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Faculty of Engineering & Architectural Science
Department of Mechanical and Industrial Engineering

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☐ **Industrial Engineering**

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Instructor	Dr.Jamy Li - GA Shereen Altamimi
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Case Study Final Report

Report Title	Case Study
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Executive Summary

Understanding the significance of engineering methods, standards and work design is extremely important for industrial engineers. By the analysis of a Simplicité brand stand mixer using the methods of the course, we are able to form an in-depth bill of materials, identify the root causes of assembly issues and optimize the entire work process for the worker. Time standard analysis through Maynard Operation Sequence Technique was done for the current state as well as an order of operations methods to understand the flow of assembly. The result of all these findings lead to a redesign and reanalysis of the system through defined methods and troubleshooting in order to find the most efficient, cost effective and the most optimal and feasible solution.

Time studies were conducted with the goal being to determine the standard time of an assembly and where the most delays occurred. Delays were found due to the strength of the magnet in the tool, the fact of the manual tool and that the assembly of the speed button required much precision to assemble. Finally line balancing was done to create a new order of operations and best split the worker 1 and worker 2 splitting.

The redesign process led us to creating a new jig with a 360 degree revolving turnstile with adjustable depth in order for the user to not turn their head the entire length of the process. Regarding fixtures, a new stand/sit table was created with multiple figurations with the second worker. Regarding tools, two twos were replaced with a single tool to complete the task. The purpose of these changes were to improve the worker-assembly experience and ensure health and safety measures are met. Process flowcharts and the introduction of an assembly conveyor line were implemented to understand and outline the tasks and expectations of each worker.

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Introduction (can include background info, brief research on product area, report scope, goals)

An electric-mixer is a kitchen appliance that uses a small motor to rotate the set of mixer arms, which mix foods or liquids contained in a bowl. The electric-mixer helps eliminate time required for mixing produce by hand. The product runs on electricity and has to be connected to a power supply. In today's market, there exist a wide range of electrical mixers. Some are handheld and others are stand mixers, for this project the specific model that was used is the Simplicité 5-Speed Hand Mixer, White is $15.99 and is available at Canadian tire. The aim of this project is to grasp a better understanding of the Hand-Mixer manufacturing process and determine a cost-effective production method which increases efficiency, cuts down on costs and saves some time in production. A bill of materials was constructed to better understand the materials utilized in the manufacturing process of the selected product. After analyzing the steps and processes a process chart was created, along with the calculation of the standard time and total time spent at each step. Correcting and implementing improvements on the issues in the production process regarding the workstations and workers will yield a decreased amount of time required at workstations. Which in turn will speed up the production process, increase efficiency and increase the production rate of the Simplicité 5-Speed Hand Mixer. The main purpose of this project report is to analyze and review the production process of the hand mixer and suggest improvements to the process. Improvements which in turn will better the efficiency, quality, safety and decrease the unit cost of the product.

Methodology Overview

Information and applications of the analysis of the current assembly process as well as the redesign process are applications of the information provided *Neibel's Methods, Standards and Work Design 13th Edition*. Assembly data was obtained by our group and the video provided by Dr. Jamy Li in the class courseshell. Other redesign and supplemental information was provided by the references provided at the end of the report. Using this information, line balancing, MOST analysis, costing and line efficiency were conducted to find the best process and worker conditions to assemble the Simplicité 5-Speed Hand Mixer.

Current System

Product Details (can include BoM, blow up or other images, tree diagram)

- Bill of Materials

The hand mixer has disassembled and all its parts were noted down in order to create the (BOM) Bill of materials. The BOM includes the part names, the quantities, type of material, an image and description. These parts were grouped into two categories: External and Internal parts.

- Tree Diagram

This Hierarchical Tree diagram represents the hierarchy of the hand mixer part assembly. Although the operator did not assemble the packaging, the tree diagram does not include packaging and respective parts because the video that was provided did not include them nor did it include the assembly of packaging.

Process

- Operations Process Chart (OPC)

The OPC chart shows the chronological order of operations, inspections and time required at each step. The main purpose of this diagram is to visually represent the manufacturing process.(every subassembly has a branch on its own). The time required for the OPC is based on the video recorded time, and the precedence is also found from the video provided.

- Flow Process Chart (FPC)

The FPC chart is defined by ASME standards, it contains the 5 different types of workflows defined as the following; Operation, Transportation, Storage, Delay and Inspection. Figure 2.8 in Neibel Textbook. The Flow Process Diagram is dependent on the OPC and hierarchical tree diagram in order to understand the subassemblies and recorded times.

- Flow Diagram

To have a better understanding and conduct and analysis on the workstations, a Flow Diagram was created. The diagram illustrates and represents the relationship between the workers and the workstation.

Line, Worker Utilization, Production Rate and Cost Analysis

Time Standards

MOST Analysis

Blue highlight = Done by worker 1

Yellow highlight = Done by worker 2

Table 1: *MOST times and FPC assembly time comparison table.*

Assembly	MOST TIME (s)	FPC TIME	%Utilization (Most/FPC) x 100%
Internal	13	18	72.2%
Control	81.3+4.32	114+ 8	70.2%
Electrical	113.02 +58.92	164+65	75.1%
External	73.20	98	74.7%

The consensus from this table is that the control assembly is the least efficient assembly in the process, followed by electrical. This is because of the tough viewing angles present along with the ineffective therbligs of present as well as the workers inability to put the screw on the screwdriver tip, in the redesign we will propose a screwdriver with a better magnetic tip with a long handle to reach the assembly locations. Lastly, the alignment of the speed button internally is extremely tedious and requires a high amount of precision to insert it into the right position, in MOST the way to write this only occurs once, meaning that time is wasted hence the % utilization being far from the actual time.

Table 2: *Standard Time Table from MOST ANALYSIS.*

Worker	TMU	Seconds	Standard Time (s)
1	5760	207.32	207.32
2	3790	136.44	136.44
Total	9550	343.76	343.76

Worker(s) at workstation 1 is responsible for the internal, control 1 and electrical 1 assemblies. While worker(s) at workstation 2 are responsible for electrical 2, control 2 and external assembly.

Cycle time = time taken by the slower worker to do their job = 207.32 seconds

Cycle time = $207.32 sec \ * \ (1 \ minute \ / \ 60 \ seconds)$ = *3.455 minutes*

Time Comparison

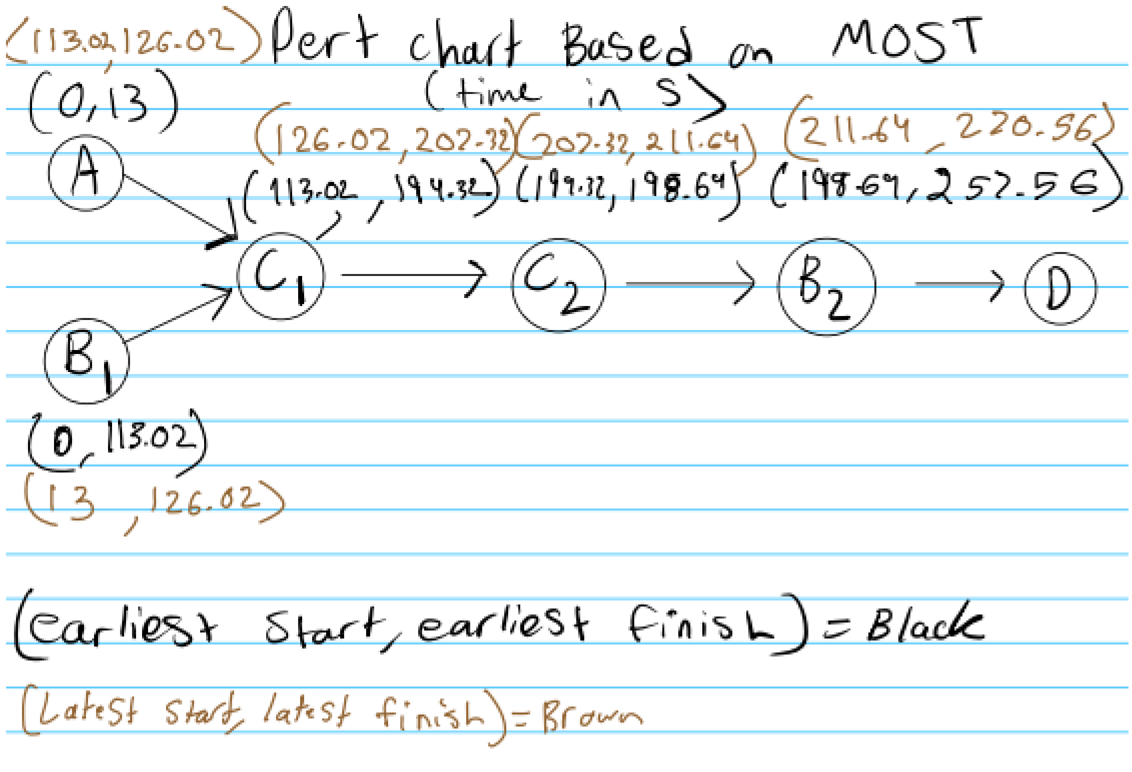
Table 3: *Actual time vs. Standard Time.*

Worker	Actual Time (s)	Standard Time (s)
1	297	207.32
2	171	136.44
Total	468	343.76

Ratio = 343.76 / 468 x 100% = 73.5%, the determined ratio discrepancy is in the appropriate range to conduct an analysis.

PERT

Figure 1: Pert Analysis based on MOST



Therefore, the determined critical path is B_1, C_1, C_2, B_2, D

The difference in the time is only present in A, it has 113.02 seconds to complete a task that only requires 13 seconds to finish.

Workstation Design

The proposed workstation design is one with a conveyor belt system that would easily transport the part to the next workstation. For workstation 1, the internal component would come up on the conveyor belt and the 5 respective bins with the screws would be color coded and organized on the table. For the second workstation, the required part would automatically be transported from the first workstation via the conveyor belt. On this workstation there would be two color coded bins with the necessary screws located in the cutouts. Whisk and whisk handles (P2.06 + P2.07) are placed off to the side of workstation 2, because they are not necessarily involved in the assembly. The next change that was made to the workstation design is that the turnstile becomes fixed in front of the worker anywhere along the conveyor path, meaning that the person can adjust the position to suit their arm length. Lastly, splitting the bins in the manner in which they are used allows the user to have less cognitive processing to do to look for the parts. The bins are arranged in a way that the pattern is from right to left.

Workstation Efficiency

Table 4: *Standard time vs. Actual Time for the 2 Workstations.*

Workstation	Assembly	Standard Time (seconds)	Allowed Time (seconds)
1	*Internal*	13	207.32
	Control 1	81.3	
	Electrical 1	113.02	
2	*Control 2*	4.32	207.32
	Electrical 2	58.92	
	External	73.20	

E $_{\textbf{workstation 1}}$ **=** $(\boldsymbol{\Sigma}\, SM \,/\, \boldsymbol{\Sigma}\, AM) \times 100\% \;=\;$ **(**207.32 / 207.32) x 100% = 100%

E $_{\textbf{workstation 2}}$ **=** $(\boldsymbol{\Sigma}\, SM \,/\, \boldsymbol{\Sigma}\, AM) \times 100\% \;=\;$ **(**136.44 / 207.32) x 100% = 65.8%

Production Rate

In the current assembly operation process, the MOST analysis demonstrates that workstation 1 requires a total of 207.32 seconds and workstation 2 requires a total of 136.44 seconds.

Assuming that the worker works an 8-hour shift not including the weekends, the worker would be working 20 days out of the month. The MOST analysis concluded that the cycle time is 3.312 minutes or 207.32 seconds, the greater number from the two workstations used in the production process. Using this valuable information, the daily and yearly production rates of operation can be determined:

Yearly Production rate =

$(480\ min/day\ *\ 20\ day/month\ *\ 12\ month/year\ *\ 60\ sec/min)$ / $207.32\ seconds$ =

= 33,339 units per year

Daily Production rate =

$(33339\ unit/day)$ / $(20\ day/month\ *\ 12\ month/year)$ =

= 138 units per day

Efficiency

$E\ =\ (\mathbf{\Sigma}\ SM\ /\ \mathbf{\Sigma}\ AM) \times 100\%\ =$ (207.32 + 58.92 + 4.32 +73.20) / 414.64 = 82.90 %

Idle time = 100% - E

Idle time = 100 - 82.90 = 17.10%

Worker Utilization

The expected number of workers per workstation was later determined using the desired rate:

R = 1 / 207.32 = 0.0048235

$N_{\text{workstation 1}}$ = $R \times \mathbf{\Sigma} AM$ = 0.0048235 * 207.32 = 1 worker

$N_{\text{workstation 2}}$ = $R \times \mathbf{\Sigma} AM$ = 0.0048235 * 207.32= 1 worker

According to the calculations above it is determined that only one worker is required for workstation 1 and one worker is required for the second workstation.

% Utilization = Duration of work / cycle time

These times are taken out of the MOST analysis table. The duration length is based on the assemblies of each worker. The cycle time is based on the time required for the slower worker to finish his work.

Worker 1

% Utilization of worker 1 = (21.6 + 77 + 113.02) / (207.32) = 100%

Worker 2

% Utilization of worker 2 = (58.92 + 4.32 + 73.20) / (207.32) = 65.8%

Line Balancing

The following times are taken from the MOST Analysis

Table 5: Elements in current stage

Element	Duration (s)	Immediate Precedence
A (Internal)	13	N/A
B_1 (Electrical) *B_2 (Electrical)*	113.02 58.92 TOTAL= 171.94	N/A
C_1 (Control) *C_2 (Control)*	81.3 4.32 TOTAL= 85.62	A, B_1 A,$\mathbf{C_1}$
D (External)	73.20	A, B_1, B_2, C_1, C_2

In order to increase the efficiency of the workers, half of the total duration from the MOST analysis was taken and calculated to be 5.73 minutes / 2 = 171.9 seconds.

The change we are going to make is that worker 2 starts with C_1, C_2, B_2 and D in that order, this makes the durations of each worker more balanced. Now the process is split better, before the change, the TMU split was 5760:3790. Now the TMUis 3500.1 TMU

Table 6: Positional Weight for each Element

Duration (s)	Element	A	B_1	B_2	C_1	C_2	D	PW
13	A				x	x	x	171.82
113.02	B_1				x	x	x	271.84
58.92	B_2					x	x	136.44
81.3	C_1					x	x	158.82
4.32	C_2						x	77.52
73.2	D							73.2

Cycle 1 (guy 1) = 207.32 seconds
Cycle 2 (guy 2) = 136.44 seconds

Table 7: Line Balancing

Element	PW	Precedence	Time (s)	Cumulative time (s)	Unassigned time (s)
B_1	271.84	-	113.02	113.02	126.72
A	171.82	-	13	126.02	113.72
C_1	158.82	A, B_1	81.3	81.3	158.44
C_2	77.52	A, C_1	4.32	85.62	0
B_2	136.44	A, B_1, C_1, C_2	58.92	166.54	0
D	73.2	A, B_1, C_1,C_2,B_2	73.20	239.74	0

Workstation 1: B_1, A, C_1

Workstation 2: B_2, C_2, D

Looking at the precedence weights, it was decided that B_1 should be performed first at the first workstation. The times taken for each assembly element and the precedence weight were taken into account to determine any changes. However, the time taken for each workstation to finish their job is roughly similar, keeping the PW in mind it was decided to keep the assembly process roughly the same. Therefore there were no changes made to the work elements of each workstation.

Cost Analysis

The cost analysis has been conducted to figure out the total factory cost of each unit in the production process. The total factory cost was calculated using the cost of materials, direct labor and factory expenses. The formulas used in these calculations are demonstrated below and their respective given costs are shown in a table. Disclaimer, we included packaging because although it was not in the video, we were provided with the cost and the stand mixer has packaging itself. The cost analysis becomes more accurate as a result of the inclusion.

Table 5: Approximate material costs for each sub-assembly.

Name	Labour Cost ($/hr)	Material cost ($)
External Assembly	16.5	1.31
Internal Assembly	16.5	0.05
Control	16.5	0.46
Electrical	16.5	0.98
Packaging	16.5	0.5
Total	-	*3.3*

Calculations:

Given Material cost = $3.3

Direct Labour cost =

Unit cost = material cost + (cycle time * minute rate of worker * number of workers)

= 3.3 + [(198.72 *16.5/3600)*2] = $ 5.1216

Unit cost = $ 5.1216

Cost to manufacture per day = units produced per day * unit cost + overhead

= (144 * 5.1216) + (0.43 cost to manufacture per day)

= 0.67 cost to manufacture per day = 144 * $5.1216

Cost to manufacture per day = $ 1100.762

Overhead = 0.43 * Daily total cost or cost to manufacture per day (found on Niebel's page 1)

Overhead = 0.43 * $1100.762 = $ 473.3276

Total unit cost after overhead = unit cost + overhead per unit

= 0.67 total unit cost after overhead = $5.1216 = $7.164418

Total unit cost after overhead = $ 7.164418

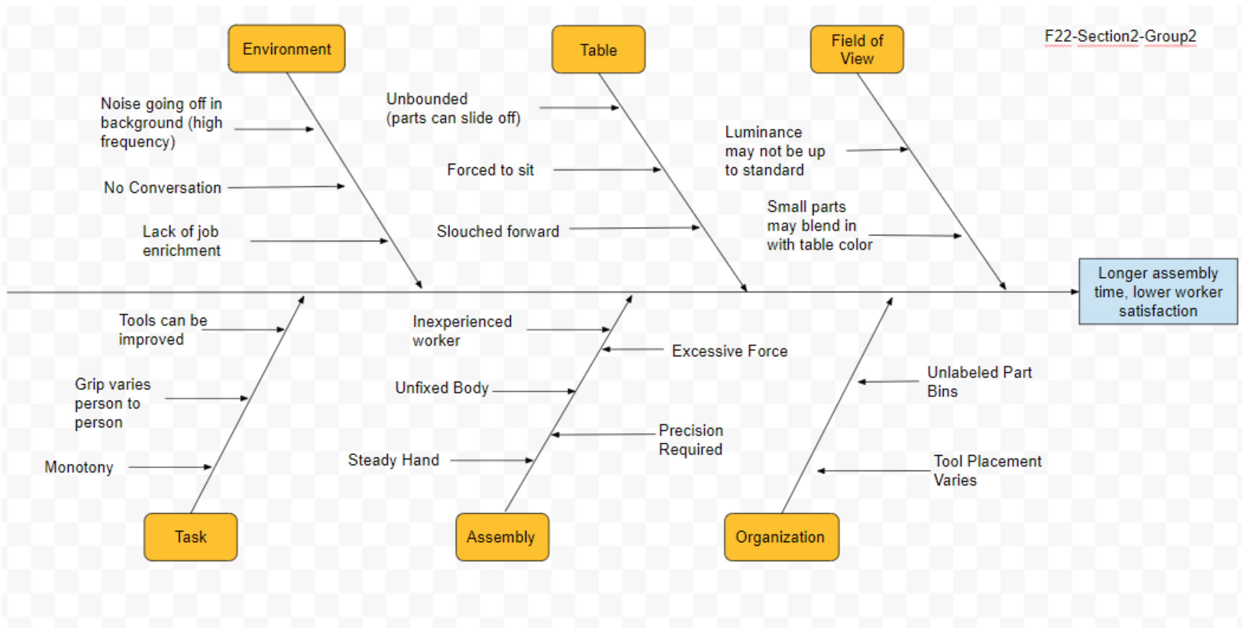
Overhead per unit = 0.43 * total unit cost after overhead = 0.43 * $7.16448

Overhead per unit = $3.287

Fish Diagram

The Fish Diagram or Ishikawa Diagram was created to identify the most relevant root causes for having assembly taking longer unnecessarily. In the next stages of the project and redesign, the goal is to negate, reduce and eliminate these factors if possible.

Figure 2: Fish Diagram / Ishikawa Diagram



It can be illustrated from the diagram that there are 6 major issue categories based on the provided video including Organization, Field of view, Assembly, Workstation/Table, Environment, and Task but not limited since there might be others to investigate, which can impact the assembly time and overall worker satisfaction behind the scenes.

Root Cause Analysis

The determination of the root issues comes with the recommendation of the textbook, experience and what people have said leads to bad working environments inside an office or center such as this one. Improving as much as we can not only improve job performance, but improve job satisfaction, and there is a direct correlation between job and overall life satisfaction (Ritter, 2002).

The first and most important root cause is the *Organization of the bins.* This root cause was identified to be greatly significant since the worker uses the same station throughout the entirety of the production process. Due to unlabeled part bins and varying tool placement, the person at the workstation takes more time to find the parts and wastes energy looking for the correct part or tool.

The next identified root cause is the *Field of View*, the luminance level and the color of the table/workstation. These negatively affect the worker's time to pick or locate required parts throughout the production process since it can lead to poor perceptual and cognitive human factors.

The *Assembly* itself can be another main root cause since it can prolong the processing time. By inspecting the worker's approach to the device, considerable factors were identified which can significantly impact the assembly time. Assembling the device requires sufficient precision, which an inexperienced worker with an unsteady hands or unfixed body can exert unnecessary excessive forces. This can not only result in muscle strain, fatigue and injuries, but also decrease the worker's satisfaction to do the tasks.

Another root cause was identified to be the *Workstation or Table,* the surface is unbounded and certain parts from the assembly can slide off. In that case the time taken to complete the required task would increase. Additionally, the flat surface at times requires the worker to slouch forward whilst working, over time this can have an effect on the overall physical health of the worker and thereby would affect the production process.

The next identified cause is the *Environment* around the station, background noise not only can potentially distract the worker, but also if it becomes too loud, it can have an impact on the worker's physical health. The individual worker was not having a conversation with other workers, and a process can be added to characterize job enrichment in order to make the tasks more motivating for the worker, such as skill variety increase, feedback reports, and autonomy creation. Consequently lack of job enrichment leads to lower productivity and eventually job satisfaction.

Finally, *Tasks* can be a burden through completing the process. High number of tasks, monotony and repetitiveness will make the work less controllable for the worker in overall. Understanding fundamentals can contribute to redesigning tasks accordingly. For instance, the grip varies in each individual for the same task, so tools need to be improved regularly, and unreasonable actions should be reduced or eliminated.

In a study in the Journal of Economic Management and Perspectives, in a survey of 136 employees. It was found that the employees greatly benefited from giving workers more autonomy, increased job satisfaction significantly and allowing tasks to become more fluid, reduced worker absenteeism and increased problem solving skills through motivation.(Alias *et al*. 2018)

Analysis of Equipment Requirements

In the assembly of the Simplicite Hand Mixer, the worker utilizes their hands and uses a screwdriver to put together the product. Time is lost from the assembly process due to the worker using his own hands to pick up and place the screws in the correct position while he uses the other hand to hold the part(s) down. Making use of a magnetic screwdriver eliminates the need to manually place each screw in its required position. If magnetic screwdrivers are utilized in the assembly process, they would provide additional control over the different types of screws used in the assembly.

The person at the workstation often uses their hand to hold the product at various steps of the assembly process, this means that the used hand is not performing a useful function. To eliminate this step a fixture should be used to hold down the part for the assembly steps. Making use of a fixture would increase the accuracy of work and would firmly hold the part in place while the work is being performed.

As mentioned previously, the person working at the station uses a screwdriver to place the screws into the product. Only using a singular screwdriver to assemble numerous machines per day may cause a cumulative trauma disorder due to the repetition of the same task over and over again. The worker uses a weak grip when performing the task and in turn uses a poor wrist angle to perform the operation. The grip of the tool can be modified to require the person to use in-line grip for the assembly process. Additionally, the screwdriver can be replaced with an automated version of the tool. This change would remove the need for the worker to repetitively screw in each screw throughout the production of the product.

Analysis of worker (Human Factors Engineering, Ergonomics of Assembly):

Human factors, the job according to Neibel only exerts 2.2 KCAL per minute, therefore the rest allocation is as follows:
$R = (W - 5.33)/(W - 1.33) = (2.2-5.33)/(2.2-1.33) = 3.59$
Since the job is not physically demanding, the expectation is that there are 2-3 breaks in an average 8-hour workday with an average of 20-25 Mins per break. This task can be kept up for hours at a time with no heart rate jump unless the assembler is put under significant stress or pressure by the boss to hurry up. Although this is an extremely simple way of looking at the situation and it cannot be seriously considered unless looking at more factors.

Postural Analysis: In the current situation, the person is forced to sit on a chair with their body slouched over or to stand with their neck bent down. In the redesign, the standing feature can be adjusted to a healthy head posture while the sitting feature can be adjusted to a healthy back posture. In white collar jobs such as this assembly, posture is almost a third of your day and sitting or standing for 1 place for that time is necessary, as a result your posture is a big part of your life, so much so that a study in the Wall Street Journal found that many people with bad posture from their jobs end up getting depression over time (Whalen, 2014). Depression can cause people to become unmotivated, and all sectors of the work will worsen.

Third Class Forearm Motion: Both workers at the workstations are working with the third class motion. This motion includes the movement of the fingers, wrist, and lower arm. These actions are performed by the arm below the elbow level while the upper part of the arm is stationary. The workstation is positioned such that the worker does not need to move their upper and lower arm at all since all the parts are a short distance away and the elbow is kept at 90 degrees during the assembly process. Puting the product together requires finger motions and a few wrist movements, to grab the respective parts the worker must move their lower arm in a circular motion to grab the parts from the bins at the workstation. This motion class is ideal when compared to the rest, since the forearm has strong muscle fibers and has non tiring muscles.

Redesign

The main objective of the redesign portion is to improve the working conditions of the worker. Thereby focusing on improving the safety of the worker, productivity and quality, these changes will increase the quality of work, quality of product while also decreasing the unit cost of production and improving the overall assembly process.

SORT:The common solution is to have a bin pattern that is different for each worker, as each worker has to deal with different subassemblies and it makes the most sense to split the worker stations separately and have each bin pattern and screw pattern. The bins will be ordered by the order of assembly as can be seen in the MOST Analysis.

STANDARDIZE: The tools used should be the same for the entire length of the assembly, there should not be a switching of screwdrivers as it increases the time of the assembly. Such as in the video TIME() The assembler is considered to be trained and competent and he still made the error of picking up, trying to screw in a screw failing and having to switch screwdrivers and repeat the process over again.

Another issue is that all the screws blend in with the white table and look the same, there can be mistakes that take place when screws are switched for each other and the person cannot identify the difference in a quick manner. In the redesign, the table color is a dark gray and led lights are put into bins in order to better see parts without having to adjust the head position to look into the depth of the bin . Finally, each respective worker only has access to the parts that they need and only have access to the screws they need.

Jigs/Fixtures

Worker autonomy is incredibly important and is key to keeping the worker-leader dynamics intact. It also improves worker self efficacy and allows the worker to be in more control of the way they want to assemble the part. This was the reason behind fixing the body on a 360 degree revolving turnstile with adjustable depth. The first half of the body will come in on a conveyor belt and will fit in front of worker 1, worker 1 will be able to revolve and lock the body as well as push the turnstyle up and down. This is made because in the original video, the worker is often seen turning his head and putting his head posture in awkward positions. This will completely be eliminated with the new fixture and one hand will be free to use during the entire length of the assembly.

Adjustable Stand/Sit Desk: The integration of the stand/sit desk, instead of a fixed desk gives the user more autonomy, the neck position in the first video is due totally to the boundaries of the desk itself, or in the picture of the worker standing it is due to the table frame of reference. In the redesign the table being adjustable allows the neck to always be in the correct position and line of sight. Optimal postural results can be achieved for the person. The option to stand is also another benefit of the adjustable desk, before the worker was forced to sit down and work on the assembly. A person may not be comfortable working sitting down and providing the choice is creating a work environment of choice and catering to the needs of others. The desk now has ledges to prevent parts from moving off and slipping during assembly, parts slipping off consumes time and in most cases the worker has to bend and twist(Ineffective therbligs) these do not advance the work and must be eliminated as much as possible. For example, the act of one screw slipping off the table leads to the following ineffective therbligs, **searching** with the eyes to determine where the screw has fallen, and **planning** how the worker is going to bend down and retrieve the screw.

Fixed Drop Position: During the video, the worker can be seen multiple times having to choose, pick up and put down the screwdrivers (2) in fixed positions in order to continue working. The solution is to make a single groove in the desk within 2 inches of the person's hand, meaning if they simply just drop the screwdriver, it will roll or be placed in the position and will be found in the same place every time. No more does the worker have to look for where the screwdriver is and place it next to the other one. In the final table, the groove is not showing, but the table is sloping downwards towards the lip of the table ever so slightly, meaning that where ever the screwdriver is loosely dropped, it will roll towards the lip of the table where the person is sitting, but it will not roll off the table.

Video justification: At 4:12 instead of completely turning his head at an angle, the jig should adjust 45 degrees up or down in order to see in between the speed button and the motor.

The number of bins being split: Since there are 2 different workstations instead of both workers sharing the same table, the parts are split up between what worker 1 needs and what worker 2 needs, therefore the user has less bins in front of them while assembling. This is part of the 5 S: SHINE, that the workplace should be neat and tidy at all times.
The jig included causes the body to become fixed at 4 points, it is known to be fixed when the *click* noise is heard.

Table configurations: The tables can be moved around, either to be facing the other worker, or to be beside them. The table itself can be lifted up or down allowing the worker to choose whether they want to sit or stand for the length of the assembly. More than in the first assembly can work exceptions be handled because of this change (Ng, 2008). The table design shown below shows a rail design of production, meaning when the first person is done working, the assembly is moved along the tracks to the next person when it is disengaged from the jig, so the person will not have to get up and go get the part to begin working on it. Once the first person disengages the jig, a new external body is passed along the rail to begin working on the next assembly. This method was chosen because conveyors are the best means for reach and move in manual work design.

The table and workstation were redesigned to be bounded, some parts have a possibility of sliding off the table during the assembly process. To avoid this issue and to avoid incurring any additional time required to finish the operation, the table is designed to have bounded edges with small carved out pockets for small parts such as the screws. There are two carved out pockets at each workstation, each of which is used for a specific type of screw. The workstations are also stuck to one another and are paired with a conveyer belt that would transport the assembled parts to the next workstation.

Tools redesign: Analysis of the video showed us multiple examples of the worker fumbling screws off of the screwdriver or struggling to put on screws, the solution is to purchase a single screwdriver with a stronger magnetic tip. This will make the assembly less about worker precision and the worker will be able to focus completely on assembling the product in a timely manner. The screwdriver should also have a longer handle to grip for the user and have a plastic groove that is soft to the touch.

Lastly, to sustain all these redesign changes, the changes established will be audited at a later date and the entirety of the report will be redone with the new implementations. The importance of auditing is that it gives the company owners the clarity within their assembly process on what is being done and what is capable of being accomplished in a similar time. Both internal audits and stakeholder audits should be done for a company of this magnitude in order to get both a descriptive analysis as well as an analytical, quantitative analysis of the process (Eulerich,2017).

All table as well as bin redesign can be observed in the appendix

Conclusion

Although the assembly of the Simplicite Hand-Mixer is quite simple and short, by implementing changes through the workstations and operators there would be a great increase in the productivity and efficiency of the assembly process. By scanning the assembly process and the operators, the team was able to determine the errors and issues present in the current process. After analyzing the assembly process and investigating the workstations, it was determined that the process could be greatly improved with the implementation of new tools, redesigned workstations, correct arm movements and improved working tools. The first issue was the workstation and the lighting around it, the optimal suggestion to improve on the two was the redesign of the workstation to have bounded edges with carved cutouts to hold the smaller parts and a good light source. Additionally the organization of the part bins should be appropriately labeled.These changes would greatly impact the operator, since they would now require less time and less motion to grab the required part.To minimize any injuries or muscle traumas it was suggested that the third arm motions be utilized.

Some of these redesign suggestions can be costly, however each one can yield a positive effect on the production times and production process while also benefiting the operators that work long hours. These improvements can heavily impact the productivity, efficiency and quality of the production process. To conclude based on the conducted research, the changes suggested on the redesign portion of the study are considered greatly beneficial to the organization if applied appropriately.

References

Alias, N. E., Othman, R., Hamid, L. A., Salwey, N. S., Romaiha, N. R., Samad, K. A., & Masdek, Nik Rozila N M. (2018). Managing job design: The roles of job rotation,job enlargement and job enrichment on job satisfaction. Journal of Economic & Management Perspectives, 12(1), 397-401.

Eulerich, M., Henseler, J., & Köhler, A. G. (2017). The internal audit dilemma – the impact of executive directors versus audit committees on internal auditing work. *Managerial Auditing Journal, 32*(9), 854-878. https://doi.org/10.1108/MAJ-08-2016-1435

Niebel, B. W., & Freivalds, A. (2014). *Niebel's methods, standards, and work design*. McGraw-Hill.

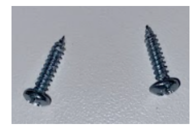
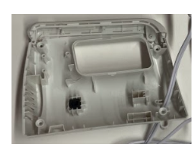
Ritter, J. A., & Anker, R. (2002). *Good jobs, bad jobs: Workers' evaluations in five countries*. Deutsches Zentralinstitut für soziale Fragen/DZI. https://doi.org/10.1111/j.1564-913X.2002.tb00244.x

Ng, K., Ang, S., & Chan, K. (2008). *Personality and leader effectiveness: A moderated mediation model of leadership self-efficacy, job demands, and job autonomy.* American Psychological Association. doi:10.1037/0021-9010.93.4.733

Whalen, J. (2014, Jun 23). How Bad Sitting Posture at Work Leads to Bad Standing Posture All the Time; Good posture means aligning ears over the shoulders, shoulders over hips, and hips over the knees and ankles. *Wall Street Journal (Online)*
http://ezproxy.lib.ryerson.ca/login?url=https://www.proquest.com/newspapers/how-bad-sitting-posture-at-work-leads-standing/docview/1539329495/se-2

Appendix

Table 6: Bill of Materials for the Simplicite Hand Mixer

Item	Part Number	Quantity	Description	Material	Figure
Body Screw	P1.01	4 1.4CM	The Tri-Tip head is about half inch in length.	Metal	
Wire Harness Screws	P1.02	2 0.8 cm		Metal	
Circuit board Holder Screws	P1.03	2		Metal	
Speed Button Screws	P1.04	3		Metal	
Category: External					
Left Side Body	P2.01	1	White, hard	Plastic	
Right Side Body	P2.03	1	White, hard	Plastic	
Speed button	P2.04	1	Dark gray, hard	Plastic	

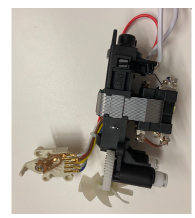
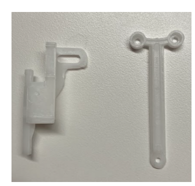
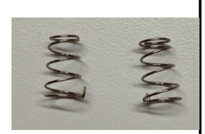
Eject button	P2.05	1	Dark gray, hard	Plastic	
Whisk	P2.06	2	Light, long	Stainless Steel	
Whisk storage holder	P2.07	1	White, Hard	Plastic	
Category: Internal					
Motor	P3.01	1			
Wire harness	P3.02	1	Hard, Transparent	Plastic	
Internal mixer button (plastic with 3 metal screws)	P3.03	1	Hard, White	Plastic	
Springs	P3.04	2	Cylindrical, small	Metal	
Wire and Plug	P3.05 AP3.01	1	Thin, long	Copper, plastic	

Figure 3: Tree diagram of Hand Mixer

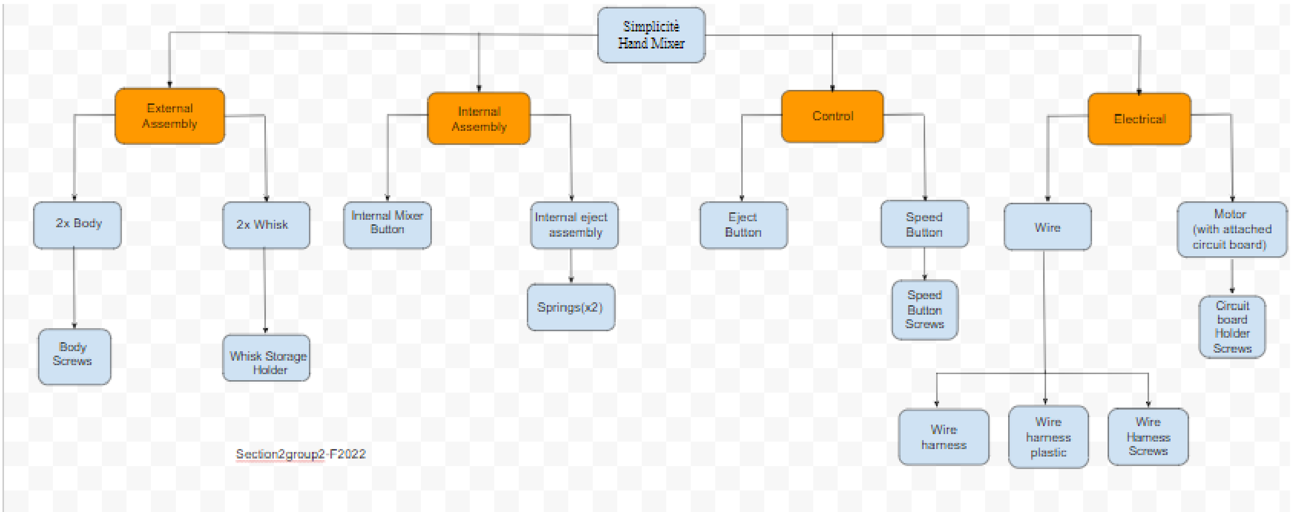
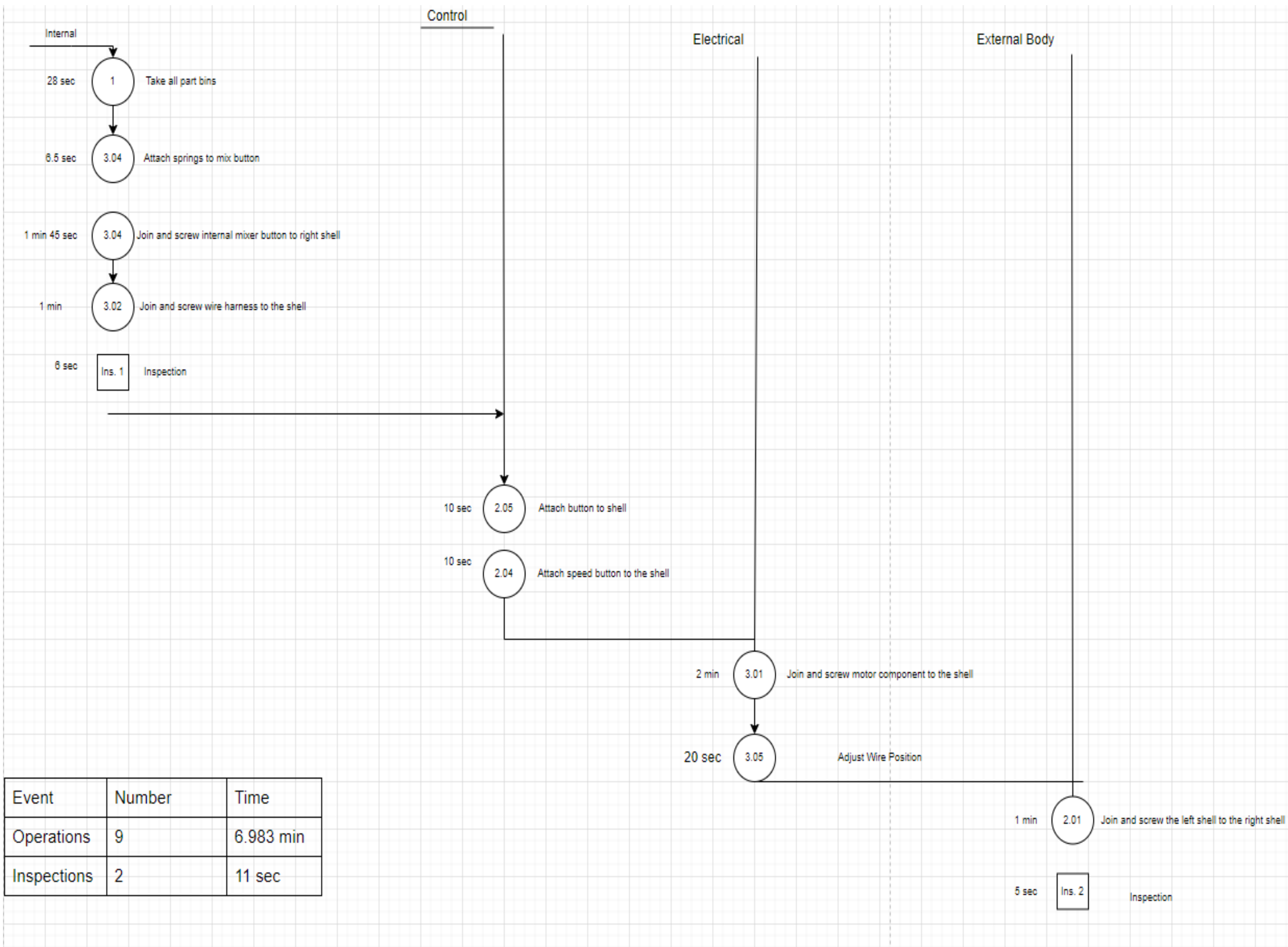


Figure 4: Operations Process Chart



Event	Number	Time
Operations	9	6.983 min
Inspections	2	11 sec

Table 7: Operative FPC of Internal Assembly.

Event Description	Symbol	Time (s) - Video Time	Method Notes:	Sub Assembly
Get eject button function & insert springs	Operation	8		Internal
Push on springs to make sure they are secure	Inspection	2		Internal
Insert eject button and 2x springs combined into body	Operation	8	identifying the correct side c	Internal

Table 8: Operative FPC of Control Assembly.

Event Description	Symbol	Time (s) - Video Time	Method Notes:	Sub Assembly
Inspection on 2 parts that make the speed button control is in the correct position	Inspection	3		*Control*
Place speed function internal assembly into the body internal	Operation	13		Control
Get screwdriver and put 1 screw on	Operation	2		Control
attempt to screw in Speed button internal	Operation	2		Control
Drop Screwdriver with screw gently	Operation	2		Control
Attempt to precisely insert speed adjustment function parts together and into body	Operation	10		*Control*
Speed button assembly collapses on table and must be recombined	Delay	4		*Control*
Final attempt to place speed button correctly	Operation	36		*Control*
Tighten 3xscrews secure speed button internal	Operation	40		*Control*
Make sure speed button is secure	Inspection	2		*Control*

Table 9: FPC of Electrical Assembly.

Event Description	Symbol	Time (s) - Video Time	Method Notes:	Sub Assembly
Get wire Harness and screws roughly in position, TURN BODY TOWARDS YOU	Operation	20		*Electrical*
Attempt to screw in wire harness, switch screwdrivers	Delay	4		*Electrical*
SCREW IN wire harness	Operation	40		*Electrical*
Inspect if wire harness is screwed in properly	Inspection	3		*Electrical*
Insert motor into body,tucking circuit wires underneath	Operation	42		*Electrical*
Insert circuit board in between the eject button function	Operation	15		*Electrical*
Fit Motor and eject function together	Operation	26		*Electrical*
Inspect motor fan and wire position	Inspection	4		*Electrical*
Pick up body with motor circuit combination	Operation	5		*Electrical*
Bring two screws towards you	Operation	3		*Electrical*
Inspect wire end positions	Inspection	2		*Electrical*
Lift circuit board with screwdriver and finger	Operation	12		*Electrical*
hold circuit board in place	Operation	6		*Electrical*
pick up screw with screwdriver and place on end	Operation	5		*Electrical*
screw in circuit board	Operation	35		*Electrical*
Inspect if motor is in place	Inspection	7		*Electrical*

Table 10: FPC of External Assembly.

Event Description	Symbol	Time (s) - Video Time	Method Notes:	Sub Assembly
pick up body left side and insert it	Operation	**38**		*External*
loose fit 4 screws	Operation	**10**		*External*
screw in body screws	Operation	**45**		*External*
Final body inspection	Inspection	**5**		*External*

Figure 5: Flow diagram

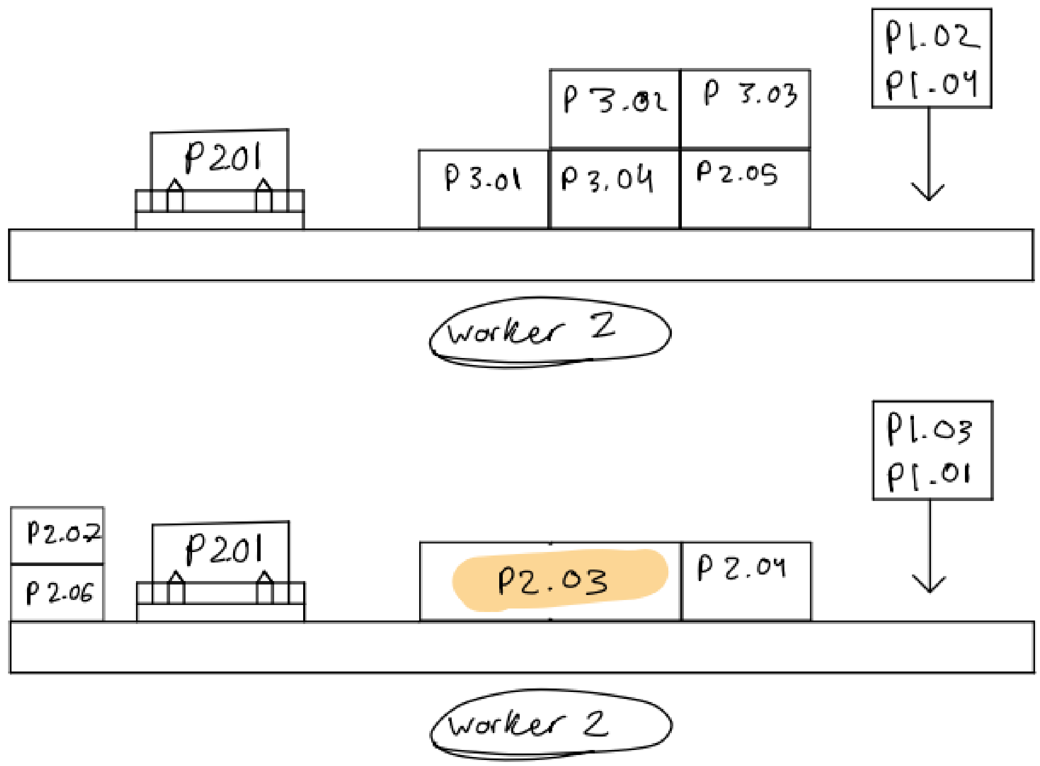


Table 11: MOST Analysis for worker 1

Task	Task Description	GET	PUT	Put aside	Frequency	TMU	Notes
	MOST Analysis with broken down steps						
Task	Task Description	GET	PUT	Put aside	Frequency	TMU	Notes
1	Get eject button function & insert springs	A1B0G1	A0B0P6 F6	A1B0P3	PUT X2	320	You must do two wrist strokes each and insert inside the body position tight
2	Push on springs to make sure they are secure	A0B0G1	A1B0P3	T6	x2	160	
3	Insert eject button and 2xSprings combined into body	A0B0G1	A0B0P6	A1		80	
4	Inspection on 2 parts that make the speed button control is in the correct position	A0B0G1	A1B0P1	T3		60	
5	Place speed function internal assembly into the body internal	A0B0G1	M0X0I16			160	Attached to another object 2nd part of speed button internal Alignment of non-typical object, sharp thin and flimsy
6	Get screwdriver and put 1 screw on	A1B0G1	A0B0P3			50	
7	attempt to screw in Speed button internal	A0B0G0	A1B0P6			70	
8	Drop Screwdriver with screw gently	A0B0G0	A1B0P1	A1		30	
9	Attempt to precisely insert speed adjustment function parts together and into body	A0B0G0	A0B0P6			60	
10	Speed button assembly collapses on table and must be recombined	A1B0G1	A0B0P6		GET X2	100	
11	Final attempt to place speed button correctly	A0B0G0	M0X0I16			160	Attached to another object 2nd part of speed button internal Alignment of non-typical object, sharp thin and flimsy
12	Tighten 3xscrews secure speed button internal	A1B0G1	A1B0P6	F24 A1B0P3 A1	X3	1080	
13	Make sure speed button is secure	A0B0G0	A0B0P3	T3	X3	180	Inspect 3 points Across from eachother
14	Get wire Harness and screws roughly in position, TURN BODY TOWARDS YOU	A1B0G1	A1B0P3	A1		70	
15	Attempt to screw in wire harness, switch screwdrivers	A1B0G1	A1B0P1	A1		50	There should be one standard tool, it shouldnt require this step
16	SCREW IN wire harness	A1B0G1	A1B0P3	F32 A1B0P3 A1	X2	860	33 TOTAL TURNS with LONG SCREWDRIVER
17	Inspect if wire harness is screwed in properly	A0B0G0		T3		30	
18	Insert motor into body,tucking circuit wires underneath	A1B0G3	A1B0P6		X12	1320	INTERLOCKED WIRES he adjusts 12 different wire positions
19	Insert circuit board in between the eject button function	A1B0G1	A1B0P3	T3		90	Assembler turns his head in order to look in between and insert it. Takes him roughly 25 seconds in the video
20	Fit Motor and eject function together	A1B0G1	A1B0P6	T4	X3	390	inspection in 4 points for each, in a tough angle
21	Inspect motor fan and wire position	A0B0G0	A1B0P1	T3		50	
22	Pick up body with motor	A1B0G1	A1B0P3	A1		70	
23	Bring two screws towards you	A1B0G3	A1B0P3			80	
24	Inspect wire end positions	A1B0G0		T5	A1	70	

Table 12: MOST Analysis for worker 2

	Worker 2						
24	Lift circuit board with screwdriver and finger	A1B0G1	A1B0P1			40	Finger should not be put in such a tight spot, tool is picked up in reach, tool should be approriate for the job
25	hold circuit board in place	A0B0G0	A0B0P1	T3		40	
26	pick up screw with screwdriver and place on end	A0B0G1	A1B0P3			50	
27	screw in circuit board	A1B0G1	A1B0P6	F24 A1B0P3 A1	x4	1440	
28	Inspect if motor is in place	A1B0G1	A1B0P0	T3		60	
30	Insert speed button and eject button EXTERNAL	A1B0G1	A1B0P3		X2	120	One for each button, audible click* is heard
31	pick up body left side	A1B0G1	A1B0P3			80	Bin for body should be bigger than the other bins in redesign, currently is the same size
32	fit 4 screws	A1B0G1	A1B0P3	A1	x4	240	
33	screw in body screws	A1B0G1	A1B0P6	F32 A1B0P3 A1	x4	1840	Body screws had to be rescrewed in and rechecked, same as screwing in 8 screws
34	Final body inspection	A0B0G0	T5			50	
		Grand Total	9550		Time (s)	343.8	
		TMU			Time (min)	5.73	Actual Time 468

Table 13: Cost Analysis calculations per assembly

External Assembly			
Quantity	Item Name	MTL	Total Cost
4	Short Screws	0.02	0.08
2	Metal Mixer	0.5	1
1	Plastic Hold	0.03	0.03
2	Plastic Base	0.1	0.2
		TOTAL	1.31

Internal Assembly			
Quantity	Item Name	MTL	Total Cost
1	Plastic A Shape	0.03	0.03
2	Springs	0.01	0.02
		TOTAL	0.05

Control			
Quantity	Item Name	MTL	Total Cost
1	Flexible Silicone	0.2	0.2
1	Plastic Cover	0.2	0.2
3	Short Screws	0.02	0.06
		TOTAL	0.46

Electrical			
Quantity	Item Name	MTL	Total Cost
1	Motor	0.5	0.5
1	Wire	0.3	0.3
1	Plastic Brace (fo	0.1	0.1
4	Long Screw	0.02	0.08
		TOTAL	0.98

Packaging			
Quantity	Item Name	MTL	Total Cost
1	Box	0.3	0.3
1	Documents	0.1	0.1
1	Cardboard Inser	0.05	0.05
1	Bag	0.05	0.05
		TOTAL	0.5

Figure 6: Redesigned Workstation

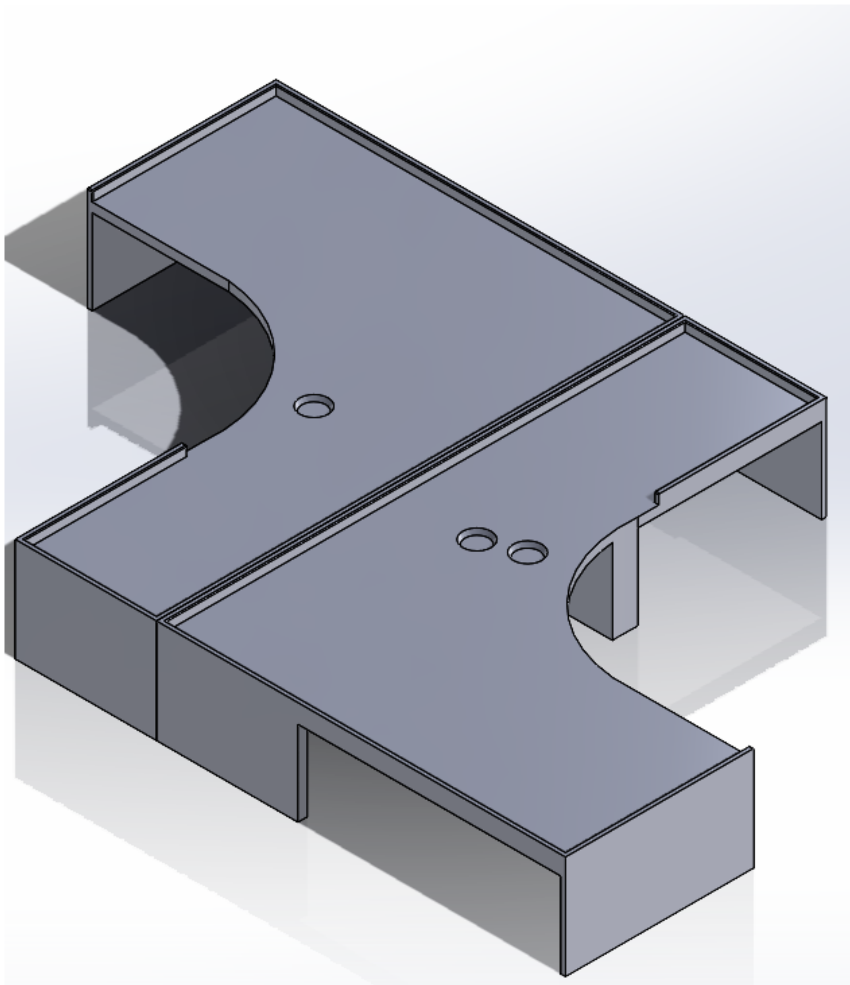


Figure 7: Conveyor System on workstation.