Improving ABS (Acrylonitrile Butadiene Styrene) Paint Shop & it's Cost Analysis for Atlas Autos

INTRODUCTION

CE 3.1

I am an industrial engineering graduate from University of Engineering and Technology, [redacted] Throughout my career I worked on multiple projects and have valuable acquired experience from them. In my final year of bachelors in industrial engineering, I worked on a project with the title "[redacted]& it's Cost Analysis for [redacted]" as part of my Final Year Project. This project was finalized in the year [redacted] Duration of the project was [redacted]

BACKGROUND

CE 3.2.1

[redacted], a leading automotive manufacturing company based in [redacted]is a subsidiary of[redacted](Private) Limited and has been operating since its incorporation on [redacted] is primarily engaged in the manufacturing, processing, and trading of automotive parts, components, accessories, and tools, including trading alternatives. With its registered office situated at Federation House on[redacted], the company operates under the regulatory oversight of the Securities and Exchange Commission of Pakistan (SECP). [redacted] is a key investment company of the [redacted] Group, responsible for making strategic investments in new ventures.

CE 3.2.2

The paint shop at [redacted], a prominent manufacturer, faced numerous challenges. The painting technique suffered from inconsistencies, resulting in uneven coatings and color variations across batches of products. Moreover, the limited storage area caused congestion, impeding workflow and increasing the risk of product damage. Handling issues further compounded the problem, leading to scratches due to inadequate techniques. To address these shortcomings, I undertook a project to improve the paint shop. By implementing electrostatic painting techniques, optimizing the storage area by changing the layout of the storage area and implementing FIFO system, redesigning the trolley for better material handling. The project aimed to enhance the efficiency, quality, and safety of the painting process. These improvements were crucial for [redacted] Company to ensure consistent product finishes, streamline operations, and maintain a competitive edge in the market.

CE 3.2.3

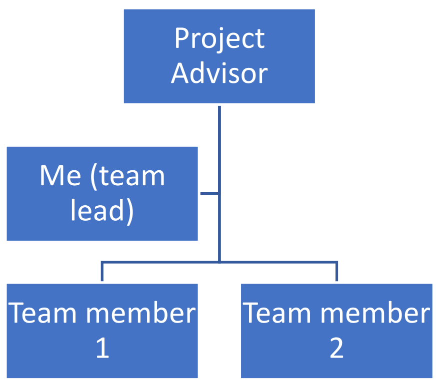
I devised the following methodology for the completion of this project:

- Literature review
- Research and Analysis
- Electrostatic Painting Technique Implementation

- Redesign Process of Trolley for Material Handling.
- Understanding of the existing storage area layout.
- Optimization of layout for the storage area
- Implementation of FIFO System.
- Evaluation and Analysis of entire system.

CE 3.2.4

I followed the engineering constraints and obligations throughout the project and handled the essential documentation, which I presented to our project supervisor on a weekly basis. Initially, I developed a project plan that included all of the criteria and requirements needed to meet the project's objectives. I created routine weekly reports to keep my supervisor up to date on the development of my team and the project. These reports allowed constant input and modifications to keep the project on track. Finally, I created a detailed final project report that addressed all parts of the project, such as design considerations, data collecting, and equipment decisions. As team leader, I assumed responsibility for the project and my team.



Project Hierarchy

PERSONAL ENGINEERING ACTIVITY

CE 3.3.1

I first conducted a thorough literature review in which I studied the Analytical Hierarchy Process (AHP). Thomas Satty developed this method in the [redacted] On of the advantages I studied was that AHP provides the client with an outline of criteria. I studied that AHP offers several advantages, including illustrating how changes in priority at higher levels affect criteria at lower levels, providing an overview of criteria and their functions, and accommodating changes and additions to the hierarchy. It also enables ranking of criteria based on client needs, leading to more precise supplier selection. However, I noticed that AHP also has its drawbacks, such as its implementation inconvenience, potential complications from different opinions on criterion weights, subjective decision-making based on expertise and judgment, and a lack of consideration for risks and uncertainties. Nevertheless, AHP's strength lies in its ability to structure complex problems hierarchically, its user-friendly nature, and the quantification of consistency. Qualitative criteria in supplier selection have gained attention, leading to the utilization of methodologies like AHP and Fuzzy in decision-making models.

CE 3.3.2

I also conducted literature review for various material handling and storage systems. The term material refers to all kinds of raw materials, subassemblies, work in progress and finished assemblies. a primary objective of a handling system is that material is safely delivered and the final destination without any kind of damage safely. While conducting the literature review, I went through various types of material handling equipment. The equipment includes Trolleys which are useful in our in daily life, we often encounter situations where we need to carry numerous objects up and down stairs. This can be exhausting and time-consuming, especially when elevators are unavailable or crowded. Common scenarios include transporting items in schools, offices, hotels, and residences. I studied further equipment such as Industrial Racks, Conveyers, Monorails, Hoists, Cranes, Automatic Storage and Retrieval Systems.

CE 3.3.3

I conducted a thorough literature review to study the FIFO (first in first out) System. FIFO and inventory accounting are methods used to manage inventory and financial aspects related to a company's cash flow. FIFO refers to the practice of recording and selling the oldest inventory items first. This process ensures that the cost associated with the earliest purchased inventory is expensed first. FIFO allows for more efficient use of workspace by eliminating gangways and can save up to 40% of space. I studied that the FIFO System has its advantages. One significant advantage of using the FIFO method in warehouses is that it addresses issues related to fluctuating inventory prices. FIFO ensures that inventory value closely aligns with the current market price. This method also recognizes the conventional physical flow of goods, where the subtracted inventory costs reflect the oldest unit prices. Additional benefits of FIFO include its straightforward application and the acknowledgment that companies cannot manipulate income by selectively choosing which units to ship.

CE 3.3.4

In this project, my main objective was to improve painting technqieus of [redacted] Parts, the layout of the storage system and to improve the design of the exiting trolleys by minimizing rejects. Next, I had to maximize the production rate and minimize cycle time. The deliverables of my project were [redacted], current production rate and the FIFO System. Furthermore, I used AHP to analyze effective painting techniques.

CE 3.3.5

The next step in my Final Year Project was to determine how the entire process takes place. In the [redacted] shop, plastic parts arrive in trolleys from inventory. The parts are loaded onto hangers on a conveyor belt after removing protective sheets. They are wiped, cleaned with air, and continuously painted as the belt moves. Heating systems are used for baking. Inspected parts are polished and stripes are added for different models. Finished parts are loaded onto trolleys and stored. The entire process is illustrated as follows

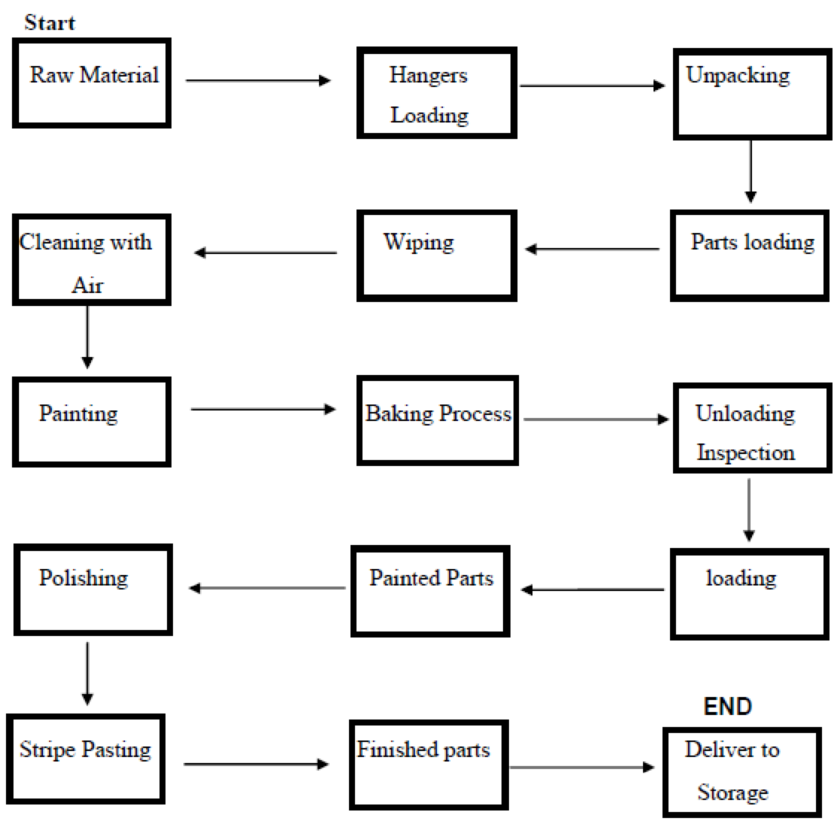


Figure 1: Process Flow Chart

CE 3.3.6

The next step involved my team to find the root causes and their effects. After analysis, we were concerned with the 6 M's of the [redacted] paint shop which are Machine, Manpower, Mother nature, Measurement, Material, Method. All of these were analyzed by my team to come up with root causes and how they were affected.

Machine	Spray gun	Spray gun should be maintained properly
Machine	Air tank	Air tank should be cleaned cause rejection.
Material	Side cover, Cowl, fender, wiser, Shroud	Raw material of all parts is plastics which is not charge holder
Measurement	Inspection	Inspection mostly lead rejection when unloading from trolleys.
Environment	Temperature	Paint booth has a range from 25° to 30° it should not exceed nor decrease from given limit
Environment	Humidity	Paint booth has a range from 60 to 90 it should not exceed nor decrease from given limit
Man power	Shifts	In night shift the performance is less as compared to day shift
Man power	Employee experience	In experience employees due to inexperience in performing different operation produce more scrape
Man power	Training	Untrained and unskilled employees are less efficient

Figure 2: Process Elements consisting of Potential Causes

CE 3.3.7

Data Collection

For my Final Year Project, [redacted] was kind enough to provide me with data for the [redacted] paint shop. The data included various information such as daily production, cycle time, number of trolleys, dimensions, area for trolley storage etc. My first analysis was of the cycle time per hanger

Name of parts	Number of parts per Hanger	Cycle time for each part
Side cover	4	15sec
Cowl	4	15sec
Fender	2	30sec
Wiser	2	30sec

Figure 3: Cycle Time for Gravity System

as per the gravity system. I observed that six parts per hanger were moving on a conveyer belt and the time between two hangers was 1 minute.

The next analysis I did was of the daily production rate. The shop has production capacity of 2432 units per day of black and red colors and different parts. The type of parts includes Side Covers, Fenders, Visors, Side Cowls, Shrouds of various models.

CG 125 Side cover (black) (NIPPON)	
Description	**Consumption PER Piece (L)**
Paint (BLK)	0.045
Thinner	0.022
Hardener	0.022
JP-4	0.003
TOTAL (mix)	0.092
CG 125 Side cover (Red) (NIPPON)	
Description	**Consumption PER Piece (L)**
PU silver	0.013
Paint (RED)	0.035
Thinner	0.021
Hardener	0.022
JP-4	0.003
TOTAL (mix)	0.094

Figure 4: Consumption Rate of Gravity System

In the storage unit, A trolley system is implemented for efficient movement of finished parts from one area to another. These trolleys play a crucial role in streamlining the internal logistics and ensuring smooth operations throughout the shop.

DESCRIPTION	NO OF TROLLEYS	NO OF PARTS/TROLLEY
Side covers	100	CG 125 (120), others (80)
Cowl	20-25	120
Visor	40	40
Fender (CB 150)	6	35
Fender (others)	24	40
Shroud	Using cowl trolleys	90

Figure 5: Number of Trolleys

I observed that the trolleys used in the storage unit had the dimensions as followed:

Description	Length (ft.)	Width (ft.)	Height (ft.)	No of layers	Space of box (inch)	Part height (inch)
Side covers	6.2	3.4	4.11	8	8	4
Cowl	5.11	3.11	5.2	5	12	5
Visor	6.8	2.1	5.3	4	17	12
Fender	6.8	2.85	5.3	5	12	8

Figure 6: Trolley Dimensions

Figure 7: Existing Trolley Design

I noticed that the storage area had no proper schedule. The storage was very oold and the same door was used for incoming as well as outgoing trolleys which makes it very inefficient. I observed that the storage area had ample space to accommodate various parts and trolleys. The storage area had the dimensions as followed.

LENGTH	139 ft.
WIDTH	25 ft.
NO OF TROLLEYS	155

Figure 8: Storage Area Dimensions

CE 3.3.8

Analysis Phase

In the analysis phase of my Final Year Project, the main objective in the analysis phase was the selection of a new and improved painting technique for the ABS parts. AHP Analysis was utilized as a means for selection of the new method. The main criteria I was concerned was the cycle time, quality, and the consumption rate. The options I had to consider were gravity methods and electrostatic methods.

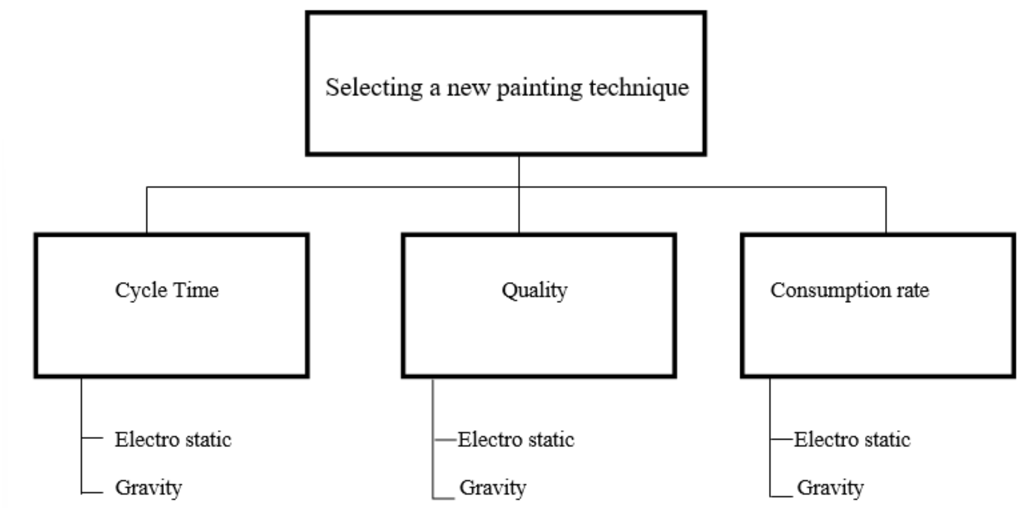


Figure 9: Hierarchy Tree

I used my judgements to determine the rank of criteria. Quality of the parts was 2 times as important as consumption rate. Cycle time was 3 times as important as consumption rate. Quality was 4 times as important as cycle time. I then used AHP Analysis to determine the comparison for qualitative alternatives which were either Electrostatic Methods or Gravity Methods.

1st Iteration					
	Electrostatic	Gravity		Sum	Normalized
Electrostatic	2	4		6	0.6667
Gravity	1	2		3	0.3333
			Total	9	1

Figure 10: Ranks for Qualitative Alternative by squaring

	Electrostatic	Gravity		Sum	Normalized
Electrostatic	8	16		24	0.6667
Gravity	4	8		12	0.3333
			Sum	36	1

Figure 11: by squaring 1st Iteration

I then utilized AHP Analysis again for quantitative alternatives to determine cycle time.

Quantitative for cycle time		
	Cycle time/hanger(sec)	Normalized
Electrostatic	30	0.3333
Gravity	60	0.6667
sum	90	1

Figure 12: Ranks for Quantitative Alternative (Cycle Time)

	Consumption rate/pc	Normalized
Electrostatic	0.0666	0.4194
Gravity	0.0922	0.5806
Sum	0.1588	1

Figure 13: Ranks for Quantitative Alternative (Consumption Rate)

					Criteria score	
	Cycle time	Quality	Consumption rate		0.3196	Cycle time
Electrostatic	0.3330	0.6660	0.4193	*	0.5584	Quality
Gravity	0.6660	0.3330	0.5806		0.1220	Consumption rate

Figure 14: Multiplying Criteria Score with Alternatives

After careful anaylsis, I concluded that the electrostatic system is preferred over the gravity system due to its higher weightage of 52% compared to the gravity system. This indicates that the electrostatic system is considered to be more advantageous and favorable in the given context. In this technique the paint is given a charge and the parts if metallic are given an opposite charge to increase the transfer efficiency. In case of plastic parts, a metallic primer is painted on the plastic parts to create conductivity. This technique has the transfer efficiency of 70%.

CE 3.3.9

Improvement Phase

I concluded that the electrostatic system outperforms the gravity system in several key aspects. The electrostatic system was exhibiting a lower consumption rate, resulting in cost savings and environmental benefits. Additionally, it showcased a shorter cycle time, indicating improved efficiency and higher productivity. Furthermore, the implementation of the electrostatic system led to a significant reduction in production time, enabling faster turnaround and enhanced customer satisfaction. I have given the improved consumption rate as follows

ELECTROSTATIC SYSTEM (BY INCREASING EFFICIENCY FROM 30 TO 70)	
CG 125 Side cover (black) (NIPPON)	
Description	Consumption PER Piece (L)
Paint (BLK)	0.027
Thinner	0.0132
Hardener	0.0132
CONDUCTIVE PRIMER	0.0132
TOTAL (mix)	0.0666
CG 125 Side cover (Red) (NIPPON)	
Description	Consumption PER Piece (L)
Paint (RED)	0.021
Thinner	0.0126
Hardener	0.0132
CONDUCTIVE PRIMER	0.0132
TOTAL (mix)	0.0600

Figure 15: Improved Consumption Rate

I had given the difference of consumption rate between gravity and electrostatic systems.

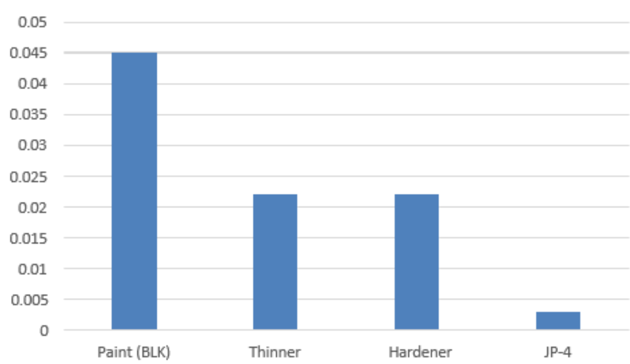


Figure 16: Gravity Consumption per Piece (black/L)

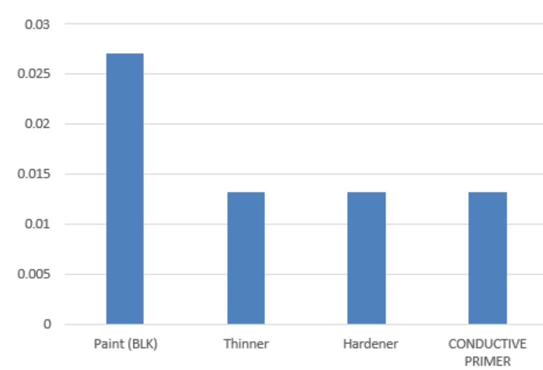


Figure 17: Electrostatic Consumption per Piece (black/L)

CE 3.3.10

I then concerned myself with the storage system. The existing system had no proper schedule and the same door was used for incoming and outgoing trolleys. I devised a new design for the trolleys which greatly enhanced [redacted] capacity to store parts. I made a new design which increased the height of the trolley by 2 inches and it also increased the capacity of each trolley by over 30 pieces. I also implemented bearings in each layer which enabled the trolley to be easily dragged out. I also increased the number of steps. Overall, I was able to increase the capacity of the trolley from 120 to 150 pieces. The new and improved design was made on a CAD Software.

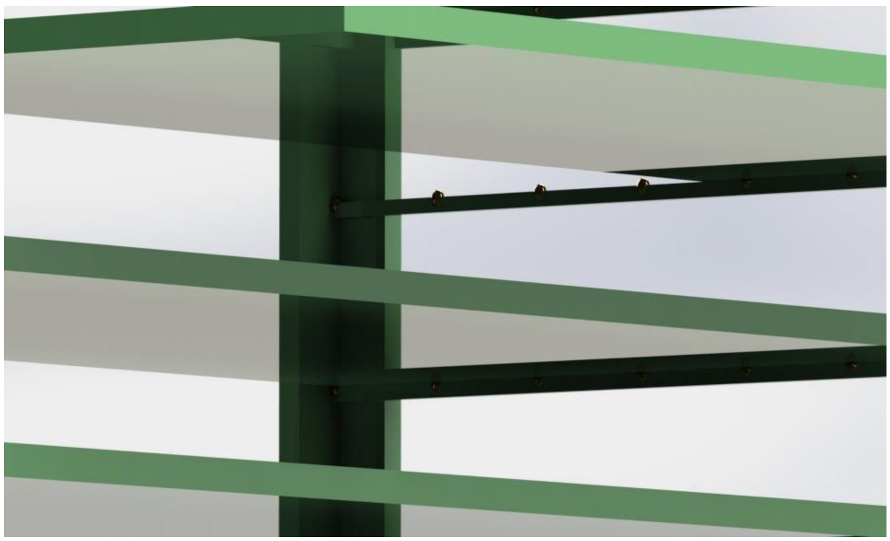


Figure 18: Improved Trolley Design

Figure 19: Improved Trolley Design

CE 3.3.11

As part of my implementation, I introduced the FIFO (First-In, First-Out) system to align with the demand of the assembly line. This system ensured that the earliest received items were utilized first, maintaining a streamlined and efficient workflow. A total of seven tracks were dedicated to this purpose, with each track accommodating 20 trolleys. This arrangement allowed for proper organization and segregation of inventory based on arrival sequence. Moreover, adhering to the principle of FIFO, the storage duration for each set of trolleys was limited to a maximum of one day. This approach facilitated timely utilization of materials, reducing the risk of obsolescence and ensuring optimal inventory management throughout the assembly line process.

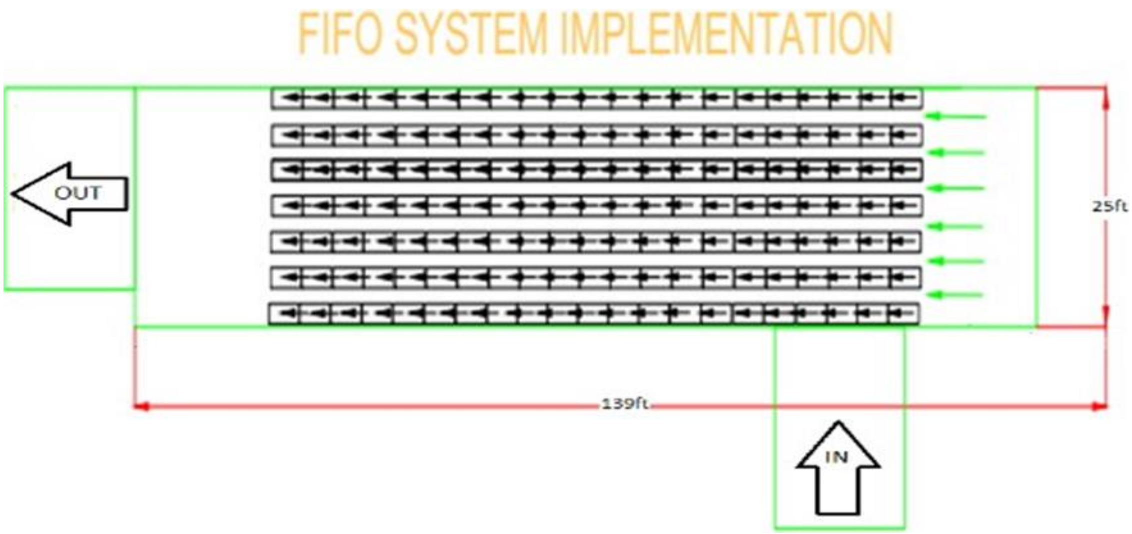


Figure 120: FIFO System

CE 3.3.12

Cost Analysis

I conducted a comprehensive cost analysis to compare the gravity system with the electrostatic system specifically for the side cover of CG125 motorcycles, considering both black and red colors. The findings of the analysis revealed significant cost savings associated with the implementation of the electrostatic method. In the case of the black color variant, the electrostatic system resulted in savings of over 4,114,944 rupees. These savings were primarily attributed to the optimized consumption of paint and energy, reducing material waste and minimizing operational costs. Additionally, the improved efficiency of the electrostatic system, with its precise paint application and reduced touch-up requirements, contributed to further cost reduction. Similarly, for the red color variant, the electrostatic system demonstrated even higher cost savings of 5,081,472 rupees. The factors driving these savings were consistent with the black color variant, emphasizing the effectiveness and economic advantages of the electrostatic method in both scenarios. By analyzing and comparing the cost implications of the two systems, it was conclusively determined that the electrostatic system offers substantial cost benefits for the production of CG125 side covers in both black and red colors. These cost savings not only enhance the financial performance of the manufacturing process but also contribute to the overall profitability and competitiveness of the company.

COST SAVING BY APPLYING ELECTROSTATIC STYSTEM CG 125 (Side Cover)					
	Per production	Per piece saving	Per day saving	Monthly saving	Yearly Saving
Black	1216	11.75	14,288	3,42,912	41,14,944
Red	1216	14.51	17,644	4,23,459	50,81,472

Figure 21: Cost Saving by Electrostatic System

SUMMARY

CE 3.4.1

In this Career Episode, I designed and fabricated a cyclone separator for an industrial plant to collect wheat husk particles. I conducted a feasibility study to identify the problem and design requirements and decided to use a cyclone separator due to its low-maintenance, portable, and self-sustaining nature. I designed the cyclone separator by calculating the cut point diameter and selecting the appropriate material for fabrication. The fabrication process involved CNC metal laser cutting, press bending, manual rolling, and Tungsten inert gas welding. Real-time testing proved the cyclone separator's efficiency and reliability in collecting husk in an industrial plant.

CE 3.4.2

In my career episode at [redacted], I embarked on a challenging project aimed at enhancing the performance of their paint shop. The primary focus was to compare the efficiency of the gravity and electrostatic methods for painting ABS parts. Employing the Analytic Hierarchy Process (AHP) analysis, I meticulously evaluated various critical factors including cost-effectiveness, quality, and productivity. The comprehensive analysis yielded a clear conclusion: the electrostatic method outperformed the gravity system in all aspects.

To complement this finding, I devised a new design for the trolleys used in material handling, ensuring improved ergonomics and ease of movement. Additionally, recognizing the importance of organized inventory management, I implemented a First-In, First-Out (FIFO) system in the storage unit. This system optimized material flow, minimized waste, and facilitated better tracking and retrieval of parts.

The impact of these improvements was remarkable. The electrostatic method demonstrated superior paint application quality, reduced material consumption, and enhanced overall productivity. The revamped trolleys and FIFO system significantly streamlined the material handling process, saving time and effort. The paint shop's efficiency skyrocketed, resulting in cost savings, improved customer satisfaction, and increased competitiveness for [redacted]