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Makeready reduction in a platen die cutting operation: an analysis of process improvement methodologies

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Makeready Reduction in a Platen Die Cutting Operation: An Analysis of Process Improvement Methodologies.

By

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Makeready Reduction in a Platen Die Cutting Operation: An Analysis of Process Improvement Methodologies

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Abstract

The research focused on determining whether specific process improvement methodologies performed in a Kaizen event could reduce the overall makeready process in a platen die cutting operation. Data was collected and analyzed in order to identify opportunities that would reduce the effort (procedure steps and time) within the makeready procedure.

Analysis was conducted on the makeready procedure at a packaging company in Rochester, New York. The researcher worked with the Center for Excellence in Lean Enterprise (CELE) at Rochester Institute of Technology (RIT) in conducting the Kaizen event. An initial analysis with the use of a 5S audit and Individual X-Chart was conducted in order to qualify the types of process improvements that would later be implemented during the Kaizen event. Video recording and spaghetti-mapping diagrams were prepared during the makeready analysis. The information from these two process improvement analysis techniques revealed procedure improvements that were captured during the research.

This research revealed opportunities for a Bobst SP-102E platen die cutting machine makeready process by removing the excessive motion to develop a more effective makeready process. With the use of process improvement methodologies in the print manufacturing environment, company leaders can utilize the research methodology as a guideline to reduce an

operation’s makeready time, and thereby reduce costs of manufacturing by eliminating waste in the operation.

The operator performed the makeready in 86 steps in 1 hour 18 minutes which was the existing makeready condition for the platen die cutting operation. The goal for the research was to identify if specific process improvements would improve the current makeready process as mentioned. Significant reductions to the makeready procedure were identified during post analysis: steps were reduced by 29% from 86 to 61 and the time was reduced by 40% from 1 hour 18 minutes to 40 minutes.

Factors such as declining run lengths, increasing competition from other media, and off shoring are threatening U.S. print manufacturers and forcing companies to locate areas to reduce costs in order to maintain clients. This research was an important aspect that contributes to the efforts to reduce cost in print manufacturing by analyzing the effects of process improvement methodologies for a platen die cutting operation.

Chapter 1

Introduction and Problem Statement

Introduction

Lean manufacturing (Lean) techniques are beginning to gain more support from the print industry. Significant issues that are affecting printing companies are market competition, rising manufacturing costs, and pressures in profit maximization (shorter lead times and lower quantities); these issues must be addressed in order to sustain profitability. Printers are realizing that Lean, as demonstrated in other industries, improves productivity and creates the opportunity for greater manufacturing achievements and can be applied to their printing company. Durkalski-Hertzfeld (2008, ¶56) said that during times of economic turmoil, companies are turning to strategies that further continue their competitiveness to bring profits in the near future. A survey by Durkalski-Hertzfeld indicates that 62% of board converting facilities are focused on Lean as a significant element to promote efficiency and profitability.

The purpose of this research was to determine if Lean, Single-Minute Exchange of Die (SMED), and Total Productive Maintenance (TPM) could reduce makeready-time in a print manufacturing operation. The platen die cutting operation was analyzed as a convenient model. The researcher contacted the

Rochester Institute of Technology's (RIT) Center for Excellence in Lean Enterprise (CELE) for assistance in performing a study in process improvements. CELE responded by facilitating a Kaizen event with a carton-converting print manufacturing company in Rochester, New York.

The company agreed to participate in the thesis study and permitted the researcher to analyze a platen die cutting operation's makeready procedure. The researcher and Center for Excellence in Lean Enterprise (CELE) assessment focused on implementation of process improvement methodologies to optimize the operation's current makeready procedure. Initially the platen die cutting operation was not considered a Lean operation, based on the fact that a 5S (Sort, Straighten, Shine, Standardize, and Sustain) had not been performed in the operation, nor had a standard been implemented for the makeready process. The researcher worked with CELE to analyze the operation, perform the Kaizen event, and reduce the makeready process.

Statement of Problem

Nick Howard (Howard, 2009), an associate with Howard Graphic Equipment, said that print manufacturers do not sell press time anymore, but are now in the business of selling makereadies. Essentially the era of "long-run" print manufacturing has come to an end, and the requirement for quick makereadies is an essential part of the current manufacturing process. In his stament, Howard makes reference to the increase in short-run volume production. This

phenomenon is now pressuring manufacturers to fill in the gaps of lost production capacity due to print contracts shrinking volume sizes in order to regain lost revenues.

This topic of process improvement is important for print manufacturers because it identifies methods that create opportunities for reductions in an operation's makeready, which essentially lowers costs in production. Scott Reighard, Vice President of Operations for Acorn Press, Inc, says that poor processes can never be resolved with new technology. Fixing the specific process itself is the key to improvement (Cross, 2001, ¶13). Economic pressures are forcing companies to reduce their internal manufacturing costs, and one of the greatest potential savings in a die cutting operation is found in reducing the makeready time within the operation (Folding Carton Industry, 2006).

Reason for Study

The researcher is interested in Lean and process improvements as it can be related to the print manufacturing industry. Market pressures are a significant factor due to increasing competitiveness from other media and off shoring which is another reason that the U.S. printing industry must begin to adapt to the principles of Lean manufacturing and other process improvement methodologies.

The researcher has grown-up in a family printing company and observed inefficiencies that derive from excessive motion, lack of standardization, and unpredictable makeready time.

The researcher feels there is value within Lean for print manufacturers because of the requirements for predictability and efficiency that play a significant role for industry leading companies. Lean's emphasis is to eliminate waste within the operation by removing any business tasks that do not add value to what the customer is willing to pay for. Lean emphasizes these methodologies in order to re-assess a company's business operation (Cooper, 2006, ¶4).

Chapter 2

Theoretical Basis

The focus for this research was to utilize specific techniques that could reduce the makeready process for a platen die cutting operation. This chapter details the concept of Lean manufacturing and the tools and techniques associated with improving a makeready process, such as 5S, Single-Minute Exchange of Dies (SMED), and Total Preventive Maintenance (TPM).

Lean Principles

Lean manufacturing is a manufacturing process that promotes the elimination of wasteful activities within an operation. In their book *Lean Thinking*, James Womack and Daniel Jones (1996/2003, p. 10) define Lean manufacturing as a multi-step process that builds an operation to create value for the customer. It introduces and sustains "flow" within the customer value stream, which allows customers to "pull" products from a system that significantly reduces inventory. Lean strives to constantly improve the manufacturing environment by manufacturing only what the customer is ready and willing to pay for.

Kaizen (Japanese word for continuous improvement) creates value, while eliminating waste and enhancing respect for people. These factors are principles of manufacturing that are recognized at the Toyota Motor Company in Japan.

They were developed through innovative thinking by the Toyota Motor company founders and influencers: Kiichiro Toyoda, Eiji Toyoda, Taiichi Ohno, Shigeo Shingo, and Shoichi Saito, to name a few. These individuals are the principal engineering body of the Toyota Production System and the Toyota Way (Art of Lean, 2004, p. 5; Cooper, Keif and Macro, 2007, p. 18-19).

Lean principles are centered on constantly improving an operation; they maximize a system by reducing costs and eliminating defects that arise from waste. Ohno contends that 95% of all costs are comprised of the following "Eight Wastes" which are listed as: Overproduction, Waiting, Transportation, Non-Value Added Processes, Excess Inventory, Defects, Excess Motion, and Underutilization of People (Bodek, 2005; Liker & Meier, 2006, p. 34; Kilpatrick, 2003, ¶4).

The following elements in the theoretical basis are tools and techniques which are the primary functions used to accomplish process improvement within a makeready procedure.

5S Tool (Sort, Straighten, Shine, Standardize, Sustain)

5S presents itself as the essential housekeeping procedure and a prerequisite contributor to Lean manufacturing sustainability (Tapping, Luyster, & Shuker, 2002, p. 45). 5S can be applied to any company, from the shop floor to the office environment. This Lean tool helps to clear the area from distractions

within a manufacturing facility. David G. Dodd of Point Balance explains the fundamentals of 5S in Table 1 (Dodd, 2008, The Tools and Techniques of Lean Part 1).

Table 1. 5S Process, Translation, and Definition (Liker and Meier, 2006, p. 64)

Process/ Translation	Definition
Sort/ Seiri	Put to the side all tools and materials from the work area, keeping only the necessities.
Straighten/ Seiton	Strategically designate specific places for storing all necessary tools.
Shine/ Seiso	Systematically clean the workspace.
Standardize/ Seiketsu	Standardize tasks needed to maintain Shine; responsibilities are assigned to the workforce.
Sustain/ Shitsuke	Make the other four steps in 5S a habit.

Process Standardization Tool

The International Organization of Standards (ISO) (2008, ¶1) defines standardization as an approved documented process that provides guidelines for activities, as well as results that are achieved. Standards are based on consolidated results of science, technology, and experience that promote community benefits. Standardization is a model built and used to create predictability and reliability. Essentially, it results in the replacement of the craft-

form of production with the mass-form of production. Assembly lines are given standards in order to maintain similar manufacturing of products. For example, Toyota engineers can go to any facility around the world and see matching processes (Liker, 2004, p. 142).

Improve Standards

Standardization is essentially a baseline from which improvements originate. A process is difficult to improve when it has not been standardized. Liker (2004, p. 142) advocates standardization before stabilization; this must occur before improvements can be organized. Lean enables workers to design and build a standard to accomplish their work. Within a Lean environment, management utilizes the workforce to identify what is being accomplished on the production floor. Lean emphasizes the utilization of the workforce to communicate information back to management in order to create improvement opportunities.

Standardization Promotes Individuality and Creativity

Traditionally, employees view standards negatively. The belief is that standards that are dictated from management undermine the capability and autonomy of the workforce. The correct intention of the standardization tool is to become a positive and effective function that brings teams together within the workforce (Liker, 2004, p. 142). The concept, “ownership of a process” is a

critical factor with Lean, and standard processes that are developed and owned by the workforce have the tendency to receive greater acceptance.

Visual Control Tool

Individuals on the shop floor tend to be very visually oriented, and the use of floor markings, signs in the work area, or tool board labels are easy indicators for the workforce to verify that the work area is maintained to the set standard. Visual control tools sustain improvement efforts and simplify decision-making processes by giving employees the right to participate in managing production. An example of employees managing production is the decentralization of inventory control for operating functions (Grief, 1989/1991, pp. 100, 121; Liker & Meier, 2006, p. 139).

Grief, in his book *Rules for Visual Control*, describes the practicality of visual tools. He says that they indicate the actual state of affairs, provide information on orders, determine an operation's current workload, determine whether production is backed-up, and provide foresight for scheduling to eliminate unexpected downtime (1989/1991,pp. 109-110).

Continuous Improvement Tool (Kaizen)

Kai-zen is the Japanese term meaning "improvement" or "making it right." Kaizen is an approach for an organization to quickly seek improvement by rebuilding a process (Liker, 2004, p. 252; Miller, 1998, ¶2). A Kaizen event is a

team-based, rapid-improvement function that is used to create immediate changes within an operation. A team should be prepared to quickly study the ailing process, collect and analyze data, apply change and refinement, and present results with a plan to sustain the change.

The Kaizen event should be distributed over five days (Miller, 1998, ¶15; Rizzo, October, 26, 2008, pp. 42-43):

- Day 1: Learn the process
- Day 2: Confirm current state of operation
- Day 3: Analyze and propose improvements
- Day 4: Decide on improvements and implement
- Day 5: Debrief and present results of improvements

The concept of Kaizen is to prepare a team of workers to create improvements within their operation. The Kaizen approach also has the capabilities for improving profitability and the quality of work life for employees (Miller, 1998, ¶42).

Single-Minute Exchange of Die Technique (SMED)

The ability to significantly reduce machine makeready can be accomplished by utilizing SMED techniques authored by Shigeo Shingo. Within

an operation's makeready, Shingo (1985, p. 33) describes the two constant functions of internal setup (IED) and external setup (OED), which are applicable in most operations. Internal Setup (IED) is an activity during makeready that can only be accomplished while the machine is stopped. External Setup (OED) is an activity during makeready that can be accomplished while the machine is still in operation.

Shingo (1985, p. 31) describes the process of makeready improvements by first distinguishing each internal setup (IED) activity and each external setup (OED) activity. Then, where possible, he recommends converting as many IED activities to OED activities to streamline functions within makeready and to capture process improvements.

Traditional Improvements vs. SMED Improvements

Reducing makeready cost by consolidating multiple-lot production into a single-lot of production is the traditional approach for makeready improvement. The increase in output production will generally lower unit production costs associated with a makeready. Traditionally improvements are based on achieving production economies of scale. In today's manufacturing environment, small-lot production is essential because of diversification requirements mandated by customers. As a product diversifies, lot size inevitably decreases. Shingo (1985, p. 13) confirms that slowing product diversification is difficult, especially with frequent demands for product change. Shingo (1985, pp. 17, 18)

states that the economic lot size theory is correct, but the concept tends to conceal the fact that makeready reductions are possible even with small-lot production.

Internal and External Activities

Internal activities (IED) are standardized functions and necessary makeready activities most often directed by the original equipment manufacturer (OEM). Specific considerations for these activities are operator safety and equipment reliability. On the other hand, External activities (OED) are considered opportunity time in SMED. The way OED activities are utilized is by undertaking makeready activities for the next job, such as gathering job information, tooling and equipment, prior to finishing the current job.

Parallel Activities

Parallel activities allow operators and assistants to accomplish makeready functions simultaneously with safety and effectiveness. Safety is very important during parallel activities, and to maintain safety, it is necessary for the operators to signal each other so the next function can be safely undertaken. Signaling can be done vocally, by hand motion, or with a noise device.

Elimination of Excessive Adjustments

Equipment must be predictable and dependable; the elimination of excessive adjustments can be achieved by calibrating equipment to OEM specifications. Shingo advocates the elimination of adjustments and test runs.

He claims that excessive adjustments account for as much as 50% of makeready; establishing a process which eliminates, not just reduces, adjustments leads to tremendous timesaving (Shingo, 1983, p. 66).

F.A.S.T.

The acronym F.A.S.T. was coined by CELE in order to create rudimentary understanding of the Internal activities (IED) and External activities (OED) during the process improvement for the process improvement event. Foresight (F) describes the preparation of equipment, information, and other tools required to manufacture the next job in a manufacturing operation. These tasks can be accomplished while the equipment is still in operation because these tasks can be safely accomplished away from production. Attachment (A) refers to the necessary parts required for the equipment in order for the project to function properly. Setting and Tuning (S) of equipment is required in order to qualify the equipment to manufacture the product properly. Trial Runs and Adjustments (T) are the final adjustments to equipment before quality production commences. Foresight is considered an external activity and Attachment, Setting, and Trial Runs and Adjustment are internal activities. The concept of F.A.S.T. was developed to educate individuals during the process improvement event on the simplicity of SMED principles.

Total Production Maintenance (TPM)

Fifty years ago, Japanese industries began to learn from the U.S. concept of preventive maintenance, productive maintenance, maintenance avoidance (reducing long periods of maintenance), and reliability engineering of equipment and machines. They eventually took what was learned and formed their own style of productive maintenance that is referred to as Total Production Maintenance (TPM). TPM is a technique of equipment maintenance that involves all employees in every function of operations within an organization. For TPM, a key concept is scheduled autonomous maintenance (operator maintenance programs) routines that keep equipment operating in top running condition without constant use of a maintenance team. With the use of TPM, equipment operators are able to detect problems before breakdowns occur (Japan Institute for Plant Maintenance, 1982/1989, pp. 1, 2).

TPM enhances equipment effectiveness and maximizes output by increasing Production, improving Quality, reducing Cost, shortening Delivery time, improving Safety conditions, and enhancing company Morale, also known as (PQCDSM). TPM also emphasizes the elimination of the ‘Six Big Losses’ in manufacturing (Table 2).

Table 2. Category of 'Six Big Losses'

Category of Loss Type	**Six Big Losses**
Downtime	1. Breakdown due to equipment failure 2. Makeready and adjustments
Speed Losses	3. Idling and minor stoppages 4. Reduced speed
Defects	5. Defects in process and rework 6. Reduced yield between machine startup and stable production

The Japan Institute for Plant Maintenance (1989, p. 10) suggests that the elimination of the "six big losses" can be achieved by removing production systems which promote equipment breakdowns, eliminating waste (scrap or rework), reducing prolonged makeready, and eliminating slow-running production equipment incapable of meeting productivity requirements. These factors are listed in Table 2 (Japan Institute for Plant Maintenance, 1982/1989, p. 10).

Total Production Maintenance (TPM) Equipment Program

A TPM equipment program begins with company leaders' establishing the goals for TPM that are carried out by employee teams. The program is achieved with five mutually supportive company goals: Improved equipment effectiveness, Autonomous maintenance by operators, Routine maintenance by the maintenance department, Training to improve operator skills, Preventive

maintenance to eliminate start-up problems (Japan Institute for Plant Maintenance, 1982/1989, p. 20).

Maintenance programs must be continually assessed in light of these goals which provide feedback to assist in refining current maintenance of equipment and improving overall maintenance programs.

Overall Equipment Effectiveness (OEE)

The Overall Equipment Effectiveness (OEE) measurement reveals the efficiency of daily efforts for an operation. OEE has the capability to identify deficient processes that need improvement (Japan Institute for Plant Maintenance, 1982/1989, p. 365; Cooper, Keif & Macro, 2007, p. 57).

The OEE measurement tool gauges equipment effectiveness by multiplying the ratio of availability by performance and quality; Overall Equipment Effectiveness = Availability x Performance x Quality (Equation 1). From the given ratios, a company’s measurement of equipment effectiveness can be accurately determined, and deficiencies within the operation can be pinpointed with individual results.

The equations for OEE, Availability, Performance, and Quality are listed below:

OEE = Availability x Performance x Quality (1)

Availability = Planned Availability x Uptime (2)

Performance = Actual Production ÷ Expected Production (3)

Quality = Quality Production ÷ Actual Production (4)

Where

Planned Availability = Operating Time ÷ (Operating Time + Makeready) (5)

Uptime = (Operating Time – Breakdown time ÷ (Operating Time) (6)

Actual Production = Total Output Produced[1] (7)

Expected Production = OEM Production Rate x Hours[2] (8)

Quality Production = Actual Output Produced – Waste (9)

[1] Total Output Produced is measured during the period of time that the machine is scheduled for production and does not include any unscheduled production time (unscheduled shifts, holiday's, etc.)

[2] Hours of production scheduled for machine

The first multiple is the equipment availability percent, as seen in (Equation 2). The availability measurement is the product of Planned Availability and Uptime; see (Equations 5 & 6). The result of Availability is a proportion of time that a machine is available for production. The second multiple is the performance percent, (Equation 3). Performance is the quotient of Actual Production output divided by Expected Production output. Actual production equals the Total Output Produced during the given period of analysis; see (Equation 7). Expected Production is a calculation specified by the Original Equipment Manufacturer (OEM). Expected Production is the product of the Production Rate of OEM by the Hours of Production Time analyzed; see (Equation 8). The quality rate is the proportion of deliverable quality products; see (Equation 4). It is the quotient of Quality Production and Actual Production; see (Equation 7 and 9). (Japan Institute for Plant Maintenance, 1982/1989, p. 366; Rizo 2008; Cooper, Keif & Macro, 2007, p. 63-64). Average OEE levels for a manufacturing firm range from 40% to 60% and best-in-class is 85% to 95% (Cooper, Keif, & Macro, 2007, p. 65; Nakajima, 1989, p. 38; Vorne, 2002).

The tools described in this chapter underpin the principles which form the theoretical basis for this research. These principles and tools are vital to understanding the methods of the research. These improvement tools and techniques were used in analyzing the platen die cutting operation and guided the data collection for improving the operation’s makeready procedure.

Chapter 3

Literature Review

This chapter is an overview of the literature describing the reasons process improvement methodologies are initiated and the factors that prevent continuous improvement efforts within operations from being effectively implemented and maintained.

With the print manufacturing industry being the focus, this chapter considers literature that describes the challenges and opportunities printers face with the application of process improvement. In specific, it seeks to review literature that deals with makeready reduction in a platen die cutting operation

Lean Manufacturing

The objective of Lean manufacturing is to improve an operation through the categorical removal of non-value added processes within the operation; it identifies and eliminates wasteful activities with the use of Kaizen (Japanese for continuous improvement) and provides a plan to create activities that are efficient (Womack and Jones, 1996/2003, p. 15; Kilpatrick, 2003, ¶3, 5; Davis, 2006, ¶3; Caldwell, 2008, p. 40).

Improvements Through Lean Leadership

Lean is described as a philosophical paradigm-shift in the way business is conducted. Lean manufacturing derives from the Toyota Production System (TPS) of manufacturing. Liker (2004) recognizes in his book, *The Toyota Way,* that it is possible to use TPS tools, while not adhering to the foundation principles of TPS. Not utilizing Lean principles produces limited results with short-term performance improvements that will not be sustainable in the long run (Liker, 2003, p. 41). Survival in the global economy for U.S. manufacturers depends on their ability to constantly improve the quality aspects of their products while reducing the cost of manufacturing. This is necessary in order to sustain a competitive advantage and develop leadership within their markets (Sim and Rogers, 2009).

Sims and Rogers (2009) investigate the "depths of resistance to change" and note in their research that after Kaizen events demonstrate process efficiency and improvements, the operations return to their original chaotic mode of manufacturing. As Purdum (2006) states in her article, it is vital for leadership to forge all improvement efforts in order to prevent backtracking from occurring.

Purdum (2006, ¶3,4), in her article *Lauren Manufacturing Embraces A Lean Environment to Compete,* describes an important principle of a "philosophical paradigm-shift thinking" within company leadership; she describes the actions of the CEO of Lauren International, Kevin Gray, who supported the

Lean transformation and placed the managing body and workforce on the same course toward a Lean environment. Gray announced the “concept of change” by expressing the need to eliminate waste in order to stay ahead of their competition, and he emphasized that this would not be accomplished with tangible applications but rather with the elimination of “mental walls” that existed with traditional manufacturing methods (Purdum, 2006, ¶3,4).

U.S. manufacturers are realizing cost reductions with Lean. In 2002, Lauren Manufacturing Company faced an organization-wide dilemma: global competition, which began to encroach on their markets. Lauren Manufacturing left their traditional way of doing business to embark on a transformation that ultimately improved the way business was conducted (Purdum, 2006, ¶1, 2; Kelly, 2003, ¶14). Lisa Huntsman, vice president of operations, approved of the way management openly embraced Lean. Huntsman comments on how traditional manufacturing profitability can be deceptive, but once Lean concepts were understood, an inventory (portion of a business’s assets) analysis clearly illustrated tremendous deficiency in cash flow and Lean revealed opportunities for improvement (Purdum, 2006, ¶5,14).

Limitations Affecting Lean Practices in the U.S.

In today’s manufacturing systems current Lean programs lack focus, and manufacturers that try to embrace Lean are having difficulty grasping Toyota’s true vision within their traditional environments (Kilpatrick, 2003, ¶10; Smalley,

2004, ¶1; Womack, Jones, and Roos, 1990/2007, p. 10; Farris, Van Aken, Doolen, & Worley, 2008, p. 10). Smalley goes on further to state that, during Lean programs, companies do not use financial metrics to determine Lean benefits through cost reduction. U.S. companies have the tendency to become captivated with Lean theory and continue to overlook Lean principles. Leadership is an important aspect of Lean, and U.S. companies do not emphasize the development of leaders to create and guide their improvement teams (Smalley, 2004, ¶1).

A study by Sim and Rogers (2009, p. 45) discusses an important aspect of management support that prevents continuous improvement from having a successful implementation. Employees felt that management did not follow through on various improvement action items that arose from Kaizen events and were not supporting commitment to continuous improvement. In the study, employees were surveyed, and most agreed that continuous improvement was essential to staying competitive in a global market and that, if they owned their own company, they would implement Lean practices.

Lean challenges company leaders to confront their traditional manufacturing styles. Kilpatrick (2003) and Davis (2006) agree that in order to be more competitive, manufacturing companies must shift from the mass-production style to a more Lean minded system (produce only what is ordered

and paid for), with even greater focus on quality than their non-lean counterparts (Kilpatrick, 2003, ¶9; Davis, 2006, ¶1).

Lean in Print Manufacturing

The concept of Lean in print manufacturing has become a popular and practical application for process improvement, and the rising popularity of Lean concepts attests to their importance to the print-manufacturing environment. Dodd revealed data from his 2008 survey that finds 51% (Figure 1) of print manufacturers have embraced the concepts of Lean and are actively participating in Lean functions (Dodd, 2008a).

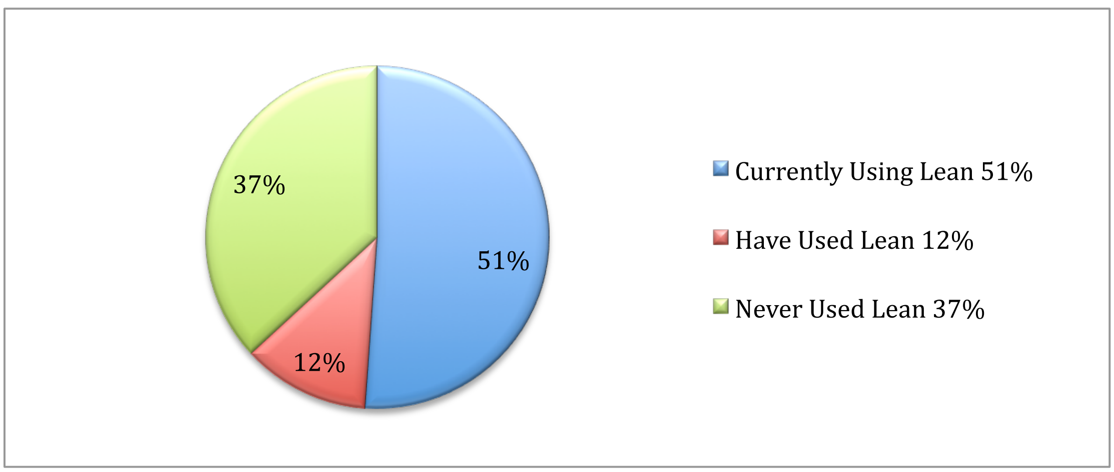

Figure 1. Printing Companies Involved in Lean Manufacturing Tools/Techniques

The positive effect is that Lean has produced visible improvements for the printing industry in recent years, and Dodd (2008b) states that because of market competition, increases in manufacturing costs, and pressures in profit

maximization (shorter lead times and lesser quantities) printers have embraced Lean manufacturing in order to create opportunities for improvements (Koltzenburg, 2004, ¶2; Dodd, 2008b, ¶9; McIntosh et al, 1996, p. 5). Since 1998, 7,500 printing facilities were forced to close their doors from those contributing factors (Cooper, Keif, & Macro, 2007, p. 16). Dodd (2008a, ¶9) in his article *The "Leaning" of Print* recognizes that printing company leaders are developing a greater interest in improving productivity for their companies. Printers are realizing that Lean, as demonstrated in other industries, improves productivity and creates the opportunity for greater manufacturing achievements and that it can be applied to their company.

Challenges are many and printing company managers are under enormous pressure with shorter runs, rush jobs, and cost reductions, which have become common requirements of print-buyers (Whalen, 2001; O'Brien, 1999; Cross, 2000; Cross, 2001). Print manufacturing companies that are advancing in Lean have focused on eliminating costs permanently, increasing throughput efficiently, and developing more sustainable and predictable processes that achieve the operational goals with continuous improvement methodologies (Cross, 2001, ¶1-3).

Process Improvement

Elimination of waste in an operation, such as idle production time, rework, excess variation, and underutilization of resources is the focus for process

improvement (Summers, 1997/2006, p. 25). The function of a makeready is commonly included in the selling price of a job that the customer is willing to pay for. Print manufacturers might ask the question, why improve the process if the customer is paying for the makeready time? In response, one needs to realize that the makeready does not add value to the product. Cooper, Keif, and Macro (2007, p. 45) state that if competitors are able to reduce their makeready time, then the cost of manufacturing can also be reduced, thus improving those firms' competitive advantage.

Maximizing sellable production and minimizing downtime is the focus in makeready improvements (Womack and Jones, 1996/2003, p. 69; Ynostroza, 2000, ¶9). The print industry average percentage of a machine's chargeable time to total available time is about 75%, among the most efficient plants 85%, and top performers' percentage as high as 90% which leaves only 10% for downtime and breakdown, as illustrated in Figure 2.

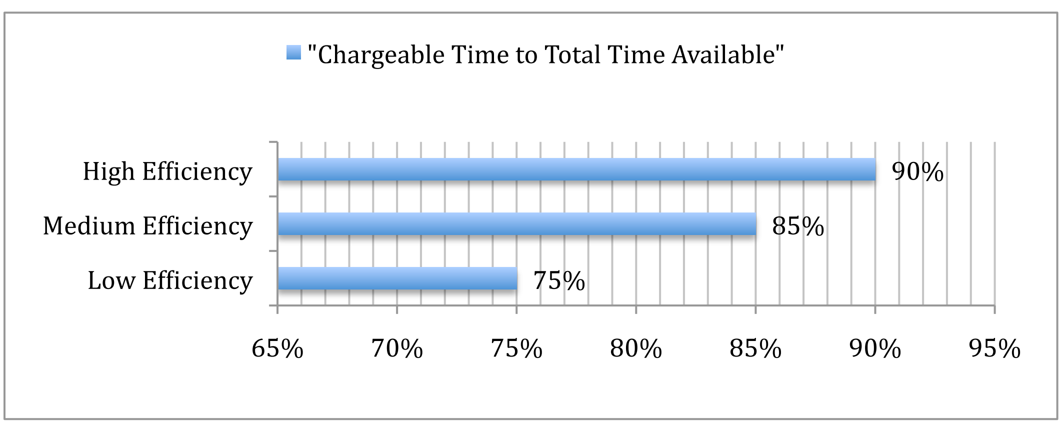

Figure 2. Analysis of Total Time Chargeable on a Given Machine

Makeready Improvements for Platen Die Cutting Operation

In 2001, Process Graphics Services, Inc. (PGS), in Grand Prairie, Texas, a printed sheets finishing/ converting manufacturer, was receiving increased pressure from customers for just-in-time (JIT) manufacturing in platen die cutting. Initial reaction was to hire skilled personnel for immediate improvement, but a lack of skilled personnel did not allow that option to emerge. PGS researched their operation and analysis verified an increase in job-turnaround would occur from optimizing the current working process with faster makereadies and greater productive efficiencies (Whalen, 2001, ¶13, 16). The company contacted the Bobst Group for a process performance solution called Total Optimization Project (TOP), which uses Single-Minute Exchange of Die (SMED) principles with mechanical improvement suggestions as a method to reduce makeready time for a platen die cutting operation. The SMED principle used during the analysis identified that time was being lost due to inefficient processes and that improvements could be achieved if the methods were altered. The Bobst Group suggested using videotaping, makeready task documentation, and makeready task analysis as methods for uncovering opportunities for improvement to the makeready procedure. The objective and goals for production improvement were set by PGS in order to meet customer demands. The analysis Bobst conducted demonstrates a usefulness of SMED and other Lean techniques in platen die cutting. Establishing the foundation of why an improvement is necessary should

be comprehended prior to any activity. Three vital elements before conducting the improvement initiative should be considered:

- What level of improvement can be expected?
- How will the business benefit from this improvement?
- What structure should a successful improvement initiative have? (McIntosh, Culley, Gest, Mileham, & Owen, 1996, p. 8)

<u>SMED for Platen Die Cutting Operation.</u>

SMED is described as a dynamic application used to develop process improvements that reduce work-in-process inventory and to develop operation efficiencies to diversify production to better meet customer specifications.

During the TOP program, one of the recommendations to PGS was to finish tooling for the platen press for the next job while the machine was finishing a current job. Pfaff (2002, ¶5-7) and Witzig (2006, ¶7) affirm that significant productivity loss, due to necessary and unnecessary downtime, reduces a company's profitability and is commonly a result of poor preparation and communication from upstream processes. Whalen (2001, ¶28, 29) estimates time-savings of up to 50% for an operation can be achieved within the makeready procedure. The utilization of improvement techniques such as Single-Minute Exchange of Die (SMED) has the capacity to accomplish the goal of maximizing revenue with makeready process efficiency.

Mark Smith, the technology editor for *Printing Impressions*, states that short-run manufacturing is a growing trend and the opportunity to sell more press time will assist in balancing the print manufacturer's loss from the lack of long-run jobs. Printers must utilize efficiencies within their entire operation in order to sell more makereadies, which essentially will maximize revenues (Smith, 2008, ¶2).

Long-Term Implementation Difficulties for SMED.

Amid these issues of excessive downtime, Shigeo Shingo (1985, p. 13) recognizes makeready as a necessary downtime, and he suggests improvements to makeready can be achieved with the SMED concept.

Once an analysis of an operation is done and the SMED methodology is implemented, an area of great concern for companies should be the sustainability factor for the makeready improvements.

Process improvement initiatives routinely have the capability to demonstrate degrees of improvement, but considerations for potential obstacles that reduce improvement sustainability efforts must be addressed. The first obstacle of measuring and reporting changeover (Shingo, 1985, p. 11) mentions the importance of monitoring the makeready performance accuracy. The company must acknowledge the performance improvement because the effects that the production time improvement has in scheduling and estimating should be considered in order to fully benefit manufacturing. Negative factors such as monitoring the setup period in isolation and integrating unrepresentative

performance dates hinder process improvement initiatives. During process improvements, it becomes important to narrow attention to adjustments where changes are made in order to positively affect the manufacturing outcome. The production and quality measures help determine when quality defects arise during production. A summary of obstacles is listed in Table 3.

Table 3. Post-Improvement Initiative Difficulties (McIntosh et al, 1996, p. 10)

Obstacles to Overcome	Description
Measuring and Reporting Changeover	Measuring accurately to understand progress that has been made.
Monitoring the setup period in isolation	Isolating makeready time to total elapsed time and not capturing when run-up period ends and true volume production begins.
Integrating Unrepresentative Performance Data	Focusing on the makeready period in sections and not as a whole. Identify areas of overall makeready variation.
Attention to Adjustment	Adjusting excessively tends to obscure the makeready period of inserting tooling and equipment and run-up period for quality adjustments.
Production and Quality Measures	Linking subsequent line performance data to the changeover, which essentially reduces improved production and quality rates.

Improving Equipment Performance with Reliability.

Total Productive Maintenance (TPM) is essential for continuous efficient manufacturing (Smalley, 2005, ¶1, 13). Rizzo (2008, p. 22) and Nakajima (1989, p. 39) state that the loss that affects equipment efficiency can be described as either sporadic loss (sudden and infrequent loss of time) or chronic loss (recurring defect from equipment, operators or materials). The goals of improving machine uptime with TPM can assist by making certain machines operate with minimal time loss (Cooper, Keif, Macro, 2007, p. 57). Rizzo (2008, p. 21) and Dodd (2008, ¶6) describe TPM as a rigorous program that is developed by the workforce to realize the optimal condition for equipment with process reliability. Sporadic and chronic losses that do occur will hinder production efficiency, but TPM is a capable technique of resolving those equipment problems.

Printers who have adopted a preventative maintenance program tend to run faster and have fewer time losses in production. Ninety percent of those who have a maintenance plan realize that the maintenance plan reduces their press down time; while 60% found it produces less waste. Jewell et al (2005, p. 426, 432, 437) discuss a significant decrease to a machines' designed speed with the absence of a maintenance system although greater equipment performance can be achieved with a quality maintenance system implementation. TPM is a very important aspect for process improvement; it has the capability to raise the level

of total equipment effectiveness by improving all related factors of availability, performance, and quality (Smalley, 2005, ¶17; Nakajima, 1989, p. 34). Process improvement focuses on removing the waste that exists in the manufacturing environment.

Growth and development of process improvement are not established with only tools and techniques but with a philosophical paradigm shift in the way business is conducted. If managers do not embrace the true vision of process improvement, Lean programs lack focus and become limited. Print manufacturers are under pressure to meet customers' increasing demands and reduce manufacturing costs. For these reasons, process improvement methodologies have been embraced by printers as a practical and popular application to improve production operation. Applying methods, such as Lean, Single-Minute Exchange of Die, and Total Productive Maintenance, results in increased opportunities for improving operation efficiency.

Chapter 4

Research Statement

The researcher was to determine whether process improvements (Lean, SMED, and TPM) that are performed in a Kaizen event would increase the Overall Equipment Effectiveness (OEE) metric within a platen die cutting operation. Increase to OEE was facilitated by reducing the overall makeready time and reducing the number of steps within the makeready procedure.

Limitation of the Study

The company that sponsored the research for makeready reduction did experience a lack in process improvement leadership. The Kaizen event was not executed with the full involvement of administrative personnel. Customer Service representatives and Human Resources associates were not included in the evaluation of the die cutting operation in order to gain an administrative perspective (Liker & Meier, 2006, pp. 456-457).

A limitation inherent to the platen die cutting makeready process was the significant variation that existed from one job-project to the next. Essentially the dies and tooling for each product that is constructed and installed in the platen die cutting machine change in their design, structure, and material. These elements are the primary sources that create variation within the platen die

cutting makeready procedure. Essentially the limitation to the makeready reduction would be that improvements would only be realized for one project but would not be transferable to another due to significant project variation.

Another limitation applies to SMED, which utilizes parallel activities during the makeready and requires a full-time individual in order to achieve reductions. It is important to mention that the platen die cutting operation that was analyzed used an assistant to conduct the makeready process, but in some instances the assistant was not available because a full-time makeready assistant had not been assigned to the operation.

The equipment that was used in the makeready analysis was a Bobst SP-102E, which was manufactured in 1989. The Bobst SP-102E does not meet the capabilities of newer Bobst platen die cutting machines that are currently available for purchase which offer greater automation, speed, and other technological advancements. The makeready improvements established for this research are limited to only the Bobst SP-102E model and not to newer more sophisticated models.

Chapter 5

Description of Equipment and Process

The research experiment was conducted at a packaging company in Rochester, New York. The company will be referred to as Company DP. The company worked directly with Rochester Institute of Technology Center for Excellence in Lean Enterprise (CELE). From this relationship an opportunity arose to work with Company DP on their platen die cutting operation. Summarization of the platen die cutting operation and the makeready process used at Company DP are provided in Appendix A. Company DP and the researcher coordinated a schedule to analyze the die cutting operation during live production in order to research makeready reduction utilizing process improvement methodologies.

Chapter 6

Methodology

The research methodology clarifies the steps and procedures used to analyze platen die cutting makeready procedures data. The data collected is then used to identifying reductions in makeready time used to identify process improvement methodologies.

Initially, production sheets for the platen die cutting operation from two shifts per day were collected and analyzed over a 2-week production period. The data was used to calculate the Overall Equipment Effectiveness (OEE) metric as a baseline for the operation, to graph a pareto chart to identify the proportion of time spent on the various operational functions, and to analyze the variation of makeready through the use of an Individual X Chart.

A Kaizen event was initiated to evaluate current makeready procedures and the involvement of makeready toward productivity for the platen die cutting operation. The procedures were scrutinized so that unnecessary steps within the makeready could be identified and overall makeready process time could be reduced in order to improve productivity. At the conclusion of the Kaizen event, management was presented with improvement proposals that demonstrated a significant impact on the production area and on reducing the time needed for the

makeready process. Analysis of the research will describe the before and after of the Kaizen results, and upon determination by management, improvements were to be implemented, standardized, and trained upon. In continuation with monitoring results of the Kaizen event and with management approval, quantitative analyses of makeready improvements were captured by collecting information from production and comparing the new information to the original productivity baseline of Overall Equipment Effectiveness.

The researcher presented to management potential improvements to the process and the additional requirements to implement improvements, but due to the current economic situation and other unforeseen circumstances, Company DP was not able to proceed with implementation of the suggested improvements.

Machine Effectiveness Analysis

Various tools were utilized to capture relevant information concerning the platen die cutting makeready process. Identifying each step within the makeready process was elaborated with the use of a production data form. Once the information was cataloged, a pareto chart was developed to determine the production time breakdown for the operation, an Overall Equipment Effectiveness (OEE) metric was calculated as a measure of operation efficiency, and an Individual X Chart was constructed to establish an initial baseline for the platen die cutting operation. The information was collected from a convenient sample of 23 makeready data points over a two-week period.

Table 4. Production Data Form Analysis

Type of Data	**Description**
Job Number	Identification of data.
Machine Number	Identification of specific machine.
Type of Function (Makeready, Production Run, Down time)	Specification of exact function being performed.
Start and End Time	Allocation of time to perform each process of the operation.
Gross Quantity	Specification of total converted press sheets or carton blanks manufactured including waste/ defective sheets.
Waste Quantity	Specification of discarded or defective press sheets or carton blanks from production.
Net/Good Quantity	Specification of Gross Quantity less Waste Quantity.

Table 4 shows the operation characteristics analyzed in the research. The production data form captured specific criteria for each production run. The platen die cutting operator was using this specific form in order to identify each function being conducted. The production form was used throughout the production week, capturing start and stop times, and totaling net production for the platen die cutting press.

Information acquired over the two-week period with 23 samples was displayed within a pareto chart graph. A pareto graph provided a breakdown of production time information during the two week period in which the platen die cutting operation was categorized into makeready time, run time, and downtime.

Essentially this information identified what functions make-up the majority of production time and which downtime area should be focused on for significant improvement to production uptime (Gryna, Chua, & Defeo, 1904/2007, p. 69).

Calculating the Overall Equipment Effectiveness (OEE) metric also assisted in verifying sources of productivity loss in the platen die cutting operation. With the OEE, productivity was assessed from three indicators: availability, performance, and quality. Information to calculate the OEE equation (OEE = Availability x Performance x Quality) was compiled from the two-week production period (November 21, 2008 – December 4, 2008). The information was entered into an Excel spreadsheet to calculate the OEE (see Appendix C).

The sample of 23 individual makereadies (during 11/21 – 12/04) was statistically analyzed with an Individual X chart. The chart was appropriate because of the small sample size of 23 data points and was used to assess whether the makeready procedure was within the control limits of a normal distribution at a 99.73 percent confidence level, which the measured values fall within plus or minus three standard deviations of the mean for the 23 data points. Calculation and description for the Individual X Chart mean and control limits are described in Table 5.

Table 5. Calculation for Individual (X) Chart

X-Chart	
Centerline: Estimated long-term mean of a process in a control chart	X-Bar: Average time of 23 data points
Upper Control Limit: Top limit in control chart, above the centerline	X-Bar + z (MR-Bar/d2)
Lower Control Limit: Bottom limit in control chart, below the centerline	X-Bar – z (MR-Bar/d2)

Another opportunity statistical analysis provided was to identify whether the process variation was common or whether variation was assignable for the makeready process. In cases of assignable causes of variation, usually the operation requires a single action to correct variation, while common variation can be treated with process improvement methodologies.

Kaizen Event

The Kaizen event focused on uncovering ways to reduce makeready time for the platen die cutting operation. Time reduction, standardization, and best practices for the makeready procedure were the focus for the Kaizen event.

Focusing on key points of data during analysis was very important to the success of the Kaizen event. Rochester Institute of Technology's Center for Excellence in Lean Enterprise (CELE) provided the following forms to be used

during the Kaizen event in order to keep data organized for successful analyses (see Appendices B and C):

- Kaizen Event Schedule Form
- Kaizen Event Area Profile Form
- Kaizen Newspaper Form
- Set-up Observation Analysis Form
- Platen Die Cutting 5S Audit Form

<u>Kaizen Group</u>

The researcher developed a Kaizen group by selecting from a subgroup of available individuals who possessed diverse experiences and perspectives – upstream and downstream – from the operation, as well as individuals from within the platen die cutting department. According to Lean methodologies, it was essential that the workforce group contribute their expertise in order to extract best practices.

<u>Kaizen Event Schedule</u>

The researcher, work crew, supervisors, and company owners collaboratively determined the event schedule for the Kaizen. Day events were scheduled to occur once a week for five weeks. The Kaizen was conducted during working hours, and the individuals selected to participate in the Kaizen

were asked to be mentally and physically prepared as if they were attending a normal day of operation (see Appendix B).

Kaizen Event Area Profile

The Event Area Profile was constructed to summarize the important aspects of the Kaizen event and was documented in an Excel spreadsheet. These data provided a qualitative analysis for the Kaizen event by documenting information about the Kaizen team and Kaizen event schedule. The Event Area Profile form described the initial difficulties within the operation and listed the primary objectives for improving the platen die cutting makeready process. The Kaizen Event Area Profile (see Appendix B) form was constantly revised and developed with the latest version being exhibited to the Kaizen team, as the difficulties within the process were increasingly better understood.

Kaizen Newspaper

The Kaizen Newspaper was a visual display that conveyed the activities of change. The researcher used the Kaizen Newspaper form to notify Company DP's work environment of activities that were taking place during the Kaizen event. Information placed in the Kaizen Newspaper was displayed on a visual board within the production environment; this was necessary in order to keep the information flowing to all workers of the Kaizen event and to those outside of the event. Essentially, with the Kaizen Newspaper form, the researcher stated the problems of the platen die cutting operation, the objectives, countermeasures,

and individuals responsible for the countermeasures. The Kaizen newspaper also gave the anticipated due dates for completing the necessary countermeasure tasks before the Kaizen event ended. Keeping track of a task's progress was monitored within the team and the responsible personnel would confer a percentage of the task complete for each countermeasure (see partial of Kazien Newspaper in Appendix B).

Kaizen Blitz[3]

To ensure that the makeready analysis would be effective, the researcher and the Kaizen group assessed the needs of the production area by conducting a systematic 5S blitz and then the researcher performed a Makeready Blitz which included the development of a spaghetti-mapping diagram and the use of a video recording of the makeready process. Once all information of the makeready process was collected, the Kaizen group and the researcher conducted post-analyses to develop improvements for the makeready process utilizing Single-Minute Exchange of Die (SMED) techniques.

5SBlitz

The researcher initially analyzed the organization of the operation by utilizing the 5S concept of sort, straighten, shine, standardize and sustain. The researcher walked around the production area and conducted a 5S audit,

[3] Blitz is short for *Blitzkrieg* – German word for a sudden overpowering attack. In this context, Blitz refers to taking something apart and putting back together a better way.

relying on immediate perception and photographs of the production area to determine proper organization based on the following criteria: Sort, to distinguish between needed and not needed; Straighten/ Set, to organize for easy access, straighten up and put things away; Shine, to sweep, wipe-down, clean, and fix the equipment and production area; Standardize, to implement a standard procedure for sort, straighten, and shine; Sustain, to establish a leader or group of leaders for the program.

The 5S audit checklist (see Appendix C) was used to initially classify the production area with a zero to five basis scorecard (zero indicated "no activity had occurred" and five indicated "no sustained violations" within the area). Essentially, the researcher's 5S analysis addressed the elements listed on the 5S audit checklist. Once the 5S audit was completed, a 5S total score was assigned by the Kaizen team, to the production area and was noted in the Kaizen Newspaper and Area Profile Event form.

Makeready Blitz

The researcher assessed the makeready process with a spaghetti-mapping diagram and video recording. Information from the assessment was placed into the Setup Observation Analysis form (see Appendix B), which arranged the makeready tasks and categorized them as internal activities or external activities, according to the SMED technique. As with Advanced Medical Solutions in Winsford, Cheshire, U.K., the company utilized similar practices by

observing the actual makeready, conducting a spaghetti-mapping diagram to distinguish the operator's path, and evaluate potential opportunities for makeready improvement. This information was to be used to increase manufacturing flexibility by reducing long makeready times (DTI-Manufacturing Advisory Service, n.d.).

Spaghetti-Mapping Diagram. The current state map of the makeready process was captured through the use of a spaghetti-mapping diagram. During a live-makeready the diagram was populated by identifying steps used by the operator and then marking them, from the beginning to the end of the makeready process and the diagram exactly at the locations at which the operator performed them.

To complete the spaghetti-mapping diagram of the makeready process, the researcher constructed an illustration of the platen die cutting production area with a pencil and paper. Once steps were completed, the researcher numbered each step on the spaghetti-mapping diagram. During the analysis the spaghetti-mapping diagram captured eighty-one steps needed to complete the makeready process. The eighty-one steps were listed in a Set-up Observation Analysis form that was used to analyze the current makeready procedure step-by-step. To visually demonstrate the path, the researcher constructed the same production area in an Excel spreadsheet and traced the path by the number sequence as shown in Figure 3.

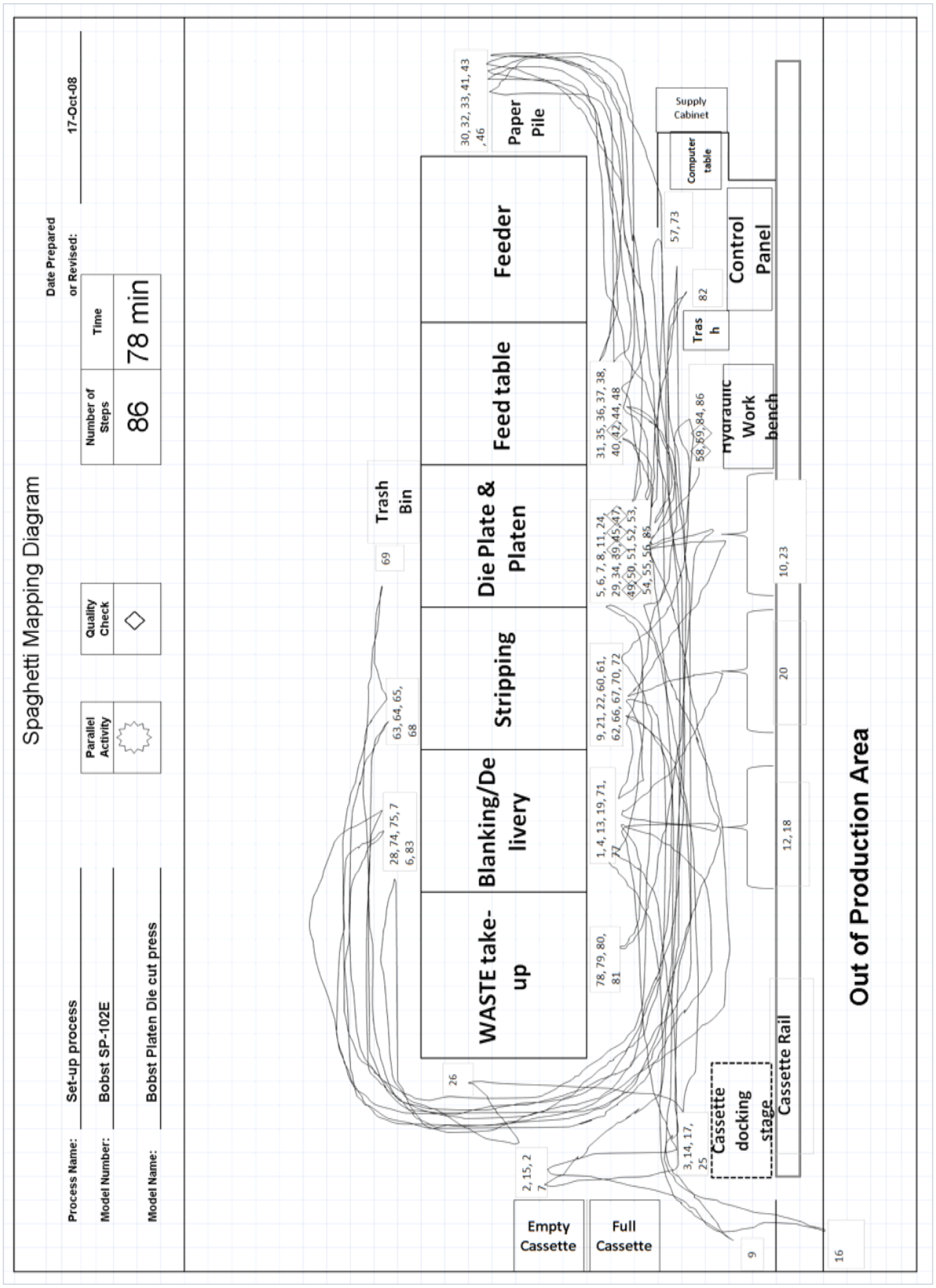

Figure 3. Current State of Workflow Spaghetti-Mapping Diagram

Video Recording. Video recording provided another method that captured data on the makeready process. The advantage to video recording was the built-in timer in the camera that provided accuracy in capturing the time that each step took. The Kaizen benefited during the analysis session with the operator who conducted the makeready because he was also a part of the Kaizen group and provided excellent post-analysis commentary. The operator worked concurrently with an assistant during the process, and the researcher recorded the parallel activities with a separate video recording device in order to have extensive data to scrutinize.

Set-up Observation Analysis Form. From the Spaghetti Diagram and Video Recording, the researcher used a Set-up Observation Analysis form to analyze the Makeready Blitz (see Appendix B).

The form was used to catalog the tasks and describe the actions for each step, while documenting the time to complete each step during the makeready. The Kaizen group, along with the researcher, collectively analyzed and developed various suggestions for improvement of the makeready process. The entire Kaizen group was responsible for implementing the improvements.

The Set-Up Observation Analysis form assisted in classifying the internal activities (IED) and external activities (OED) that were identified in the spaghetti-mapping diagram and video recording because these activities are commonly characterized when utilizing SMED techniques. Each task during the makeready

was defined under the acronym (F.A.S.T) developed by CELE to categorize each step within a process as seen in Table 6.

Table 6. F.A.S.T. Categorical Analysis

F – Foresight	Preparation of equipment, information, and other tools while machine is operating.
A – Attachment	Attaching necessary parts that the equipment requires to function properly.
S – Setting Condition	Setting and tuning of equipment to prepare the current project.
T – Trial Runs and Adjustments	Run-up of equipment to finalize makeready activities

Data Analysis

The data gathered during the Kaizen blitz was analyzed using Lean, SMED, and TPM tools and techniques to evaluate the makeready procedure for process improvements.

<u>Analysis of Machine and Process Effectiveness</u>

The researcher used the pareto chart, statistical analysis, and OEE metric to analyze the platen die cutting operation from November 21, 2009 through December 4, 2009. The pareto chart showed that makeready time was a

significant element to focus on, and statistical analysis, the Individual X Chart, was important in determining process stability. The researcher focused on improving the makeready process with improvements that could be measured indirectly through the OEE metric, which emphasized improving machine availability, performance, and quality output with process improvement methodologies.

5S Analysis

The initial assessment with the 5S audit created a starting point for the Kaizen event. The 5S carefully identified every shelf, cabinet, wall/shadow boards, sign, floor marking, equipment, tool, and visuals based on the 5S audit form. Continued effort to maintain 5S in the production area was essential even after the Kaizen event was completed. A Platen Die Cutting 5S audit was formulated to sustain the 5S initiative (see Appendix C).

Makeready Analysis

The objective of the makeready analysis was to assess inefficient tasks within the makeready process during a real-time analysis. Opportunities to collect specific data pertaining to the makeready process were achieved during the spaghetti-mapping and video recording. Information about the process was analyzed in greater detail with the use of Setup Observation Analysis form.

Makready Checklist Form. The information for the Makeready Checklist was the result of scrutinizing the current makeready process using the Setup Observation

Analysis form. The Makeready Checklist form was used to describe each process task, in numerical sequence (first task to last task), from the initial makeready observation. The list noted the standard time to execute each task, labeled as either an internal or external (I/E) activity, and indicated who was responsible for accomplishing the task during the makeready process (O – Operator; BT – Back tender/ Assistant; Both – Operator and/ or Backtender/ Assistant). The Kaizen group analyzed the procedures within the makeready and focused on the removal of excessive motion and the conversion of internal activities (IED) to external activities (OED).

Once the improvements had been confirmed and documented, a second checklist was developed to revise the original checklist for the platen die cutting makeready process. The Makeready Checklist form became a template for standard operating procedures for the makeready process. The form would also assist workers in determining whether they are ahead or behind in the makeready process by providing specific time duration points of reference when conducting makeready procedures (see Appendix C).

The methodology that was used during the Kaizen event was developed specifically for Company DP's platen die cutting operation. The Kaizen event identified the tools and techniques most commonly used for makeready process improvements and the data obtained was used to create decision opportunities to improve the platen die cutting makeready process.

Chapter 7

Results and Discussion

This section discusses the research results from the pareto chart, the Individual X Chart statistical analysis, and the OEE for the die cutting operation. The results also consider the improvements to the makeready process from the Kaizen event with the use of the 5S audit (Sort, Straighten, Shine, Standardize, and Sustain), the spaghetti-mapping diagram, and the video recording.

Overall the Kaizen event was successful in providing a better understanding of the makeready process, while also demonstrating opportunities for time reduction and simplification to the makeready process.

Machine and Process Effectiveness Analysis

From the data that was gathered during the November 21, 2008 to December 4, 2008 production period, a pareto chart was constructed to reveal the overall production time breakdown.

Pareto Chart

The pareto chart identified 4 categories of downtime where the makeready provided the greatest opportunity to reduce categorical downtime in order to increase run time. The makeready procedure is a necessary element of the

platen die cutting operation and approximately 32 percent of overall production time was spent in the makeready (MR) procedure (Figure 4).

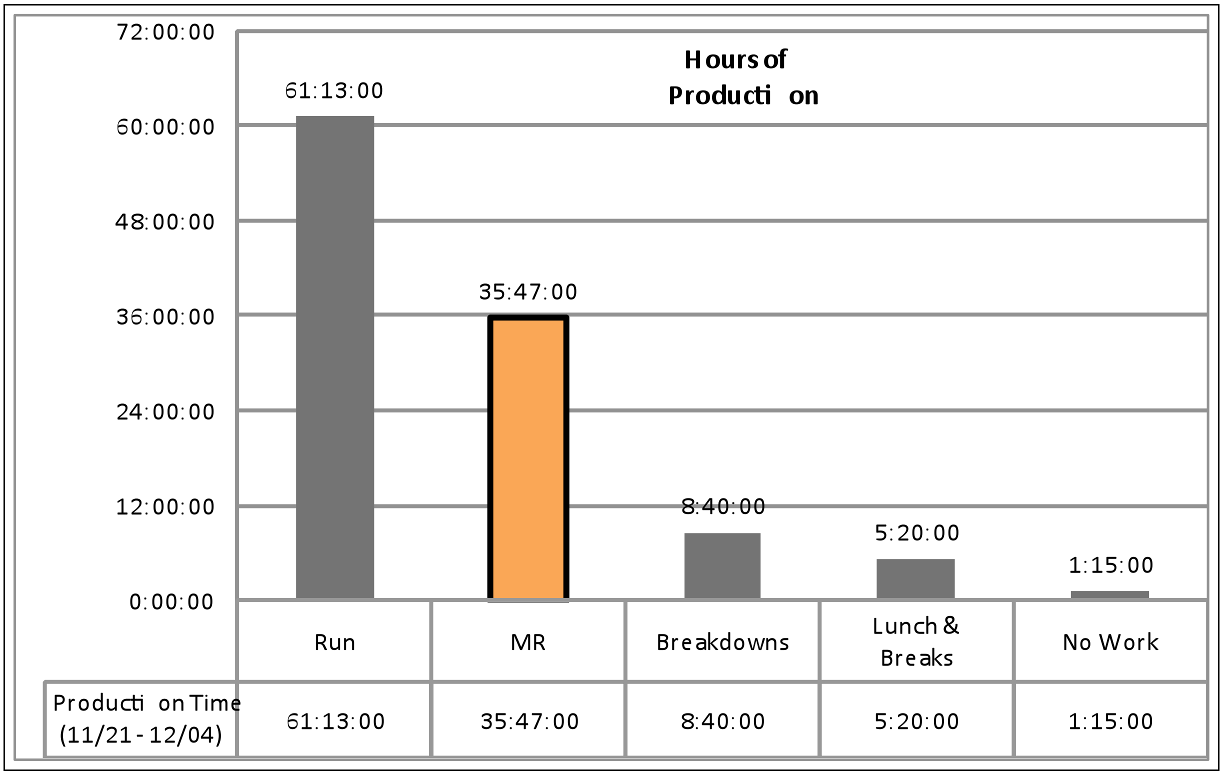

Figure 4. Production for Platen Die Cutting (11/21 - 12/04)

<u>Individual X Chart</u>

The Individual X Chart displays single-unit group measurements for the makeready time of 23 data points. The results of the Individual X chart indicated that the makeready process does not conclusively reveal a significant source of variation around the sample mean of 1.50 (1 hour 30 minutes)

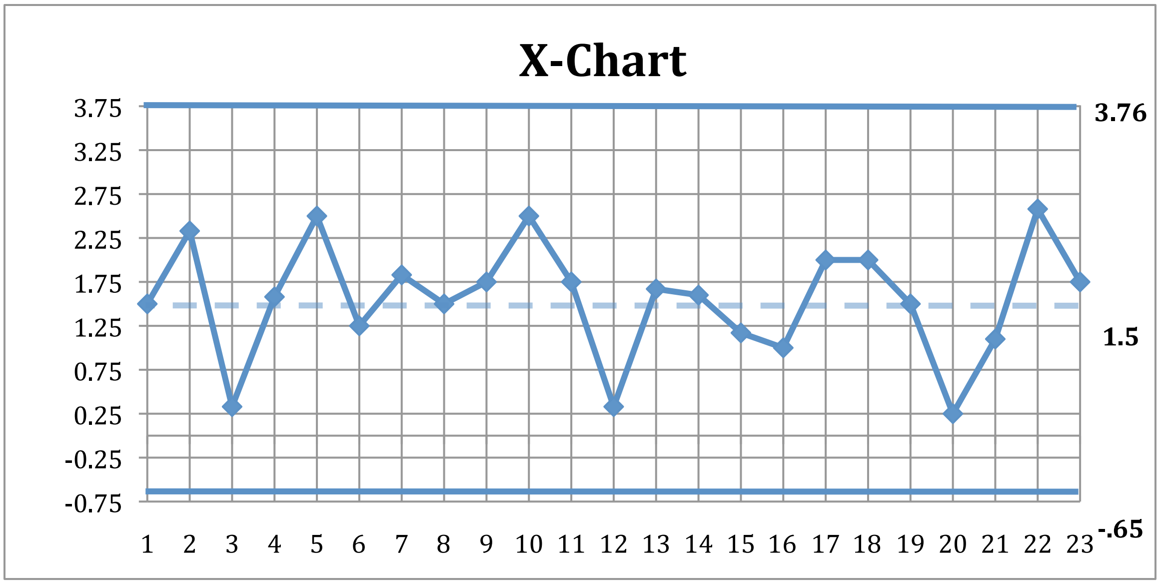

Figure 5. X-Chart Makeready Analysis

Figure 5 shows the X Chart makeready analysis of 23 data points. The Upper Control Limit (UCL, 3.76) and Lower Control Limit (LCL, -.65) were set at +/- 3 standard deviations from the Centerline (Mean, 1.50). The researcher used these control limits to determine whether the makeready process was within the standard normal curve. The makeready data points are shown in Table 7.

Table 7. Data Collection of 23 Makereadies (MR)

MR	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Data	1.5	2.33	.33	1.58	2.5	1.25	1.83	1.5	1.75	2.5	1.75	.33
MR	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	
Data	1.67	1.6	1.17	1	2	2	1.5	.25	1.1	2.58	1.75	

Discussion of OEE

The OEE metric was calculated for the production period November 24, 2008 to December 13, 2008 (see Appendix C). The OEE calculation multiplied three factors: Availability, Performance, and Quality. The initial OEE data set contained twenty-three makeready time samples and the OEE results are as follows:

- Availability = 57.9 percent
- Performance = 40.8 percent
- Quality = 99.9 percent
- Total OEE = 23.6% (which was significantly below industry average).

Theoretical Results. Results from the Kaizen event indicated that makeready directly affected the availability of time production time during the platen die cutting operation, an increase to availability could directly increase the makeready for the platen die cutting operation.

A comparison was made between the initial Availability and the Theoretical Results of an improved OEE as seen in Table 8.

Table 8. Comparison Results of Availability and OEE to Makeready Improvements

	Availability	**OEE**
Initial Result	57.9 %	23.6 %
Improvement Results	75.2 %	30.7 %

The overall makeready time during the two-week production period was 35 hours 47 minutes. With the use of SMED techniques, a possible 18 hours (or 51 percent) of makeready time could be isolated and improved in order to increase machine Availability.

Table 9 shows a completed Theoretical Analysis of OEE with Availability, Performance, and Quality affected by the changes.

Table 9. Overall Equipment Effectiveness Comparison Analysis

	Before	After
Total Time	112:15:00	112:15:00
Planned Downtime	6:35:00	6:35:00
AVAILABILITY		
Running Time	105:40:00	105:40:00
MR	35:47:00	17:32:02
Operating Time	69:53:00	88:07:58
Planned Availability	66.1%	83.4%
Breakdowns	8:40:00	8:40:00
Net Operating Time	61:13:00	79:27:58
Uptime	87.6%	90.2%
AVAILABILITY (A)	57.9%	75.2%
PERFORMANCE		
Expected Production	428540	428540
Actual Production	174961	174961
PERFORMANCE (P)	40.8%	40.8%
QUALITY		
Waste Sheets	91	91
Quality Sheets	174870	174870
QUALITY (Q)	99.9%	99.9%
OEE (AxPxQ)	23.6%	30.7%

With a 51 percent reduction to makeready time, OEE is still below ideal industrial average ranges of 40 percent. Quality is at an optimal rate of 99 percent but with the increase to Availability improvement to OEE is realized. Performance is an area that was not directly impacted by the platen die cutting makeready improvements. Further investigation would be needed to determine the improvements necessary to increase equipment productivity.

Platen Die Cutting 5S Results

From the initial 5S Audit, the researcher and Kaizen group distinguished what was needed and not needed in the production area for the platen die cutting operation. Results from the 5S blitz significantly optimized the production flow in the platen die cutting production area by removing the unnecessary items and keeping only the required tools, equipment, supplies, and information that are essential during platen die cutting production.

Figure 6 illustrates the before and after condition of a supply cabinet illustrating the need to keep on hand only necessary supplies. The cabinet was completely emptied and only the necessary items for the platen die cutting operation were retained and then organized in the cabinet.

Figure 6. 5S Process, Before (left) and After (right) of Supply Cabinet

The cabinet items were replenished by an individual in purchasing; consequently, the responsibility for sustaining the cabinet inventory was placed within the purchasing department. Information on replenishing supply items would be communicated to the purchasing department as directed in the policy for Company DP.

The researcher along with the Kaizen group developed an idea to place machine tools (allen wrenches, knives, mallets, etc) on the platen die cutting machine itself; tools were labeled and color-coded orange, in order to increase visual identification. Figure 7 illustrates a before and after result of the organization of tools on the platen die cutting machine.

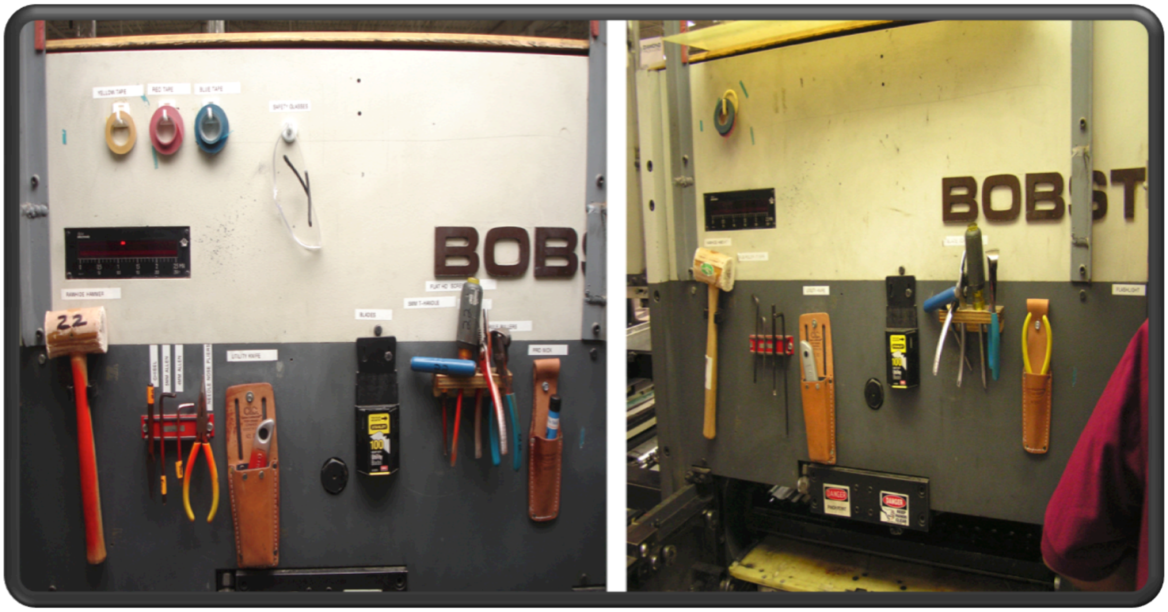

Figure 7. 5S Process, Before (right) and After (left) of Machine Tools Operator Side

The orange-colored tooling clearly showed that the tools belong in the platen die cutting area, thus serving as a visual stimulus to keep the tools in that production area. Previously, tools were often borrowed and never returned to their proper location.

The method of organizing this system for tools was to list each required tool needed in the operation. The platen die cutting operator produced a list, and the tools were brought together and painted orange. Magnetic strips were placed on the machine at each position where the tool would be within an arm's distance reach for the operator. Once the tools were set in their proper position, each tool

name and size were listed on the Platen Die Cutting 5S Audit list in order to standardize the location of the tools.

The platen die cutting workbench was another area of concern during the 5S. During the Kaizen event, the researcher and Kaizen group identified that the die cutting workbench was very cluttered and disorganized. The application of the 5S methodology was applied to the workbench, as seen in Figure 8.

Figure 8. 5S Process, Before (left) and After (right) of Workbench

Modifications to the workbench were to convert the flat surface into an inclined easel platform. During a discussion with the operator, he commented that the workspace was limited in size and maintaining the area's organization during production was becoming increasingly difficult. The operator, along with

the Kaizen group, proposed to redesign the workbench area. The workbench platform was completely cleared and an in-house carpenter collaborated with the operator and discussed the exact specifications for the easel. The easel was such an improvement to the workbench area that it became a standard feature for other production areas at Company DP.

Maintaining 5S Results.

The Platen Die Cutting Audit form was developed to sustain the 5S initiative. The audit assisted by continually removing the unnecessary items and keeping the production environment intact post-Kaizen event. It was suggested that the 5S platen die cutting audit would maintain an ongoing score, and the result of each audit would be placed on a communication board within the production area so management could monitor results. The responsibility for maintaining the 5S audit would be assigned to the platen die cutting work crew and its supervisor.

Platen Die Cutting Makeready Analysis

The researcher used statistical analysis, video recording and a spaghetti-mapping diagram to reveal improvement opportunities for the platen die cutting makeready process.

Spaghetti-Mapping Diagram

The Kaizen Group and researcher used spaghetti-mapping diagrams to identify opportunities for developing a standard procedure that minimizes excessive motion and increases predictable motion within the makeready process. Figure 9 illustrates the possible reduction of excess motion. Improvements were experienced as a result of the spaghetti-mapping, because the makeready process would now have a specific procedure from start-to-finish. This would create predictability during makeready and reduce excessive motion by the operator.

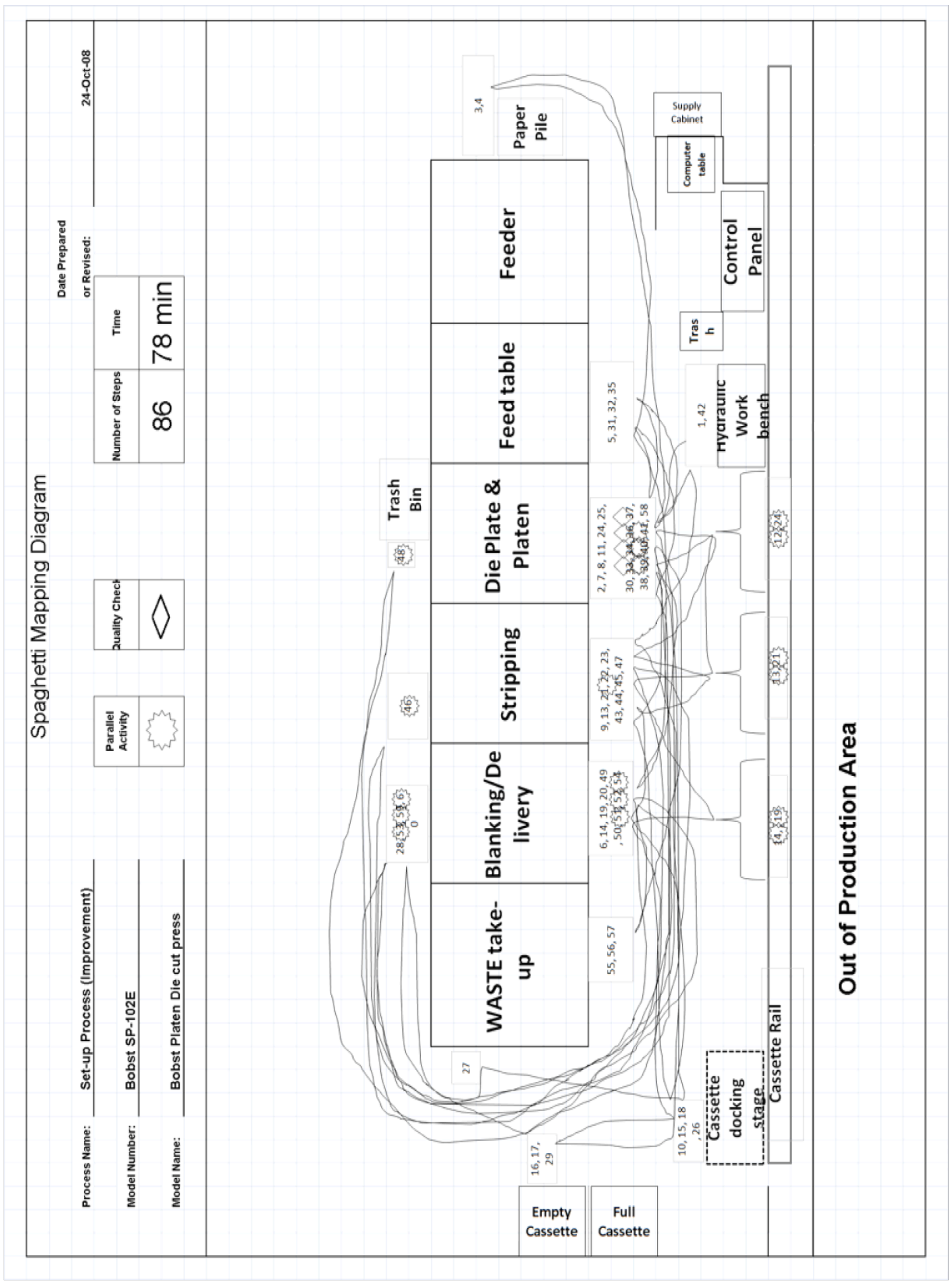

Figure 9. Reduction Path of Makeready Process, Spaghetti-Mapping Diagram

The improvement results to the process were identified by the elimination, combination, or re-sequencing of makeready process steps, which had a direct effect on smoothing the makeready process workflow. For example, Table 10 shows an improvement to the distance traveled during the makeready, which was reduced by 13.75% or 1,380 feet, from the original distance of 1,600 feet. The excessive motion analyses identified 220 feet of unnecessary motion by the operators during the makeready process.

Table 10. Distance Traveled during Makeready

	Initial Analysis	**Post-Analysis**
Walking Distance during Makeready (ft)	1,600	1,380

The second improvement results were classified as directional improvements. Essentially, the researcher and Kaizen group recognized a consistent and steady workflow that could reduce excessive motion during the process. With such information, the implementation of new procedures had the ability to moderate the workflows direction, by where an operator begins tasks on one side of the press and the assistant complements by working on other tasks from the opposite side of the press. When needed, the two can join efforts in a congruent workflow.

Video Recording Observation Analysis

The video of the makeready process lasted approximately 78 minutes 9 seconds within the makeready process requiring 86-steps (see Appendix C).

The post-analysis discussion of the video recording identified a reduction in makeready time by 40% which translated to a need for 40 minutes to accomplish the entire makeready procedure. Previously, over 78 minutes were needed. Results also reduced the steps in makeready process from 86 to 61 steps, as seen in Table 11.

Table 11. Makeready Analysis

	Initial-Analysis	**Post-Analysis**	**% Improvement**
Makeready Time	00:78:09 minutes	00:40:00 minutes	51%
No. of Makeready Steps	86 steps	61 steps	29%

Discussion of Video Recording Improvement

The researcher identified an opportunity to increase parallel activities during the makeready. During the post-analysis discussion, the Kaizen group and researcher brainstormed over the makeready procedure according to the principles of SMED in order to convert internal activities to external activities and develop opportunities to increase parallel activities.

Essentially, the improvement would require two individuals working in parallel activities 88.75 percent, whereas the original makeready was done primarily by one worker and only conducted parallel activities 29 percent of the time. The application of converting internal activities to external activities and the use of parallel activities resulted in significant improvements to the makeready process.

Figure 10 displays the Initial Analysis against the Post Analysis. The graph is separated into three sections: Operator, Assistant, and Parallel Activities; these sections represent the division and union of labor that were required to perform the makeready procedure.

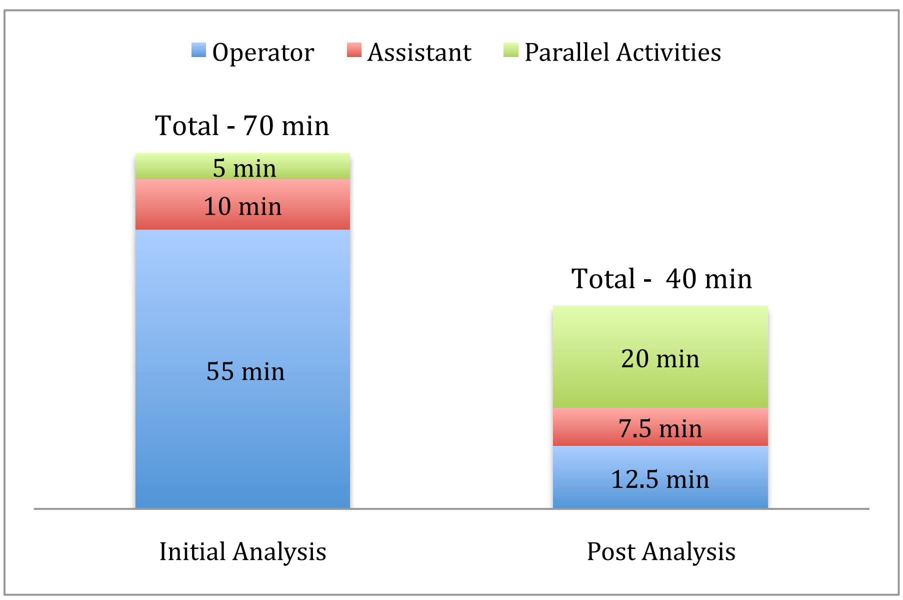

Figure 10. Balance Chart for Makeready Activity, Initial and Post Analysis

During the Initial Analysis the majority of tasks were performed by the Operator (55 minutes) and the minority in parallel activity (5 minutes). In the Post Analysis, the majority of tasks were performed in union with parallel activities (20 minutes) and the minority by the assistant, performing individual task for 7.5 minutes. As illustrated, Post Analysis makeready activity demonstrates significant improvements by incorporating a blending of abilities with the Operator and Assistant.

The Kaizen event results provided an array of information which was useful in analyzing the platen die cutting makeready process. Identifying operator's procedures was important in collaborating improvement opportunities for each task because required time spent in each makeready function was critical in successfully processing job makeready. Statistical analysis provided an objective analysis that assisted the research into promoting further examination of parallel activities. Overall, theoretical improvements to makeready procedure was realized with a 30 minute reduction in overall makeready time.

Chapter 8

Summary and Conclusion

Process improvement methodologies had an effect on the makeready process by reducing excessive motion and improving procedures resulting in greater predictability during the makeready workflow. Improvements to the makeready were instantaneously realized with the 5S initiative which removed the first layer of waste from the operation, and the spaghetti-mapping diagram and video recording were other important steps in documenting, categorizing, and placing a time on each task, thus preparing the platen die cutting operation for continuous improvements.

This information from the Kaizen event provided greater understanding of the operation and essentially resulted in discarding traditional ideas that sustained excessive motion during the platen die cutting makeready procedure. Results of the post-analysis demonstrated unquestionable improvement to the makeready procedure, particularly with parallel activities between the platen die cutting operator and the assistant.

Testing the makeready improvements was not possible because during the last days of the Kaizen event, Company DP had experienced a significant drop in production. As a result, members of the Kaizen group were not made

available for completing the project and for maintaining leadership beyond the study. The Kaizen event did reveal numerous opportunities that are still applicable to the platen die cutting operation, and from the theoretical analysis improvements during the study were achieved.

Usefulness of Methodology

Implementation of the researcher's methodology is designed for live-production analysis of a work environment. The Kaizen forms were used specifically for the platen die cutting operation, but these documents may be useful for other operations in the print manufacturing environment.

5S (Sort, Straighten, Shine, Standardize, and Sustain)

Initiating the 5S process to remove the unnecessary elements within the production area was an essential portion of the research during the Kaizen event. Improvements would not have been possible without sorting, straightening, shining, standardizing, and sustaining the platen die cutting operational environment. Once the 5S was performed in the platen die cutting production area, it was essential to develop a method for maintaining it in the future. The 5S removed the first layer of waste, but sustaining it was a key factor for the improvement initiative.

Makeready

The SMED methodology was the primary technique for reducing the time required for the makeready process. The spaghetti-mapping diagram was a useful tool, which allowed the researcher to identify excess motion during the makeready process. The analysis of the video recording assisted in refining the makeready process by converting internal activities to external activities and incorporating much needed parallel activities. During the post analysis, the SMED techniques revealed significant reductions in the time needed in makeready process. The Kaizen forms (Makeready Checklist form and Setup Observation Analysis form) were developed by CELE and were an essential part in the improvement initiative. The forms provided increased understanding of tasks, classification of tasks, and assignments for completion-time of tasks during the brainstorming and scrutinizing period of the Kaizen event.

OEE was a useful metric to reference improvements within the platen die cutting operation, from the initial measurement to the post analysis measurement. The researcher estimated that improvements to the makeready process would have a direct effect on the Availability proportion of the OEE metric.

The Availability metric in the initial analysis of the operations was 57.9%. Based on 16 hours of daily production, the platen die cutting press was available for 9.26 hours of the working day. From the calculation, it was determined that

the machine manufactured at less than half the Original Equipment Manufacturer's (OEM) predicted speed. Due to the age and usage of the equipment an assumption can be made that the equipment was not capable of manufacturing at the specified OEM rate of 7,000 impressions per hour. Verifying this assumption could be a case for further research. Once the OEE metric is established, a daily measurement should be measured in order to identify any problem areas that immediately affect the operation.

Recommendations for Further Studies

The study analyzed only the actual production times and did not assess the financial metrics to determine Lean benefits through cost reduction (Smalley, 2004, ¶1). Further research could investigate the annual dollar amount of makereadies and then determine the difference between the initial analysis and the post analysis improvement. This information could be used to derive the financial savings from the improvement initiative and calculate cost of poor quality as an addition to the financial assessments.

A specific financial assessment could focus on the dollar amount that is returned from implementing process improvements to the operation. For various process improvement events, certain investments are made to facilitate each event, such as the Facilitator's fee; employee's hourly wages to participate in the Kaizen event; investments for new equipment, and training. The solutions and results from the events could be analyzed through the company's Return on

Investment (ROI) policy to determine whether the process improvement is significant. This research could be very important, especially with companies that are inclined to purchase new technology in order to improve the older manufacturing rates of older equipment.

This research was essentially a collection of three methodologies: The Lean methodology which embodies the methodologies of SMED and TPM. These techniques were used as the principles for the study. It would be of interest for future research to compare strictly the SMED methodology with the TPM methodology as independent entities and identify deficiencies in each. It may also be useful to identify where the two are complementary to each other. An important analysis would be to analyze the subtle differences that exist between SMED and TPM.

The idea for this research was to identify methods that could be used to guide production improvement efforts in print manufacturing. Utilization of process improvement principles at Company DP could lead to undertake further implementation in the near future.

Bibliography

Art of Lean. (2004). Eiji Toyoda on the Roots of TPS. In *Art of Lean* [TPS History Article]. Retrieved February 28, 2009, from http://artoflean.com/files/Eiji_Toyoda_On_The_Roots_of_TPS.pdf

Bodek, N. (2005, October). Lean Manufacturing. *Mold Making Technology*, mmt columns. Retrieved December 26, 2008, from http://www.moldmakingtechnology.com/articles/1005lean.html

Buonomo, V. (2008, September 29). *Lean Training & Kaizen Preparation*. PowerPoint Presentation presented at Diamond Packaging, Rochester, New York.

Caldwell, K. (2008, November). Managing Outcomes in a Lean Enterprise. *Quality, 47*(11), 40-41.

Cooper, K., Keif, M. G., & Macro, K. L., Jr. (2007). *Lean Printing: Pathway to Success*. Pittsburgh: PIA/GATF Press.

Cross, L. (2000, November 1). Turbocharging Job Turnaround. *Graphic Arts Online*. Retrieved March 1, 2009, from http://www.graphicartsonline.com/article/CA54164.html?q=Turbocharging+Job+Turnaround

Cross, L. (2001, June 1). Honing Manufacturing Strategies. *Graphic Arts Online*. Retrieved January 3, 2009, from http://www.graphicartsonline.com/article/CA89916.html?q=Honing+Manufacturing+Strategies

Davis, A. G. (Ed.). (2006, June). *Eliminate Non-Value Added Effort Through Lean Manufacturing*. Retrieved January 5, 2008, from http://www.qcinspect.com/article/lean_mfg.htm

Dodd, D. G. (2008a, July 17). Expert Row. *What They Think*. Retrieved September 11, 2008, from http://members.whattheythink.com/expertrow/080717dodd-the-leaning-of-Print.cfm

Dodd, D. G. (2008b, July 31). Expert Row. *What They Think*. Retrieved September 10, 2008, from http://members.whattheythink.com/expertrow/080731dodd.cfm

Durkalski Hertzfield, E. (2008, May/June). Exclusive Census Report 2008: Board Converters Are Feeling Gloomier This Year. *Paperboard Packaging*, 16 - 26.

Farris, J. A., Van Aken, E. M., Doolen, T. L., & Worley, J. (2008, September). Learning From Less Successful Kaizen Events: A Case Study. *Engineering Management Journal, 20*(3), 18-20.

Greif, M. (1991). *The Visual Factory* [The visual factory: building participation through shared information] (Les Editions d'Organisation, Ed., L. Lockwood, Trans.). Portland, Oregon: Productivity Press, Inc. (Original work published 1989)

Howard, N. (2009, January 12). *Conversation with Howard Graphics*. Phone Conversation presented at NA, NA.

International Organization for Standards. (2008, March 25). Definitions. In *Information Centre* [Standards and Regulation]. Retrieved December 30, 2008, from Standards and Regulations database: http://www.standardsinfo.net/info/livelink/fetch/2000/148478/6301438/standards_regulations.html

Japan Institute for Plant Maintenance. (1989). *TPM Development Program: implementing total productive maintenance* (S. Nakajima & B. S. Blanchard, Eds.). Massachusetts: Productivity Press. (Original work published 1982)

Jewell, E., Wells, N., & Claypole, T. C. (2005, September). A Study of Maintenance Practice in the Printing Industry. In *Technical Association of Graphic Arts* (Rep. No. 50426, pp. 426-438). Sewickley, PA: Technical Association of the Graphic Arts.

Kelly, S. (2003, August 12). Lean Enterprise: Getting Lean from Manufacturing to Selling. *WhatTheyThink*. Retrieved February 27, 2009, from http://members.whattheythink.com/specialreports/030812kelly.cfm

Kilpatrick, J. (Ed.). (2003). *Lean Principles*. Retrieved September 28, 2008, from http://www.mep.org/textfiles/LeanPrinciples.pdf

Koltzenburg, T. (2004, August 1). The Latitudes of Lean. *American Printer*. Retrieved January 1, 2009, from http://www.americanprinter.com/mag/printing_latitudes_lean/index.html

Lane, G. (2007). *Made-To-Order Lean: excellence in a high-mix, low-volume environment*. New York: Productivity Press.

Liker, J. K. (2004). *The Toyota Way*. New York: McGraw Hill.

Liker, J. K., & Meier, D. (2006). *The Toyota Way Fieldbook*. New York: McGraw Hill.

McIntosh, R., Culley, S., Gest, G., Mileham, T., & Owen, G. (1996). An assessment of the role of design in the improvement of changeover performance. *International Journal of Operations & Production Management,* *16*(9), 5-22.

Miller, J. (1998). Role of the Kaizen Blitz in a Lean Enterprise Transformation. In *New at Gemba* [Recent Articles]. Retrieved March 9, 2009, from http://www.gemba.com/uploadedFiles/Appendix%20C%20-%20The%20Role%20of%20Kaizen%20Blitz%20in%20Lean%20Enterprise%20Transformation.pdf

O'Brien, K. (2006, July 1). Going with the Flow. *American Printer*. Retrieved January 2, 2008, from http://americanprinter.com/mag/printing_stitch_time_2/index.html

Pfaff, M. R. (2002, January 1). Time is Money. *Packaging-Online.com*. Retrieved March 1, 2009, from http://www.packaging-online.com/paperboardpackaging/Industry+Report/Time-is-Money/ArticleStandard/Article/detail/5998?searchString=Time%20is%20Money

Purdum, T. (2006, August 1). Lauren Manufacturing Embraces A Lean Environment To Compete. *Industry Week*. Retrieved January 6, 2008, from http://industryweek.com/ReadArticle.aspx?ArticleID=12309

Rizzo, K. (October 26, 2008). Boosting Pressroom Performance Using Lean Tools. In *Graph Expo*. Chicago, IL.

Sim, K. L., & Rogers, J. W. (2009, January). Implementing lean production systems: barriers to change. *Management Research News, 32*(1), 37-49. Retrieved March 1, 2009, from www.emeraldinsight.com/0140-9174.htm

Shingo, S. (1985). *A Revolution in Manufacturing: The SMED System* (A. P. Dillon, Trans.). Cambridge, Massachusetts and Norwalk, Connecticut: Productivity Press.

Smalley, A. (2004). TPS versus Lean: Additional Perspectives. In *Articles* [Internet Articles]. Retrieved February 28, 2009, from http://artoflean.com/documents/pdfs/TPS_versus_Lean_additional_perspectives_v3.pdf

Smith, M. (2008, March 1). Process Optimization — Makereadies Mean Money. *Printing Impressions*. Retrieved December 31, 2008, from http://www.piworld.com/article/process-optimization-and-8212-makereadies-mean-money-92388_1.html#

Summers, D. C. (2006). *Quality* (4th ed.). New Jersey: Pearson. (Original work published 1997)

Tapping, D., Luyster, T., & Shuker, T. (2002). *Value Stream Management: Eight Steps to Planning, Mapping, and Sustaining Lean Improvements*. New York: Productivity, Inc.

Vorne Industries. (2002). Fast Guide to OEE. In *OEE Downloads* [PDF]. Retrieved March 12, 2009, from http://www.oee.com/pdf/fast-guide-to-oee.pdf

Whalen, G. J. (2001, February 1). You Want It When? *Packaging-Online.com*. Retrieved January 1, 2009, from http://www.packaging-online.com/paperboardpackaging/Industry+Report/You-Want-It-When/ArticleStandard/Article/detail/31867?searchString=You%20want%20it%20when?

Witzig, P. (2006, July 1). Make the Best of Makeready Time. *Packaging-Online.com*. Retrieved January 1, 2009, from http://www.packaging-online.com/paperboardpackaging/article/articleDetail.jsp?id=358405&searchString=Make%20the%20Best%20of%20Makeready%20Time

Womack, J. P., & Jones, D. T. (2003). Introduction: Lean Thinking versus Muda. In *Lean Thinking: Banish waste and create wealth in your corporation* (pp. 15 - 90) [Introduction]. New York: Simon & Schuster. (Original work published 1996)

Womack, J. P., Jones, D. T., & Roos, D. (2007). *The Machine that Changed the World*. New York: Simon and Schuster. (Original work published 1990)

Ynostroza, R. (2000, December 1). Some Compelling Views from Line Managers. *Graphic Arts Online*. Retrieved January 2, 2009, from http://www.graphicartsonline.com/article/CA55228.html?q=Some+Compelling+Views+from+Line+Managers

Appendix A

Kaizen Event Forms

Appendix A: Description of Equipment and Process

Platen Die Cutting Press

The platen die cutting press (Bobst SP-102E) requires cutting dies, stripping tooling, blanking tooling, and printed materials.

Bobst SP-102E Process

The Bobst SP-102E platen press operates by lifting the substrate pile load up to the feeder and then stream-feeding press sheets onto the registration table. In-feed registration is achieved on press with the lead and side-guide edge lining up the sheet on the press head stop and operator side edge. Once the sheet is registered, it receives a die-cut or a crease-score in the platen section. The sheet passes through the stripping section where the sheets internal waste, side waste, and rear waste are removed into a trash-bin. The sheet then enters the blanking section where the carton-blank[4] is separated from the press sheet and is simultaneously piled up individually onto a wooden pallet in the delivery section of the press.

[4] Carton-blank is an individual carton that converts into a foldable box formed from paperboard.

Tooling and Equipment

The tooling required for the Bobst SP-102E platen die cutting press is separated into three sections on the press. The three sections are the platen section, the stripping section, and the blanking section. The platen section receives the die, while each of the other sections requires specific tooling equipment that is designed to manufacture the product properly.

Platen Section. The platen section receives a die, which is inserted into the platen area along with a metal counter plate. The die board is made up of two solid 5/16”x28”x40” lumber boards of either maple wood or rayform composite material. The pieces are glued together and then compressed to form one solid die board held in a metal-chase frame. The die knives and rules are constructed by automated cutting equipment, in which the carton blank design layout data are transferred to a Gerber table cutter through Artios CAD© software. The die board is then sawed to the exact specification to receive the cutting rule and/or a crease-score rule from the grooves that the table saw creates. The metal-rule heights and thicknesses vary based on caliper of stock and complexity of the structural design. Once the platen die is successfully manufactured, it is then paired with a metal counter plate.

During the operation, the platen section receives a sheet from the feed table and centers the sheet onto the platen section. The die impacts the material to stress (the impact breaks the joining fibers of the material) the carton board to

improve the cut through the material according to the carton blank shape from the die. The sheet then horizontally passes to the next section of the press.

Stripping Section. Typically the platen die cutting press requires tooling for the stripping section. This tooling removes paper-waste from within the sheet, on the side of the sheet, and from the rear of the sheet.

Stripping tooling is made up of two opposite facing frames with rails running across the frame with metal fingers that are locked onto rails and positioned to strike the paper-waste areas on the press sheet. The substrate enters the stripping section from the platen section. Simultaneously the upper and lower frame strips the material and breakaway waste from the sheet into a trash-bin and then delivered the press sheet horizontally to the blanking section.

Blanking Section. The carton blanks are held together by what is left of the original press sheet, but once the stripping section has eliminated waste, the sheet passes into the blanking section, and the carton blanks are impacted, detached from the sheet, and simultaneously piled individually. Tooling for the blanking section requires an upper protruding tool frame and a lower receiving tool frame. The upper tooling is a replication of the actual carton blanks cut-out as mentioned previously the carton blanks are piled onto a pallet.

Waste take-up section. The final section in the platen die cutting press is the waste take-up. This section does not require special tooling, only a conveyor belt and trash take-up wheels which transport the remaining waste press sheet into

the recycling bin. Once the carton blank has been removed from the original sheet, the waste take-up section processes the skeleton (name given for remains of press sheet, post blanking section) of the sheet and carries the skeleton onto a conveyor, and then delivers it to the trash-receptacle for recycling.

Makeready Process

Makeready on the platen die cutting machine is considered necessary downtime used to exchange tooling (stripping and blanking equipment), die (cutting or creasing rule die and counter plate), materials (printed materials), and information (job information) from one job-project to another. The downtime measurement of a makeready begins from the last-sellable sheet (product that meets quality objectives) from one job, to the first-sellable sheet of the next job. The process for on-press makeready is accomplished by performing necessary functions, which remove one project's equipment, materials, and adjustments and replace them with those for the subsequent project.

The operator begins makeready by removing the upper and lower tooling frames from each section (platen, stripping, and blanking) of the platen die cutting press. Removed tooling is now replaced with new tooling. Although the waste take-up section does not require tooling, it is adjusted to receive the sheet skeleton for delivery to the trash-receptacle correctly.

The new project's material is placed into the feeder load section, and adjustments are made on the feeder according to the characteristics of the substrate (the base material used for carton converting). Adjustments on the feeder load section consist of centering the material load and adjusting the air-suction pick-up, the air-blast and the feeder back-end guide. Setting the side-guide and in-feed registration occur on the feeder table, which is located between the feeder load section and the platen section of the press.

Additional adjustments to the press are the alignment of the continuous feed swords. The swords are positioned directly below the waste take-up section. Their function is to travel horizontally in the opposite direction from their set position toward the blanking section right under the sheet. They hold the carton blank piles while a new pallet replaces a complete pallet in order to maintain a continuous operation.

Appendix B

Kaizen Event Forms

Appendix B: Kaizen Event Forms

Table 12. Kaizen Event Description

Type of Event	Description
Formal Introduction to Lean manufacturing	*Day 1.* Training, educating, and understanding Lean principles. A combination of lecture and discussion is used to enhance knowledge of the following topics: 5S, SMED, TPM, and Visual Management.
5S & Safety Audit, On-floor analysis, Brainstorming	*Day 2.* Perform audits to identify improvements and address operator's frustration. Utilizing continuous improvement tools and techniques to apply into the platen die cutting operation. The group considers the upstream and downstream operations that flow through the platen die cutting operation and suggest changes to improve workflow. Video analysis, photographs and spaghetti mapping to flesh-out existing makeready process.
Prep stage with Breaking down issues, counter measure, task list for execution	*Day 3.* Information from on-floor analysis is broken-down to describe problems and suggest counter-measures. Follow-up strategy is developed and members of the group are given a list of "to-do" actions items to successfully achieve the implementation stage.
Implementation stage of improvements for makeready on platen die cutting operation	*Day 4.* The group implements the new makeready process. The majority of this day is used to train and conduct the new procedures for makeready.
Evaluation of improvement process, follow up with revisions to Standard Operating Procedures (SOP), and presentation of action plan to company leaders	Day 5. Disclosure of improvements is presented company leaders. A formal presentation to company leaders is conducted. Company leaders are asked to engage in order to sustain momentum. SOP's can be revised. Kaizen team leader will provide closing remarks and acknowledge team.

Table 13. Kaizen Event Area Profile

CELE Center for Excellence in Lean Enterprise

CENTER FOR INTEGRATED MANUFACTURING STUDIES

Kaizen Event Area Profile

Team # : Company DP

Event Description:
Decrease make ready times on diecutting machine #22 and standardize the processs

Event Dates:
November 3-4, 2008

Preliminary Objectives:
Decrease make ready time
Better compliance to internal schedule
Ensure weekly PM are done on a timely fashion resulting in better uptime
Decrease walking distance
Decrease number of steps during make ready
Decrease number of sheets used during make ready
Decrease make ready range of times for similar setups done by different people and shifts
Hand tooling in proper location for usage
Easy access to tooling
Make sure structure of carton are verified before going to press
Proper functional tooling from premake ready
Sustain the 5S efforts

Team:
Eddie Mathis - Leader
Sandy Reifenstein
Greg Terranova
Dave Smith

Production Requirements (Takt Time):
NA

Facilitator:
Vinnie & Charles

Process Information:
1 operator for machine #22 and 1 operator for machine #26
2 backtenders on 1st and 2nd shift: support machine #22, #25, & #26
2 backtenders on 3rd shift: support #22, #25, #26, and Stamping
4 cassettes for 2 machines: currently 3 loaded and 1 empty
Average approximately 2 make ready per shift per machine
Weekly Operator PM currently takes 2.5 hours

Current Situation and Problems
lack of visuals for cassette locations
overpatching of make ready sheets
low and high spots in the platen area
searching for job packets
premake ready area not currently doing structure, underlaying for diecutting
door in platen area not functioning properly
lack of communication between operator & backtender (between shifts) result in "delays"
vinyl does not match press sheet
operator workbench cluttered
poor lighting at platen area
schedule to die cutter include jobs not printed or ready
Weekly operator PM not scheduled in the system
Load tags not being filled out with next operation

Table 14. Kaizen Newspaper form (Item No. 1-15)

CELE Center for Excellence in Lean Enterprise
CENTER FOR INTEGRATED MANUFACTURING STUDIES

Kaizen Newspaper

Team Number:___________ Date: _____________ Page:_____ of:_____

Item No.	Description of Problem	Counter Measure	Person Responsible	Due Date	% Complete	Date Complete
1	Plan for event	Film setup (from registration to end)	Charlie / Eddy			
		Spaghetti Diagram (from reg to end)	Gary			
		Review DWIs for diecutter and backtender revise as necessary	Sandy			
		Review video	Team			
		Film last good sheet to first good sheet missing purging - see #47	Charlie / Eddy			
		Spaghetti Diagram of complete make ready Calculate distance traveled	Sandy			
		Waste spotter idea	Team			
		Communication board	Charles			
		5S audit	Team			
		Photos of the area	Team			
		Review photos	Team			
		Complete kaizen forms	Team			
		Schedule kaizen day(s) with machine 22 not running	Team			
		Train on new checklist & revideo	Team			
2	Operator loading section is missing tools * Does the Magnet work? Operator box needed?	Get list of things we need and want to dupicate from machine #26	Eddie	27-Oct		
3	Oil spot under stripping area	Maintenance Notified Work order issued & assigned	Dave			
4	Operator Maintenance Shadow Board is missing parts and is not maintained	5-s; Revisit the usefullness of board	Eddie	10/27/08		need to get funnel
5	Red Cabinet locked Filter and hoses on top of cabinet	Hang existing key behind cabinet 5S - min/max system for reordering	Greg/Dave	27-Oct-08		
6	Plexy-glass Cabinet	Move items into red cabinet? Plexiglass cabinet removed	Dave & Greg	2-Nov-08		
7	Grease Gun	Ask Operator or Maintenace where to locate On Operator Pm shadow board	Eddie	27-Oct-08		
8	Grind that is built-up inside the table track	Add it to weekly operator PM list Initiated change request - submitted to Heidi	Dave			
9	Schedule arriving late to Operator (can be 12:30pm) Jobs on sheets that have not been printed/ready	Receive schedule sooner and more accurate Mini scheduling board at diecutters with duplicate cards created from scheduling (previous opeeration not started (red), first load done (yellow), job previously done (green). Mount on quality board	Scheduling & Supervisors Dave & Greg	5-Nov		Board up - need to do dry run. Create procedure for use of board
10	Empty shelf board - used to band Gillette jobs	Remove	Eddie	27-Oct		
11	Taped Sensor on Rail	Inform Maintenance to fix/repair	Eddie / Maintenance	27-Oct		
12	Hydraulic WorkBench is too cluttered	Simplify desk, ask operator what is needed and what can be removed	Eddie	5-Nov		
13	A lot of hanging tools on frame of machine Whats needed?	Sketch tool/location on digital photos	Eddie	5-Nov	100%	
14	operator cabinet and computer area on platforms disorganized	remove cabinet & desk and replace with single shelf for computer. Add another shelf	Sandy & Dave	14-Nov		
15	items on control panel	5S	Eddie	5-Nov		

Table 15. Kaizen Newspaper Form (No. Item 16-43)

CELE Center for Excellence in Lean Enterprise
CENTER FOR INTEGRATED MANUFACTURING STUDIES

Kaizen Newspaper

Team Number:___________ **Date:** ____________ Page:_____ of:_____

Item No.	Description of Problem	Counter Measure	Person Responsible	Due Date	% Complete	Date Complete
16	bins on operator hydraulic workstation broke & cluttered	remove or fix & 5S and relabel	Eddie	5-Nov		
17	unlabeled bottle at machine	follow MSDS labeling requirements	Eddie	27-Oct		
18	operator and backtender roles not standardized during make readys	Document roles in MR checklist	Sandy	1-Dec		
19	Use of trash can Trash getting mixed with bottles etc.	Needed with set location		4-Nov		
20	maintenance manual cabinets cluttered	5S but leave in the cabinet	Dave	4-Nov		
21	lack of floor markings for items (slip sheets, etc)	outline with tape/label Need to paint floor for permanent marking	Eddie Dave	5-Nov		
22	cutout sequence on make ready sheets not numbered for repeat jobs and new jobs	print number sequence at PMR Observe process LT and get PMR involved for ST	Sandy			
23	patch rolls can get knocked off	better hanging device for tape along with posted colored label size (see machine #26)	Dave	4-Nov		
24	backtender loaded pile upside down for 2 sided job	Note (marked in yellow) special instruction for diecutting on factory tickets	Vinnie / Charles / Ryan			
25	allocated make ready hours not revised after 1st run	estimated MR hours based on prior setups review logs	Vinnie / Charles / Bert			
26	operator / maintenance responsibility on equipment? Operator PM skipped in Oct 08 (50%). Operator PM not shared across all shifts	Review and revise checklist for Operator PM Review production log. Track response time for Maint. WO	Eddie & Vinnie / Charles Ryan			
27	Not checklist for make ready	Create - review Bobst MR book see #18	Sandy			
28	Cassette staging not fully identified. Staging is not full identified.	Mark floor for cassette empty and loaded see #21 - tape / color cassettes	Eddie	5-Nov		
29	Rail not clean	Clean & add to Operator PM Checklist see #8	Sandy / Dave			
30	Develop a tool for Platen screw locks	Maintenance/ Dan Gurbacki	Dave			Long term
31	Bent swords	Maintenance needs to fix or purchase new ones; Inventory swords for each press. Spray paint swords	Eddie & Greg	4-Nov		
32	Sword installation into press	Create a template; Sandy Install assembly of swords done externally?	Sandy & Dave Vinnie			Long term
33	Platen door is not functioning properly	Maintenance needs to fix Work order issued	Dave	7-Nov		
34	Centering tape to be installed on back end and color lines need to be painted	Color vertical lines on back end with paint and install a tape measure (paper then magnet); Maintenance/Team	Team & Dave			
35	Excess movement in setting feeder wheels	Team and Maintenance to consider a solution for connecting wheels	Team & Dave			Long term
36	Feeder wheels setting requires excess movement	Maintenance; develop a tape measure on the feeder wheel rail to determine setting like machine #25	Team & Dave			
37	Poor lighting	Maintenance schedule (Clean, Change bulbs, and install a clear screen). 2 more bulbs added	Dave	4-Nov		
38	Low spots on platen section	Fingerprint press; Maintenance/ Operator	Dan			Long term
39	Define criteria for overpatching a make ready sheet	DWI should standardize. Talk to Dave Z. Part of DC DWI improvement - see #1c. Validate with QA	Sandy			
40	Number sequence not on new make ready sheet	Print number sequence on make ready sheet; Leslie in die design - See #22	Sandy			
41	Define a work area	Install an easel on work table; Team/Maintenance Sketch work surface	Eddie / Greg / Dave	5-Nov		
42	Constructing box	Pre make ready can construct the box before tooling is loaded, and they send to design dept. Need to do history defect analysis (RCA). Create visual sample for scores with inhouse examples to be used by DC operator. Remove step, QA does it, or done externally?	Vinnie /Charlie / Ryan / Heidi			
43	Install flashlight on bottom of press	Team; install flashlight on gear side of press	Eddie	4-Nov		

Table 16. Kaizen Newspaper Form (Item No. 44-55)

CELE Center for Excellence in Lean Enterprise
CENTER FOR INTEGRATED MANUFACTURING STUDIES

Kaizen Newspaper

Team Number:__________ Date: __________ Page:____ of:____

Item No.	Description of Problem	Counter Measure	Person Responsible	Due Date	% Complete	Date Complete
44	Blanking tooling is not accurate	Calibrate Pre make ready system with machine table part #38	Dan			Long term
45	Locate one big wheel for waste take-up	Phil Thesen; Maintenance; Team to buy $10k - do Cost Benefit Analysis (min 1:30 per setup) not including production & downtime issues with wheels	Sandy/Dan			
46	Number of make ready per period of time & range of current make ready unknown	Review daily production worksheets to get data	Charles /Vinnie			
47	purge process not observed during film	observe purging process	Charles			
48	Missing machine bolts	Create list of missing hardware & put on Maint WO Life of machine #22?	Eddie / Charlie			
49	5S machine	Clean machine Create showcase - Paint machine. Need to schedule activity	Charlies			
50	Sustain 5S efforts on machine	Create 5s checklist between shifts - leave for the day (DWI) Start auditing process. Hang near easel	Eddie / Vinnie			
51	Training on scheduling board	Need 7 sessions (DC/BT for each shift, PMR for each shift, & Jeff/Ryan meeting first				
52	Launch Operator PM & 5S audits	Meet with Jeff/Ryan week of Nov 17th	Eddie	8-Dec		
53	Jobs still "trumping" Make ready slot on board	Create parking lot of 1 week of jobs for DCs with noted/ highlight for dies built	Team			
54	Get managemet support	Coordinate meeting through Dan	Charles/Vinnie	4-Dec		
55	Production Logs filled out but no feedback to employees	Post summary data at scheduling board	Charles/Vinnie			
56						
57						
58						
59						
60						

Table 17. Kaizen 5S Audit Checklist Form

CELE Center for Excellence in Lean Enterprise
CENTER FOR INTEGRATED MANUFACTURING STUDIES

THE 5-S AUDIT CHECKLIST

Department / Area ________________________ **Date**____________ **Person**_____________ **SCORE**

SORT (SEIRI): Distinguishing between the needed and the not needed __________

0	No activity has occurred.
1	The criteria to determine needed vs. unneeded items has been determined. Needed items for the work area have been identified. There are no more than **8** violations of unneeded items present in work area.
2	Initial red tagging exercise has been conducted and unneeded items have been removed. There are no more than **6** violations of unneeded items present in work area.
3	A separate red tag holding area exists and an unneeded items log is posted in the plant. There are no more than **4** violations of unneeded items in work area.
4	Red tagging is performed at set time intervals, and the red tag holding area is evaluated at set time intervals. All items are reviewed regularly for need. There are no more than **2** violations of unneeded items in the work area.
5	Only needed items ever enter the work area. There are **no** violations of unneeded items in the work area.

SET IN ORDER (SEITON): Organizing for ease of use, straightening up and putting things away __________

0	No activity has occurred.
1	All needed items are present, it's not difficult to determine items in use. There are no more than **8** set-in-order violations.
2	It is obvious where needed items (including tooling, tools, procedures, etc.) belong (using lines, labels, signs). There are no more than **6** set-in-order violations.
3	The entire work area is visually indicated (including aisleways, workstations, equipment, storage locations, etc.) There are no more than **4** set-in-order violations.
4	Items are put away immediately after use. It is easy to determine what items are in use. There are no more than **2** set-in-order violations.
5	Height and quantity limits are visually obvious. There are **no** set-in-order violations.

SHINE (SEISO): Sweeping, scrubbing and cleaning and keeping things that way __________

0	No activity has occurred.
1	Area cleaning is done randomly. There are no more than **8** cleanliness violations.
2	Initial cleaning has occurred (floors, walls, stairs, surfaces). Machines and equipment have been cleaned. There are no more than **6** cleanliness violations.
3	Cleaning/housekeeping responsibilities are documented and followed daily. Cleaning materials are easily accessible. There are no more than **4** cleanliness violations.
4	Cleaning is used as an inspection tool for preventive maintenance. Cleanliness problems are identified and preventive action is taken. Machines have been painted. There are no more than **2** cleanliness violation.
5	The entire work area is spotless. Surgery could be performed in the area. There are **no** cleanliness violations.

STANDARDIZE (SEIKETSU): Implementing standard procedures for the first 3-S's and visual controls __________

0	No activity has occurred.
1	5-S standards for conditions of Sort, Set in Order and Shine have been set. Each of the first three S's is rated 1 or higher. There are no more than **8** standardize violations.
2	5-S standards are documented and posted in work area using a workplace scan display or other visual method. Each of the first three S's is rated 2 or higher. There are no more than **6** standardize violations.
3	Needed items, Standard Work for 5-S, and Visual Controls are in the work area. Each of the first three S's is rated 3 or higher. There are no more than **4** standardize violations.
4	5-S is measured and posted in work area. Each of the first three S's is rated 4 or higher. There are no more than **2** standardize violations.
5	5-S documentation is routinely reevaluated and updated (including the workplace scan). Each of the first three S's is rated 5. There are **no** standardize violations.

SUSTAIN (SHITSUKE): Establishing the necessary discipline to consistently sustain 5-S stds. __________

0	No activity has occurred.
1	25% of employees in work area (on all shifts) have been trained in 5-S. Each of the first 4 S's is rated 1 or higher. There are no more than **8** sustain violations.
2	50% of employees in work area (on all shifts) have been trained in 5-S. Each of the first 4 S's is rated 2 or higher. There are no more than **6** sustain violations.
3	All employees in work area (on all shifts) have been trained in 5-S. Each of the first 4 S's is rated 3 or higher. There are no more than **4** sustain violations.
4	All employees in work area perform daily and weekly 5-S activities as part of their standard work. Each of the first four S's is rated 4 or higher. There are no more than **2** sustain violations.
5	Area employees help create a planning worksheet to sustain 5S standards and guidelines. 5-S activities are documented in each employee's standard work instructions. Each of the first four S's is rated 5. There are **no** sustain violations.

5-S Total: __________

Table 18. Kaizen Setup Observation Form

CELE Center for Excellence in Lean Enterprise
CENTER FOR INTEGRATED MANUFACTURING STUDIES

Set-Up Observation Analysis Sheet

Date:
Page: 1

Machine #:
Part & OP:
Note:

Step	Time				Task Category				Kaizen Action			
#	Cum.	Task	Int/Ext	Element / Task Description	F	A	S	T	Problem Identified	Countermeasure & Time Savings	Who	When
1	0:00:00	0:00:00										
2	0:00:00	0:00:00										
3	0:00:00	0:00:00										
4	0:00:00	0:00:00										
5	0:00:00	0:00:00										
6	0:00:00	0:00:00										
7	0:00:00	0:00:00										
8	0:00:00	0:00:00										
9	0:00:00	0:00:00										
10	0:00:00	0:00:00										
11	0:00:00	0:00:00										
12	0:00:00	0:00:00										
13	0:00:00	0:00:00										
14	0:00:00	0:00:00										
15	0:00:00	0:00:00										
16	0:00:00	0:00:00										
17	0:00:00	0:00:00										
18	0:00:00	0:00:00										
19	0:00:00	0:00:00										
20	0:00:00	0:00:00										
21	0:00:00	0:00:00										
22	0:00:00	0:00:00										
30	0:00:00	0:00:00										
	#REF!											

Task Categories
F.) Foresight A.) Attachment S.) Setting Conditions T.) Trial Runs & Adjustments

# of Steps Moved to External: ______
Time Moved to External: ______

Steps Reduced: ______
Time Reduced: ______

Steps Eliminated: ______
Time Eliminated: ______

Appendix C

Kaizen Event Results

Appendix C: Kaizen Event Results

Table 19. Platen Die Cutting 5S Audit Form

5S AUDIT CHECKLIST - DIE CUTTER MACHINE #22 **Auditor(s)** ____________________

Perform at the end of each shift by incoming operator **Shift** **A** **B** **C**
Weekly audits / reviews by supervisor
Week: ____________________

LOCATION	**LOOK AT**	**LOOK FOR**	**OK Sun**	**OK Mon**	**OK Tue**	**OK Wed**	**OK Thur**	**OK Fri**	**OK Sat**
Back Side of	Tools	5mm Allen							
		10mm Wrench							
		Job Block							
		Flashlight							
Computer Area	Shelf 1	Hold Tags							
		Load Tags							
		Red Rubber / White Rubber							
	Shelf 2	Bridges (6)							
		Silicon Can (2)							
		All Purpose Cleaner (1)							
		Degreaser(1)							
		Type Wash (1)							
	Shelf 3	Computer							
		Small Rack							
		Rubber Gloves (1)							
		Preventive Maintenance Book							
Control Panel	Top of Panel	Only Razor Blade Can							
Operator Side	Feeder	Wheels (2)							
	Wheel Area	41mm Wrench							
Operator Side	Platen Area	ProNick							
		Rule Pullers							
		Pliers							
		Flat head Screwdriver							
		5mm T-handle							
		Blades							
		Utility Knife							
		Needle Nose Pliers							
		4mm Allen							
		5mm Allen							
		Chisel							
		Rawhide Hammer							
		Safety Glasses							
		Patch Tape B/R/Y							
		No unneeded items							
Operator Side	Blanker	Breakerbar and Socket							
	Area	8mm T handle							
		5mm Allen Short Nose							
		8mm Allen							
		6mm Allen							
		10mm Wrench							
		17 mm Wrench							
		Hook Extender							
		Clamp Extender							
		No unneeded items							
Operator Side	Waste Take Up	6mm T Handle							
Operator Side	Workbench	Job Packet							
		Vinyl							
		Hand Book							
		Bins Contain Only Label Items							
Frontside of	Swords	Only Orange Swords Hanging							
	Floor Space	Slips Sheets							
		Empty/ Return Cassette							
		Make Ready Cassette							
Gear Side	Housekeeping	Broom							
	Supplies	Helmet							
		Dustpan							
		Crowbar							
		5mm T Handle							
		Flashlight							
Gear Side	Operator	Funnel							
	Maintenance	Grease Gun							
	Board	5mm T Handle							
		30mm Wrench							
Gear Side	Floor Space	Conveyor							
		Empty Bins (2)							
		Ladder							
		Slips Sheets							
		Hand Jack							
		Black Skids							
Total # Violations									
General Comments									

Table 20. Setup Observation Analysis Sheet

CELE Center for Excellence in Lean Enterprise
CENTER FOR INTEGRATED MANUFACTURING STUDIES

Set-Up Observation Analysis Sheet

Machine #:	DieCutter #22	Note:	Date: 13-Oct
Part & OP:	Sunoco Job		Page: 1

Step #	Time: Cum.	Time: Task	Int/Ext	Element / Task Description	Task Category: F	A	S	T	Kaizen Action: Problem Identified	Countermeasure & Time Savings	Who	When
1	0:00:25	0:00:25	I	Open Blanking unit door		x						
2	0:01:22	0:00:57	E	Retrieving empty Cassette	x				Cassette location	Place an empty cassette at machine dock station at all times		
3	0:03:03	0:01:41	I	Lift Cassette onto Platform		x			Dirty rail, causes delays	Add to monthly maintenance routine		
4	0:03:35	0:00:32	I	Unlock Blanking unit tooling		x						
5	0:04:36	0:01:01	I	Unlock Platen tooling		x			Was not ready when cassette arrived onto the platform; Need tool to unlock screws	Begin unlocking platen tooling when cassette is being raised; consider a wing-screw rather than a flat-head-screw (eliminates a tool)		
6	0:05:36	0:01:00	I	Zeroing the platen			x		Not understood as to why "zeroing" the platen counter table must be accomplished.	?		
7	0:05:45	0:00:09	I	Removing Die tooling from Platen section into cassette		x						
8	0:05:55	0:00:10	I	Place die life on platen	x				Is excessive paper work	Can travel with cassette to the machine, stays with cassette and returns to Pre-make-ready department with tooling		
9	0:06:50	0:00:55	I	Remove stripper platform and taking it to bottom of platform		x						
10	0:07:20	0:00:30	I	Moving cassette to platen section		x						
11	0:07:40	0:00:20	I	Removing platen tooling		x						
12	0:08:15	0:00:35	I	Moving cassette to blanker section		x						
13	0:08:30	0:00:15	I	Removing blanker tooling		x						
14	0:09:26	0:00:56	I	Moving cassettee off platform into docking stations		x						
15	0:10:12	0:00:46	I	Removing loaded cassette with old job into misc. staging location	x				Staging location was at mach. No. 26	Establish a staging location near mach. No. 22		
16	0:11:15	0:01:03	I	Retrieve new tooling cassette for next job at current staging area	x				Retrieved wrong tooling cassette	Better indication as to what tooling will be installed.		
17	0:12:07	0:00:52	I	Placed tooling in machine dock station and lifted cassett onto platform		x						
18	0:12:32	0:00:25	I	Stopped cassette in-front of blanker section and placed new blanker tooling into machine		x						
19	0:12:45	0:00:13	I	Locked blanker tooling in machine			x					
20	0:13:04	0:00:19	I	Horizontal movement of cassette to stripping section		x						
21	0:13:25	0:00:21	I	Placed tooling into stripping section - 3 items were inserted		x						
22	0:13:40	0:00:15	I	Locked stripping tooling in machine			x					
23	0:13:55	0:00:15	I	Horizontal movement of cassette to platen section		x						
24	0:14:33	0:00:38	I	Loading die tooling into platen, removed die life paperwork		x			Does die life paperwork need to travel with die, then separate once installed	Keep die life paperwork attached to cassette		
25	0:15:00	0:00:27	I	Move empty cassette off platform into docking station		x						

Table 21. Setup Observation Analysis Sheet

CELE Center for Excellence in Lean Enterprise
CENTER FOR INTEGRATED MANUFACTURING STUDIES

Set-Up Observation Analysis Sheet

Date: 13-Oct
Page: 1

Machine #: DieCutter #22
Part & OP: Sunoco Job
Note:

Step #	Time: Cum.	Time: Task	Int/Ext	Element / Task Description	Task Category: F	A	S	T	Kaizen Action: Problem Identified	Countermeasure & Time Savings	Who	When
26	0:18:33	0:03:33	I/E	Setting the Swords			x		Most of the procedure is more artistic; eliminate the guessing; swords are bent and not all are functional	Die shop can establish sword position; standardize the sword sizes; assembly of swords be done externally, fix bent swords in maintenance		
27	0:19:00	0:00:27	E	Moving empty cassette from docking station	x				Excessive cassette movement; is not available for immediate change-over in case emergency job is required	Leave cassette in docking station, it does not have to be staged for pick-up		
28	0:20:30	0:01:30	I	Setting the electric eye for delivery pile			x		why does the eye need to be reset	Locate a position so the eye does not need to be constantly reset.		
29	0:21:55	0:01:25	I	Tighten tooing in platen section			x		Door is busted and does not lock easily	Maintenance project		
30	0:22:30	0:00:35	I	Place pile into feeder		x						
31	0:22:43	0:00:13	I	Measuring side jogger guide			x		Operator is manually measuring sheet size for set-up	Use color bar on feeder wall to establish mid-point in sheet size and add the information onto ***Load Tag***		
32	0:22:57	0:00:14	I	Set jogger guides			x					
33	0:23:08	0:00:11	I	Set back jogger/back stop guide			x					
34	0:23:53	0:00:45	I	Bring tonnage down			x		Tonnage was at higher levels then what is prescribed	Tonnage should be zeroed out as soon as job concludes. This is a step to zero-out the machine.		
35	0:26:24	0:02:31	I	Setting sideguide on feed table for infeed registratin			x		Side guide on feeder table and jogger guides are out of sync	Back-tender should communicate more effectively during step 31 and 32 (half sheet size for midpoint) & half sheet size noted on factory ticket on diecutting section		
36	0:27:20	0:00:56	I	Set double sheet feed detector			x					
37	0:28:05	0:00:45	I	Setting sideguide on feed table for infeed registratin			x		Repeat step 35 because of poor communication between back-tender and operator	Back-tender should communicate more effectively during step 31 and 32		
38	0:28:49	0:00:44	I	Set feeder wheels			x		A sheet of material must be used to set feeder wheels; operator has to move from operator side to gear side to make full wheel adjustments	Develop a tape rule on feeder bar that dictates sheet size; construct a control bar(1or 2) or a stool that allows for a reach-over to set up feeder wheels from operator side only		
39	0:29:44	0:00:55	I	Check scores for sharp edges and platen registration				x				
40	0:30:12	0:00:28	I	Setting sideguide on feed table for infeed registratin			x		Registration is off on die cut because of incorrect setting of side guide on feeder table and jogger guide	Back-tender should communicate more effectively during step 31 and 32		
41	0:31:12	0:01:00	I	Set back end to center pile			x		Centering pile after load was set	Back-tender should communicate more effectively during step 31 and 32		
42	0:31:31	0:00:19	I	Check registration infeed			x		Registration is off on die cut because of incorrect seeting of side guide on feeder table and jogger guide	Back-tender should communicate more effectively during step 31 and 32		

Table 22. Setup Observation Analysis Sheet

CELE Center for Excellence in Lean Enterprise
CENTER FOR INTEGRATED MANUFACTURING STUDIES

Set-Up Observation Analysis Sheet

Date: 13-Oct
Page: 1

Machine #: DieCutter #22
Part & OP: Sunoco Job
Note:

Step #	Time: Cum.	Time: Task	Int/Ext	Element / Task Description	Task Category: F	A	S	T	Kaizen Action: Problem Identified	Countermeasure & Time Savings	Who	When
43	0:31:51	0:00:20	I	Moving back-end fingers			x		Was done late during the set-up process	Should be set when back end is being set by back-tender		
44	0:32:03	0:00:12	I	Check registration infeed			x		Registration is off on die cut because of incorrect seeting of side guide on feeder table and jogger guide	Back-tender should communicate more effectively during step 31 and 32		
45	0:35:04	0:03:01	I	Check registration for scores and cuts				x	Operator complained of poor lighting	Clean lamps (or cleaner cover) can be apart of operator preventive maintenance. Can change light bulbs for brighter work area		
46	0:38:52	0:03:48	E	Check gear-side suckers	x				Adjustment knob for gear-side suckers was broken	Maintenance needs to check air pressure for machines, add to preventive maintenance		
47	0:39:32	0:00:40	I	Check registration for scores and cuts				x	Several low spots exist on platen section	Steel bed is not properly adjusted to a parallel position. Need to fingerprint the platen stamp. Front section near gripper bar on machine 22 always low (have premake ready put an underlay for all jobs more then 10 up)		
48	0:39:42	0:00:10	I	Fine adjustments for infeed side-guide			x					
49	0:40:10	0:00:28	I	Check registration for scores and cuts				x	Several low spots exist on platen section	Steel bed is not properly adjusted to a parallel position. Need to fingerprint the platen stamp		
50	0:40:40	0:00:30	I	Increase tonnage and set pressure guide for double sheet			x					
51	0:41:59	0:01:19	I	Check registration for scores and cuts to die vinyl				x	Vinyl has the tendency to not match press sheet	Vinyl should be qualified upstream before reaching die cutting operation. Use "review job" pink sheet to communicate mismatch		
52	0:44:29	0:02:30	I	Check cutting to patch first row				x	Overuse of patching tape	Use underlay when low spots occur; define criteria (see DWI 53.10) for "over-patching" and when new make ready sheet should be issued		
53	0:47:09	0:02:40	I	Pull platen out of machine and patch first row				x	Overuse of patching tape	Use underlay when low spots occur		
54	0:48:43	0:01:34	I	Check cutting to patch second row				x	Overuse of patching tape	Use underlay when low spots occur		
55	0:49:28	0:00:45	I	Patching second row				x	Overuse of patching tape	Use underlay when low spots occur		
56	0:49:53	0:00:25	I	Putting platen back into machine		x			Automatic locking door does not work properly	Maintenance project		
57	0:50:01	0:00:08	I	Retrieve job pack	x				Work area must be better defined for operator	Develop a work area with flat surface and easel		
58	0:50:26	0:00:25	I	Check job pack for additional information and matching with proofs	x				If job info is not established ahead of time, then time will be wasted	Check this job info when job arrives at the very beginning of set-up operation. Can job packet be kitted with cassette by premake ready?		

Table 23. Setup Observation Analysis Sheet

CELE Center for Excellence in Lean Enterprise
CENTER FOR INTEGRATED MANUFACTURING STUDIES

Set-Up Observation Analysis Sheet

Date:	13-Oct
Page:	1

Machine #: DieCutter #22

Part & OP: Sunoco Job

Note:

Step #	Time Cum.	Time Task	Int/Ext	Element / Task Description	Task Category F	A	S	T	Kaizen Action Problem Identified	Countermeasure & Time Savings	Who	When
59	0:51:46	0:01:20	E	Putting box together for quality check	x				Constructing box (quality step)	Pre-make ready dept. should have constructed a box prior to set-up a cassete (for functional dies). Allow design department to qualify job before die cutting		
60	0:52:01	0:00:15	I	Run a sheet to adjust stripping section			x					
61	0:52:21	0:00:20	I	Preparing to align stripping section to sheet			x					
62	0:52:29	0:00:08	I	Apply pressure from stripping pins to strip out waste section				x				
63	0:54:14	0:01:45	I	Look underneath stripping section on gear side to make adjustment (F to B)				x	Adjustment is not made with machine adjustment mechanism	Learn machines functions and apply to stripping adjustment		
64	0:54:49	0:00:35	I	Align board to sheet (Side to Side)				x	Centerline system is not be utilized; Operator walks back up to platform for this task	Check with manufacturer on the Centerline system; complete tasks on gear side before returning to operator side		
65	0:55:04	0:00:15	I	Verify side to side adjustment underneath machine on gear side								
66	0:55:19	0:00:15	I	Bring down top stripper				x				
67	0:57:14	0:01:55	I	Adjust stripping pins to sheet (Top to Bottom)	x				Removing pre make ready pins setting	Leave pin setting the way pre make ready puts them		
68	0:58:06	0:00:52	I	Adjusting stripping pins to sheet underneath press (Bottom to Top)	x				Removing pre make ready pins setting	Leave pin setting the way pre make ready puts them		
69	0:58:41	0:00:35	I	Put trash bin collect into stripping fall-out		x						
70	0:59:03	0:00:22	I	Tighten stripping frame tooling			x					
71	0:59:32	0:00:29	I	Run a sheet to adjust blanking section			x		Operation does not need a sheet to adjust	Practice adjusting this operation without a sheet.		
72	0:59:45	0:00:13	I	Press button to remove swords from blanking and lower pallet to check box			x		Does not have to deal with this step if operator sets-up without paper	Practice adjusting this operation without a sheet.		
73	1:00:10	0:00:25	I	Retrieve flash light to check box on gear-side	x				Does not need a flashlight to check blanking	Practice adjusting this operation without a sheet, put flashlight on gear side		
74	1:03:38	0:03:28	I	Look underneath blanking section on gear side to make adjustments (F to B)			x		Adjustment is not made with machine adjustment mechanism	Learn machines functions and apply to blanking adjustments without running a sheet; adjustment would be minimized with mfg realignment (premake ready to die cut table)		
75	1:06:44	0:03:06	I	Adjusting side to side on blanking section on operator side			x		Adjustment is not made with machine adjustment mechanism	Learn machines functions and apply to blanking adjustments without running a sheet		
76	1:09:06	0:02:22	I	Checking underneath to adjust side to side on blanking section on gear side			x		Adjustment is not made with machine adjustment mechanism	Learn machines functions and apply to blanking adjustments without running a sheet		
77	1:10:16	0:01:10	I	Tighten blanking section			x					
78	1:11:28	0:01:12	I	Adjust wheels for waste delivery			x		Should not be adjusted	Position in one place and do not make any adjustments. Consider one wheel for waste delivery.		
79	1:11:34	0:00:06	I	Turn on air suction for waste				x				
80	1:11:42	0:00:08	I	Move brush in waste section				x				

Table 24. Setup Observation Analysis Sheet

CELE Center for Excellence in Lean Enterprise
CENTER FOR INTEGRATED MANUFACTURING STUDIES

Set-Up Observation Analysis Sheet

Machine #: DieCutter #22
Part & OP: Sunoco Job
Note:
Date: 13-Oct
Page: 1

Step	Time				Task Category				Kaizen Action			
#	Cum.	Task	Int/Ext	Element / Task Description	F	A	S	T	Problem Identified	Countermeasure & Time Savings	Who	When
81	1:12:41	0:00:59	I	Run a sheet through infeed, platen, stripping, blanking, and then out through waste				x				
82	1:13:01	0:00:20	I	Check layer count				x				
83	1:13:49	0:00:48	I	Check line clearence at 30 sheets				x				
84	1:16:09	0:02:20	I	Check final cut and mark for adjustment				x				
85	1:17:11	0:01:02	I	Patching for line clearance at 30 sheets				x	Overuse of patching tape	Use underlay when low spots occur		
86	1:18:12	0:01:01	I	Quality check, making sure all the info is correct and running the correct job	x				There should be no question as to running this job. All the information should be accurate at the beginning	QC is to be done at the very beginning.		
87												
88												
	1:18:12											

Task Categories
F.) Foresight A.) Attachment S.) Setting Conditions T.) Trial Runs & Adjustments

# of Steps Moved to External:	________	Steps Reduced:	________	Steps Eliminated:	________
Time Moved to External:	________	Time Reduced:	________	Time Eliminated:	________

Table 25. OEE Calculation (Initial Analysis of 23 Samples)

Total Time	112:15:00
Run	61:13:00
MR	35:47:00
Breakdowns	8:40:00
Lunch & Breaks	5:20:00
No Work	1:15:00

Total Time	**112:15:00**		**Notes**
Planned Downtime	6:35:00	<	Lunches, Breaks, No Work
AVAILABILITY			
Running Time	105:40:00		
MR	35:47:00		
Operating Time	69:53:00		
Planned Availability	66.1%		
Breakdowns	8:40:00		
Net Operating Time	61:13:00		
Uptime	87.6%		
AVAILABILITY (A)	57.9%		
PERFORMANCE			
Expected Production	428540	<	Using speed of 7000 sh/h
Actual Production	174961		
PERFORMANCE (P)	40.8%		
QUALITY			
Waste Sheets	91	<	Recorded on production sheets
Quality Sheets	174870		
QUALITY (Q)	99.9%		
OEE (AxPxQ)	**23.6%**		