Process improvement by application of Lean Six Sigma and TRIZ methodology
Case Study in Coffee Company

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ABSTRACT

By integrating TRIZ methodology into the improve phase of the Lean Six Sigma approach as a quality improvement strategy, this study attempts to develop a better process to ensure high productivity and effectiveness, low waiting time to eliminate waste for the unnecessary inspection/transportation of product during the operation system, resulting in a more effective process system which becomes more stability and reliable. The corresponding design procedures and prediction models are provided. Further on, a case study on the Coffee Company is discussed with emphasis on the Robusta coffee process area. The result shows that the improved prediction models successfully reduces the waste of waiting time for inspection (46.54%) and the transportation time during the operation system (38.12%). That leads to a reduction of the Non Value Added time (38.12%).

Keywords:- Lean Manufacturing, Six Sigma, Lean Six Sigma, DMAIC, D2MAIC, TRIZ

1. INTRODUCTION

Nowadays, the industrial organizations have embraced a wide variety of management program which can enhance competitiveness. The goals are to increase the productivity and effectiveness by decreasing the process variation, leading to a defect reduction and an enormous improvement in profit, employee moral and product quality. Currently, two of most popular programs are Six Sigma and Lean Manufacturing.

Six Sigma is a methodology for detection and fixing of defects in manufacturing engineering/business, which is based on well - studied and tested statistical methods of quality control, data analysis and systematic training of the entire company’s personnel involved in the process system. The Six Sigma enables determination of number of defects which are inherent in any process or any step of the process. Therefore, The Six Sigma is a methodology for uncovering defects, inherent in various processes based on statistical analysis of available data. But, this methodology does not offer many tools for elimination of these defects or for solving the productivity problem. Lean Manufacturing originated at Toyota Motor Corporation in Japan and is an approach that eliminates waste by reducing costs in the overall production process, in operation within that process, and in the utilization of production labor.

A while ago, experts, who have been utilizing the Six Sigma and Lean Manufacturing, merged these methodologies, creating, the so called, Lean Sigma or Lean Six Sigma (LSS). A lean culture provides the ideal foundation for the rapid and successful implementation of the Six Sigma quality disciplines. Further, the metrics of Six Sigma lead to the application of the discipline of lean Manufacturing when it is most appropriate. Furthermore, the techniques and procedures of Six Sigma should be used to reduce defects in the processes, which can be a very important prerequisite for a lean production project to be successful (Jiang et al, 2002).

However, both of these applications faced a lack of creativity in their approach methodologies, when they were “incorporating” TRIZ into their offerings which were started in the late 1940s and in the 1970s when it absorbed a large segment of value engineering. The theory of inventive problem solving (TRIZ) is a systematic methodology that allows creative problems in any field of knowledge to be revealed and solved, while developing inventive/creative thinking skills and a creative personality. TRIZ is an effective method for analyzing customer needs and developing innovative solutions to meet customer needs, while it also provides minor changes in a system under consideration, optimizing its parameters and resolving minor conflicts that arise during the development of its subsystems as well as the optimization & substantial transition to a new, improved system. Here, we propose a new model which is a new approach that integrates TRIZ into the improve phase of the LSS approach to illustrate the process improvement for the business/manufacturing process with high productivity and effectiveness, along with low waste of waiting time for the unnecessary inspection & transportation during the operation system.

2. LITERATURE REVIEW

2.1 LEAN MANUFACTURING

The “Lean” manufacturing or Lean production philosophy is rooted in concepts of Toyota engineering. In 1990, a study was done at the Massachusetts Institute of Technology of the movement from mass production toward Lean
manufacturing in the book entitled “Machines that Changed the World” (Womack et al., 1990). This theory is also known as the Toyota Production System, Lean Manufacturing, World Class Manufacturing, and New Production System (Koskela, 2000; Liker, 2003). The popular definition of Lean Manufacturing and Toyota Production System usually consists of the following (Wilson, 2009).

“Lean is the systematic approach to identify and eliminate waste through continuous improvement by the flowing the product or service at the pull of your customer in pursuit of perfection”.

According to Drew et al., 2004 the lean operating system consists of the following:

“A lean operating system follows certain principles to deliver value to the customer while minimizing all forms of loss. Each value stream within the operating system must be optimized individually from end to end. Lean tools and techniques are applied selectively to eliminate the three sources of loss: waste, variability and inflexibility”. Lean thinking (Womack and Jones, 1996) helps us to understand the fundamental conception of lean. As the purpose of Lean is creating more value for customers with fewer resources then lean thinking starts with the customer and the definition of value. In lean manufacturing, the value of a product is defined solely based on what the customers actually requires and is willing to pay for. Production operations can be grouped into following three types of activities:

- **Value-added activity**: These activities transform the materials into the exact product that the customer requires.
- **Necessary non value-added activity**: These activities don’t add value from the perspective of the customer but are necessary to produce the product unless the existing supply or production process is radically changed.
- **Non value-added activity**: These activities are not required for transforming the materials into the products in which customers are not willing to pay for. Anything which is non-value-added may be defined as waste.

### 2.2 SIX SIGMA

Six Sigma was established by Motorola in 1987 as a strategic initiative. The initiative was specifically designed to attack any problems derived from variation, both by reducing variation as well as breakthrough improvements. In the original definition of Six Sigma, it was assumed that a process could shift 1.5 Sigma without detections. Therefore, a 1.5 sigma drift margin was built into the standard definition of Six Sigma. If a Six sigma process shifts 1.5 sigma units from the process mean to either side, the final products would be 99.97% defect free, having 3.4 DPMO (Arnheiter, 2005.). Although the Six Sigma metric of reducing defects to only a few parts per million for a process still applies, Six Sigma has become a complex quality improvement philosophy and approach. The problem solving methods are performed by employing the “Magnificent Seven” tools of quality: control charts, histograms, check sheet, Scatter plots cause-and-effect diagrams, flow chart and Pareto charts. These concepts and tools are adopted by the Six Sigma Strategy (Antony, 2005).

The normal approach used in Six Sigma to solve problems is the DMAIC cycle, which stands for Define, Measure, Analyze, Improve and Control, the steps taken to attain Six Sigma quality management (Banuelas, 2005):

**Define**
- Define the scope and boundaries of the project
- Define defects
- Define team charter to identify process definition, critical –to-quality parameters, benefit impact, key milestone activities with dates, support required and core team member as well as estimate the impact of the project in monetary term.

**Measure**
- Map process and identify the process inputs and outputs
- Establish baseline process capability and measure system capability
- Conduct cause and effect analysis
- Establish the data collection plan

**Analyze**
- Gather data and identify possible sources of variation that causes problem
- Perform cause and effect analysis to identify parameters that most significantly affect the process
- Select critical –to-quality parameters to improve

**Improve**
- Screen potential causes that affect process
- Perform design of experiment to identify optimal setting of process parameters to eliminate problem
- Discover variable relationships and establish operating tolerances

**Control**
- Plot control charts to establish new process capability
- Develop a control plan to sustain improved quality
2.3 LEAN SIX SIGMA

Wedgewood (2006) states that: “Lean and Six Sigma are ultimately both initiatives for business process improvements”. Six Sigma is described as the systematic methodology to find main elements for the performance of a process and set them to the best levels, while Lean is described as a systematic methodology of eliminating waste and reducing the complexity of a process.

The potential risks in the improved project are noted because the tools of the Lean Six Sigma movement are excellent if applied in the right way, by developing learning and a cultural change at the company (Liker and Franz, 2006).

George (2003) argues that a merger between Lean and Six Sigma is needed due to the fact that Lean does not provide statistical control for a process and Six Sigma cannot radically improve process speed. Furthermore, George (2003) describes the Lean Six Sigma methodology as follows: “Lean Six Sigma is a methodology that maximizes shareholder value by achieving the fastest rate of improvement in customer satisfaction, cost, quality, process speed and invested capital”.

Very simply stated, Lean Six Sigma is a combination of principles/tools/techniques from Lean and Six-Sigma. In one sentence, Lean means to reduce the waste in an organization; Six Sigma means to reduce the defects, which is also called waste; and both enable employees to reduce the variations.

There are some research papers which have concentrated on the DMAIC (Define, Measure, Analyze, Improve and Control) Six Sigma methodology which can help the group of Six Sigma to identify a problem and work out a suitable and applicable solutions in a logical and structural way (George, Rowlands et al., 2006). This is proposed in Lean Six Sigma literature. Furthermore, this is developed to provide some guidance which regard to how to properly integrate and apply the best of both systems. As illustrated in the work on “D’MAIC” (Jiang et al., 2002) the author describes their research as one which represents a logical, sequential structure for driving process improvement. That paper contributed to the viewpoint to construct an improvement roadmap and find the best combination of Lean and Six Sigma techniques to create a robust solution.

2.4 LEAN SIX SIGMA WITH TRIZ

The LSS approach is a popular methodology to improve the business opportunities in customer satisfaction, cost and process speed for manufacturing. LSS also can be integrated with TRIZ methodology to improve customer satisfaction, enhance the traditional techniques of LSS (Wang and Chen, 2010).

The author first became acquainted with Theoria Resheneyva Isobretatelskehuh Zadach (TRIZ) in April 1991. In TRIZ, statistical data is used for discovery and use of the laws and patterns of technology. Integration of these approaches allows for development of an instrument, capable of broadening the capabilities of both methodologies.

The Six Sigma and Lean Production, faced with lack of creative approach in their methodologies, began “incorporating” TRIZ into their offerings. In every such case, TRIZ was presented as a contradiction matrix only, thus severely limiting the potential impact TRIZ tools could have in a particular problem solving process.

3. PROPOSED THE INTEGRATED MODEL FOR PROCESS IMPROVEMENT AND ASSOCIATED DESIGN TOOL.

A systematic integrated model specifically applicable to process improvement design is proposed to present the progress of the use of the new model; highlight the problems to project advancement, and describe the manner in which these problems were overcome with the application of the process improvement model, as given in Figure 1. It can be noted that the procedure designs improvement into each development process (Diagnose & Define, Measure, Analyze, Improve and Control), especially in the improve phase. There are some combined techniques used to form a complete set of improvement framework in each of the five-infrastructure shells. The symbolic concepts are made for each of the group tools. The (◎) represents lean concept tools, the (■) stands for Six Sigma concept techniques; the (☐) represents TRIZ tools and the (@) symbolizes concepts or tools existing both Six Sigma and Lean Manufacturing.
3.1 DIAGNOSE AND DEFINE PHASE

This phase is to discover the causes of quality deficiencies or investigate the symptoms of the process, as well as to seek to understand the critical problems, key factors and expectations of the customer that affect the process output. Analyzing historical data available; Interview & Survey those that might know what has happened in the past and direct observation start tracking the current process and then continue in future (check-sheet, etc…).

![Diagram of the Improvement Model](image)

Figure 1. The Improvement Model

After that, the current state analysis describes the present situation (flow process) at the company and should be identified as well as the main processes/areas/products which need to be focused on throughout the product family and the product Quantity Analysis (P-Q Analysis) (i.e. Figure 2 indicated that Robusta 1 & 2 become a pilot project to be improved). The clear foundation should be set in order to transform the manufacturing process. The project charter then lays out a plan to follow and SIPOC gives us an input - process - output mentality. Table 1 is a completed example using SIPOC for company.

![Graph of the coffee export structure in Year 2010 - 2012](image)

Figure 2. The P-Q Analysis of the coffee export structure

Table 1
### 3.2 MEASURE PHASE

Next comes the important part of the improvement model: Determining the characteristics that influence the behavior of our process and, understanding quickly what the inputs and outputs are of a process or finding out what kind of activities occur during the production process. This is accomplished by making measurements and collecting data from current manufacturing process. In this case, process mapping and layout mapping give more understanding about the production process of Robusta as given in Figure 3.

**Table 1: SIPOC for the Coffee Company**

<table>
<thead>
<tr>
<th>Supplier</th>
<th>Output</th>
<th>Process</th>
<th>Input</th>
<th>Customer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growers/ farmers, local collectors, or other company' branch.</td>
<td>Coffee Robusta</td>
<td>Grade Size</td>
<td>Raw coffee bean or Classified coffee bean</td>
<td>INTERCAFE AG; MARUBENI, NEDCOFFE BV; ROTHFOS; ARORIETAL COFFE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grade color</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Polish</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grade weight</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bagging for Boxed</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bagging for shipping</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 3. Production Flow of Robusta Coffee**

The processes are a conveyor system that operates continuously and only stops when problem occurs, such as machines that are stuck/ broken or problems with workers. The total average time for the process systems due to the machine capacity for each step as well as quantity of coffee which are lost in operational process due to having to remove lower quality coffee, foreign matter; black coffee… are estimated as given in Figure 4. The results indicate that the estimated processing time is 60,540 seconds or 16.82 hours and the lead time or Non value added time (NVA) is 198,300 seconds for 126 tons coffee Robusta export.

**Figure 4. Current State mapping at Coffee Company**
3.3 ANALYZE PHASE

During this phase, the data collected in the measurement phase is used to analyze the gap between the current and desired performance. Lead time is known as the average time that it takes for one unit to go through the entire process – from start to finish – including time waiting between sub-processes.

Based on the VSM – current state map (see Figure 4), we can summarize the total time which is consumed for this process as given in table 2 which shows that the company spent more time for waiting time to move and seek materials as well as arranging inventory to store because of no any plan for inventory. The stored and waiting time is 24,400 seconds or 6.7 hours, it also indicates that the high level of inventory makes system lead time for storage or waiting become high. Each process can have a different throughput volume because of the amount input of the defects and foreign matters. The estimated percentage of defects/foreign matter for each process can be obtained in Figure 5.

<table>
<thead>
<tr>
<th>No</th>
<th>Category</th>
<th>Total time (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Value added time (VA/T)</td>
<td>60,540</td>
</tr>
<tr>
<td>2</td>
<td>Non Value added time (NVA/T)</td>
<td>249,240</td>
</tr>
<tr>
<td>3</td>
<td>Workers</td>
<td>71</td>
</tr>
</tbody>
</table>

Table 2: The total time for producing 126Tons coffee Robusta

In addition, the company consumed more time for inspection as it had no standard procedures for materials quality which cause the waste of transportation due to the current layout. It also increases defects due to setting incorrect parameters for machine systems. Grade color and grade size are the major contributors to the process defects. The causes of the defect can be presented by the Cause & Effect Diagram. It clearly reveals lot of reasons for poor performance in the company, as given in Figure 6.

Figure 5. Pareto charts for the process defects or foreign matter
Failure mode and effects analysis (FMEA) is used to identify in advance the factors that may cause function failure in the key process and locate a risk priority number (RPN) as depicted in table 3. A common industry standard scale uses 1 to represent no effect and 10 to indicate very with failure affecting system operation and safety without any warning. Factors with a high RPN, usually defined as greater than 90, will be selected and corrective actions will be recommended.

### 3.4 IMPROVE PHASE

In this phase, we integrate TRIZ methodology into tradition Lean Six Sigma to identify the problems in order to implement an improvement plan. Four steps are given:

**Step 1:** Propose and Develop solutions – Based on the findings of the significant causes in the analyze phase, the TRIZ methodology proposes improvement activities. The contradiction matrix is applied, as shown in table 4.

**Step 2:** After analyzing each of the principles, the implementation of the improvement plan is conducted to generate the improvement action according to the problems.

#### Table 3. FMEA analysis for the key process

<table>
<thead>
<tr>
<th>Details of process</th>
<th>Potential failure mode</th>
<th>Potential failure effects</th>
<th>S</th>
<th>E</th>
<th>V</th>
<th>Potential causes</th>
<th>O</th>
<th>C</th>
<th>Current process controls</th>
<th>D</th>
<th>R</th>
<th>P</th>
<th>T</th>
<th>Actions recommended</th>
<th>Action taken</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor raw materials</td>
<td>Too many bad quality components</td>
<td>Foreign matter, stone, black, broken</td>
<td>Increase defects/ wastages</td>
<td>5</td>
<td>6</td>
<td>6</td>
<td>Delivery/re storage condition</td>
<td>No matter specification required</td>
<td>No have standard for quality of raw materials</td>
<td>Reduce inspection during the process system operate</td>
<td>1</td>
<td>0</td>
<td>5</td>
<td></td>
<td>Setting standard procedure for quality of raw materials</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Clasifying raw coffee by quality</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Operating machines</td>
<td>Setting parameters for machine is improper</td>
<td>Efficient/ wastages</td>
<td>No have standard for quality of raw materials</td>
<td>Lack of skills or expertise of workers</td>
<td>Accept defects because of waiting the feedback results from inspection</td>
<td>5</td>
<td>6</td>
<td>Switch the parameters of machines by hand</td>
<td>1</td>
<td>0</td>
<td>5</td>
<td></td>
<td>Setting standard procedure for quality of raw materials</td>
<td>Move quality check department close to process system</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4</td>
<td>4</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td>Matching specifications required and train for all employees</td>
<td>4</td>
<td>4</td>
<td>6</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Personnel performance</td>
<td>Improper operation</td>
<td>Increase defects/ wastages</td>
<td>Lack of skills or expertise of workers</td>
<td>Lack of education or training experience</td>
<td>Workplace is dirty &amp; noisy</td>
<td>6</td>
<td>4</td>
<td>No</td>
<td>5</td>
<td>2</td>
<td>0</td>
<td></td>
<td></td>
<td>The manual loading/unloading is replaced by lifting conveyor</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 6.** Cause and effect diagram of the process inefficiency

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From the analyzed problems, Human and machines are also critical causes which affect to process efficiency. Therefore, some of suggestions for the improvement plan are:

- Staff training with functional tasks & set the criteria for recruitment as well as Improving the performance appraisal for key staff - The operators can check the quality as well as basic maintenance/repair
- Teamwork – divide subgroups by region/parts with functional tasks
- Have a plan for arranging labor - Reduce the labor by using flexibly fork lift for delivery defects/foreign matter in each step.
- Machine maintenance should be done according to standard procedure for quality and safety in maintenance
- Set the error proof mechanism in operation system.
- Re-layout workplace (can be seen in Appendix)

There is significant improvement for waiting time of delivering or moving for inspection creating a buffer; the inventory management efficiency also is established to help to reduce time for seeking/moving or avoid high level for inventory as well as the quality of products. That makes the process to become more stability and reliability. On other hand, in this case study it is suggested that use the lift conveyors should replace manual loading/unloading, which will increase cost investment for the short-term, but for long-term, it will help to avoid a shorthanded situation; reducing labor costs by; reducing the time for rest due to fatigue...

**Step 3**: Re-design the value stream map and look back at the new layout to evaluate/verify the efficiency of the solutions. The Figure 6 shows a new value stream map at Coffee Company. Table 5 shows the results that the average waiting time for transportation (Non Value added time) is reduced dramatically from 50,940 seconds or 849 minutes to 31,520 seconds or 525.33 minutes for whole operation, and decrease 38.12% respectively.

**Table 5**: The total time for producing 126 Tons coffee Robusta before and after improvement

<table>
<thead>
<tr>
<th>No</th>
<th>Category</th>
<th>Total time Before</th>
<th>Total time After</th>
<th>Improvement percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Value added time (VA/T)</td>
<td>60,540</td>
<td>58,740</td>
<td>2.97%</td>
</tr>
<tr>
<td>2</td>
<td>Non Value added time (NVA/T)</td>
<td>249,240</td>
<td>218,070</td>
<td>12.50%</td>
</tr>
<tr>
<td>2 a</td>
<td>Necessary Non Value added time (NNVA/T)</td>
<td>198,300</td>
<td>186,550</td>
<td>5.93%</td>
</tr>
<tr>
<td></td>
<td>- Inspection</td>
<td>24,600</td>
<td>13,150</td>
<td>46.54%</td>
</tr>
<tr>
<td></td>
<td>- Stored and waiting time (control by 3rd party)</td>
<td>172,800</td>
<td>172,800</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>- Check quality of raw materials before</td>
<td>900</td>
<td>600</td>
<td>33.33%</td>
</tr>
</tbody>
</table>
3.5 CONTROL PHASE

This phase is designed to help the improvement teams confirm the results and make the gains long-lasting. The main purpose of the control phase is to document the changes and new methods, and maintain an organized, clean, and high performance process. This goal of this phase is to sustain the improvements implemented. It is used to the control plan because the control checks continuous and report any variation when some variation is out of control.

To implement the 5S, which can create a clean, well-organized and efficient work environment to reduce searching time; improve worker safety; quality and throughput. That will help keep value added efficiency and minimal waste.

### Table 4. Non Value Added Time (NVA/T)

<table>
<thead>
<tr>
<th>Process</th>
<th>NVA/T (sec)</th>
<th>OEF (%)</th>
<th>NWF (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Uptime</td>
<td>450,940</td>
<td>53.12%</td>
<td>46.88%</td>
</tr>
<tr>
<td>b. Non Value added time (NVA/T)</td>
<td>31,520</td>
<td>90.4%</td>
<td>9.6%</td>
</tr>
<tr>
<td>- Transportation (for delivery to inspection</td>
<td>13,500</td>
<td>91.5%</td>
<td>8.5%</td>
</tr>
<tr>
<td>are)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Delivery &amp; store coffee R1 in step 2 and</td>
<td>11,700</td>
<td>90.4%</td>
<td>9.6%</td>
</tr>
<tr>
<td>finished product in step 6 (buffer)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Remove foreign matter/defects</td>
<td>25,740</td>
<td>90.4%</td>
<td>9.6%</td>
</tr>
<tr>
<td>3 Workers</td>
<td>71</td>
<td>99.3%</td>
<td>0.7%</td>
</tr>
<tr>
<td>50</td>
<td></td>
<td>99.4%</td>
<td>0.6%</td>
</tr>
<tr>
<td>29.57%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. CONCLUSIONS

This thesis project has proven to be an extremely rewarding experience for our group. We have accomplished all the goals that we outlined in our objective for this project, which are: (1) familiarize ourselves with the new Model procedure guideline; (2) complete critical analyses of the case study for process improvement and innovation by the application of Lean Six Sigma and TRIZ methodology.

We dedicated the earlier phase of our project towards the research of the topic and the reviewed of the previous studies. From reviewing extensive literature, we attained a deep understanding of the Lean Six Sigma approach and TRIZ methodology as well as implementing framework of the methodology that we would later apply in this case study at the coffee company. The case study successfully eliminates the waste of waiting time for inspection (46.54%) and the transportation during the operation system (38.12%). That lead to a reduction of the Non Value Added time (reduce 38.12%), respectively.

The improvements and control plan were proposed. Setting a standard for quality of raw materials as well as the operation procedure & training plan with functional tasks for workers resulted in proof that the application of Lean Six
Sigma combined with TRIZ methodology will become a new approach which can bring successful improvement for manufacturing engineering as well as the improvement of service activities.

**FUTURE RESEARCH**

In this case study, some tools of the Model are not still used because of having limits for collected data or no real experiment, so we still not cover the benefits of the new Model, except for the examples related to improvement. For the future research, with carefully using and expanding new techniques or idea, the Model can be enhanced efficiently and effectively in order to achieve the quality improvement, reduced wastes, reduced cost as well as the process system becoming more stable and reliable.

**REFERENCES**


AUTHOR

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APPENDIX

Figure 7a. The current layout warehouse at Coffee Company
Figure 7b. The enhance layout warehouse at Coffee Company