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**SHANGHAI CUNDI CLOTHING MANUFACTURING COMPANY –
PRODUCTION LINE IMPROVEMENT**

Major Qualifying Project Report

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Abstract

Cundi is a clothing manufacture that was founded in 2015 that wants to apply lean manufacturing knowledge to optimize the system, so that the cost and time of production can be reduced. Based on the observation and data collected, several wastes were detected. This report provides the company corresponding solutions to the wastes that slow down the process.

Acknowledgements

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I would like to thank professor Amy Zeng. Without her, I wouldn't be able to start this project. Her valuable questions and suggestions help me to think from different aspects to solve the problem. I am very thankful for her to advise this project and provide so many useful suggestions throughout the project. Professor taught me how to be well prepared and how to see things in a long term.

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1.0 Introduction

This session will be discussing the background of Cundi manufacturing company and the problem that needs to be solved. It is important to understand why Cundi has this problem and what are things should be concerned before implementing a solution. The scope of the project is also defined in this session.

1.1 Cundi Manufacturing Company

Cundi is a garment manufacturing company that consists of around 40 workers and 15 staff in the factory. It was officially founded in 2015. It is now located in Fengxian, Shanghai, China. It is a supplier for many clothing companies in Europe and Australia, one of which is Hockery. Cundi is the main supplier for Hockery, which is an e-retailer that sells customized formal menswear. Customers can choose from the number of buttons on the suit to the types of collar based on the template. All the suits are more or less different. This flexibility hinders the manufacturer from forecasting the number of orders. In order to reduce the waste on materials, the manufacturer try not to keep too much cloth as stock. The factory will only receive orders that they have materials available. The office that allocates orders only needs to guarantee that the factory will receive 40 orders everyday. Due to the fact that purchased cloth is expected to arrive at the office within two days. Currently, main products of the factory are shirts, suits and trousers for men. Manufacturing, inventory storing and order shipment are in three different locations. All orders should be ready for shipment by 6:30pm everyday. The

goal is to allow customers receive their packages within 14 days since they place the order. The lead-time is 6 to 7 days when the order is received and ready to be shipped.

1.2 Problem Statement

The biggest thing that is concerning Cundi is that now the minimum wage in China is increasing rapidly, and the rate of production is still the same. That raises an issue is that the profit is reduced. In order to maximize the profit in total, wastes will be first detected in the production, because any waste will be counted towards the cost of production at the end. For example, any worker's idle time in the process can be a waste of labor. Maximizing the utilization of every worker will make the whole production line be more efficient and thus the lead-time will be decreased. Figure 1 is the current layout of the factory. The whole production line is now classified into three parts. First part has CAD making, cutting, and fusible interlining. Second part has unpacking, assembly line,



Figure 1: Overview of the production line

button Attaching, and handmade. The last part has ironing, QC, pairing and shipping.

According to the sponsor, the main bottleneck that occurs in the whole production line is at the cutting station. In general, the cutting station includes CAD making, cutting and fusible interlining. What causes the bottleneck is that fusible interlining cannot be started if not all clothes are cut. At the cutting, the worker needs to cut both the inside and the outside of tops. Those cut insides and outsides will then be sent to the fusible interlining station after being organized. However, to be time saving in the cutting machine, the worker wants to start cutting the outside after cutting the inside. That means people in fusible interlining literally do not have anything to do until at the very beginning when they just receive a new pile of orders. Figure 2 is the detailed layout of the first part. The goal of this project is to first identify the waste from the assembly line, and then find solutions to reduce the waste.

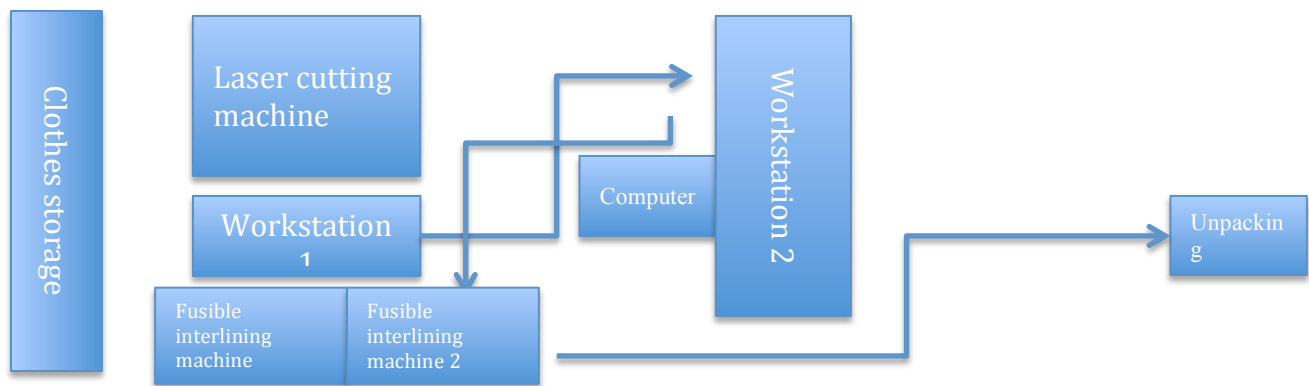


Figure 9: Current layout of the cutting station

2.0 Literature review:

This section provides necessary and brief background on the knowledge that will be applied in order to achieve the goal that is set for this project. It briefly discusses what is behind the popularity of mass customization and what seven wastes are defined as in lean manufacturing. Furthermore, some case studies are collected for brainstorming.

2.1 Mass Customization

In order to survive in this competitive market, more and more companies adapt the customization to attract more customers. However, the drawbacks of customization are that the cost is increased and the timely production becomes a challenge.

Timely production is important as if products cannot be delivered soon enough, customers may leave.

Mass customization is embraced by many companies to reduce the unnecessary cost and complexity in operation due to the customization service.

In order to help managers identify what type of customization they should pursue, four distinct approaches are identified, which are collaborative, adaptive, cosmetic, and transparent. A service design can include one or more than one approach.

In this case, Cundi is applying the adaptive approach, since one standard, but customizable product is given to customers.

In clothing industry, or in footwear specifically, Nike and Converse have built popular “mass customization” services. On the website, they will provide samples of pairs of shoes with no color or pattern on it. Samples can be in different categories, such as sneakers, board shoes etc. Similar to Nike, Cundi also provides samples from different

categories, like ties and suits. Customers are given a wide range of choices, from color to materials. However, recently some managers also find out that mass customization can produce unnecessary cost and complexity as well.

There are also challenges to the mass customization. The first one is cost. The cost of production is usually higher than the mass production. Products cannot be produced in large amount of batches, since all customers may have few things different from others. If producing too many products, there will be a problem of overproduction, which is also a waste of money.

Besides, finishing goods in a timely manner can also be a challenge. Due to the fact that it is difficult to predict what customers want, forecasting can be not reliable. Thus, most of the companies will only start the production when the order is received. As the head of Bain & Company's Digital Transformation Group, Elizabeth Spaulding mentioned: "Footwear customers are willing to wait three to four weeks for a product to be delivered, but interest in customized men's shirts declined after a two week wait time.

One solution to this problem advised by Joseph Pine, a business strategist and an author is to move the factories close to customer. Unfortunately, this suggestion cannot be applied to Cundi. Majority of the customers are located in Europe and the United States. Customers are very diverse with regard to locations. It requires oversea shipping everyday from China to other countries.

Another solution is asking to customize base on one standard, such that some parts can be pre-made, and then put them together upon the requests.

2.2 Seven wastes in manufacturing

Lean manufacturing, a method that is used to reduce waste in production plans, manufacturing and customer relations concludes seven wastes. Waste is also considered as “muda” in Japan, where seven wastes were originated in.

Transportation

The waste of transportation is also considered as the waste of movement between stations. While transporting goods from one station to another is the non-value added time, especially in some manufacturers, there are transporting equipments involved, such as forklift trucks. Usually, the cause of this problem is either overproduction or inefficient layout of the manufacture. Traditionally, stations that serve the same purpose will be together, for example, the entire cutting is done in one area, and sewing is done in different areas. That creates the need to transport the goods and materials between stations. Sometimes the distance can be long and unnecessary.

Inventory

The second kind of waste is inventory. This is usually created by overproduction. It takes space and time to store the overproduced goods. In lean manufacturing, JIT-“just in time” is ideal for most of the manufactures. Just in time ensures that the manufacturer only produce goods that customers want at the right time. On the other hand, having unnecessary inventory indicates that there are unused goods or materials, and then the whole production process may not have a continuous flow. The order of the products can be very difficult to keep track of.

Motion

Similar to the waste of transportation, the waste of motion also refers to the waste of the movement, but within the processes. The waste of motion can apply to workers and machines. If someone needs to move back and forth for one process, then it is considered as waste of motion. Similarly, if a machine needs to travel for few seconds before it actually gets to the product, which is also considered as waste of motion. This waste is also tightly related to the layout of the production line and the design of tools and equipment. If someone needs to bend all the time to work, then staying in that position for a long time will stress out the worker as well, eventually will decrease the quality and the rate of production.

Waiting

Waiting refers to the idle time of people, machine and items. This is commonly seen in manufactures, once an item is in the process of waiting to be transferred to next workstation, this item is considered as idle. The same thing applies to workers, if the previous station is in bottleneck or the item fails to be delivered to the right station; they are idle, because they have nothing to work on. A good layout of the production line can also solve this problem. Once the distance between stations is shorten and processes are linked together so that one can feed directly into the next station, the idle time of people, items and machine can be highly reduced.

Overproduction

Overproduction is to manufacture an item before it is needed. This waste can be very costly to a manufacturer, since the unsold products will then be considered as inventory, which requires high storage costs. Manufactures often overproduce to prevent

any accident that may occur and also expect customers will buy it. This is referred to “Just in Case”. Even though most of the manufactures have the exact number need to produce based on the forecast or accurate analysis, manufactures may still produce some more try maximizing the amount of time machines run for to minimize the relative time taken to set them up. This is a waste can be eliminated right away but also takes a lot of courage to do so, as many problems may be revealed.

Over-Processing

Over- processing is putting more time and effort than expected. For example, using high-tech machinery can be unnecessary if other simpler tools can be sufficient. By doing so, only the cost the production is increased, but the revenue is still the same. Instead of purchasing expansive high precision machines in one station, it is better to invest in smaller and more flexible machines in multiple stations.

Defects

Defective items are items need to be reworked. Reworking requires extra time, money and labor. More than that, one also needs to reschedule and invest more time and energy to create replacements. After all, the loss is not only time and labor takes to rework, but doing the whole process again. Thus it is very necessary for workers have good understanding of what are being inspected to reduce the frequency of defects.

2.3 Case Studies

Studying cases that are also applying lean manufacturing knowledge to improve the efficiency in the production line in other companies can be very helpful. Two cases were gathered as good examples of optimizing the system in the manufacturer. Even

though two cases are both serving the purpose to reduce to time and cost of production, two companies are optimizing the system from different aspects.

Case study of a Turkish Textiles Firm

A team came to Turkish Textiles Firm to help the company increasing the efficiency in the production line by implementing the lean manufacturing knowledge.

Figure 3 concludes the background information of Yesim Textiles.



Figure 3: Result of applying lean to Yesim Textiles

First of all, the team toured around the company and detected some issues and facts about the production line. One thing detected is that the production line has high rates of inventory and work-in-process. That takes a lot of space and money to keep those products in stock. Besides that, the reworking rate is also high, especially in sewing process. That also slows down the whole production rate, and creates the waste of

resources and time. That also leads to another problem, which is it requires a lot of sorting at the end due to the amount of defects. The third issue mentioned was that each step of the process happens separately from the next. That increases the possibility of overproduction, since workers will only work on their own stuff. However, despite all the negative problems, most of the employees are very enthusiastic. That can be very important and helps the implementation of lean manufacturing be more successful.

After listing out all the problems that hinder the manufacturer increasing the rate of production, the team worked on the solutions. Due to the fact that various manufacturing processes taking place in the factory, a pilot area, machine or a line was selected from each production area. For the selected pilot area, the team first moved the control activities to the end of each process, so that all defected pieces will be repaired right away once detected. By doing so, inventory and work-in-process can be reduced. All the pieces going to the next station will be qualified. After that, the team also added Andon lights on every machine and every production line as visuals. The view is always boring in the factory, and important information will be neglected. Having those lights as visuals can help workers know what is happening right away. For example, when the red stack light is on, it means that the machine stops due to a quality problem, and requires a technician to come and fix the problem. Another problem mentioned earlier was that each step of the process happens separately. In order to improve this problem, the team classified the products by product family and grouping them by production line, so that same family products will be in the same line and will make the sorting later easier and save time for the whole process. Another reason that makes the sorting difficult is that there high rate of reworking. Thus, the team also asked the leaders of the factory to

pioneer the process after giving the training on the 12-step kaizen format. Checklists were used to assess the performance and plan follow up actions. Meanwhile, leaders of the factory should encourage worker to express their thoughts in order to establish a problem solving culture. All the operators should receive training to reduce the rate of reworking. Training is a crucial step to improve the efficiency of the production line in a long term. The goal of the training plans is to give operators knowledge of operating more than one machine and line. In more detail, operators in the factory will be classified into four groups. Group one has operators that require receiving training. Group two are operators that are able to complete the work with support. Group three are operators that are able to complete the work independently. Group four are operators that are able to provide training. By giving trainings to all operators, the flexibility in the factory will be increased. Another operator can fill in when some is absent.

After implementing those ideas, the result was very positive. As a result, the space required for the production line is reduced. Now the empty space is turned into meeting rooms. The cost of production is also reduced, and those reduced cost is used for new investments, without laying off any employees. Figure 4 is the conclusion of the improvements and resulted benefits from applying lean manufacturing knowledge.

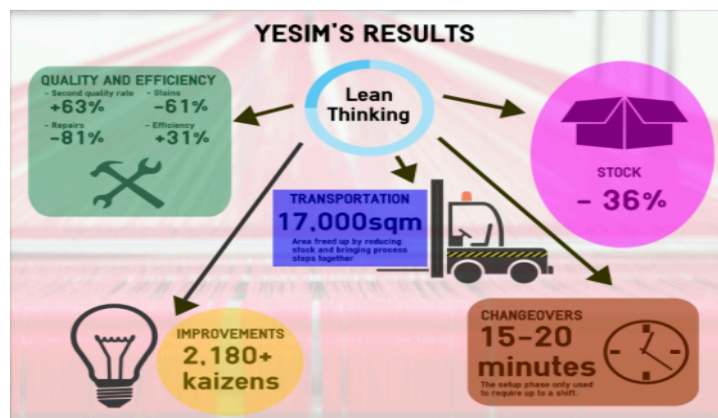


Figure 4: Results of Yesim's Textiles

Case study of AB Sewing Factory

AB Sewing Factory has a monthly demand of 375,000 pieces. The factory is operating 25 days per month. This case is about the AB Sewing Factory implementing the lean manufacturing to improve the efficiency. Layout redesign and line balancing are applied as lean techniques to reduce five types of waste: defects, inventory, overproduction, transportation and waiting time.

Based on the observation, transportation takes large portion of the waste. First, the cost of transportation is calculated based on the formula:

$$\text{Cost of transportation} = \text{NB} \left(\frac{\text{LMN} * \text{AWD} * \text{T}_{\text{AWD}}}{60} \right) * C_h,$$

LMN is the line movement number. AWD is the average walking distance by worker.

T_{AWD} is the time during the AWD in minutes. NB is the number transported batches. 60 denotes minutes per hour. Based on the data collected and information given by the

factory, the cost of transportation is \$310 for the study period, where is taking account of 13,350 pieces. According to the manager of the factory, the waste of transportation is half of the cost of transportation. Thus, the waste is about \$155.

In order to reduce the waste of transportation, a new layout is designed. Figure 5 indicates differences between two layouts. The above one is the current layout, and the one below is the new optimized layout.

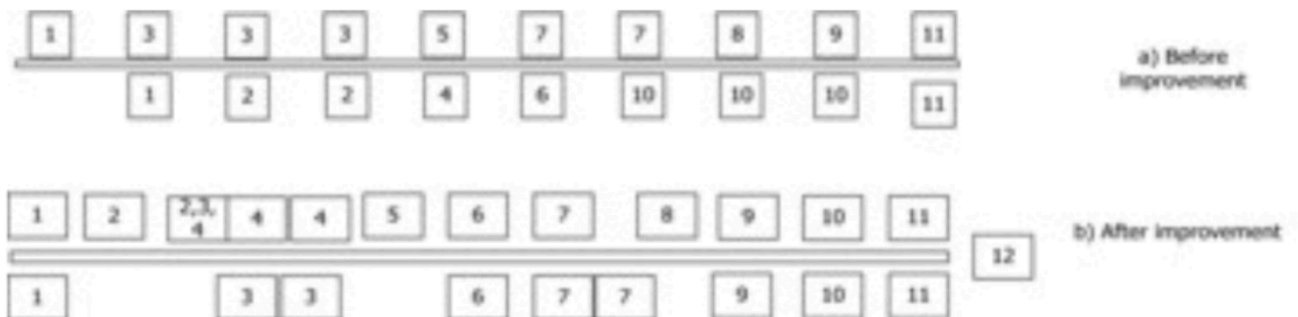


Figure 5: Line layout before and after improvement

Currently, the layout does not support the smooth flow of the production that figure 6 shows and all stations have equal space between each other. Having gap between same stations increases the time and cost of transportation.

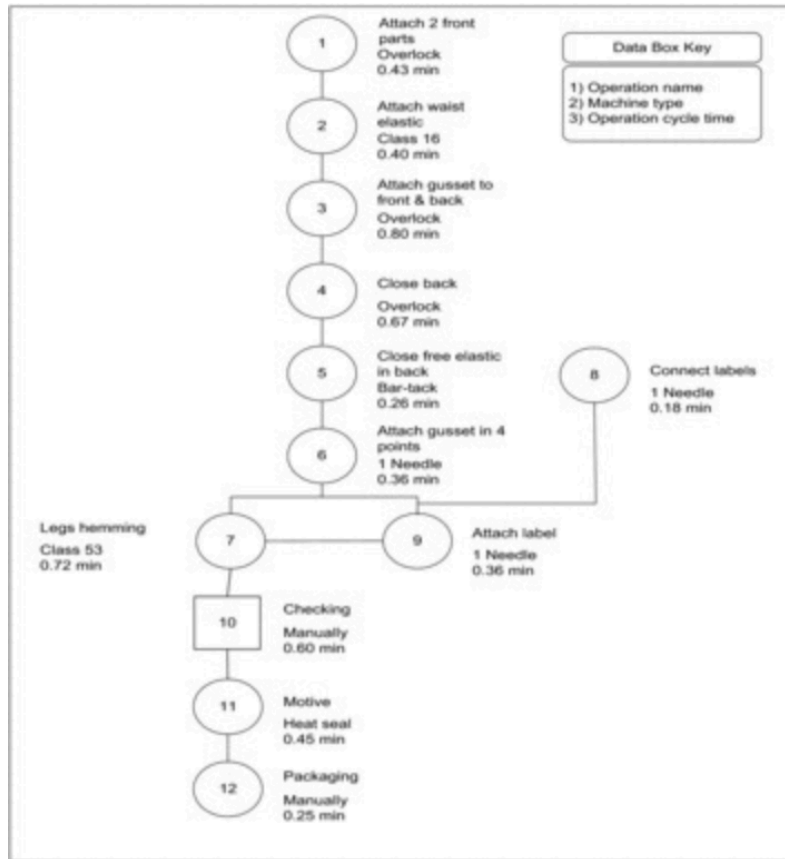


Figure 6: Production line details

In the improved version, workstations are placed one after another based on the production flow to ensure that the cellular manufacturing between stations in series can be enhanced. Furthermore, large buffers are also eliminated to reduce the waste in transportation. A new station 12 also is added to the new layout, which helps to reduce the worker transportation between workstations 11 and 12 specifically.

3.0 Methodology:

This session helps outline the detailed process of this project. Focus group was first conducted to understand the scope and the main objectives of the project. After the scope and the goal are set, staff in the certain station was then interviewed to get more first hand information on the production line. Interviews help me to understand where the problems occur most frequently and what are the issues should be aware of. Then it requires supportive data to be collected and analyzed to improve the whole system. The figure 7 is a flow chart of how the process of this project.

Figure 7: Flow chart of the process of the project



3.1 PQP in D term

Before the project started in Shanghai, I first did the literature review on concepts suggested by the advisor to have more solid understanding of lean manufacturing, which helps the planning afterwards. The report only includes the ones that actually applied to the purpose of this project. However, beyond that, I also did research on forecasting, inventory management, postponement, and productivity measurement. Each section

includes the general background of the topics and necessary calculations of them in different aspects of business models.

3.2 Focus group and interview

As the project started, the manager of the factory, the sponsor and I had a focus group discussing the current situation and problem that hinders them from increasing the production rate. Low attendance rate is one of the reasons. The attendance rate at the production line is about 90%, 7% lower than the attendance rate in other two offices. This problem directly leads to the occurrence of bottleneck, as all the work is separately distributed. Only one to two people know how to do other people's job, but not 100%. Both the managers and the sponsor want to focus on the cutting station first, because that is the beginning of the whole production line, and it is also the station that the most bottlenecks. It is crucial to ensure all the jobs are done efficiently so that the following stations can be follow the right track.

After deciding first focusing on the cutting station first, I then interview the staff there to collect their opinions on the problems occur to them. One thing that the staff complains a lot is that the utilization of workforce is low. Some workers spend hours waiting for orders to come to their station during the daytime, and then their total working hour is extended because the rule is everyone needs to finish at least 40 orders a day before they leave. Even though they get paid based on the hours they work, workers still wish to be able to go home early. After collecting the thoughts like that, I interviewed the manager for his thoughts. According to him, workers in the cutting station and in the ironing station are the ones need to work overtime most frequently. That is because they are the beginning and the end of the whole process, and the office

takes orders at 3-4pm everyday, which is already about the time to get off work. However, if not enough pieces are cut before the next day, the assembly line will have nothing to do.

3.2 Data collection

After understanding the background of the company and the project, it is necessary to start collecting the data of the company. Data and observation can help identify the waste and problem that should be solved later. For the rest of the two weeks, I stayed in the production line, mainly the cutting station to find the reason that slows down the whole production line. First of all, it was necessary to understand how each process is connected with each other in the whole production line. Then go more specifically, how many steps are broken into within the cutting station.

All the data is collected after the new round of orders start, where staffs complain the most. There are five people in total working in the cutting station. One person is in charge of CAD making. One is working at the cutting station. Another is organizing the pieces from the cutting machine. Fusible interlining takes one person. Another one is an intern that is helping out at this station.

The whole process starts from CAD making, which is putting all the information into CAD for it to generate graphics used for cutting later. After that, the cutting person selects the order and type in the parameters, such as power and velocity. Then the machine will start cutting the clothes based on the CAD graph. After the machine cutting is done, the worker will tear down the cut pieces and pair them up, such as putting the left and right sleeves together. Then the cut pieces will be sent to next station, where they need to organize the pieces or cut the burnt edges of the clothes that are left by the laser

machine. Even though the laser machine leaves marks on all clothes, it only appears very obvious on white or lighter colored clothes. Thus, it takes an extra 10 minutes for them to clear the burnt edges for each order. After all the pieces are organized, they will be then sent to the fusible interlining station. This step is to glue the inside and outside together for the tops by the heat and high pressure. It requires fusible interlining machine. This machine requires 30 minutes to warm up and another 30 minutes to cool down. The worker first needs to pair up two pieces and then send them into the machine. The whole process for one order takes about 5minutes.

The figure below is the flow chart of the cutting station. Usually from 3-5pm, people working in fusible interlining are idle. They need to wait till all the pieces are cut, because this process is to glue the inside and the outside clothes together. To eliminate the time of changing clothes, they cut the insides for all 40 orders first, and then cut the outsides.

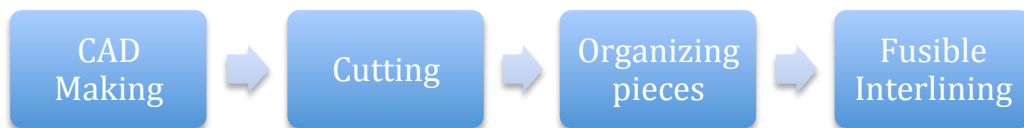


Figure 8: Flow chart of the cutting machine

4.0 Analysis, Results and Implementation

The collected data was then processed and analyzed in Excel. This session shows the result of those data and corresponding problems that can be detected from it.

4.1 Analysis

Upon the observation, there are different types of wastes occurred in the production line.

Two major ones are occurred during the waiting and transportation.

Waiting

First of all, two to three people were idle at the cutting station after 4pm. The reason is that the person working at the fusible interlining station needs to wait till all the clothes are cut to start fusible interlining. The one that is in charge of CAD making, as mentioned earlier, doesn't take more than a minute pre order. Thus it is understandable that he finishes his work sooner than the others. Two people that were supposed to organize the pieces for fusible interlining were cutting the burnt edges left from the laser machine. Those edges are only obvious when it comes to white or lighter colored clothes. Usually, those white or lighter colored clothes will be cut at the first, so that those two can start working on clearing the edges. However, once they are done with this job. They become idle as well. Besides that, while the machine is working, the person that is in charge of the cutting is idle as well. After she spends about a minute to get the next order ready in the computer. She doesn't have anything to do as well.

In general, most of people are idle when a new round of order starts. They do not have anything new to work on until cuttings are done. For now there are five people in total working in this station, which seems unnecessary. Besides that, machines are idle for about 20-30% of time at the beginning. Two machines, one is the laser cutting

machine, and another is fusible interlining machines are both very power-consuming. Thus, when two machines are idle, there is huge waste of resources. To have better understanding if there is great amount of energy wasted in the cutting station, there is data collected. Below is the data about the idle time for the laser-cutting machine. As a result, there is about 30% of time that the machine is idle. The idle time for white or lighter colored clothes is greater than darker colored clothes, due to the fact that the worker will organize the pieces for white colored clothes to save time for people need to cut the edges. On the other hand, she doesn't organize the darker colored pieces but only tear them down from the machine and throw them into the basket wait other people do the organization job

Order –lighter colored	Machine cutting(mins)	Machine idle time (mins)	Total(mins)	Notes
1	2:41	1:30	4:11	
2	2:41	1:35	4:16	
3	2:41	1:32	4:13	
4	2:41	1:36	4:17	
5	2:56	1:55	4:51	
6	4:30	2:42	7:12	for three sets
7	1:52	1:25	3:17	
8	2:57	1:50	4:47	
9	2:41	1:07	3:48	
10	3:01	2:00	5:01	
11	2:42	1:21	4:03	
Average	2:51	1:41	4:32	
Percentage of idle time		0.371495327		

Table 2 records the time that takes to cut darker colored clothes. In average, it takes less time than the lighter colored clothes, because the speed of the laser machine can be set higher, as the burnt edges are not obvious for darker colored clothes. The reason that order 6 takes much longer time than the others is that the changing clothes time was also added to it.

Table 2: Table of idle time of cutting machine for darker colored clothes

Order (darker colored)	Machine Cutting (mins)	Machine idle time (mins)	Total (mins)
1	4:00	1:19	5:19
2	2:56	1:30	4:26
3	2:21	1:29	3:50
4	3:33	2:27	6:00
5	1:31	1:03	2:34
6	3:44	0:58	4:42
7	1:06	0:54	2:00
8	3:29	1:17	4:46
9	1:20	1:11	2:31
10	3:20	1:18	4:38
11	1:25	1:27	2:52
12	2:39	0:47	3:26
Average	2:37	1:18	3:55
Percentage of idle time		0.33286119	

Table 3 records the idle time calculated for fusible interlining. On average, the idle time is 1:28 mins and there is 18% of time the machine is idle per order as one order takes about 7:45mins in total. However, if including the time that machine takes to warm

up and cool down, there is about the same as the cutting machine idle time, as both warm up and cooling down takes about 30 minutes.

Table 3: Idle time of fusible interlining machine

Fusible Interlining		
Number of basket	Machine idle time (mins)	
1	1:25	
2	1:13	
3	1:19	
4	1:01	
5	2:15	
6	0:56	
7	0:52	
8	1:53	
9	1:41	
10	0:42	
11	0:59	
12	0:52	
13	1:34	
14	1:22	
15	1:38	
16	1:27	
17	2:04	White cotton and linen
18	1:59	White cotton and linen
19	2:40	White cotton and linen
Average	1:28	
Percentage of idle time	0.189111748	

Calculation in table 3: Total time for 40 orders : $(3:55)*40=142$; Total idle time for 40 orders: $(1:18)*40+60=107.2$; Percentage of idle time: $107.2/140=76\%$

Besides the time that when the machines are idle is considered as a waste, the waiting time for each order being transferred into next station is also non value added.

Table 4 is the data collected on the average time that a basket stays in one station before being transferred.

Table 4: Waiting time of orders

Basket number	Time arrives at the station	Time leaves the station	Time in station (mins)
40141418	14:30	15:10	0:40
41145018	14:35	15:10	0:35
41328218	14:39	14:49	0:10
41088318	14:44	14:49	0:05
41250618	14:48	14:49	0:01
40887318	14:52	15:06	0:14
40456118	14:57	15:06	0:09
31151118	15:02	15:06	0:04
38057318	15:08	15:10	0:02
35105718	15:13	15:14	0:01
36302818	15:16	15:45	0:29
41166910	15:21	15:45	0:24
34546818	15:25	15:45	0:20
32610718	15:29	15:45	0:16
41263918	15:35	15:45	0:10
40069718	15:40	15:45	0:05
345546818	15:45	15:46	0:01
Average			0:13

In average, each order stays about 10 minutes in one station. The data also shows that the standard deviation of the wait time is huge. Basket number 40141418 has the longest wait time of 40 minutes, which is about an hour, whereas some have shortest wait time of 1 minute. Upon observation, trousers usually are moved out of the cutting station faster than the tops, because trousers can be directly sent to unpacking station, unlike tops need to be fusible interlined first, according to the manager.

Transportation

Upon observation, the layout of the cutting station makes the transportation between workstations cliché and waste of time. Workers need to go back and forth to get baskets. Figure 9 is the current layout of the cutting station with the arrows showing the routes of workers moving from one station to another. From the graph, it shows that workers have very complicated routes within the cutting station. Workers in the cutting station need to go back and forth in this crowded area. Worker in the station 2 needs to get baskets from the station 1, and then sends the baskets back to station 1 for people in the fusible interlining station to fusible interline.

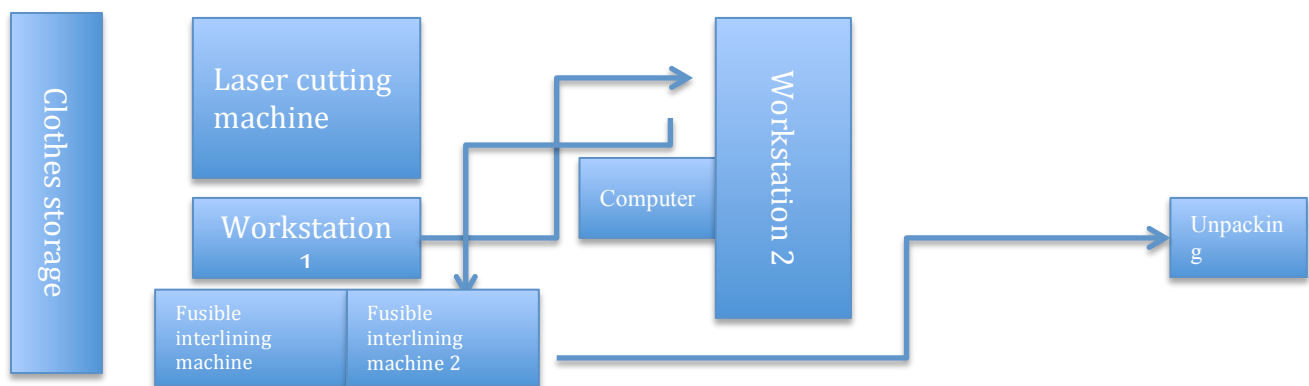


Figure 9: Current layout of the cutting station

4.2 Results

For wastes that are detected above, two solutions were then agreed on to resolve the problems that are causing those wastes.

Checklist of process

The first solution that was agreed on is to add checklists on each station. Checklists will mainly include things that will be checked later in the Quality Control station. By doing so can reduce the rate of reworking and reduce the idle time of other workers. When someone is absent or overwhelmed by the excessive amount of work, another person that is idle can fill up or help out based on the rubrics. Especially in the cutting station, where there are normally two to three people are waiting for the clothes be cut. Based on the rubric, they will be able to know what they are supposed to do to pass the inspection. Meanwhile, the idle time of machines can be reduced as well, since

New layout of the cutting station

The second solution is to change the layout of the cutting station. The following figure is the new layout. Instead of walking back and forth to get baskets, the new layout only asks workers to go in one direction. Workstation one and two in the current layout are combined into one. In the current layout, the workstation one is only used to place the cut pieces, then someone will come and get the baskets to workstation two to organize. Now in the new layout, once the cut pieces are put on the workstation, they will be organized and then organized pieces will be directed to the next station. Thus, there will be one person standing between the workstation and the laser machine to tear down the

clothes and out them on the workstation table. Another person or two people will be standing between the fusible interlining machine and the workstation to organize the pieces and pass the basket to the fusible interlining station. Currently, there is about a half of the space of workstation and a third of the space of the workstation 2 is not utilized. Thus in the short run, they can replace the workstation one in the current layout with the workstation two to reduce the cost and save the space in the factory. The size of the workstation two is twice as big as the workstation, thus, there will be about 100% utilization of this workstation in this new layout based on the current amount of orders. In the future, if the number of orders increases tremendously, they can always add another small workstation right next to it as well. Also, placing a toolbar between two fusible interlining machines help two workers get materials and tools conveniently. As now there is usually only fusible interlining machine on, the one that uses less electricity is placed closer to the next station, which is the unpacking station.

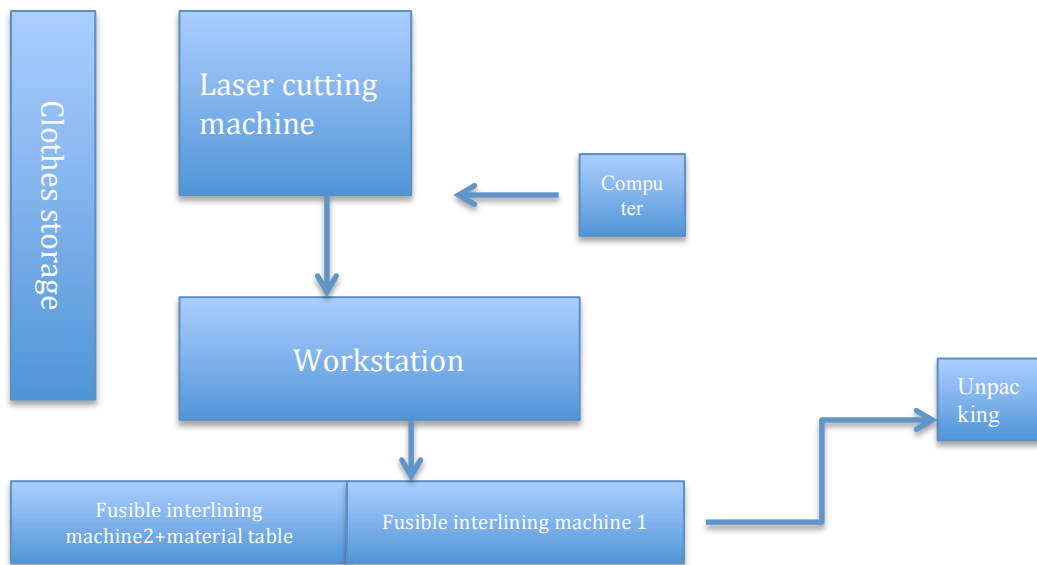


Figure 10: New layout of the cutting machine

4.3 Implementation

The company first implemented the first solution, which is hanging checklist for each station, so that other people can fill up the empty spot by looking at the checklists if someone is absent. It is also designed to improve the rate of reworking at the end by notifying workers what will be evaluated at the quality control station. Figure 11 is a sample of the checklist hanging on label and pocket attaching station.

Due to the fact that changing a layout can be time consuming and has great impact on the whole production, especially there is only one production line in total that is working. After discussion, sponsor decides to postpone implementing the new layout till some time there are not many orders. There was disagreement on how big the workstation should be, since for now two workstations are not fully utilized. After discussion, we decide that we can now replace the workstation one with the workstation two in the short run to minimize the cost and maximize the utilization of the workstation. In the long run, they can always add another workstation next to it if there are excessive amount of orders. Same for the fusible interlining station, the second fusible interlining will be kept and serve as a place for extra materials in the short run, since the second one is more power-consuming. If unnecessary, this machine won't be started to save energy.

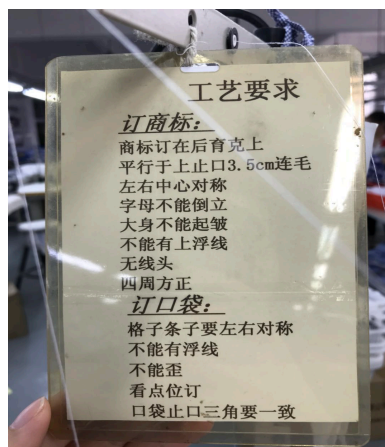


Figure 11: Sample of checklist for label and pocket attaching station

5.0 Recommendation

As the goal of this project is to first detect the wastes in the production line, and try to eliminate the wastes observed, after data collection and touring the plant, a focus group was conducted again to discuss possible solutions to eliminate the wastes were detected. Two main solutions were agreed on from the focus group to solve the problem of unnecessary waiting and transportation time accordingly. However, the improvement should not stop at this point. Some further recommendations for the long run and the short-run are listed.

5.1 Limitations

Due to the limitation of time of this project, the actual data on how the cycle time of each process in the cutting station has been changed after implementing the checklist cannot be presented in this report. Furthermore, a new layout will not be implemented in the project time, as changing the layout will acquire a lot of time and effort. The company is still looking for the time that they don't have that many orders to implement the new layout.

5.2 Short-term recommendations

In the short-run, the factory can first try reorganizing the tables that store materials. For now, workers work around baskets of orders and materials. The figure below shows how the workplace is organized currently. It can be waste of time for workers to rummage through the materials and orders. Currently, all the pieces are layered in the basket. Usually the worker in the next station needs to take extra time to

find the right piece to work on. It will be more efficient if all the pieces are put in different blocks in the basket, instead of lying on each other. In that way, it will be more obvious to see where is the collar and where are the sleeves.



Figure 12: Current arrangement of table

More than that, some chairs can be replaced. For example, this worker barely sits on her chair, because the height is not adequate for her. Once she sits down, she would need to bend over more. However, it is also very tiring for her to stand more than hours to work. That can also affect the quality and quantity of the production.

5.3 Long-term recommendations

In the long run, it is very necessary to replace the current laser machine. The biggest issue it has right now is that it burns the edge of light colored clothes. Even though it's impact on the cycle time of the whole process is not obvious right now, as

there are people are idle anyway. It is still a waste of resources-clothes. One possible cause of it is that the power is not big enough to cut the materials without leaving marks. However, according to the staff that is running the machine, she has already tested for many times to find the correct parameters for different clothes. That means there is limitation to how much the power can reach for this machine. In that case, the factory needs to change the whole machine for greater power. Another possible cause of this problem is that the current machine is using air as the auxiliary gas. It is cheap and more accessible. However, using air, which has 20% of oxygen will cause the materials be oxidized. Then the edges will appear to be dark brown. The better option is to use argon as the auxiliary gas. Argon is considered as inert gas. It can prevent materials be oxidized, so that the edges won't be left on brownish marks for lighter colored clothes. Meanwhile, it is more expensive than using air.

Besides that, it is also suggested to provide system training to all workers. Hanging checklists in front of all stations will help reduce the rate of reworking. However, in the long run, as the manager stated, the factory wants to improve the quality to a higher level, not just pass the quality control. More details need to be taken care of, so that the unit price of products can also be increased. In the future, the factory can set up few hours a week to ask a well-trained operator to train the workers.

6.0 Reflection

6.1 Discussion of design in the context of the project

To better utilize the space and eliminate the waste on transportation between stations, a new layout was design. In order to design a new layout that saves space and time for workers to move baskets and get materials.

First step was to know what the work flows like. A flow chart was first made to determine which process will be linked to another, and which process will be affecting multiple different stations. Then stations should be organized in the order corresponding to the actual procedure. In the new layout, stations are next to each other in a vertical order. One can pass around the basket by turning instead of walking for a minute, and possibly bumping into someone else.

It is also important to determine where the repetition happens. Based on the observation, workstation one is where workers usually need to come back and forth. The cut pieces will be placed on workstation one and then someone will come and move the baskets to workstation two for organization. After organizing, baskets will then be sent back to the workstation one. Thus workstations should be put in the middle place. Meanwhile, the workstation will be used as a medium between the cutting station and the fusible interlining station. Upon the observation, if someone at the fusible interlining station finds defects on the cut pieces, she needs to walk around the fusible interlining machines to talk to the person in the cutting machine. Due to two fusible interlining machines, the distance between two stations is even bigger. Now the new design allows them to communicate through the workstation between those two. The cut pieces will be

put on the workstation, and the workers in the fusible interlining station can get those from the workstation once they are organized without walking. Once they find defective pieces, they can put it back to the workstation and let the others know. Workers will be standing on two sides of the workstation so that they can pass out the baskets in more fluent way.

6.2 Discussion of constraints considered in the design

During the project, few constraints were considered. First of all, it should be economically friendly. Any improvement should not base on recruiting new workers, however, some other costs, such as creating rubrics should be minimized. Meanwhile, The good thing is that during the project, no extra worker is needed. One worker might be considered as part time later, as his job now is sending baskets and materials from station to station, and help out when is necessary. When the new layout is implemented, no more worker is needed to move around the baskets. Secondly, designing the new layout of the cutting station should take everyone's safety in to concern. The result is that the new layout of the cutting station makes the whole process into one flow, reducing the chances that workers may bump into each other to get hurt.

6.3 Discussion the need for life-long learning

This is the first time for me to actually work in a manufacturer and apply the knowledge that is learned in WPI. At the very beginning, it was difficult to communicate about lean manufacturing and industrial engineering concepts, since they are not well known in China. However, after few meetings and actually presenting the problems

found in the data collected, others are getting more and more familiar with what industrial engineer does. Meanwhile, I also start to know more about this major and lean manufacturing. After actually apply that knowledge and design the new layout, even it is only part of the production line, I am still very happy to see that sponsor and other staff are very satisfied with the new layout. It was a life learning experience for me to see how often the uncertainty can occur in the reality and how to weigh between two or more than two things, even though it is very unfortunate to see the new layout being implemented within this project. After all, I am able to enhance the knowledge I learned and help the company to reduce the waste in the production line.

6.4 Discussion of the interdisciplinary aspect of the project

Even though the main goal of this project is to reduce any possible wastes in the production line to increase the rate of production in general. A reason that increasing the rate of production becomes so urgent is that the minimum wage in Shanghai, China has been increasing tremendously. That is why sponsor wants to increase the rate of production without recruiting more workers. Especially, now it is very hard to recruit more workers as well in China. More and more people in Shanghai are well educated and refuse to work in low salary. This is an economic and political issue in China right now. A lot of companies are struggling with the same problem. Luckily, optimizing the layout of the production line and creating rubrics for each station helps the manufacture to be less dependent on workers, so that the company does not need to recruit any more workers, but meanwhile the rate of production can be increased in the long run.

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