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GNG 1103
Design Project User and Product Manual

Convey by Team C7

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List of Acronyms and Glossary

Table 1. Acronyms

Acronym	Definition
CPM	Cans Per Minute
OEE	Overall Equipment Efficiency
POI	Point Of Interest
UI	User Interface

Table 2. Glossary

Term	Acronym	Definition
Overall Equipment Efficiency	OEE	A measure of manufacturing productivity that evaluates how effectively a machine or production line is utilized
User Interface	UI	Form of software that allows a user to navigate and perform some set of functions within a given system
V curve theory	N/A	Optimization theory specifically used for bottleneck processes, where the assumption is that any station after the bottleneck should run 10% faster

		<p>than the previous, and every station</p> <p>before the bottleneck should run 10%</p> <p>faster than the station preceding it</p>
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1 Introduction

The goal of our project is to develop a software optimisation system. The system was to work completely offline, where client data would be provided and then optimised using a database. The main assumptions that were made include: V-curve theory data was considered real, whereas client data is real. Data nomenclature was used to determine conveyer speeds, and OEE was calculated based on overall CPM error. The document will consist of eight main components: introduction, overview, initialization, system use, troubleshooting, product documentation, conclusion, and bibliography. The purpose of this paper is to document the design well enough that clients or other users could use the system to reproduce it completely.

This User and Product Manual (UPM) provides the information necessary for Mill Street Brewery to effectively use Convey and for prototype documentation.

2 Overview

Mill Street Brewery's brewing line process is not as efficient as it could be. The reason why this issue is so important is that Mill Street Brewery actively loses out on a considerable amount of revenue due to this inefficiency, and it is an issue that recurs every time the process is run. The user is looking for an offline optimization system that can convert client speed data into ideal speed data to allow the program to produce percent error readings and efficiency readings and identify any stations or conveyers within the line that are not running optimally for the can, keg, and bottle lines, which will lead to an overall efficiency increase of at least 2%. The user needs the program to be easy to use and learn, with relatively little general maintenance. The user interface must be aesthetically pleasing, allowing the client to switch between lines and interpret data with ease. The main differentiation between our product and others is flexibility. All the optimization data is computed using Excel, which is an application that the users are already familiar with, and it will make it extremely easy for clients to input new sets of run data that will then be optimized. Furthermore, the program is extremely user-friendly, as it is not limited to one method of hardware, as it is accessible using a computer, an iOS device, an Android device, and more.

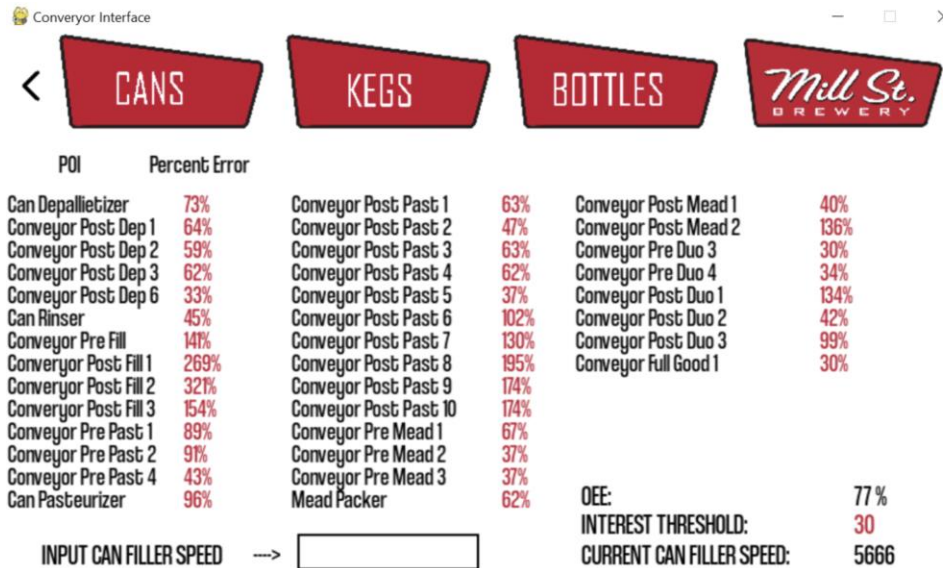


Figure 2.1: User Interface final prototype displaying optimization data

The fundamental concept of the design is the use of V-curve theory. V-curve theory is an optimization process specifically used for bottleneck processes, in which the bottleneck is defined as the slowest station in the system. The V curve theory states that any station after the bottleneck should run 10% faster than the previous, and every station before the bottleneck should run 10% faster than the station preceding it. This process is applied to client data by creating ideal V-curve theory values and real client data values. The system consists of two main components: the database and the user interface. The database is used to store and compute all data, and the user interface allows the user to input a specific filler speed for any line, for which all relevant optimization data is retrieved and presented. Another key feature that was implemented into the system is the point of interest function. The point of interest function relies on a threshold value. The threshold value is a metric that determines what optimization data is presented in the user interface at any given time. The threshold value can be set at a specific percentage, at which point all stations or conveyors within the line that meet that percentage of error will appear in the user interface. This implies that if the threshold value is increased, all stations or conveyors within the line with that increased percent error will show up in the interface as identified areas that are not running optimally.

3 Getting started

The first step in accessing and using the optimization system is to open the program. When the program is opened, a password is required to access the functions within the program.

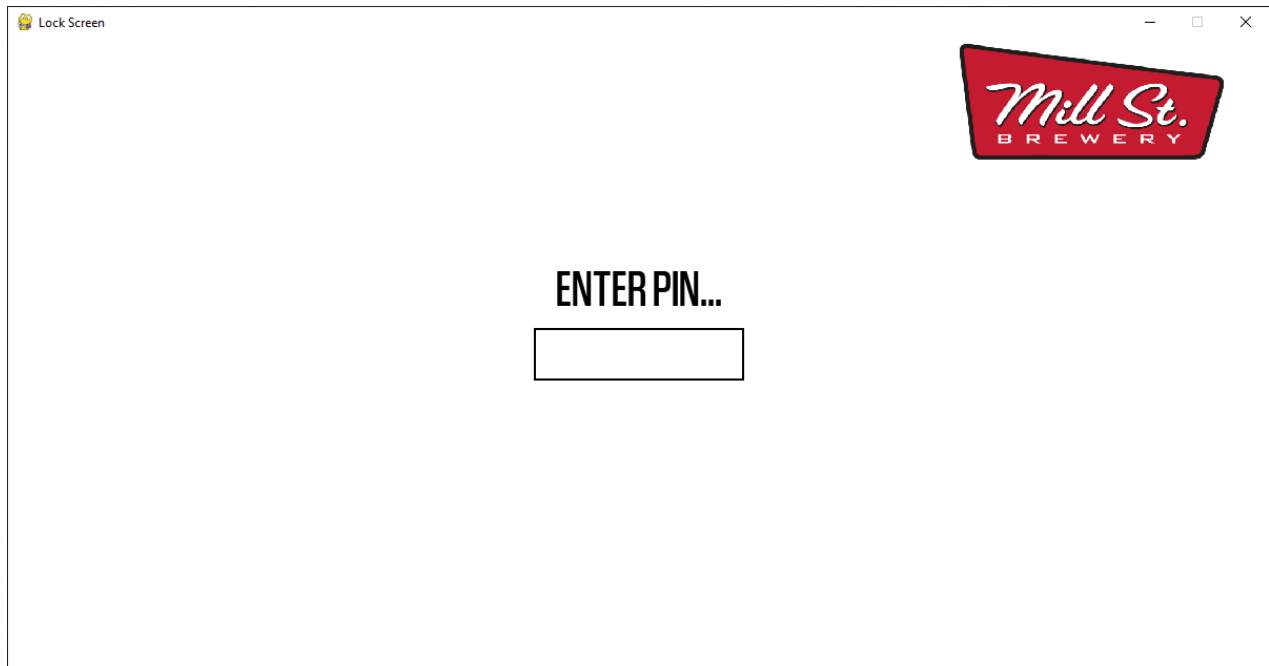


Figure 3.1: Lock screen when application is first launched

When a password is inputted, the system will retrieve the password from the database, verifying its validity, and access will be granted. The user will be directed to the main menu, and they will be able to see the current filler speeds of can, keg, and bottle lines as well as buttons that will direct them to any three of the lines or close the program.

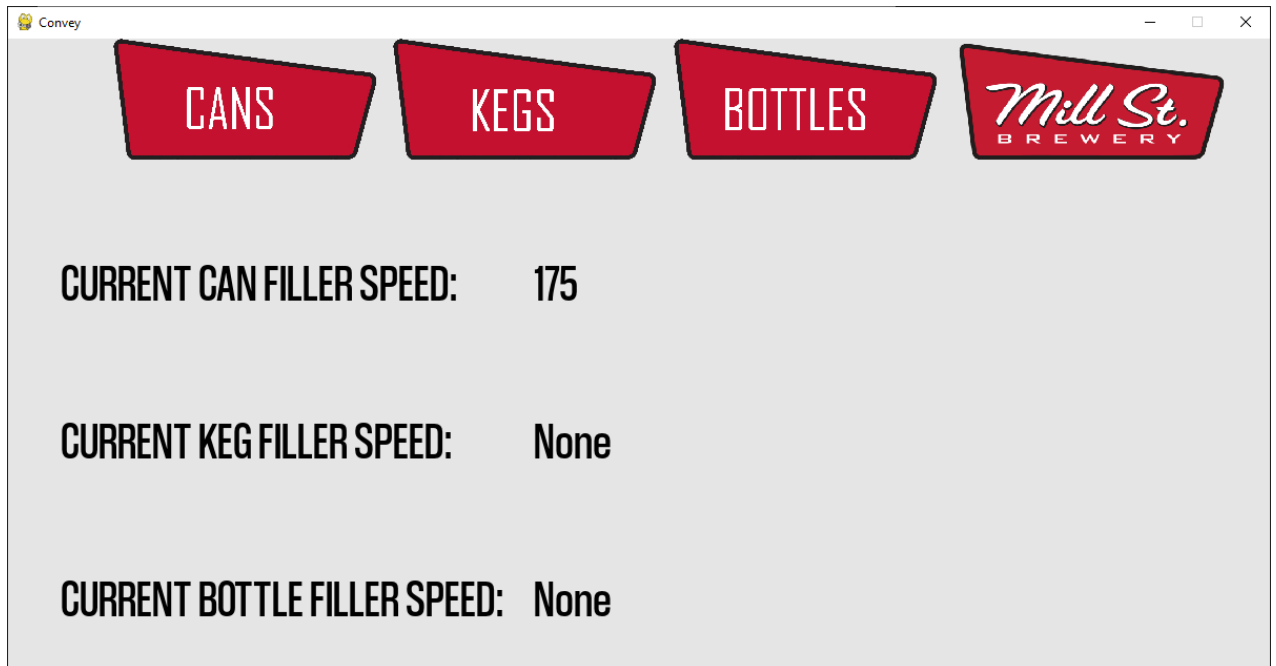


Figure 3.2: Main menu showing the current speeds as well as providing the option to select each individual line

From the main menu, the user will be able to click a button directing them to one of the specific brewing lines, where they will then see the current optimized data for that specific line and filler speed.

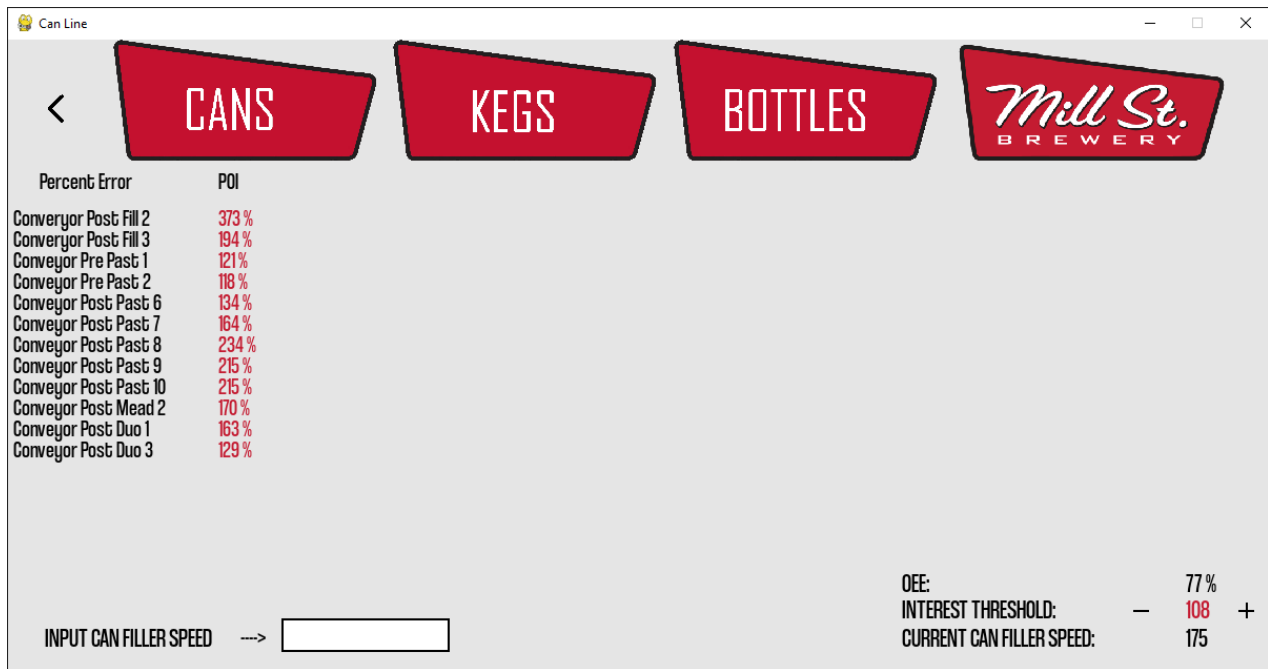


Figure 3.3: Can line shows all the percent errors of each station relative to the inputted speed

The user will be able to change the filler speed and the threshold value, after which the user interface will retrieve and present updated optimized data from the database. The user will be able to quickly switch between lines or close the program if they choose to.

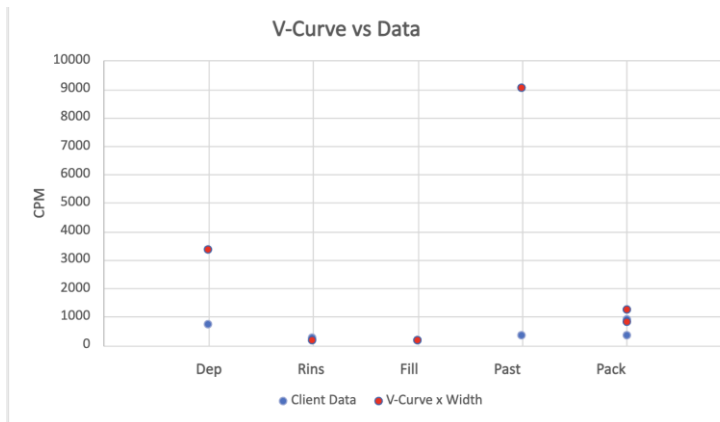
3.1 Configuration Considerations

The first software prototype developed was the database. The database was used to compute all optimization data originating from raw client speed data. The database was developed using Excel on a laptop, in which client speed data was converted to ideal speed data using the V curve theory. When ideal speed data was computed, percentage errors for each station and conveyor were calculated.

Process Machine	Percent Error	Data	Ideal
Can Depallietizer	77.41%	1004.035	3360
Conveyor Post Dep 1	65.44%	339.4238	840
Conveyor Post Dep 2	60.98%	290.8143	630
Conveyor Post Dep 3	63.87%	272.5506	630
Conveyor Post Dep 4	27.53%	531.0522	630
Conveyor Post Dep 5	2.55%	225.7206	210
Conveyor Post Dep 6	37.15%	319.8489	210
Can Rinser	49.61%	319.8489	192.5
Conveyor Pre Fill	71.26%	482.349	175
Can Filler & Seamer	0.00%	200	175
Conveyor Post Fill 1	312.10%	739.4457	175
Conveyor Post Fill 2	373.65%	843.4083	175
Conveyor Post Fill 3	194.36%	509.5104	175
Conveyor Post Fill 4	46.11%	258.0333	175
Conveyor Pre Past 1	121.38%	417.2553	192.5
Conveyor Pre Past 2	118.70%	420.5334	192.5
Conveyor Pre Past 3	5.58%	203.2422	192.5
Conveyor Pre Past 4	35.78%	494.5248	770
Can Pasteurizer	96.11%	352.1616	9047.5
Conveyor Post Past 1	57.91%	324.0636	770
Conveyor Post Past 2	15.10%	464.5536	770

Figure 3.4: Selected data in Excel database

From here, we were able to approximate an overall equipment efficiency reading by equating the OEE to 1 minus the sum of the percent error. Graphs were created to easily represent how correlated the raw vs. ideal data was for each main station in the system.



$$OEE = \left(1 - \left| \frac{real - ideal}{ideal} \right| \right) \times 100\%$$

Figure 3.5: Graphical analysis displaying correlation between client and v curve data

Figure 3.6: Approximation used to calculate Overall Equipment Efficiency

The second software prototype was the user interface. The user interface was coded in Python, and the usable buttons and graphics were created using the PyGame module. The user interface was created completely on a laptop and is accessible on all platforms.

3.2 User Access Considerations

The main user of this product will be Mill Street Brewery. The users will use the system to analyze their current efficiency readings, through which they will be able to identify stations that are not running optimally and then make changes accordingly. In terms of restrictions, because of the password system, only certain members specified by Mill Street Brewery will have access to the full functionality of the product.

3.3 Accessing/setting up the System

To access the Excel database, the users will simply have to download the Excel file onto some form of hardware. To turn on and access the system, the users will first need to have the program downloaded to some form of hardware. From there, the users can open the program, where a password will be required to gain access. The passwords will be specified by Mill Street Brewery and can be entered directly into the database. To reset or change a password, the user will have to simply modify the current password(s) in the database.

3.4 System Organization & Navigation

Database

The database was used to compute all optimization data originating from raw client speed data collected offline. The database allows the program to retrieve specific data.

Lock Screen

The lock screen appears when the program is first launched. A password is inserted, and the program retrieves it from the **database**, in which the program will then open.

Main Menu

From the main menu, the user can access each **specific line**, view current filler patterns, and close the program.

Specific brewing line

The specific brewing lines consist of the can, keg, and bottle lines. The user can examine and alter data, in which case the program will retrieve optimized data from the **database**. The user can return to the **main menu**, switch to a different line, or close the program.

3.5 Exiting the System

An "X" button is in the top right corner of the screen at each component of the program. The user simply needs to press the X button to exit or close the program.

4 Using the System

4.1 Lock Screen

When the program is first launched, the user is faced with a lock screen that requires a 4-digit pin, as seen in figure 1.

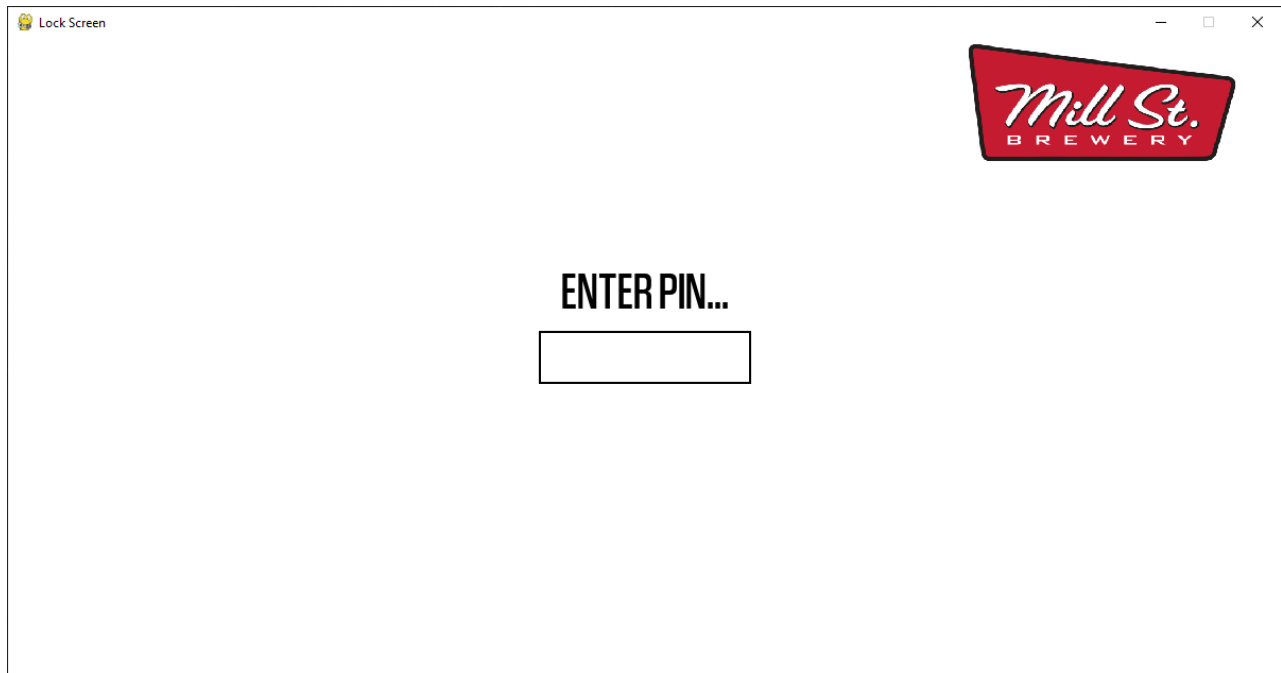


Figure 3.1: Lock screen when application is first launched

The user must input a PIN that is in the list of PINs connected to an excel sheet. If the user inputs an incorrect password, a message reading "Incorrect PIN" is displayed to let the user know. Once a correct PIN has been entered, the user is shown the main menu. The user also can add or change PINs by accessing the excel sheet.

4.2 Main Menu

The main menu gives a quick and simple overview of the current speeds for each of the lines. Each individual line is shown at the top and can be clicked on to be taken to a more informative page for that line.

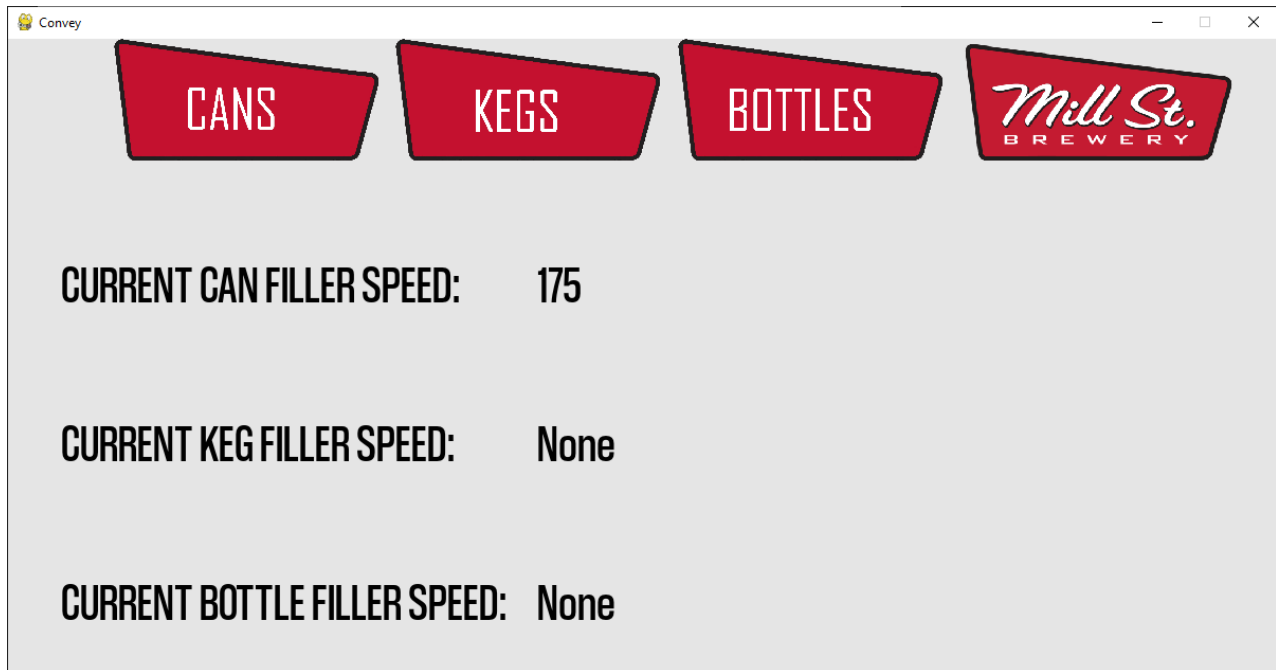


Figure 3.2: Main menu showing the current speeds as well as providing the option to select each individual line.

4.3 Different Lines

At the time this report was being written, the only data set that was provided was that of the canning line. Because of this, the only working menu now is the menu on the can. When the can line is selected, the user is shown all the percentage errors of each station relative to the optimal values based on the input speed.

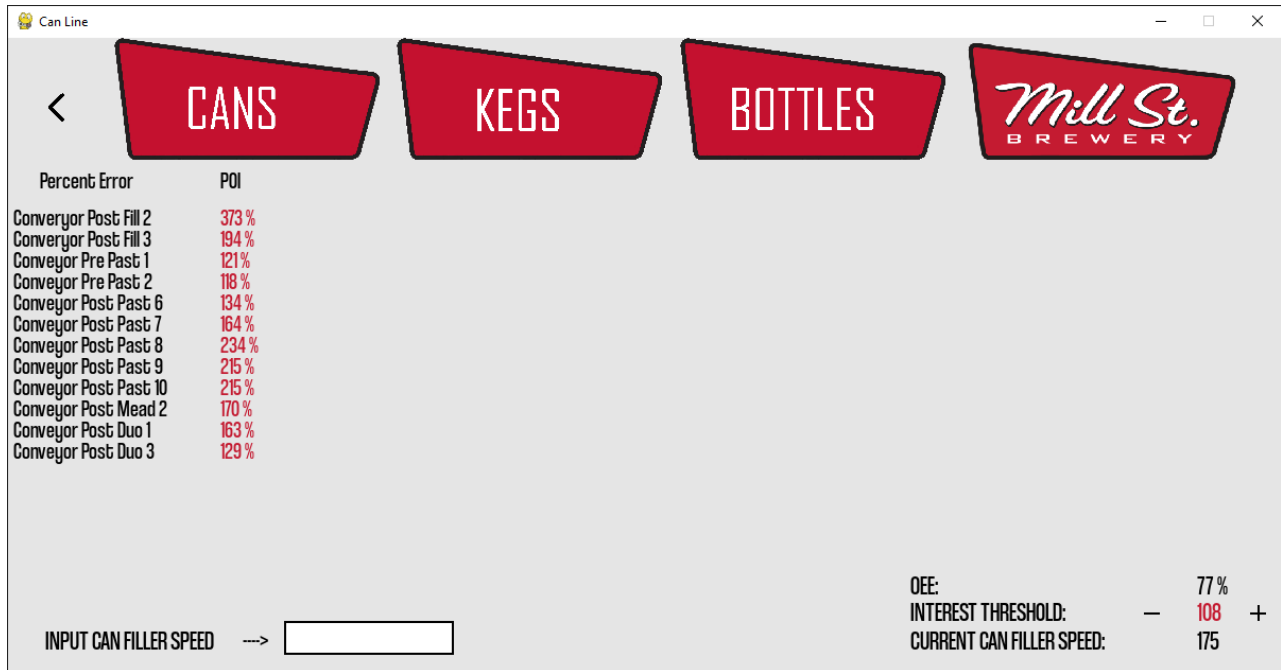


Figure 3.3: Can line shows all the percent errors of each station relative to the inputted speed (bottom right)

From this menu, the user can input a filler speed that corresponds to the filler speed of a data set that they provide to the program. When the user then inputs a speed, the program will calculate the percentage error for each station and then update the screen with the correct values. The user also can adjust the interest threshold, which will adjust the range of the percentage errors that will be shown on the screen at a time. If the user only wants to see errors above 100%, they can quickly adjust this by clicking the plus or minus buttons and then pressing 'u' to update the screen.

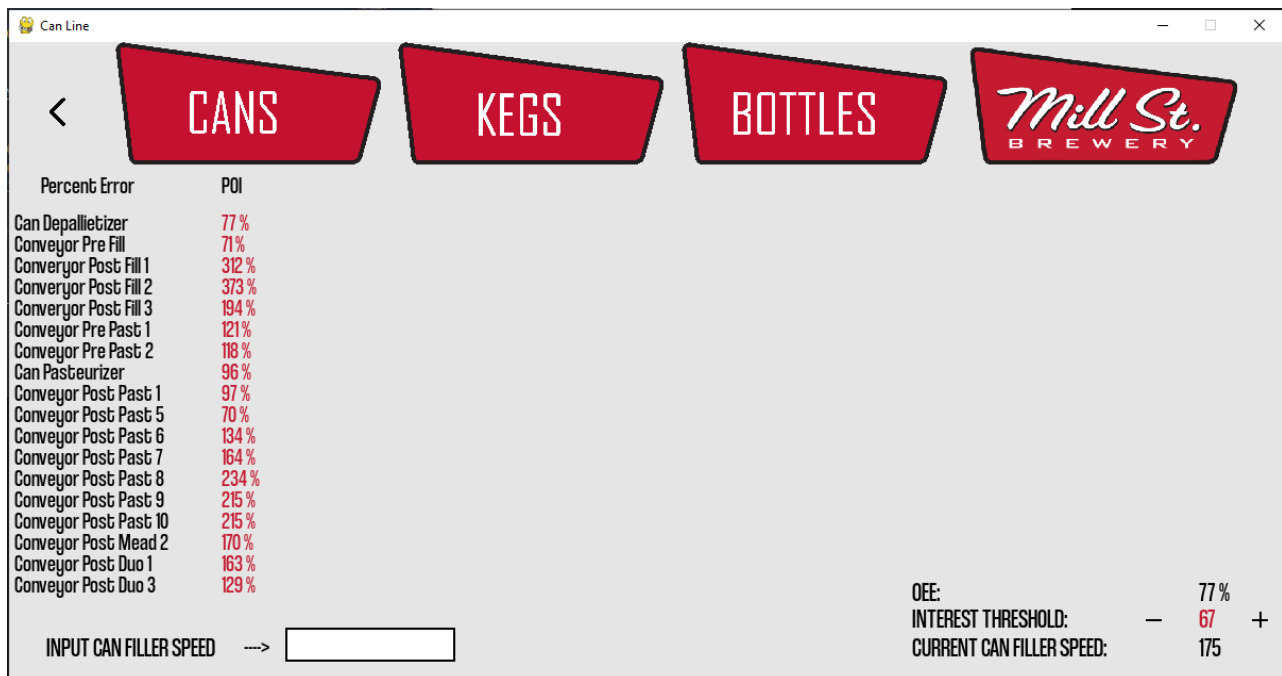


Figure 4.1: Adjusted interest threshold shows more values to the user.

At the bottom right of the screen, the OEE is also shown. This allows the user to know right away how effective their current speeds are. Once the user is done looking at this data, they can click on the arrow at the top left of the screen to return to the main menu, or they can close the window to leave the application.

5 Troubleshooting & Support

5.1 Error Messages or Behaviors

You may receive error messages if you find a bug in the code, and/or edit the code incorrectly. To resolve this issue, you could trouble shoot possible reasons for this error online using resources such as Stack Overflow or ChatGPT. You also may get an error message if you try to sign in with the pin. This means you entered the incorrect pin, and you must enter the correct pin to proceed.

5.2 Special Considerations

If numbers aren't lining up and/or aren't working as intended, but the code has no errors, check the excel data sheet. If the excel data sheet doesn't line up with the code, it could cause issues. This can be resolved by formatting the data in the excel sheet correctly.

5.3 Support and Maintenance

Although no maintenance should be necessary as this product is a software, for any support or maintenance issues, email the creators: Jake Appleby (jappl028@uottawa.ca), Kole Cantor (kcant077@uottawa.ca), Matthew Perry (mperr137@uottawa.ca), Tomas Silva Salanova (tsilv099@uottawa.ca).

6 Product Documentation

In the design of our final comprehensive prototype, the Team merged the previously built user-interface and data storage system. This was the teams chosen approach due to the client having familiarity with Microsoft Excel, allowing the user to use the product and manipulate the software with ease if required. As previously stated, the final prototype can be designated into two subsystems. The first of these systems is the user-interface, that allows the user to interact indirectly with the excel in an easy and user-friendly manner. The second subsection of the final product in the excel database, that takes inputs from the interface and utilizes that information to manipulate and output client data and feedback.

6.1 User Interface

6.1.1 Bill of Materials and Equipment List

The interface was programmed using Python, and the graphics were created with the PyGame module. The UI is solely software-based, so there is no cost to creating this UI. Note that you must have a computer with a working operating system to use Python and to download Pygame.

6.1.2 Instructions

To recreate the UI, the user will need a few things. To begin with, the user will need to have .jpeg format images of each of their desired buttons. In the case of Convey UI, Figure 6.1 shows the images that were used for the different buttons:



Figure 6.1: Images used for buttons within UI.

To create the program's user interface, a function must be created for each line. Within each function, there should be an input box that will store the input value in the correct location, and there should be an adjustable interest threshold, also for the correct data set. Events should also be handled within each function. The main function should just run the main menu UI, and from the main menu, each function should be called to navigate through the different menus.


```

70  # Button Class
71  class Button():
98
99  def listInput():
115
116  def organizeData():
136
137  POIs, speeds = organizeData()
138
139  def blitList():
167
168  def blitInfo():
185
186  def speedInt(inputStr):
203
204  def PINUI():
287
288  def mainUI():
336
337  def canUI():
465
466  def kegUI():
502
503  def bottleUI():
539
540  PINUI()

```

Figure 6.2: List of functions used for the program.

To create the buttons, a class must be made. Within this class, there should be a function that returns a Boolean when the mouse is clicked above this image. The program will know when it is clicked, and the navigation through menus can be controlled this way.

Outside of all functions, the images should be loaded, the Excel sheets should be opened, and all the variables should be defined. This way, there is no need to repeat this inside of each function.

6.2 Data Base and Manipulation

6.2.1 Bill of Materials and Equipment List

Since the data base is made entirely out of software, there are no physical materials involved and the cost is free, however; the user should note that to run and create the database he/she will need a version of Microsoft Excel, preferably the most up-to-date version. It is also worth noting that although the team used a monitor display when presenting the product on design day, such a monitor is not provided with the acquisition of the product.

6.2.2 Instructions

When first opening the database, many things should be noted by the user. The first four columns, B through E, of the excel sheet are reserved for inputting client data sets. The first two data sets have already been entered by the team from the client, the second two columns have been left black for potential future inputs. Column F of the database is also reserved for outputting machine and conveyor ideal values, using v-curve theory. In additions, columns G and H are also taken by the percent error and point of interest system, respectively. It is very important then when the user is tampering with the Excel to not modify or change any of the previously states columns and must keep in mind that the Excel isn't supposed to be modified and rather just be used by the interface. In the data base, the user should find three highlighted cells: I2, I4, I6. Cell I2 represents the calculated overall effectiveness statistic, which should not my modified by the user. The other two noted cells, represent user inputs from the interface. These cells may be modified without repercussion to the code, but it is still highly recommended that the user uses the interface to interact with the database. Finally, the user will also find a graphical representation of the v-curve data compared to the actual data, which is a minor function meant to provide visual aid if needed. The figures below display the Excel database with the corresponding description above.

	Filler Trial Speed	175	200	
1	Can Depallietizer	759.02064	1004.0352	
2	Conveyor Post Dep 1	290.346	339.42384	
3	Conveyor Post Dep 2	245.8575	290.8143	
4	Conveyor Post Dep 3	227.5938	272.5506	
5	Conveyor Post Dep 4	456.5925	531.0522	
6	Conveyor Post Dep 5	204.6471	225.7206	
7	Conveyor Post Dep 6	288.0045	319.8489	
8	Can Rinser	288.0045	319.8489	
9	Conveyor Pre Fill	299.712	482.349	
10	Can Filler & Seamer	175	200	
11	Conveyor Post Fill 1	721.182	739.4457	
12	Conveyor Post Fill 2	828.891	843.4083	
13	Conveyor Post Fill 3	515.13	509.5104	
14	Conveyor Post Fill 4	255.6918	258.0333	
15	Conveyor Pre Past 1	426.153	417.2553	
16	Conveyor Pre Past 2	421.0017	420.5334	
17	Conveyor Pre Past 3	203.2422	203.2422	
18	Conveyor Pre Past 4	494.5248	494.5248	
19	Can Pasteurizer	352.1616	352.1616	

Figure 6.3: Data storage columns B to D

V-Curve x Width	Percent Error	POI	OEE	
3360	77.41%	Can Depallietizer	88.50%	
840	65.44%	Conveyor Post Dep	Intrest Threshold	
630	60.98%	Conveyor Post Dep	0.00%	
630	63.87%	Conveyor Post Dep	Insert Filler	
630	27.53%	Conveyor Post Dep	175	
210	2.55%	Conveyor Post Dep 5		
210	37.15%	Conveyor Post Dep 6		
192.5	49.61%	Can Rinser		
175	71.26%	Conveyor Pre Fill		
175	0.00%		0	
175	312.10%	Conveyor Post Fill 1		

Figure 6.4: Data manipulation and output columns

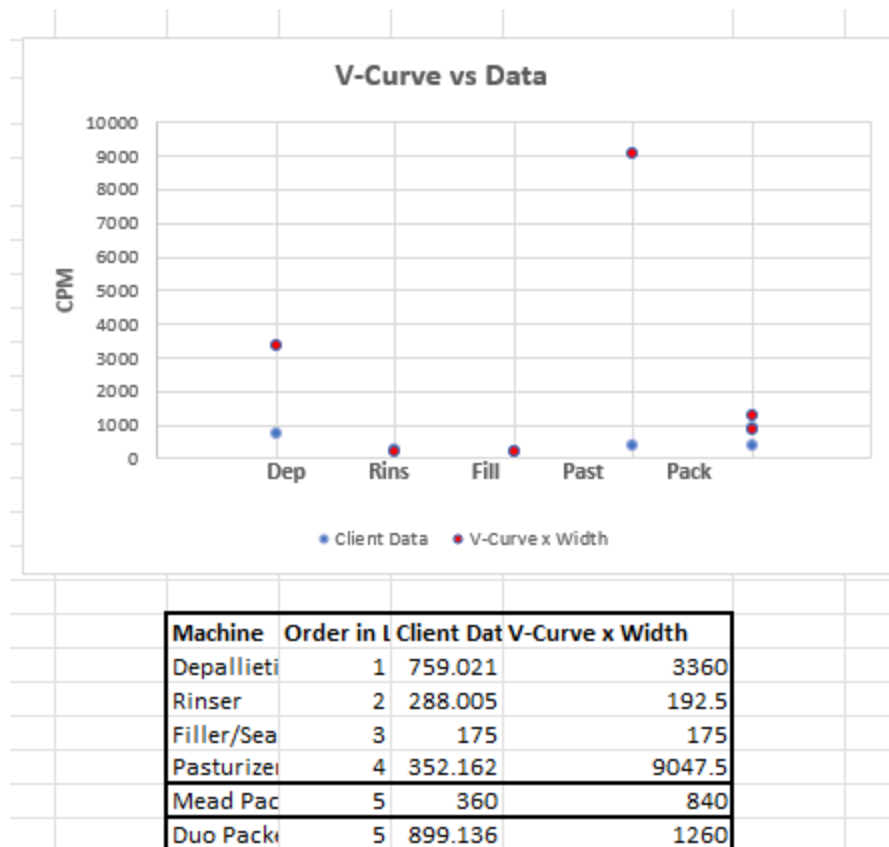


Figure 6.5: graphical component for user needs

It is important to express that the user of the product, although having access to the database, should not directly interact with it aside from inputting new datasets. If the user accidentally causes issues with the database, it is recommended that they contact the emails provided above in the ‘Support and Maintenance’ section of this document.

6.3 Testing & Validation

Many tests occurred to validate the functionality of our final product. Firstly, many error-trapping sessions took place, to attempt to debug as many potential errors as possible. This would ensure that our systems were running at the most optimal rate with minimal potential for error during design day. In addition, the team also did a public survey to gather feedback and validate the aesthetical portion of the product. Finally, the team held a private discussion meeting with the client to discuss the gathered data and findings. When the meeting concluded, the client approved of the

team's methods and results, thus validating the process. Results of this validation cannot be provided in this document due to client privacy reasons.

7 Conclusions and Recommendations for Future Work

Many lessons were learned throughout the process of designing and creating the Convey software. For our interface we found out it was better to use a familiar aesthetic to the client Mill Street as it creates a familiarity to the user. This was determined through user feedback and user experience satisfaction increases once we implemented new buttons and icons that closer resembled that design aesthetic. We also received valuable feedback to add more security to protect the user's important data from unwanted eyes. To combat this, we added a pin system where the user must input their pin to access the interface and is unable to without the pin. User feedback of this change was great, and users really appreciated having their sensitive data be secure.

If we had a few more months, we would focus our work on the versatility of Convey. Now, due to time constraints, the functionality is only for the can line of Mill Street's lines. If we had the data for the keg and bottle lines, as well as more time, we could have implemented those lines as well. We also discussed a "build your own line" system where users could manually enter their line into the software which can then be used to find the most efficient speeds and OEE of the system. This would make Convey even more accessible to other users and allow for much more versatility of the software. In addition, our client brought up the idea of having a live data collection system that automatically feeds into the Convey software. This is possible if we had a way to collect the live data. Unfortunately, due to the client only mentioning this a week before design day there was simply no way to implement it in time. If we had more time, we could perhaps develop a laser/other device to detect the cans, bottles, and kegs in real time and relay this data to the Convey software to calculate the most efficient process speeds. You could even take this a step further and allow Convey to automatically adjust the speeds of equipment to their most efficient states, which would pretty much make it self-sustaining. In total, we learned a lot from this process and there were also many things we would have liked to implement if we had the time.

8 Bibliography

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Knox, David. (2023, January 11). Lecture Notes. Retrieved from GNG 1103 Brightspace

APPENDICES

9 APPENDIX I: Design Files

Table 3. Referenced Documents

Document Name	Document Location and/or URL	Issuance Date
MakerRepo + Deliverables	https://makerepo.com/Japple/1532.gng1103c7group-7	March 15 2023
Lecture Notes	GNG 1103 Brightspace	January 11 2023
Vcurve Theory	https://news.lineview.com/is-the-v-curve-theory-the-best-option-for-setting-accumulation-line-speed	December 5 2022