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L'Oreal waste minimization

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L'Oreal Waste Minimization

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by

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Two years ago in 2009, L'Oreal had costs of nearly $2,000,000 in waste disposal. L'Oreal's corporate goal is to reduce the amount of waste generated by 50% by year 2015. This team was charged with identifying waste streams and finding solutions to reduce the waste generation for the North Little Rock manufacturing facility.

I took part in identifying the major waste streams at L'Oreal during the first tour. Initially, I was responsible for examining the nail enamel waste streams. After some preliminary calculations, it became evident that waste might be occurring in multiple places during the nail enamel process. A second tour was scheduled to analyze the nail enamel process. During that tour, I helped determine that there was not enough waste from one single source to focus our project on the nail enamel process. The attached report gives the details for this decision. The second tour also allowed the team to gain more information about the waste water generated from the washing of the Olsa tanks. I participated in the discussion with the engineers about recycling the third wash, adding equipment that would wash the walls of the tank better, and the use of ultra-filtration to reuse the majority of the waste water. This discussion identified the opportunity to optimize the washing procedures for each product which led to running experiments on the washing procedures to optimize the water usage.

My main contribution to the L'Oreal waste minimization project was to design the experiments for the optimization of the washing of the Olsa tanks, which are outlined the attached report. First, I was involved in the design the experiment for statistical analysis. Due to time limitations, the team was not able to run all the experiments on all of the products that L'Oreal makes in the mixing tanks. I encouraged the team to reduce the amount of products and to select the two mascaras that the team would test. I also discussed the parameters of L'Oreal's current washing cycle that could be optimized, such as temperature, agitation cycle placement, time of agitation, and caustic cycle placement. After the team had logically ordered the experiments, I collected the needed equipment to properly simulate the washing. Additionally, I was one of the team members who contributed in the trial run to identify set points and parameters that had to remain constant throughout all the experiments. Finally, I was responsible for setting up the equipment before each experiment, collecting the appropriate data, taking pictures, and shutting down and cleaning up the equipment so experiments could be repeated.

L'Oreal Waste Minimization Report

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Executive Summary

The purpose of this design project is to reduce the amount of waste being generated at L'Oreal's North Little Rock manufacturing facility. To accomplish this, the design team visited the North Little Rock manufacturing facility to examine the areas producing the most waste. After gaining a detailed understanding of these areas, the UP1 production line was identified as one of the largest opportunities for waste reduction in the L'Oreal manufacturing facility. In the UP1 processing area, mascara is mixed in large mixing tanks and then pumped in to barrels to be packaged. The 2,000 liter and 1,000 liter Olsa tanks are the tanks encountering problems with waste generation. The cleaning procedures used to clean these tanks between batches uses substantial amounts of water due to residual mascara left over on the tanks walls and at the bottom of the tank. There is significant opportunity to reduce the volume of wastewater generated in these procedures.

The design team examined the volume of water waste leaving this area, the lost sales from the left over mascara, and the expenses incurred to discard this waste. After each mixing batch has been completed, three to five percent of the mascara is unable to be removed from the tank. Based on this mass of mascara, the total annual lost sales from this left over mascara is around $650,000. However, additional expenses are incurred to clean the tanks due to this large mass of mascara that is left over at the bottom of the tank and on the tank walls. The cleaning procedures currently in place are extensive and consume a large volume of water to accommodate the resilient nature of fiber and waterproof mascaras. In total, 940,000 gallons of water waste are generated annually to clean the tanks. Based on a cost of $0.49 for every 100 gallons to treat and dispose of the water, L'Oreal spends about $4,600 each year as a result of this immense water consumption. To heat this amount of water, 100% efficiency and an incoming water stream at 25^{o}C was assumed. This requires 70.3 kilowatt-hours to heat one 2,200 liter tank of water. At an average energy cost of 5.68 cents per kilowatt-hour, the cost to heat each 2,200 liter tank of water is $7.99. It was assumed that it requires 20 minutes to fill and empty the tank for the first rinse and two workers to work this process and the hourly labor cost is $30. Eliminating the first rinse would save $20 in labor costs for each batch.

The design team has identified two primary recommendations that will reduce the volume of waste generated in the UP1 processing area. The first recommendation is to recycle the third rinse for the first rinse of the cleaning procedures. This would reduce the water consumption in the cleaning procedures by a third, saving L'Oreal 310,000 gallons of water annually. The water from the third rinse could be stored in a separate holding tank beside the mascara mixing tanks. This solution will have potential annual savings of approximately $41,000, 2.3 million liters of water, and 152,000 kilowatt hours.

The other recommendation that the design team has established involves customizing the cleaning procedures for each type of product. To examine this solution the team designed a scale model of the mascara-mixing tank to run experiments testing the effects of temperature and agitation time on waterproof and non-waterproof mascaras. By doing this task, the team discovered that removing the first rinse had little or no effect on the cleaning procedures. Ultimately, it was concluded that the waterproof and non-waterproof mascaras behave differently under varying conditions and should therefore be cleaned with different procedures. The team discovered that removing the first rinse had little or no effect on the cleaning of non-waterproof mascara. The removal of this wash would reduce the volume of water required to clean the tanks, and the time needed to complete the cleaning procedures.

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Part I: Project Overview

1. Introduction to L’Oreal

In 1909, Eugene Schueller, a chemist and entrepreneur began designing, producing, and selling hair dyes to hair dressers across Paris. Unbeknownst to him, this young man’s business would eventually become one of the world’s leading cosmetic companies, L’Oreal. Between the late 1950s and 1980, L’Oreal grew its brand by acquiring and producing large varieties of cosmetic products. By 1984, L’Oreal began investing large amounts of resources into research and management changes. With these changes, L’Oreal started expanding their brand and the scope of their customer base. By the turn of the century L’Oreal had achieved its goal of becoming a worldwide leader in the cosmetics industry.

Today, L’Oreal as a business employs more than 64,600 people across 130 countries. Along with the company’s economic impact on the globe, L’Oreal has a commitment to sustainable development. They plan to achieve this goal by targeting greenhouse gas emissions, water consumption, and waste generation. Specifically in the North Little Rock manufacturing plant, waste generation is a huge concern and there is a need for innovative ways to reduce the impact of the waste leaving the plant.

2. The Problem

L’Oreal needs to minimize the waste leaving their Little Rock, Arkansas manufacturing facility. When looking at the overall amount of waste leaving the plant, a significant amount of wastewater is being produced by the liquid mixing tank processes. The goal of this project is to significantly reduce the amount of water used to clean the mixing tanks after a batch is complete and to reduce the amount of water sent to the waste-water sent to treatment facility.

3. Motivation behind Project

In 2009, the North Little Rock production facility spent close to $2,000,000 in inventory destruction and waste disposal. Their corporate goal is to reduce their total waste volume by 50% by 2015. The team will specifically work on two main causes of waste in the manufacturing facility, each within the scope of the UP1 area. The team will work to reduce the amount of water used in the cleaning of the mascara mixing tanks by recycling water using a holding tank, and additionally customize the cleaning procedure for specific products that are made in the tank, resulting in a reduced amount of water used in the overall process. Although monitary savings are important to L'Oreal, they specifically wanted the focus of the project to be reducing the amount of waste leaving the facility.

4. Project Objectives

1. Define why there is a need to reduce the amount of waste leaving L'Oreal's North Little Rock Facility
2. Pinpoint what specific waste areas or processes of the plant can be reworked or redesigned in order to reduce the amount of waste leaving the facility.
3. Quantify the cost and volume of waste leaving the UP1 processing area.
4. Redesign the UP1 cleaning process for mascara mixing tank area, specifically focusing on designing a particular process for each product mixed.
5. Develop and suggest new cleaning protocols if applicable.

5. Project Transition

The waste minimization project has evolved immensely from the initial project proposal. Though all of the initiatives included in the project proposal are legitimate and would indeed lower the waste in the L'Oreal manufacturing plant, the discovery of new constraints, which will be listed, has led the design team down a new experimental path.

Reduced Scope of Project

After further investigation, the waste minimization of the nail enamel process was removed from the scope of this project. A plant tour showed that there was not one common defect in the process that led to waste. The problems in the system that there are contributing factors include labeling, cap insertion, and bottle defects, among others. Also, the overall process has a low rejection rate. Many of the rejected items in the process are re-worked to further reduce the waste from this process. Therefore, the nail enamel process was removed from the problem definition.

The second design item that was removed from the scope of the project was the further removal of mascara from the inner Olsa tank walls. This was removed for two reasons. First, focus was placed on the creation of a cleaning method for each product. The team created an experiment to find the most efficient cleaning solution consisting of a mixture of water and caustic solution for each product that enters and leaves the tank. Foregoing the research into the removal of excess mascara will allow the team to focus on these endeavors.

Second, the ability to remove excess mascara from the Olsa tank's inner wall is not practical because there is not a safe way to reach inside or insert any mechanism into the tank without jeopardizing the worker's safety. This had originally been a significant concern with the design team, as the ability to remove more mascara might have led the team to reduce the amount of water and caustic used in the cleaning process even further.

Another contributing factor for the final project design is the water consumption used in the two Symex tanks. This amount of water will not be able to be reduced because this is a fully automated wash cycle. The wash cycle already has been programmed to reduce the amount of water used to clean the tank; therefore, the team is unable to reduce the water consumption further.

Though all wash procedures consist of three rinse cycles, the final rinse cannot be manipulated because the final temperature must reach a certain degree to be deemed clean. Also, the water must not contain caustic or mascara residue to meet the guidelines imposed by the FDA. The last rinse cycle cannot be manipulated and will not be analyzed in the scaled down experiment.

New Scope of Project

With the removal of the previous items from the project, the new focus has been shifted to creating a washing process for each of the products that are produced in the tank. The two products tested in this project were waterproof and non-waterproof mascara. The overall goal of the new project is to find the best possible washing process for each product. This includes an array of variables. First, the temperature range that best corresponds to each product will have to be found. Second, the amount of caustic solution used in a cycle and also the cycle it should be used in will be analyzed. Third, the total number of wash cycles needed in the cleaning process. L’Oreal’s currently uses 3 cycles in their cleaning procedure. And finally, the team will look at the amount of agitation time that should be applied to certain cycles within the wash process.

In order to find the best possible solutions to the above criteria, the design team set up a scaled down model of the mixing tank used in L’Oreal’s North Little Rock manufacturing facility. The experiment consisted of a large plastic cylindrical container, an electric agitation system, stainless-steel plates to simulate the inner tank wall, various water temperatures, two mascara products, and various percentages of caustic. The design team has created a three-phase experimental compilation that incorporates the "important" combination of the previously mentioned variables by using a statistical program and intelligent assumptions.

6. Conclusions and Recommendations

The design team has identified two primary recommendations that will reduce the volume of waste generated in the UP1 processing area. One recommendation is to recycle the third rinse for the first rinse of the cleaning procedures. This would reduce the water consumption in these procedures by a third, saving L'Oreal 310,000 gallons of water annually. The second recommendation involves customizing the cleaning procedures for each type of product. Ultimately, it was concluded that the waterproof and non-waterproof mascaras behave differently under varying conditions and should therefore be cleaned with different procedures. The team discovered that removing the first rinse had little or no effect on the cleaning of non-waterproof mascara. Removing the unnecessary wash would reduce the volume of water required to clean the tanks, and the time needed to complete the cleaning procedures.

7. Summary of Future Areas of Study

The team was not able to cover all waste saving methods that were discussed within the semester long class. Some of these approaches are to reduce the amount of mascara from the tank prior to the cleaning process, which can be done manually or mechanically, to further study the optimization of cleaning methods for specific products, and to redesign the mascara mixing tank so that the mascara can drain or be pumped more easily. A more in depth description of these future enhancements are detailed in the Future Considerations section of the report.

Part II: Project Details

1. Current Cleaning Procedure

The overall goal of this project is to reduce the volume of waste that leaves the L'Oreal plant. This project specifically focused on the cleaning process of the two Olsa tanks on site, one with a capacity of 1,000 L and one with a capacity of 2,000 L. The current cleaning process involves three rinses cycles in the wash process. A diagram of this process is shown in Figure 1.

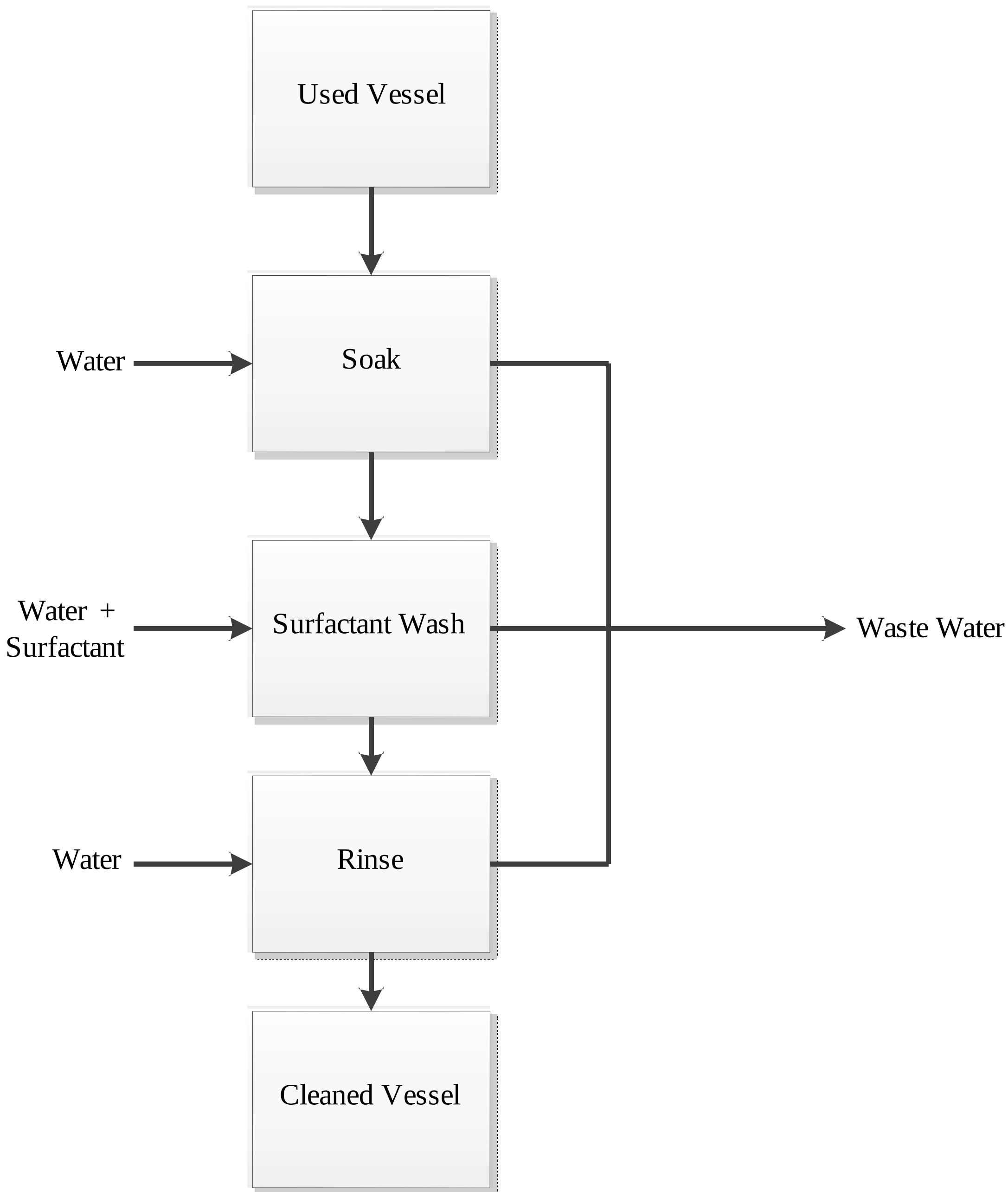

Figure 1: Cleaning Process

After the mixing of mascara or other product is completed, the product is removed from the Olsa tank via a pump and stored. The cleaning process for each of the two tanks is identical. First, they are completely filled with water at 80°C and drained immediately. The completely filled vessel contains a total volume of water of 2,200 L and 1,100 L for the large and small vessel, respectively. Second, the tank is then re-filled with 80°C water and a 4% by volume solution of KOH and surfactant. The vessel is agitated for 20 minutes after the production of non-waterproof mascara and 60 minutes after the production of waterproof mascara. The vessel is then drained and inspected by sight and smell. If remaining mascara adheres to the vessel, the vessel is further cleaned manually. Last, the third and final wash cycle cleans the vessel of residual mascara and cleaning solvent. This is currently done by completely filling the vessel with 80°C water and heating the vessel to 90°C. The cleaning process ends by steaming the vessels to ensure sanitization. This final steaming step was outside the scope of this project. Figure six in the appendix shows a detailed visual of the cleaning process.

This current process uses a considerable amount of fresh water to clean the tanks. Typically two to three batches of product are made per day, each requiring a wash after production. Based on a 360 working days per year, this result is a total of 940,000 gallons of water used per year for cleaning alone. It would cost $4600 to purchase and treat this amount of water.

This project investigates two different methods to reduce the water used in the cleaning process. The first method proposes a method to reduce the amount of water that is used while keeping the current procedures in place. The second method investigates optimizing the cleaning procedure in order to minimize the amount of water and energy used, while still having the same cleaning effect.

In the first method, it is proposed to recycle the third sanitization rinse to be used as the first soaking rinse. The third rinse will be kept in a holding tank while the product is made and pumped into the mixing vessel once the product has been removed. The third rinse will be free of the majority of mascara because the mascara will have been cleaned off by the previous rinses. This will result in the first rinse water having relatively the same cleanliness as currently used. Impurities in the recycled water should not change the effectiveness of the first rinse. By reusing the third rinse, one-third of the water consumption will be reduced. This will eliminate 310,000 gallons of waste per year.

The second set of investigations looked into the methods used to clean the Olsa tanks. This was done by conducting a set of experiments to test effects of different variables in the cleaning process. One set looked to determine the effectiveness of agitation of the first rinse. The second set determined the effectiveness of the first rinse compared to no initial rinse. The third set of experiments was to determine the effect of temperature on cleanliness. The final set of experiments investigated the effect of reducing the concentration of cleaning solvent used in the process.

2. Detail of Experiment

L'Oreal produces a variety of liquid products; however, the washing procedure is identical for all products. To try to reduce wastewater, optimizing the washing procedures was considered. L'Oreal currently uses the following washing procedures on the Olsa tanks for all products:

1. Fill tank with 80°C water and drain
2. Fill tank with 80°C water and caustic/additive, agitate for 30-60min, and drain.
3. Fill tank with 80°C water and drain.

The tank is considered ready for steam sanitization if the water for the third rinse is visually clear, the sides of the tank are visually clean, and the temperature of the sides of the tank is above 90^{o}C.

To improve L'Oreal's current procedures, many variables were considered. These variables included temperature of the water, agitation, time, caustic concentration, and various liquid products. Using a DOE software program, seventy-four trials would be necessary to account for all the variables. Due to limits on time, the trials were logically selected. The amount of products to be tested was narrowed from eleven to two. The two products selected were waterproof and non-waterproof mascaras. Table three in the appendix displays the trials that were generated in the DOE software program for the experiment. Both the waterproof and non-waterproof were subjected to the following three phases:

Phase 1: Generate baseline data using L'Oreal's current procedures.

Phase 2: Combine L'Oreal's wash 1 and 2 into one extended wash.

Phase 3: Reduce temperature of the water to 25^{o}C.

Since L'Oreal's third cycle is the clean wash and required by the FDA, it was not considered in the trials. The trials are simply trying to improve or eliminate L'Oreal's first two wash cycles.

Apparatus

The apparatus used for our experiments included four removable, stainless steel plates to fit in between the baffles of a plastic tank, an impeller, and an electric agitator. A digital display showed the rpm of the agitator. A peristaltic pump was used to transport the water into and out of the tank for safety reasons. A hot plate was used to heat the water to the desired temperature. Figure 2 shows the tank and agitator apparatus.

Figure 2: Tank and Agitator

Experimental Procedure

Phase 1:

The goal of Phase 1 is to reconstruct a reduced scale model of L'Oreal's current cleaning procedure. The data generated in this phase will serve as comparative data for the following phases.

Initial weights of the clean stainless steel plates were recorded. Non-waterproof mascara was applied to the plates and the weight of the mascara on each plate was recorded. The mascara-coated plates were placed on the walls of the plastic tank. The water was heated to a temperature of 85^{o}C using a hot plate. Once the temperature was reached, the water was transported to the tank via a peristaltic pump. A stopwatch was started at the beginning of the pumping to measure the filling time. Once the tank was filled with hot water, the height of the water was marked on the tank so the height would remain constant throughout all trials and a volume of water could be calculated. The plates soaked for 10 minutes. During this time more water was being heated to 85^{o}C for the second wash cycle. After 10 minutes, the temperature of the water was recorded and the water was transported to a waste container via the peristaltic pump. This transfer was also timed using the stopwatch. Two plates were removed to determine the effectiveness of the first rinse cycle. The other two plates remained in the tank.

L'Oreal's second wash contains a combined 4% solution of a caustic and cleaning additive. To mimic this, the second cycle contained 2% caustic and 2% additive, which was determined from the volume of water used in the first cycle. The hot water was pumped into the tank again and the caustic and additive solutions were added. The agitator was turned on to 300 rpm for 10 minutes. After 10 minutes, the agitator was turned off, and the water was transferred to a waste container. The final two plates were removed and analyzed. From the recorded times to fill the tank from Phase 1, it was determined each cycle was approximately 20 minutes from fill to drain. The time to complete L'Oreal's current washing procedures on the apparatus was a total of 40 minutes. These procedures were repeated using the waterproof mascara on the stainless steel plates.

Phase 2:

For Phase 2, the first cycle was eliminated and the current second cycle was extended. The same procedures for the second cycle of Phase 1 were used for the first cycle of Phase 2.

Initial weights of the clean stainless steel plates were recorded. Non-waterproof mascara was applied to the plates and the weight of the mascara on each plate was recorded. The mascara-coated plates were placed on the walls of the plastic tank. Water at 85^{o}C was pumped into the tank and the caustic and additive solutions were added. The tank contained 2% caustic and 2% additive, which was determined from the volume of water used in Phase 1. The agitator was turned on to 300 rpm for 15 minutes. After 15 minutes, the temperature of the water was measured, and the water was transported to the waste container. All four plates were removed. The total time from fill-up to drain was 25 minutes. This procedure was repeated for waterproof mascara.

Phase 3:

For Phase 3, Phase 2 procedures were repeated using 25^{o}C water. Initial weights of the clean stainless steel plates were recorded. Non-waterproof mascara was applied to the plates and the weight of the mascara on each plate was recorded. The mascara-coated plates were placed on the walls of the plastic tank. Water at 25^{o}C was pumped into the tank and the caustic and additive solutions were added. The tank contained 2% caustic and 2% additive, which was determined from the volume of water used in Phase 1. The agitator was turned on to 300 rpm for 15 minutes. After 15 minutes the temperature of the water was measured, and the water was transported to the waste container. All four plates were removed. The total time from fill-up to drain was 25 minutes. This procedure was repeated for waterproof mascara.

3. Results of Experiment

All results and measurements for the experiments were recorded in Microsoft Excel. After a few test runs, it was noted that in general it took approximately 5 minutes to fill up and drain the experimental tank. This time can be assumed for all results mentioned below. Also, mascara is composed of some liquid materials. Because of this, when the plates would be left out to dry to determine a dry weight they would lose some of the moisture that is normally in the product. The loss of moisture accounts for some of the unexpected weight losses seen in not only the non-waterproof mascara but more specifically in the waterproof mascara.

As mentioned in the procedures for our experiment, a 4% caustic solution was used for cycles with agitation involved. The caustic solution had two components that had to be mixed.

The two components were the detergent mixture and then the caustic solution. Equal parts of both components were used for the experiments. To determine how many mL of each component should be added to the water, the tank was filled with water to the point at which we wanted to conduct the experiments. It was then measured that the water height was 10 cm from the bottom of the tank. The diameter of the tank was then measured to be 24 cm. Using the formula shown below, the volume of the tank was calculated as 4,524 mL.

$$V_{Tank} = \frac{\pi}{4} * D^2 * H$$

The volume of 4,524 mL was then multiplied by 4% to determine that we needed to add a total of 180 mL of caustic to the water.

Phase 1

The first part of Phase 1 that was tested was the non-waterproof mascara. The two plates that were removed after cycle 1 showed an average loss of 2.1 g. This loss of mascara accounts for approximately 56% of the total mass put on the two plates. The experiment was then continued until cycle 2 was complete. After draining the tank, it was noted that the two remaining plates had been completely cleaned by the agitation cycle. The average loss and percentage loss for cycle 2 cannot be calculated because the remaining two plates were not weighed after cycle 1. The mass breakdown for each plate can be seen below in Table 1. The temperature of the water was also monitored during the experiment. The water was initially pumped into the tank at 85^{o}C, and was at a temperature of 70 C after the completion of cycle 2. This result confirmed our theory that not insulating the tank would be sufficient for the experiment.

Table 1: Results of Phase 1

Mascara	Plate	Initial Dry Mascara (g)	Mascara After Cycle 1 (g)	Mascara After Cycle 2 (g)
Waterproof	1	3.8	2.2	Removed After Cycle 1
Waterproof	2	3.8	Stayed In Mixer	1.7
Waterproof	3	3.8	2.2	Removed After Cycle 1
Waterproof	4	3.9	Stayed In Mixer	1.7
Non-waterproof	1	3.8	1.7	Removed After Cycle 1
Non-waterproof	2	3.8	Stayed In Mixer	0.0
Non-waterproof	3	3.8	1.7	Removed After Cycle 1
Non-waterproof	4	3.8	Stayed In Mixer	0.0

The final part of Phase 1 was the testing of waterproof mascara. Two plates were removed after cycle 1 just like with the non-waterproof mascara. The two plates removed showed an average loss of 1.6 g, which accounted for roughly 43% of the total mass of mascara. Cycle 2 was then completed with the waterproof mascara. Following completion, it was noted that there was still some mascara left on the plates. Because of the water left on the plates, it was decided that the plates would be allowed to dry. After drying, the weights were taken and compared to the initial amount of mascara put on them. Compared to the initial weigh in, the final plates showed an average loss of 2.1 g. This amount of loss accounts for 56% of the original mascara amount. The temperature during this experiment began at 85^{o}C and finished at 65^{o}C. As can be seen in Figure 3, the waterproof mascara seems to cake onto the bowl with the higher temperature. The initial pouring in of the hot water seems to bake the waterproof mascara which in turn leads to difficulty in cleaning later.

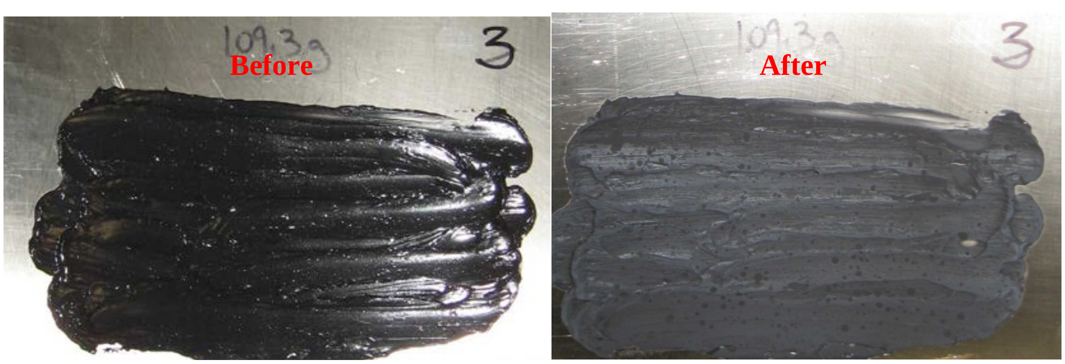

Figure 3: Waterproof Mascara Phase 1

Phase 1 led the design team to a few different conclusions. It shows us, as expected, the non-waterproof mascara cleaned much easier than the waterproof mascara. This was expected due to the nature of the waterproof mascara. Another conclusion that was reached was that the agitation during cycle 2 was relatively effective in removing mascara. The agitations largest effect was seen in the non-waterproof mascara.

Phase 2

The basis of phase 2 is exploring the effect of eliminating cycle 1 and just agitating with a caustic solution for an extended duration. The duration for this experiment was 15 minutes and focused on just the non-waterproof mascara because of the fact that it was cleaned completely during phase 1. Because there is only 1 cycle in this phase, all four plates were kept in the mixer for the entire 15 minutes. There was an average of 4.0 g of mascara put onto each plate. After the cycle had finished, the caustic and water were drained from the tank to reveal that the plates had been cleaned completely. A comparison image of the plate before agitation and after agitation can be seen in Figure 4. Just as with cycle 1, the temperature was monitored during phase 2. The temperature began at 80^{o}C and ended at 63^{o}C.

Figure 4: Non-Waterproof Mascara Phase 2

Phase 2 confirmed an expectation for the design team. It was initially thought that the fill up and draining process used during cycle 1 was very inefficient and that agitation would provide a larger benefit. The results from this experiment prove that at least in our test setup that agitating for 15 minutes provides the same benefit as the current process that L'Oreal uses, which is a completely clean plate at the end of the process. This result could lead to a large savings in water. If the entire first rinse could be eliminated in favor of a longer rinse that included agitation, the amount of water used per batch could be reduced by 33%.

Phase 3

After determining from Phase 2 that agitation produces significant results with the non-waterproof. It was decided that Phase 3 would explore the effect of temperature on the cleaning process. Because it would not be practical, due to safety concerns, to go above the already high temperature of 80^{o}C, it was decided that 25^{o}C would be the temperature to test. The 25^{o}C water was tested on both the waterproof and non-waterproof mascara just in case the waterproof mascara had a positive response to cooler temperatures.

Plates 1 and 3 were used for testing the waterproof mascara. Because of the results obtained from the 80^{o}C test in Phase 1, it was not expected that the performance of 25^{o}C would be very good. The plates showed an average loss of 1.6 g, which is 44% of the total mass put on the plates. An image of the waterproof plates before and after the completed experiment can be seen in Figure 5.

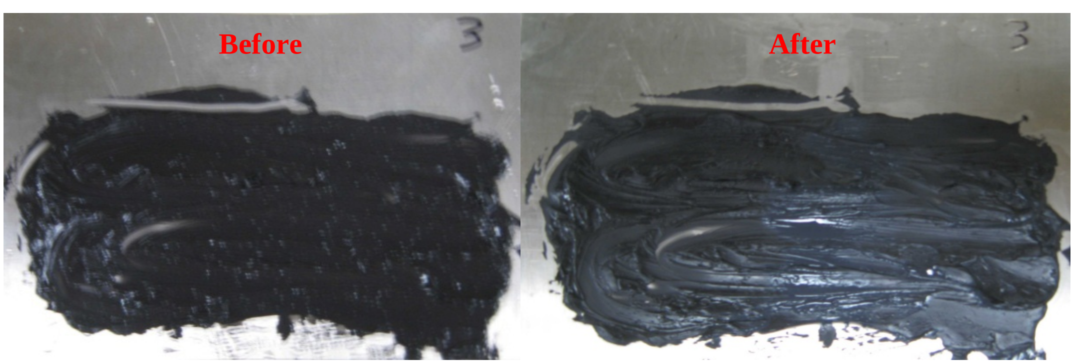

Figure 5: Waterproof Mascara Phase 3

As expected, the waterproof did not cleanup very well using the room temperature water. The complete mass breakdown for Phase 3 can be seen in Table 2.

Table 2: Results of Phase 3

Mascara	Plate	Initial Dry Mascara (g)	Mascara After Cycle 1 (g)
Waterproof	1	3.5	2.0
Waterproof	3	3.7	2.0
Non-waterproof	2	4.1	0.0
Non-waterproof	4	4.7	0.6

Plates 2 and 4 were used for testing the non-waterproof mascara. The average loss for the mascara was 4.1 g, which accounts for 93% of the total mass initially put on the plates. Unlike with the 80^{o}C water, the plates were not completely cleaned following the experiment. The 25^{o}C water did a reasonable job cleaning. It seems as though to clean the plates completely a higher temperature will be required.

4. Future Areas of Study

Left over Mascara Recovery

One of the greatest sources of waste in the UP 1 processing area is the mascara left behind in the OLSA tanks after the mixing procedure and mascara removal process has completed. The outlet that is used to pump the mascara out of the tank is located above the bottom of the tank, thus the mascara cannot be entirely removed which causes a layer of residual mascara to be left at the bottom of the tank. There is also residual mascara that sticks to the walls of the mixing tank and the agitator. There are several ways that this left over mascara incurred can be reduced such as altering the physical features or design of the tank. Also, methods may be implemented to aid in recovering this mascara from the tank to be further used.

Currently, there are two mixing tanks encountering this problem with left over mascara, the 2,000 liter and 1,000 liter OLSA tanks. On average three to five percent of the total mascara is leftover in these mixing tanks once the mixing and removal process has completed. The UP 1 processing area typically runs two to three batches a day in each of these tanks. Assuming a 360 day working year, the total annual mass of mascara waste from left over mascara in the mixing tanks is around 75,000 kilograms. The excessive left over mascara also requires unnecessary amounts of water to fully clean the tanks, so additional expenses are incurred as a result of these procedures.

L'Oreal also assigns a six dollar per kilogram value to its unpackaged mascara product. Based on this number and assuming a 360 day working year, the total annual sales loss from the left over mascara was calculated to be over $650,000. Needless to say, there is a great deal of opportunity to recover expenses that are required to dispose and remove the left over mascara and the sales that are lost from this problem.

An alternative method for reducing the amount of left over mascara could be by moving the location of the outlet from which the mascara is pumped out of. The current position of the outlet does not allow the entire mass of mascara to be removed from the tank because the outlet is located above the bottom of the tank. Consequently, mascara left at the bottom of the mixing tank is unable to be pumped out. A solution to this problem could be to add a different outlet to the bottom of the tank. The bottom of the tank could be shaped to funnel to this outlet, allowing gravity could to push the leftover mascara to the outlet for removal. This would greatly help reduce the total mass of residual mascara since the majority of left over mascara resides at the bottom of the mixing tanks.

A substitute to moving the outlet location for the mascara mixing tank may be to develop a tool that could be used to remove the left over mascara from the tank. A tool could be ergonomically designed to scoop out the remainder of bulk mascara that remains at the bottom of the tank after mixing and removal procedures have been performed. A worker could use this tool through the top opening of the tank to recover the majority of the bulk mascara at the bottom of the tank. Ideas stated previously about designing tank walls to centralize leftover mascara at the bottom of the tank would also be beneficial for removal of left over mascara with a tool. Removing a portion of the left over mascara with a tool would also reduce the volume of water required to clean the tanks and the labor expenses associated with this procedures.

Product Cleaning Procedure Customization

After conducting several experiments on how temperature and other factors affect the ability to clean waterproof and non-waterproof mascara out of a mixing tank, one thing became clearly evident, that is, the properties of these two types of mascara behave very differently under varying conditions. Therefore, the cleaning procedures implemented and used should be dependent on the type of product being cleaned. Currently, L'Oreal uses a standard three rinse protocol cleaning procedure for all of their product lines that are mixed in the UP 1 mixing tanks. The pictures in Figures 4 and 5 in the Results of Experiment section display the differences between cleaning results for waterproof and non-waterproof mascaras after the initial phase one experiment was conducted. One can see a large visual difference in the amount of mascara that was cleaned from the stainless steel plates for both products. The waterproof mascara is more difficult to clean off the plates than the non-waterproof mascara.

There are four main product categories that are mixed in the UP 1 processing tanks; fiber-based mascara, waterproof mascara, non-waterproof mascara, and foundation. Based on information from the L'Oreal personnel, the fiber-based mascaras and waterproof mascaras are the most difficult products to clean from the tanks. Therefore, the cleaning procedures were initially developed to be capable of handling the hardy nature of these products. However, the mixing tank experiment results illustrate that the two products should be handled differently. Future work may consider determining the optimal cleaning procedure for each of the four main product categories. By doing this, labor expenses and time to clean the tanks can be reduced. Also, the amount of water required to clean the tanks may be minimized.

Experimental Design Enhancements

The design team was currently only able to conduct a fraction of the total number of experiments that were initially proposed. Future considerations for customizing the cleaning procedure for each product category should look more in depth into the factors that were examined in this experiment as well as several other factors. For example, to be efficient with time the design team only tested two water temperatures for the experiments with waterproof and non-waterproof mascaras. A temperature of $80^{o}C$ was chosen as one of the temperatures to be used because this is the temperature that L'Oreal is currently using to heat their water up to fill and clean the mixing tanks in the UP1 processing area. The results obtained from these trials were then compared to the results of trials using $25^{o}C$ water, room temperature water, to analyze the effects of temperature on the cleaning process. Ultimately, $80^{o}C$ was found to be more effective for cleaning the tanks, but more detailed sensitivity analysis on temperatures between $25^{o}C$ and $80^{o}C$ may yield a more optimal temperature with superior results.

Another factor that should be considered for future analysis is the concentration of the caustic solution that is used during the second rinse of the cleaning cycle. Currently, the concentration of caustic solution in the mixing tank is four percent. Products like the waterproof mascara may be more effectively cleaned from the tank if a higher concentration of caustic is used. Increasing the caustic may help reduce the amount of time required to clean the tanks. Also, for some products decreasing the concentration of caustic may not affect the effectiveness of the tank cleaning. Therefore, expenses incurred from extra unneeded caustic solution can be eliminated.

Ultrafiltration

Ultrafiltration (UF) is a membrane separation that retains the solids and allows the water to pass through. Due the composition of the solids in the rinse water, UF would be a way to reuse the water from all cycles. A UF system that can process 300 to 500 gallons a day costs between $5,000 and $7,000 with a $300 cartridge change every three years. Currently the wastewater produced from the Olsa tanks is about 500 gallons per wash cycle. Testing to determine the effectiveness of ultrafiltration and cost analysis for a larger ultrafiltration system is needed.

5. Conclusion

In conclusion, it is the design team's recommendation that the cleaning process for both waterproof and non-waterproof mascara should be changed. A satisfactory amount of tests were not conducted to determine the optimal method of change for the waterproof cleanup, but there are a few recommendations that can be presented for non-waterproof cleanup. First, a considerable amount of water can be saved if the first cycle of cleaning involves agitation. The agitation greatly improves the amount of non-waterproof mascara that can be removed in a single cycle. It is also recommended that the volume of water used in the first rinse of the non-waterproof be reduced. The majority of the cleaning was found to occur during the second rinse. A minimum amount of water required to remove the bulk mascara remaining in the bottom should be used. Also, through our experiments it was shown that the cleaning process was not as effective when working with 25^oC water. This does not eliminate the possibility of there being an intermediate temperature cooler than 80^oC that is just as effective at cleaning the mascara. If a temperature is found that is cooler than the current 80^{o}C, money could be saved in heating costs. Due to the amount of water potentially saved by recycling the third rinse, further investigation into this recycle is recommended.

The recommendations laid out within this report, namely a removal of the first rinse and a decrease in the temperature of the water used, would reduce water usage and energy usage by one third for all non-waterproof batches produced in the Olsa tanks. We calculated a savings of approximately $30 for every batch of washable mascara produced in the 2,200 liter Olsa tank and a savings of approximately $25 for each batch of washable mascara produced in the 1,100 liter Olsa tank. These savings are broken down into a savings of 2,200 liters of water, 140 kilowatt hours of energy to heat this volume of water, and a labor savings due to a decreased time per batch for the larger tank size. If there are two batches of washable mascara made each day in each of the two Olsa tanks, this would be an annual savings of approximately $41,000, 2.3 million liters of water, and 152,000 kilowatt hours. This would represent a 4.7% reduction in total water usage in the plant. This would not satisfy all of the savings wanted by L'Oreal for the plant, but would move them several percentage points closer to their goal.

Appendix

Table 3: Experimental Design

Trial	Product Type	Temperature	Caustic Concentration	Agitation Time
1	Fiber	25	0.03	15
2	Fiber	25	0.03	30
3	Fiber	25	0.04	15
4	Fiber	25	0.04	30
5	Fiber	25	0.05	15
6	Fiber	25	0.05	30
7	Fiber	55	0.03	15
8	Fiber	55	0.03	30
9	Fiber	55	0.04	15
10	Fiber	55	0.04	30
11	Fiber	55	0.05	15
12	Fiber	55	0.05	30
13	Fiber	80	0.03	15
14	Fiber	80	0.03	30
15	Fiber	80	0.04	15
16	Fiber	80	0.04	30
17	Fiber	80	0.05	15
18	Fiber	80	0.05	30
19	Waterproof	25	0.03	15
20	Waterproof	25	0.03	30
21	Waterproof	25	0.04	15
22	Waterproof	25	0.04	30
23	Waterproof	25	0.05	15
24	Waterproof	25	0.05	30
25	Waterproof	55	0.03	15
26	Waterproof	55	0.03	30
27	Waterproof	55	0.04	15
28	Waterproof	55	0.04	30
29	Waterproof	55	0.05	15
30	Waterproof	55	0.05	30
31	Waterproof	80	0.03	15
32	Waterproof	80	0.03	30
33	Waterproof	80	0.04	15
34	Waterproof	80	0.04	30
35	Waterproof	80	0.05	15
36	Waterproof	80	0.05	30
37	Non-waterproof	25	0.03	15
38	Non-waterproof	25	0.03	30

39	Non-waterproof	25	0.04	15
40	Non-waterproof	25	0.04	30
41	Non-waterproof	25	0.05	15
42	Non-waterproof	25	0.05	30
43	Non-waterproof	55	0.03	15
44	Non-waterproof	55	0.03	30
45	Non-waterproof	55	0.04	15
46	Non-waterproof	55	0.04	30
47	Non-waterproof	55	0.05	15
48	Non-waterproof	55	0.05	30
49	Non-waterproof	80	0.03	15
50	Non-waterproof	80	0.03	30
51	Non-waterproof	80	0.04	15
52	Non-waterproof	80	0.04	30
53	Non-waterproof	80	0.05	15
54	Non-waterproof	80	0.05	30
55	Foundation	25	0.03	15
56	Foundation	25	0.03	30
57	Foundation	25	0.04	15
58	Foundation	25	0.04	30
59	Foundation	25	0.05	15
60	Foundation	25	0.05	30
61	Foundation	55	0.03	15
62	Foundation	55	0.03	30
63	Foundation	55	0.04	15
64	Foundation	55	0.04	30
65	Foundation	55	0.05	15
66	Foundation	55	0.05	30
67	Foundation	80	0.03	15
68	Foundation	80	0.03	30
69	Foundation	80	0.04	15
70	Foundation	80	0.04	30
71	Foundation	80	0.05	15
72	Foundation	80	0.05	30

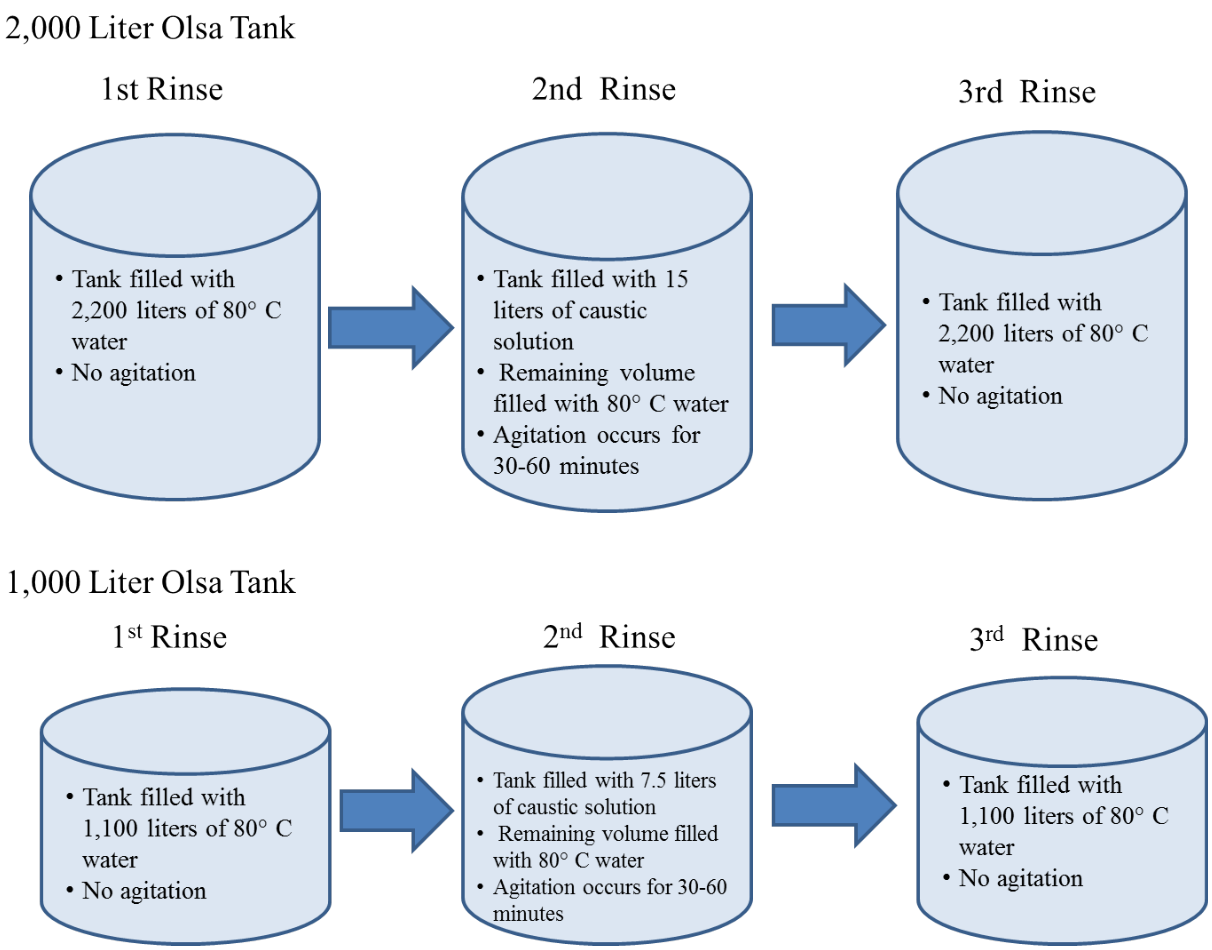

Figure 6: L'Oreal Current Tank Cleaning Process