered the total solution.