Conestoga College Institute of Technology and Adavanced Learning, Doon Campus, Ontario

Project Proposal

Automation of Decarbonization and Cleaning Process of Steel Trays in Baking Industry

Applied Electrical Motion and Control Management

ELEC8081 – Capstone

Section 1 Fall 2025 Session

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1.0 Team Engelberger Icon Portrayal

Fig 1. Robotic Industries Association. (2015, December 9). *Joseph F. Engelberger, a leader of the robot revolution, dies at 90*. Automate. Retrieved October 3, 2025, from https://www.automate.org/robotics/news/joseph-f-engelberger-a-leader-of-the-robot-revolution-dies-at-90

Joseph Frederick **Engelberger**

Title / Identity

- Known as the **"Father of Automation and Robotics."**

Birth and Death

- Born: July 26, 1925 – Brooklyn, New York, USA
- Died: December 1, 2015 – Newtown, Connecticut, USA (age 90)

Education

- B.S. in Physics (1946) – Columbia University
- M.S. in Electrical Engineering (1949) – Columbia University

Place of Work

- **Unimation, Inc.** (Co-founder, 1957): World's first robotics company.
- Worked with General Motors to deploy the **first industrial robot (Unimate).**
- Later founded Transitions Research Corporation (1984): developed hospital service robots like **HelpMate.**

Contributions

- Introduced **Unimate (1961)** – first industrial robot in a GM plant.
- Expanded robotics into **healthcare, homes, and space exploration.**
- Advocated robots for dull, dirty, and dangerous tasks.
- Authored **Robotics in Practice** (1980) and **Robotics in Service** (1989).
- Won major honours: **Japan Prize (1997), IEEE Robotics and Automation Award (2004).**

2.0 Introduction to Decarbonization and Cleaning Process

The baking industry in Ontario has seen consistent growth, forming a significant segment of the province’s food sector. By May 2025, there were 4,901 bakeries in Ontario, reflecting a 2.47% increase since 2023. Of these, 2,266 (46.24%) are independently owned, while 2,635 (53.76%) are part of multi-location chains. Toronto hosts the largest number of bakeries at 939, followed by Ottawa with 383 and Mississauga with 354. On average, bakeries in the province have been operational for nearly seven years, indicating both a relatively young industry and steady market renewal (IBISWorld, 2025).

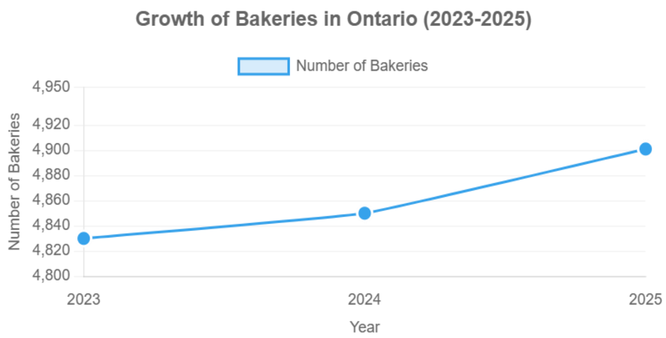

Fig 2: Growth of Bakeries in Ontario (2023–2025). The chart illustrates the steady increase in the number of bakeries in Ontario, showing a 2.47% growth from 2023 to 2025. Note. Data from IBISWorld (2025). Graph created by the author.

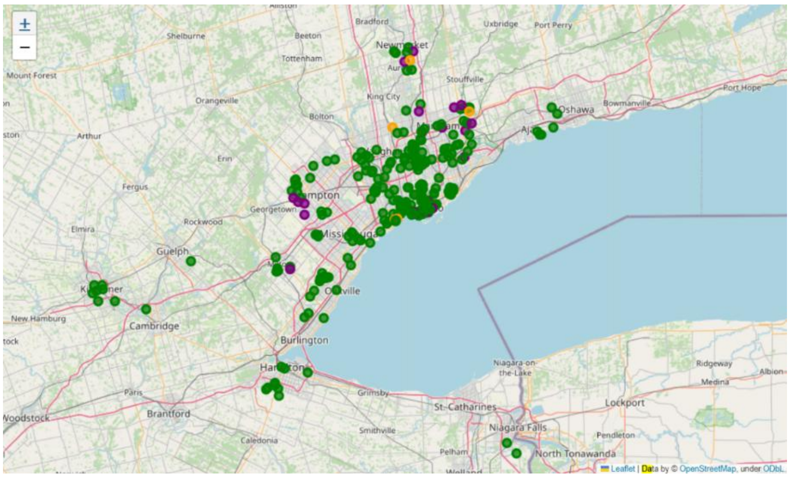

Fig 3. *Bakery distribution in Ontario. Note. Reprinted from "Search for the optimal bakery store location in Ontario with machine learning," by Knot Bakery, 2023,* https://medium.com/%40knotbakeryca/search-for-the-optimal-bakery-store-location-in-ontario-with-machine-learning-e07dddc2e2fc

Ontario's bakery sector growth reflects broader trends observed nationally and internationally. For instance, the province's bakery and tortilla manufacturing sector reported 1,248 businesses in 2020, marking a 5.3% increase over five years and generating $7.7 billion in manufactured goods revenue (Ontario Ministry of Agriculture, Food and Rural Affairs [OMAFRA], 2021). Across Canada, the bakery products market was valued at USD 10.7 million in 2024 and is projected to reach USD 15.1 million by 2033, fuelled by rising consumer demand and expanding export opportunities (IMARC Group, 2024).

Bakeries continue to rely extensively on steel trays for production, and keeping them clean is critical for food safety, process efficiency, and product consistency. Steel trays are commonly used because they are durable, withstand high temperatures, and distribute heat evenly, which contributes to uniform baking results. Despite their importance, the decarbonization of trays in many facilities is still performed manually. Workers must lift trays onto hoists, submerge them in chemical baths (decarbonization tanks), rinse, and allow them to air-dry. This method is labour-intensive, time-consuming, and produces inconsistent results while exposing staff to repetitive strain and chemical hazards (Calleri, Logroño, and Logroño, 2024).

Fig 4: Stainless steel baking tray used in bakery operations. Note. Reprinted from "Stainless steel baking tray used in bakery operations," by Webshopapp, n.d., https://cdn.webshopapp.com/shops/57149/files/33884074/600x600x2/baking-tray-in-stainless-steel.jpg

Research on automation in food production indicates that digital solutions can enhance operational efficiency and improve environmental outcomes over the product life cycle (Rahimi Fard et al., 2022). Additionally, mechanized tray cleaning systems can improve hygiene consistency, reduce labour costs, and increase workplace safety (Kyaw et al., 2022). Given the scale of Ontario's bakery industry, nearly 5,000 businesses, even the smallest efficiency improvements can have significant impact.

To address these challenges, this project proposes a fully automated tray cleaning and decarbonization system. The system would eliminate manual hoist handling, automate chemical management, and integrate mechanical tray transfer with rinsing and drying. The aim is to provide a scalable, cost-effective solution that aligns with the operational demands of Ontario's growing bakery sector.

3.0 Review of Literature

Cleaning and decarbonizing industrial trays have undergone significant transformation over the years. Historically, manual methods such as scrubbing and soaking trays in caustic or alkaline solutions were the most common practices. Although these approaches were widely adopted, they were labor-intensive, exposed employees to harmful chemicals, and frequently delivered inconsistent results. Research by Kathare et al. (2022) reported an average of 11 occupational disease cases per million workers annually linked to cleaning and disinfection agents, underscoring the health risks posed by manual cleaning practices.

Fig 5: Close-up of a person holding a green scouring pad, commonly used for scrubbing surfaces during cleaning. Note. Reprinted from "Cleaning pads," by BlakeDavidTaylor, n.d., https://www.istockphoto.com/photo/cleaning-pads-gm840957220-137048071.

With industrial modernization, semi-automated hoist systems emerged to ease the physical workload. However, these systems still demanded considerable manual involvement for loading, operating, and transferring trays between cleaning tanks, leaving many of the efficiency and safety issues unresolved (JEROS, n.d.). For instance, a mid-sized bakery in Ontario, such as Knot Bakery, handles more than 1,200 trays daily, all of which require cleaning before reuse (Knot Bakery, 2023). This volume highlights the significant labor commitment and suggests how automation could substantially improve efficiency in tray cleaning operations.

Fig 6: Automatic tray cleaning system requiring manual intervention. Note. Reprinted from "Automatic tray cleaning system from JEROS," by JEROS, n.d., https://jeros.com/products/automatic-tray-cleaning-system.

Chemical innovations, including the development of solutions such as Carbsolve, enhanced the removal of carbon deposits and shortened soaking times. Nonetheless, these products still required careful handling, appropriate disposal, and consistent manual oversight (JEROS, n.d.). Modern industrial tray cleaning equipment, such as that produced by JEROS, can now manage between 2,000 and 10,000 trays per day in larger bakeries, and some facilities even report processing up to 40,000 trays daily when operating at high capacity (JEROS, n.d.).

Fig 7: Carbosol. Note. Reprinted from "Carbosol," by Chemsoll, n.d., https://www.chemsoll.com/uploads/carbosol.min.jpg

Recent advancements have also applied automation to related cleaning processes. For example, automated dishwashers and conveyorized degreasing systems demonstrate the potential benefits of continuous flow operations and reduced labor demands. However, these technologies have not been fully adapted to the specialized challenges of heavy-duty steel tray decarbonization. Their limitations often include high installation costs, complex maintenance, and limited adaptability to different tray sizes or severe carbon buildup (Adapt Laser, 2020; cleanLASER, n.d.; Cryonomic, n.d.). Meanwhile, the global tray sealing machines sector was valued at USD 1.29 billion in 2024 and is expected to expand to USD 1.64 billion by 2030, growing at a compound annual growth rate (CAGR) of 4.2%. This trend demonstrates the industry’s increasing movement toward automated solutions (Grand View Research, 2024).

Fig 8: Automated cleaning system. Note. Reprinted from "Automated cleaning system," by Adapt Laser, 2024, https://adapt-laser.com/wp-content/uploads/2024/08/automated-lasers.jpg.

Despite these technological advances, there remains no widely implemented, fully automated solution designed specifically for industrial tray decarbonization. Addressing this gap requires developing a system that is cost-efficient, safe, and low maintenance, while integrating automation, chemical management, and process control into a single streamlined workflow.

4.0 Shortcomings in Existing Systems in the Bakery Industry

i) High dependence on manual labour

Existing tray decarbonization processes rely extensively on human operators to lift, position, and retrieve trays from hoists and tanks. This manual approach is physically demanding, time-consuming, and increases labour costs, especially in facilities with high production volumes.

ii) Variable Cleaning Effectiveness

The quality of cleaning often varies because it depends on human factors such as tray handling, soaking duration, and attention to detail. As a result, carbon deposits may not be consistently removed, potentially affecting hygiene and product quality.

iii) Worker Safety Concerns

Operators are exposed to hazards including hot surfaces, chemical solutions, and moving hoists. These conditions elevate the risk of accidents and occupational injuries.

iv) Inefficient Time and Resource Utilization

The workflow includes waiting periods during soaking or drying, and manual hoist operation introduces additional delays. This leads to lower throughput and suboptimal use of chemicals, water, and energy.

v) Challenges in Scaling Operations

Since the process depends on human labour, expanding production capacity requires more personnel, raising costs and complicating scheduling. High-volume operations are therefore difficult to scale efficiently.

vi) Absence of Real-Time Monitoring

Current systems lack sensors or automated feedback to monitor tray cleanliness or process parameters. Without real-time data, it is difficult to optimize the process or identify inefficiencies promptly.

5.0 Statement of Problem

In industrial and commercial environments, keeping steel trays clean is essential for operational efficiency, hygiene, and product quality. Currently, the process of decarbonizing and cleaning these trays is performed manually. Operators must lift each tray, place it onto a hoist, move it into a decarbonization tank for about 20 minutes, transfer it to a rinsing tank, and finally leave it to air-dry. Both tray handling and hoist operation require continuous human intervention, making the process labour-intensive and time-consuming.

This manual approach also introduces variability in cleaning results, as effectiveness depends on human handling, soaking duration, and attention to detail. Additionally, workers face potential hazards from hot surfaces, chemical solutions, and moving equipment. The heavy reliance on labour limits scalability, making it difficult to meet high production demands efficiently.

There is therefore a clear need to automate the decarbonization and cleaning process. Automation can improve efficiency, ensure consistent cleaning, enhance safety, and reduce labour costs, providing a scalable solution suitable for industrial environments.

6.0 Objectives of the Project

- To analyze the requirements and suggest the project plan.
- Research, identify and give clarity to the project.
- To design and implement an automated system for decarbonizing and cleaning steel trays.
- To create and build an electromechanical system for lifting, moving, and placing trays.
- To design and develop using the simulation software.
- Implementation and testing of software solution.
- To conduct testing and perform a detailed analysis of the results.
- To conduct cost-benefit analysis to confirm economic viability.

6.0.1 Key Constraints and Specifications:

- The system must accommodate standard tray dimensions used in the facility.
- Cleaning time per tray should not exceed the current manual process significantly.
- Chemical use should be optimized to minimize cost and environmental impact.
- The automated system must be reliable, maintainable, and scalable to meet future production needs.
- The project must be completed within the semester timeline and meet academic reporting standards, including a detailed technical report and final presentation.

7.0 Proposed Idea for Automating the System

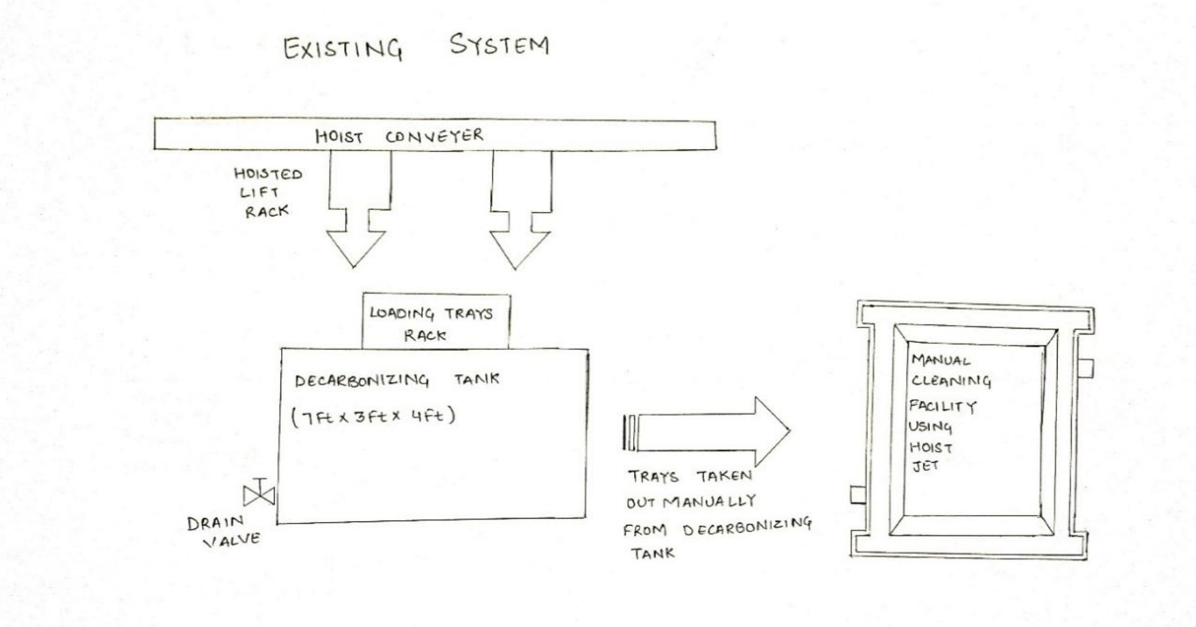

Fig 9: Existing bakery tray decarbonization and cleaning process. Created by author.

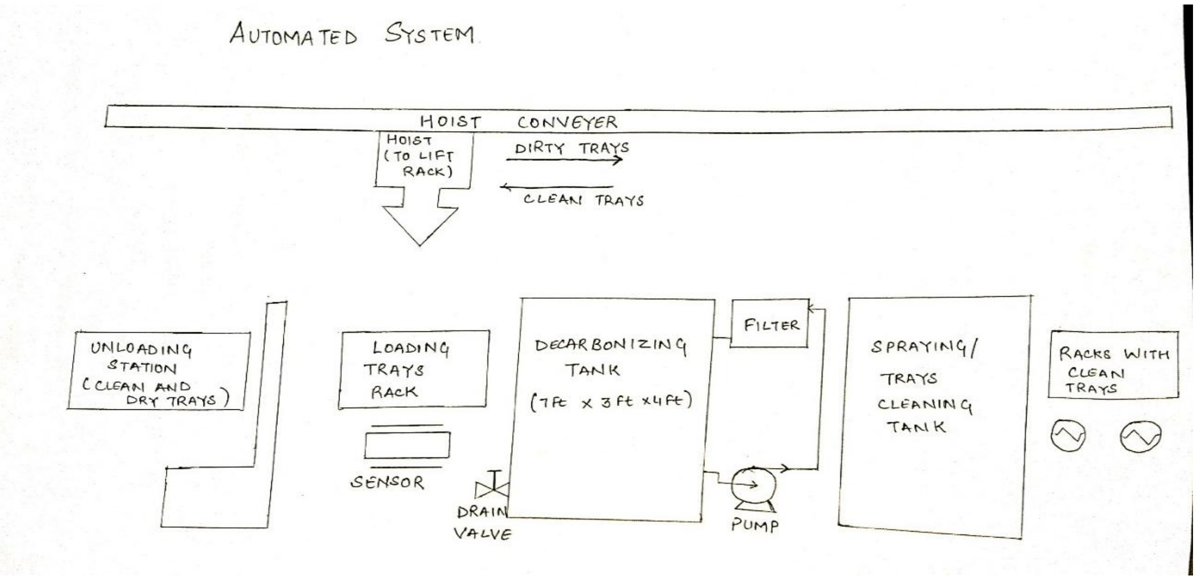

Fig 10 Automated bakery tray decarbonization and cleaning process. Created by author.

Fig 10 describes the working process of the tray cleaning and handling system. The system starts from the production floor, where trays are collected after use, and proceeds through various stages including loading, decarbonizing, spraying, and drying, before being transported back to the unloading area. The total system layout covers approximately 34 feet and each rack of trays requires about 28 minutes to complete the full cycle.

7.0.1 Step-by-Step Process Description:

Production Floor (Placing dirty trays on racks):

Trays come from the production floor after being used (e.g., in ovens). They are dirty and require cleaning before reuse. They are placed on the racks.

Rack Loading:

When the rack is full of multiple trays, the hoist picks it up and places into the cleaning system. This takes about 1 minute.

Decarbonizing Tank:

The rack with trays is submerged into the decarbonizing tank to remove carbon build-up, grease, and burnt food residues. This stage requires about 20 minutes.

Spraying Tank (Washing Stage):

After decarbonizing, the rack moves to the spraying tank. Here, pressurized water or cleaning solution is used to wash off loosened dirt. This process takes about 3 minutes.

Drying Stage:

The trays are transferred to the drying section equipped with fans/blowers to ensure they are completely dry. This process takes about 2 minutes.

Return Stage:

Rack with clean trays is returned to loading bay for reuse or storage. This takes about 2 minutes.

7.0.2 Distance and Layout:

The equipment layout covers the following approximate distances:

7 ft + 8 ft + 8 ft + 8 ft = 31 feet total length.

This represents the footprint of the line from production floor to drying stage.

7.0.3 Summary of Cycle Times:

- Loading rack: 1 minutes
- Decarbonizing soak: 20 minutes
- Spraying wash: 3 minutes
- Drying: 2 minutes
- Return: 2 minutes

Total cycle time (one rack): ~28 minutes (excluding transfer/waiting times).

8.0 Project Description

This project focuses on the automation of steel tray decarbonization, a process that is still carried out manually in many facilities. At present, operators are responsible for lifting trays and placing them onto a hoist, which lowers them into the decarbonization tank. After approximately twenty minutes, the trays are removed and moved to a rinsing tank, before being left in open space to dry. While effective, this method is repetitive, physically demanding, and exposes workers to potentially harmful chemicals. Moreover, the manual approach limits efficiency, consistency, and overall productivity.

To address these shortcomings, the project proposes the design and simulation of an automated handling system. Instead of requiring manual intervention at each stage, trays will be moved seamlessly through the decarbonization, rinsing, and drying phases by a fully automated setup. The system will also include an automatic chemical filtering mechanism, ensuring that the cleaning solution remains effective over time while reducing waste and operational costs.

The outcomes of the project will include a comprehensive simulation model of the automated process, complete with tray movement, treatment cycles, rinsing, and drying. In addition, system diagrams and process flowcharts will be developed to illustrate how automation can be applied in practice. The project will also generate performance data, such as cycle times and throughput rates, which will be compared against the current manual system to highlight improvements in efficiency, safety, and consistency.

By the end of the study, the project will deliver a detailed report and analysis, summarizing the system design, simulation results, and recommendations for industrial application. Although no physical prototype will be constructed, the simulation outcomes will provide valuable insights into how such automation can be scaled up and implemented in real-world operations.

Through this work, the project demonstrates how the adoption of automation can enhance operational performance, reduce labour dependency, improve workplace safety, and support more sustainable industrial practices.

8.0.1 Major Deliverables:

i) Simulation Model:

A comprehensive simulation of the automated tray handling, decarbonization, and rinsing workflow. Representation of tray movement, dwell times in tanks, automated chemical filtering, and process sequencing.

ii) Design Documentation:

Detailed block diagrams and flowcharts illustrating system architecture, control logic, and integration of mechanical and chemical operations. Documentation of assumptions, parameters, and constraints used in the simulation.

iii) Automation and Control Logic:

Development of control algorithms to manage tray movement, timing, and chemical filtering intervals. Simulation of process coordination, safety interlocks, and efficiency optimization.

iv) Performance Analysis Report:

Analysis of throughput, cycle times, resource use (chemical and energy), and system efficiency. Comparison of simulated automated process performance against the current manual workflow.

By delivering these outputs, the project will provide a fully modelled, functional representation of the automated cleaning system, allowing insights into potential operational improvements, labour reduction, and process optimization, while minimizing cost and risk.

9.0 Methodology of Execution

This project focuses on simulating the automation of the decarbonization and cleaning process for steel trays, emphasizing tray movement, chemical management, and overall process coordination. The simulation approach allows us to analyse system performance and optimize design parameters without constructing a physical prototype.

9.0.1 Software Tools:

Automation Studio/Factory Talk: Used to model the workflow, including tray handling, dwell times in the decarbonization tank, automatic chemical filtering, and rinsing.

Control Logic Simulation: PLC-style logic is implemented within the software to manage sequencing, timing, and interlocks between stages.

Data Analysis Tools: Excel is used to evaluate throughput, cycle times, and chemical usage to measure system efficiency.

9.0.2 Hardware Components (Modelled in Simulation):

Hoist or Conveyor System: Simulated to transport trays between stages, with adjustable speed, load capacity, and travel distance.

Decarbonization Tank: Modelled as a timed processing stage, representing chemical action on carbon deposits.

Chemical Filtering System: Includes pumps, filters, and valves in the model to simulate automatic filtering and solution refresh at set intervals.

Rinsing Tank: Modelled to remove residual chemicals, with dwell time configurable in the simulation.

Drying/Tray Unloading Station: Represents the final stage for trays to dry or be collected for reuse.

Sensors (Modelled Logically):

Limit switches or position sensors to detect tray arrival at each stage. Interlocks to prevent trays from advancing before the previous step is complete.

Actuators (Modelled as Software Components):

Motors for the hoist/conveyor. Valves for chemical solution flow and filtering.

10.0 Project Plan

10.0.1 Project Scheduling

The project plan stretches from mid-September through the end of December and is carefully mapped out with different stages that build on one another. It starts with the basics, setting up Automation Studio, before moving into more hands-on work like modelling tray handling, conveyor systems, and chemical filtration. Each of these technical steps includes regular progress checks, which act like checkpoints to make sure things don't veer off course. By late October and early November, the team's attention shifts toward developing logic systems, refining tray handling processes, and running tank simulations, eventually leading into software testing.

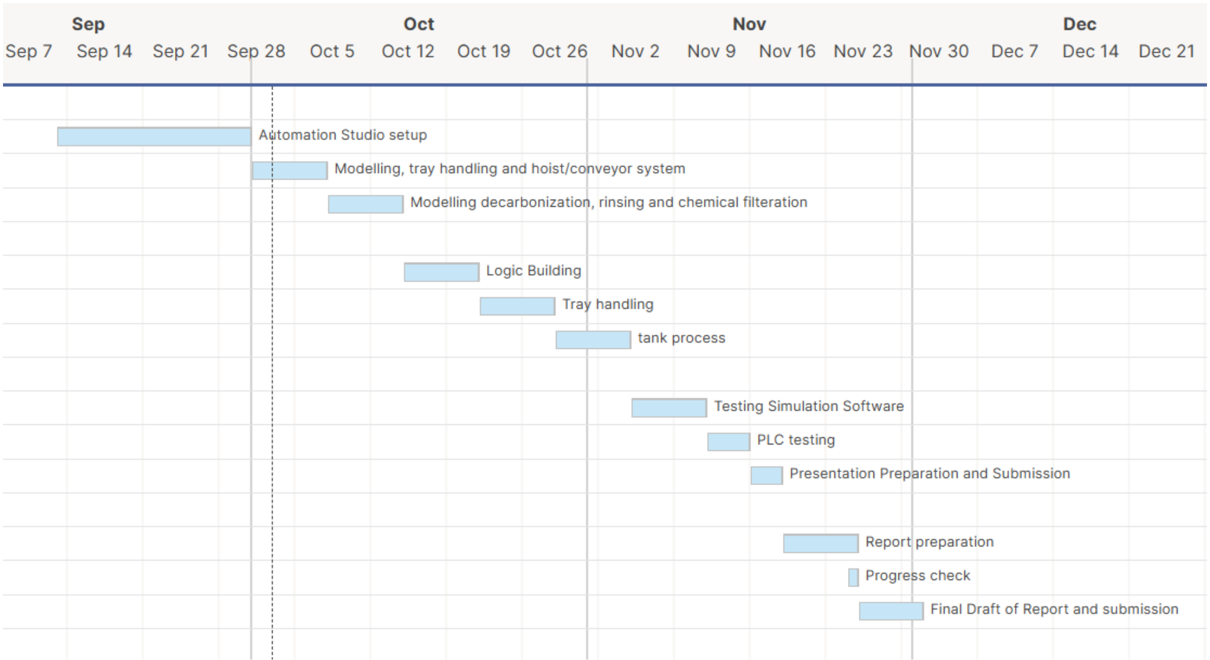

Fig 11 GANTT Chart of the project timeline. Created by author.

Task	Start Date	End Date
Simulation		
Automation Studio setup	09/13/25	09/30/25
Modelling, tray handling and hoist/conveyor system	10/01/25	10/07/25
Modelling decarbonization, rinsing and chemical filteration	10/08/25	10/14/25
Programming		
Logic Building	10/15/25	10/21/25
Tray handling	10/22/25	10/28/25
tank process	10/29/25	11/04/25
Testing and Presentation		
Testing Simulation Software	11/05/25	11/11/25
PLC testing	11/12/25	11/15/25
Presentation Preparation and Submission	11/16/25	11/18/25
Report		
Report preparation	11/19/25	11/25/25
Progress check	11/25/25	11/25/25
Final Draft of Report and submission	11/26/25	12/01/25

Fig 12 Tabular project timeline. Created by author.

The project starts with setting up Automation Studio between September 13 and 30. Once the foundation is in place, the team moves on to modelling tasks, beginning with tray handling and the hoist/conveyor system from October 1 to 7, and then focusing on decarbonization, rinsing, and chemical filtration from October 8 to 14. After the simulation phase, programming begins with logic building from October 15 to 21, followed by tray handling between October 22 and 28, and finishing with the tank process from October 29 to November 4. In November, attention shifts to testing and presentation, starting with simulation software testing from November 5 to 11, then PLC testing from November 12 to 15, and finally preparing and submitting the presentation from November 16 to 18. The last stage is report writing, which involves preparation from November 19 to 25, a progress check on November 25, and the completion and submission of the final draft between November 26 and December 1.

10.0.2 Estimated Budget

Real Time-Estimated Budget					
S.N.	Description	Qty	Unit	Rate	Amount(CAD)
1	Hardware Componenets:-Electrical	1	Set	12167.4	12167.41
2	Hardware Components:-Mechanical	1	Set	34000	34000
3	Installation & Labor	1	Set	10500	10500
4	Miscellaneous(10%)	1	Set	5666.74	5666.741
				Total	56667.41

The budgeting is split into two clear phases: the simulation side and the real-world setup. On the simulation end, costs are kept minimal, just **CAD 750** in total. This covers the essentials—like getting the right software, pulling together research materials, and preparing presentations and reports. Essentially, it's the groundwork stage where ideas are tested digitally before committing to anything physical, making it a low-risk, low-cost step in the process.

Budget Breakdown for Real Time Estimated Budget					
Hardware Componenets:-Electrical					
S.N.	Description	Qty	Unit	Rate	Amount(CAD)
1	Variable Frequency Drive	2	piece	839.29	1678.58
2	High Efficiency ECM Motor	1	piece	225	225
3	Electrical Hoist Motor	1	piece	3849	3849
4	Limit Switches	3	piece	25.73	77.19
5	Electrical Panel	1	piece	360.54	360.54
6	MCCB-32 A	1	piece	210	210
7	Contactor, Safety Relay, Wiring Relays, Communication Interfaces	1	Set	1000	1000
8	PLC	1	piece	1500	1500
9	HMI	1	piece	1267.1	1267.1
10	Dryer	2	piece	1000	2000
				Total	12167.41
Hardware Components:-Mechanical					
S.N.	Description	Qty	Unit	Rate	Amount(CAD)
1	Overhead beam + rails	1	Set	1500	1500
2	Custom horizontal trolleys (special racks)	3	Piece	750	2250
3	Recirculating pump + nozzles + filtration	1	Set	5000	5000
4	Filtration Pump(Decarbonization Tank)	1	Piece	1250	1250
4	Hot-air dryer (8 ft × 2.5 ft) Frame	1	Piece	1000	1000
5	Installation / civil / electrical / contingency	1	Set	20500	20500
6	Spraying Tank	1	Set	1500	1500
7	Transportation	1	Set	1000	1000
				Total	34000

Things look very different once the project moves into real-time implementation. Here the expenses jump significantly, adding up to about **CAD 56,667.41**. The biggest portion of this comes from mechanical components—beams, pumps, tanks, and installation—while the electrical side includes advanced tools like PLCs, HMIs, motors, and drives. On top of that, labour and installation costs are factored in, along with a contingency for miscellaneous expenses. What stands out is how the budget reflects a natural shift: from affordable digital planning to the heavy financial commitment of bringing a complex system to life in the real world.

Installation & Labor

S.N.	Description	Qty	Unit	Rate	Amount(CAD)
1	Certified Electrician	1	Unit	1500	1500
1	Certified Millwrights	1	Unit	5000	5000
1	Labor	1	Unit	1000	1000
4	Welder	1	Unit	1500	1500
5	Tools For Installation	1	Unit	1500	1500
				Total	10500

11.0 Expected Outcomes

By the completion of this project, the following results are anticipated:

i) Simulated Automated System:

A comprehensive software model that represents tray movement, decarbonization, rinsing, chemical filtering, and unloading.

Control logic integrated to manage the timing, sequence, and automated chemical solution management.

ii) Optimized Tray Workflow:

Determination of appropriate dwell times in the decarbonization and rinsing tanks.

Optimized tray movement schedule to increase throughput and reduce potential delays or bottlenecks.

iii) Chemical Solution Management:

Simulation of automatic filtering cycles to maintain solution effectiveness.

Insights on reducing chemical usage and minimizing waste while sustaining cleaning performance.

iv) Quantitative Performance Metrics:

Data on cycle times per tray, overall throughput, and potential labour savings.

Comparison of the automated simulation with the current manual process to evaluate efficiency, safety, and resource usage improvements.

v) Feasibility and Industrial Insights:

Evaluation of how the simulated automated system could be applied in real-world industrial settings.

Identification of potential operational challenges, safety considerations, and areas for further optimization.

vi) Comprehensive Documentation:

Detailed block diagrams, flowcharts, and step-by-step explanation of the simulated process. A final report summarizing findings, analysis, and recommendations for potential implementation. These outcomes will provide a clear understanding of the benefits of automation for tray decarbonization, highlighting improvements in efficiency, consistency, safety, and cost-effectiveness, while also offering actionable insights for potential industrial application.

12.0 Conclusion

This project addresses the limitations of the current manual steel tray decarbonization process, including high labour requirements, inconsistent cleaning results, safety risks, and limited scalability. The objective is to simulate a fully automated system that integrates tray handling, decarbonization, rinsing, and chemical management with automated process control.

The project plan outlines a structured approach over 11 weeks, including simulation setup, modelling of mechanical and chemical processes, control logic implementation, testing, optimization, and performance analysis. By delivering a detailed simulation model, performance metrics, and documentation, the project will provide a comprehensive understanding of how automation can improve efficiency, safety, and reliability in industrial tray cleaning operations.

Ultimately, the expected outcomes will offer a clear roadmap for transitioning from a manual process to a scalable automated solution, while minimizing risks and resource use.

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