Performance Evaluation and Improvement in the Automotive Sector

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Abstract— ***The automotive sector in Tunisia occupies a strategic position within the national economy, both through its contribution to the manufacturing industry and its growing integration into international value chains. In recent years, Tunisia has established itself as a competitive platform for the production of automotive components. However, in a context marked by increasing global competition, performance improvement has become essential to strengthening the sector's competitiveness.***

In this context, studying industrial performance in Tunisia is of major importance to understand the challenges faced by companies, identify priority improvement areas, and propose suitable strategies to ensure the sustainability and growth of the automotive sector both nationally and internationally. Our example is illustrated with a real case study in the Tunisian company.

Index Terms—**Reduce waiting time, Optimize production time, Robot implement, Digital waste**

I. Introduction (Heading 1)

Manufacturing is a constantly evolving field, where companies continually seek to improve their performance to remain competitive in the competitive market[1]. For this reason, a lot of efforts on the part of companies today are dedicated to putting their industrial performance and their position in the markets back into position [2].

Indeed, to become a leader in the field, it is important to focus on improving it is all that harms productivity and quality mainly therefore the loss of performance [3].

The global Akwel Group is a leader in the field of fuel pipeline manufacturing, and it is implemented in several countries, which explains the increase in demand for its products for the automotive industry worldwide [4].

From this perspective, this work focuses on improving performance within the company AKWEL, a Tunisian subsidiary located in Mateur. The main objective is to identify the challenges it faces more precisely within the logistics department in order to propose solutions to problems to overcome them, since the latter represents the heart of the company.

To achieve this objective, we focused mainly on two key aspects which are: improving the feed time of Autonomous Production Units APU in order to optimize production time on the one hand and the digitalization of waste in order to eliminate papers on the other hand.

The outline of the paper including the presentation of the company and analysis of its performance is provided in section 2. In section 3 we present an improvement project in the real example in the Akwel company in Tunisia. Finally, concluding remarks and directions for future research are suggested in Section.

II. Presentation of the company and analysis of its performance

AKWEL is a private, fully exporting company. Since its founding, it has always tried to strengthen impeccable product performance which involves customer satisfaction as well as the security and continuous improvement of its production, after having enriched and expanded its customer portfolio. It uses sound financial management supplemented by transparent financial information which is characterized by its long-term vision.

The Akwel group has become specialized in three areas of expertise: Fluid Management, Mechanisms, and structural parts of electric vehicles. This has provided customers around the world with ever more competitive solutions to make their vehicles more reliable, more environmentally friendly, and more pleasant to drive.

The main manufacturers that AKWEL works with are: Peugeot-Citroën, Ford, Renault, Dacia, General Motors, Fiat-chrysler, Volvo, Nissan, Toyota. The main objective of the company is to achieve zero defects, because the site is characterized by its centralization on quality and the research for zero defects with expertise in innovation, development, technologies and logistics which serves to present itself in the world with a valuable brand.

This part aims to analyze in detail the current situation of the company, and the existing performance. This in-depth analysis will allow us to identify the strengths and weaknesses, as well as the opportunities for improvement available to it. In this part we will present the context of the study of the existing situation, the objectives pursued and the main methods used to carry out this analysis.

The AKWEL company has four APU (Autonomous Production Units). Each APU specializes in manufacturing the types of products that govern the company's revenue growth.

APU 1 and APU 2: Mechatronics. These are the washing products sold for the Citroën house and electrical parts sold for the VOLVO and Renault houses.

APU 3: Fuel pipelines. The fuel pipeline which is the product of the two automobile manufacturing industries Renault, PSA Peugeot Citroën and Nissan, ...

In our work we will focus on powering these three autonomous production units: APU 1, APU 2 and APU 3.

And since AKWEL aims to transform itself towards smart industry, and in the context of UAP power supply it intends to implement an AGV (Automated Guided Vehicle) to replace handlers and reduce APU power time. Knowing that the AGV's mission is to manage the supply of trolleys from the logistics area to the delivery points, but its cost is very high given the limited financial means of the company and for this we will try to find a more optimized solution and very close to the principle of AGV solution

2.1. Performance Study: APU 3 production line

In this part we will focus on a production line rated PU326 of fuel pipelines, part of the autonomous production unit APU3, this PU326 line receives raw materials from the import store. Handlers supply the line with raw materials through the input supply, which are then processed and processed throughout the production process

Once the raw materials are on the line, they are processed and assembled to make the finished products. The different stages of production, such as machining, assembly, are carried out to obtain the finished products that comply with the required standards and specifications.

After this production step, the finished products are sent to the quality wall. The quality wall represents a critical point in the production process where finished products are carefully inspected and evaluated. Quality testing and controls are carried out to ensure that products meet required standards and specifications. Any anomalies or defects are detected and processed at this stage to guarantee the conformity and quality of the products.

Once the finished products have successfully passed quality control, they are ready to be transported to the export area. This area is responsible for preparing finished products for shipping, carrying out tasks such as packaging, labeling and any other necessary preparation.

In summary, the APU3 production line transforms raw materials into finished products through different stages of production. The finished products are then submitted to quality control on the quality wall before being transported to the export area for preparation for shipment.

a) Pareto Study

The Pareto diagram visually allows you to choose the problem to be treated by working on encrypted data. It is based on the 80/20 law, 80% of problems in a company are caused by 20% of causes, in order to choose the priority problem that must be addressed [5].

And for this reason, we choose to use this method on the PU326 production line in order to be able to detect the causes of huge stoppages observed and to subsequently be able to treat them.

In order to classify the references to be produced from week 15 to week 25 (during the year 2025), we conducted a Pareto study. We have thus carried out the necessary steps of this analysis.

First, we classified the references in descending order of the quantity to be produced. Then, we calculated the coefficients which subsequently allowed us to draw the Pareto diagram [6] . The calculation results are presented in the following table.

Table 1: References of PU326 line

Reference	Quantity produced	Percentage	Cumulative Percentage
P1021530A01	19200	46.35%	46.35%
P1021529A01	18400	44.42%	90.77%
P1022396A00	1720	4.15%	94.92%
P1022397A00	1300	3.13%	98.05%
P1021529A00	800	1.95%	100%
Total	41420	100%	

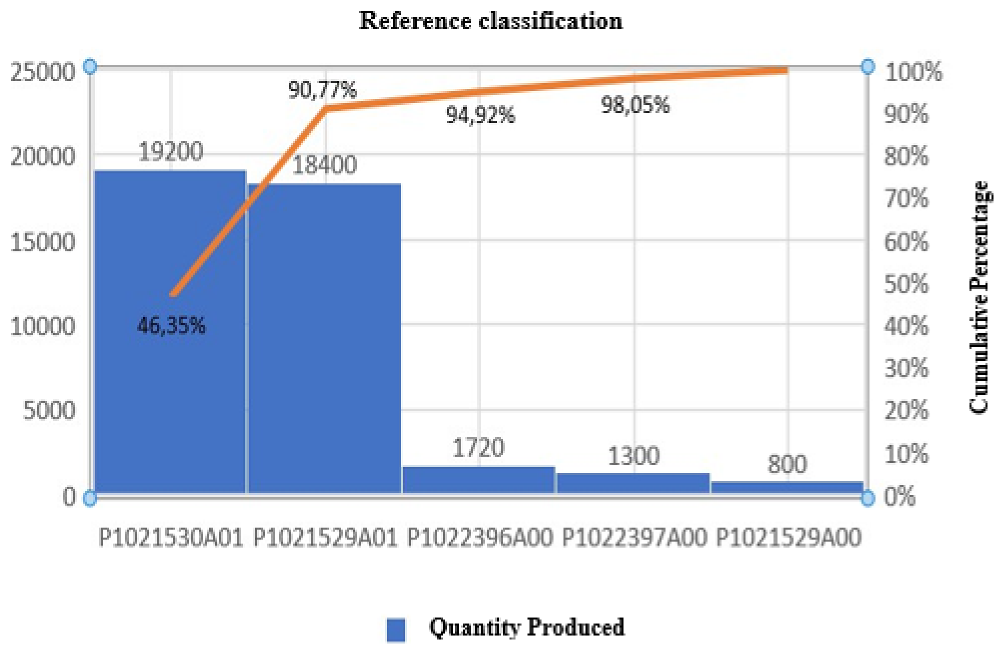

Figure 1: Pareto analysis for reference classification of PU326 line

The Pareto graph shows that the highest quantities (19200 and 18400) represent the references (respectively **P1021530A01, P1021529A01)** which considered that the largest part of the total sum of the quantity produced by PU326 line. These two categories combined represent nearly 91% of the total quantity produced.

Applying the principle of the 80/20 rule, we can conclude that these two references represent the majority of production time on the PU326 line.

The three remaining references (**P1022396A00**, **P1022397A00** and **P1021529A00**) have significantly lower quantities and represent relatively smaller share of the total sum.

b) *5W1H Methods : Formulation problems*

5W1H (What, Who, Where, When, why, How) is a tool very powerful at the level of formulating a problem and identifying all its dimensions through harvesting information relevant and exhaustive [7]. The principle consists has pose of the precise questions and systematically in order to scan all information related to the problem [8]. The table below presents the questions and their answers.

Table 2: 5W1H Analysis

What?	▪ Which problems ?	▪ Availability of line
Who?	▪ Which service ?	▪ Manufacturing service
where?	▪ Which areas are concerned ?	▪ PU326 line
When?	▪ When the problem is observed?	▪ Every 64h since the 04/10/2024
Why?	▪ Why we are interested tin this problem?	▪ Increase the performance line
How?	▪ How can we observed the problem? ▪ How to measure it ?	▪ By downtime analysis ▪ Timing ▪ Using a data base

Our objective is to try to minimize the downtime observed

c) *Production Analysis*

To analyze the production of the line we use the production history of the PU326 line, recording production hours and downtime, the yield of the line in percentage. The data is grouped in the following table:

Table 3: Production Analysis

Date	Team	Hours	Production	Yield	Stop in Hours	piece/stop
04/10/2024	Afternoon	3.5	200	82%	0.58	40.6
	Night	6.5	245	65%	2.58	180.6
04/11/2024	Morning	6	353	84%	0.66	46.2
	Afternoon	6	382	91%	0	0
	Night	8	205	53%	3	210
04/12/2024	Morning	2.5	120	69%	1.5	105
	Afternoon	6	387	92%	0.25	17.5
	Night	8	460	82%	0.83	58.1
SUM	**-**	**46.5**	**2352**		**9.4**	**658**

For visualize more better the performance of the UP326 line we will present this data in the form of a histogram, while showing the evolution of production and downtime throughout the UP326 line.

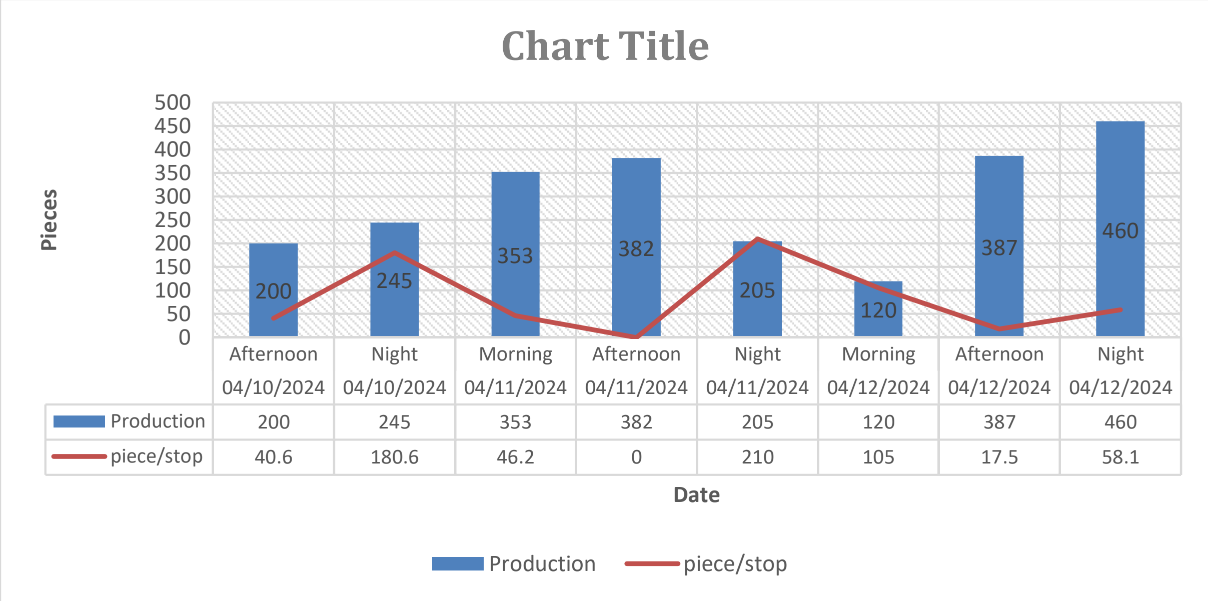

Figure 2: Performance PU326 line

It can be noted that the performance of the PU326 line is irregular

2.2 Waste Management

In AKWEL company, we were able to observe a major problem linked to waste management: the non-digitalization of waste. The company continued to use manual (paper-based) management methods, which had some limitations and disadvantages.

The non-digitalization of waste posed several challenges. First, it was difficult to accurately track and analyze waste data, such as quantity and causes. This situation made it complex to identify recurring problems and make informed decisions to remedy them effectively.

Additionally, manual waste management resulted in a loss of efficiency. Manual processes were slower, prone to human error, and less effective in communicating and making rapid decisions. This had an impact on the overall productivity of the company.

Another disadvantage of non-digital waste management was the additional costs associated with storing physical waste. With the absence of a digitalized system, it was difficult to organize and track waste optimally, leading to logistical problems and higher storage costs.

And as we can see within the AKWEL company the financial charges observed while using manual 'paper' management are almost of the order of 1937€.

These issues presented in this part provide a solid basis for making specific and relevant recommendations in the following part, in order to optimize performance and generate meaningful results for the company.

III. IMPROVEMENT PROJECTS

The improvement phase in question aims to improve a company's performance by identifying and resolving problems that hinder its operational efficiency. The objective is to optimize processes, increase productivity and reduce costs, while maintaining the quality of the products and services provided. In this part we will present the context of the improvement phase, the reasons which motivated its implementation as well as the objectives sought and we will also discuss the methodology used to achieve this phase.

3.1 Power supply by a handling robot

For powering APUs, we have three possibilities to achieve it. In order to choose the best solution, we will study and compare them.

a) Line power Supply by operators

The feeding operator's methodology is currently used at AKWEL. However, as we have already noted, this approach has many limitations. Although it can be adapted in the majority of cases, it can be rigid and occasionally cause delays in the production line.

Remember that for the three APUs, we use two operators with timing as follows:

Table 4: Feeding time of the factories

Operator	APU	Duration
1	1 and part of 2	35.66 min
2	3 and part of 2	36.66 min

THE two operators work in parallel. If we want know the average time required to power the three APUs, it is equal to the sum of the two durations: 35.66 minutes + 36.66 minutes = 72.32 minutes. And that gives an average of 24.10 minutes per APU.

b) Line power supply by AGV

The average speed of the AGV takes into account all movements of the AGV such as acceleration, deceleration, left or right turns, etc. This average speed is equal to 22 meters per minute and parking is equal to 30 seconds per station.

For example, for power any APU3, an AGV travels a distance of:

Distance = 66.6 +15 +33.3 + 15 +33.3 +66.6 = 229.8 meters.

Passing by 10 stations either *Tsta* (total time passing through all stations) $= 10 * 30s = 300$ seconds = 5 minutes.

Time total of APU3 = (229.8/22) + 5 = 15.44 minutes.

c) Line power by a handling robot

The idea of using a handler robot came after encountering difficulties with other options such as rigidity, delays in feeding by operators and high AGV costs.

For realize our idea in a real case, it is necessary to carry out a study and design of the robot.

Calculation of the robot load

We took the necessary data to calculate the load and torque of the motor [9] :

Trolley weight = 7kg

Weight of heaviest inlet supply (FE) = 12kg

Note: according to the safety standard, the trolley carries a maximum of 5 vertical backs

Total weight of 3 carts: $7 * 3 = 21\text{kg}$

Total weight of FE: $12 * 5 = 60$ kg

By using a load safety ratio of 1.5 as a tolerance for weight variations, we reduce the risk of overloading the robot

7+ 7/3 = 9.33kg ~10kg

60+60/3 = 80 ~90 kg

That is in total $(90 + 10) * 3 = 300$ kg

Calculate forces

- Friction force

Ff = N x μ

Ff is the friction force,

μ is the coefficient of friction

and N is the normal force exerted on the wheels.

$Ff = 300 * 9.81 * 0.3 = 882.9 \sim 900$ N (Newtons)

- Traction force

$$Ft = m * a$$

With

m the weight of cart,

and *a* an acceleration from where $a = 1\text{m}/s^2$

$Ft = 300 * 1 = 300$ N (Newtons)

- Total strength

Total strength: $Ftot = Ff + Ft$

$Ftot = 900 + 300 = 1100$N (Newtons)

- Torque Calculation

$$C = Ftot * r$$

With r' the radius of the wheel $r = 5$cm

$C = 1100 * 0,05 = 55N.m$

We choose to use four motors, assigning one motor to each wheel of the cart. This configuration ensures a balanced distribution of power and of propulsion torque, thus guaranteeing a better stability and optimal traction optimal on each wheel.

Hence C =55/4= 13.75N. m ~15N. m

The motor torque must be 15N.m and adopted with the robot power supply.

Robot dimensions

The necessary dimensions of the robot are:

o Length =750 mm

o Width =500 mm

o Height =330 mm

o Control display height = 1 m

3.2 Choice and comparison of solutions

We decided to work on the same speed characteristics for the AGV, even though our robot is capable of traveling at a speed of 1 m/s.

The average speed is equal to 22 m/min and parking is equal to 30 seconds per station.

As we saw in the previous solution the total time to power

APU3 = 229.8/55+5= 15.44min

We are faced with three possibilities for supplying the APUs for which it is necessary to resort to a comparative study to validate the solution chosen.

To begin the comparison of the three solutions retained, two criteria were set which are the duration necessary for powering APU and the cost of each solution.

In a first step we will make a comparison of the power supply duration, then in a second step a comparison with the price.

Comparison duration

The first comparison is carried out according to of the APU feed duration so we noticed that the duration by the handling robot and the AGV is the lowest.

Table 5: Duration for each solution

Solution	APU3 Duration
Operators	23.88min
AGV	15.44min
Handling Robot	15.44min

This comparison allows us to choose AGV and the handling robot in order to save an average of : $23.88 - 15.44 = 8.44$ minutes per APU.

Comparison prices

There second comparison is according to the price of each solution. Noted that the cost of the AGV is much higher than that of the handling robot, which makes the price comparison between the two solutions relatively insignificant.

Table 6: Cost of each solution

Solution	Cost
AGV	+25000 €
Handling Robot	2000 €

After comparing and analyzing the different power supply criteria for APUs, we see that the use of a handling robot or an AGV presents advantages compared to power supply by operators. Both solutions significantly reduce feed time, with an average time of 15.44 minutes per APU.

This represents a time saving of 8.44 minutes per APU compared to power per operator.

When it comes to cost, it's important to note that the AGV is considerably more expensive than the handler robot, with a gap of over 23,000€. This makes the choice of the handling robot much more financially advantageous.

In conclusion, taking into account both the reduced feed time and the more affordable cost, the handling robot presents itself as the best solution for powering APUs. This will optimize production chain efficiency and increase supply chain performance.

3.3 Digitalization of waste

Waste management has many benefits for businesses. First, it helps reduce costs by minimizing production scrap, saving valuable resources. Additionally, by improving product quality through preventative measures, a company can strengthen its reputation and attract new customers.

Waste management also helps optimize production processes by identifying recurring problems and making improvements, leading to increased efficiency and reduced costs.

Finally, it guarantees compliance with environmental regulations and quality standards, thus avoiding potential sanctions. By taking a proactive approach to waste management, companies can take advantage of these benefits and contribute to a more sustainable production model

a) Waste management method at Akwel

In the context of waste management within the AKWEL company, two distinct parts stand out: the collection of waste and its verification, followed by the entry of the collected data.

The first part, non-digital, involves the establishment of a waste collection system and their sorting according to their type, the waste is then checked to ensure that it complies with the management procedures established by AKWEL.

In the second part, the collected data is entered into a computer system dedicated to waste management, thus allowing their recording and subsequent analysis.

This comprehensive approach to waste management guarantees AKWEL effective traceability of its activities and provides valuable information to improve waste management practices within the company.

b) Idea for improving waste management

The proposed improvement idea consists of implementing a waste management system in the AKWEL company, which includes a non-digital part managed using shared files.

After executing the "Extract Components()" macro, the destination file is generated in the form of an array containing the part reference, its components and associated fault types. This destination file is shared on the company's internal network.

In the next phase from the process, the production service operator accesses the file destination and filled in the additional information. More precisely, the operator enters the number of faults in the corresponding box in the table. This step makes it possible to quantify the defects identified for each component associated with the part reference.

After the production service operator enters the defect quantities, the destination file is accessible to scrap verification operators. These operators carefully review the data entered by the production service operator, verify its accuracy and correct it if necessary.

Waste verification operators can also confirm the conformity of the values entered by the production service operator.

By sharing the destination file on the AKWEL company network, verification operators have easy access to information, facilitating collaboration and ensuring rigorous waste management.

This verification and confirmation process helps ensure data integrity and ensure the quality of waste information at AKWEL.

Macro Excel for waste management

The macro-Excel developed is presented in the figure below

```
Private Sub Image1_BeforeDragOver(ByVal Cancel As MSForms.ReturnBoolean, ByVal Data As MSForms.DataObject, ByVal X As S
    ' This event is triggered before a drag-and-drop operation over Image1
    ' You can add code here if needed
End Sub

Private Sub UserForm_Initialize()
    ' This event is triggered when the UserForm is initialized
    ' Set the picture of the Image control to the specified image file
    Image1.Picture = LoadPicture("C:\Users\asus\Desktop\GHASSEN MIMOUNI\download.jpg")

    ' Populate ListBox1 with the desired values
    ListBox1.AddItem "UAP1"
    ListBox1.AddItem "UAP2"
    ListBox1.AddItem "UAP3"
    ListBox1.AddItem "UAP4"
End Sub

Private Sub CommandButton1_Click()
    ' Declare variables
    Dim searchValue As String
    Dim wb As Workbook
    Dim ws As Worksheet
    Dim foundCell As Range
    Dim currentDateTime As Date

    ' Specify the path to the workbook
    Set wb = Workbooks.Open("C:\Users\asus\Desktop\GHASSEN MIMOUNI\Classeur3.xlsx")

    ' Specify the name of the worksheet where you want to perform the search
    Set ws = wb.Worksheets("MATRICULE")

    ' Retrieve the value from TextBox1
    searchValue = Trim(TextBox1.value)

    ' Check if TextBox1 is empty and ListBox1 has no selection
    If searchValue = "" Or ListBox1.ListIndex = -1 Then
```

```
        wb.Close False ' Close the workbook without saving changes
        Exit Sub ' Exit the event handler
    End If

    If searchValue = "00000" Then
        ' If the value is "00000", navigate to UserForm3
        UserForm3.Show
        Me.Hide ' Hide the current UserForm

        Exit Sub ' Exit the event handler
    End If

    ' Search for the value in column A of the sheet
    Set foundCell = ws.Range("A:A").Find(What:=searchValue, LookIn:=xlValues, LookAt:=xlWhole)

    ' Check if the value was found
    If Not foundCell Is Nothing Then
        ' Get the current date and time
        currentDateTime = Now

        ' Loop to find the first empty cell in column B or subsequent columns
        Do While Not IsEmpty(foundCell.Offset(0, 1).value)
            Set foundCell = foundCell.Offset(0, 1) ' Move to the next cell in the same row
        Loop

        ' Add the selected value from ListBox1 to the empty cell
        If ListBox1.ListIndex >= 0 Then
            foundCell.Offset(0, 1).value = ListBox1.List(ListBox1.ListIndex)
        End If

        ' Add the current date and time to the next empty cell
        foundCell.Offset(0, 2).value = currentDateTime

        ' Save changes to the workbook
        wb.Save
```

```
        wb.Save
        wb.Close False ' Close the workbook without saving changes
        Me.Hide ' Hide the current UserForm

        ' Automatically move to UserForm2 without displaying a message
        UserForm2.Show
    Else
        ' Display a message if the value is not found
        MsgBox "Non, n'existe pas!", vbExclamation, "Résultat de la recherche

        ' Close the workbook without saving changes
        wb.Close False
    End If
```

Figure 3: Macro excel for waste management

c) Comparison between current and proposed solutions for waste management

To validate the proposed solution, it is important to make the comparison between the current solution and the proposed solution. The following table presents the annual supply costs spent by the company to manage waste.

The cost of the new solution proposed for waste management after contacting a supplier for the purchase of necessary equipment and cabling to implement this solution.

Table 7: Comparison of waste management costs

Solutions	Costs
Current solution: Supply waste management	**1915 €**
Proposed solution: digitalization waste management	**1220€**

To clearly explain the difference in costs between the current solution and the proposed solution we presented a histogram which shows the cost of each solution and we found that the proposed solution is the cheapest compared to the solution, in addition it is durable and does not require a budget every year like the company's current solution.

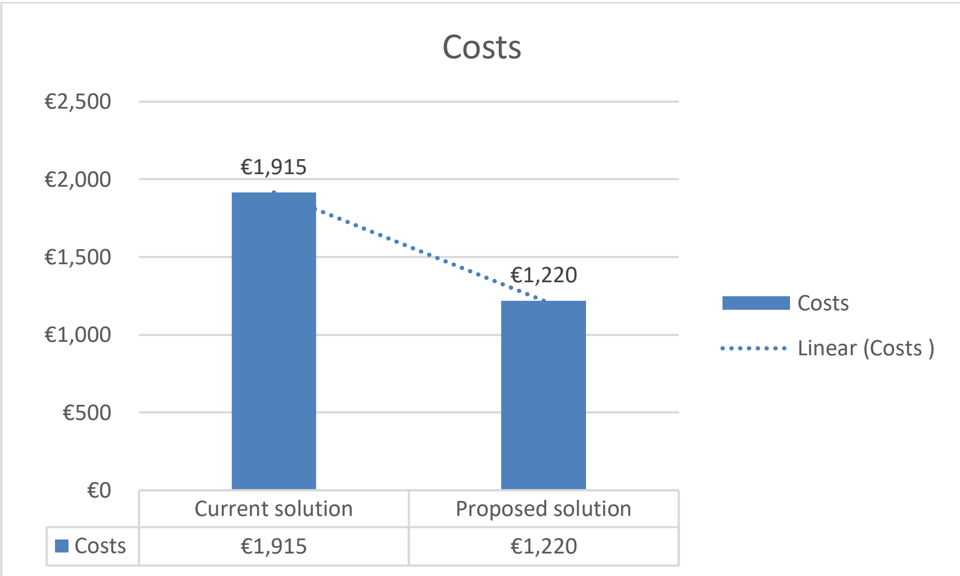

Figure 4: Comparison of waste management costs

The solution proposed for the complete digitalization waste management is a very interesting approach, offering many advantages while being more economical than the current method. It simplifies processes, reduces human errors and improves operational efficiency. In addition, it facilitates access and sharing of data between the different actors involved.

By digitizing information, it is also possible to improve the traceability of waste and analyze the causes. By reducing the costs associated with manual waste management, this solution also contributes to overall savings for the company. In short, the complete digitalization of waste management represents a modern and advantageous approach to improve processes and optimize production costs.

IV. CONCLUSION

Our work aims to find solutions and implement actions after identifying the problems encountered by Akwel at the logistics service level.

In a first phase, we carried out the study to implement a robot in APUs in order to reduce feed and waiting time and therefore optimize production time, then we solved the problem of non-digitalization of waste which will reduce manual archiving costs.

Some proposed solutions will lead the company to a digital company allowing it to better improve and excel its performance and trigger other challenges towards digital transformation and there, we are talking about an industry 4.0 in Akwel factories.

This work constitutes a starting point for solving other problems but there are other subjects to trigger in the future such as connecting the robot with SAP (Systems, Applications and Products for data processing).

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