Reduce Scrap for Kiefel Machine Non-PVC

Natalia Rivera Rivera
Master of Engineering in Manufacturing Engineering
Advisor: Miriam Pabón, Ph.D.
Industrial and Systems Engineering Department
Polytechnic University of Puerto Rico

Abstract — *The bag-making process is performed in different locations globally. IV Bags are used worldwide for various treatments. This project aims to reduce the scrap from the Non-PVC machine. This is the only one of ten department machines producing IV Bags. Because it is the machine with the highest scrap within the bag-making department, this project focuses on reducing the scrap from the Kiefel Non-PVC machine to contribute to the plant's scrap reduction of 2%.*

Key Terms — *Kiefel Machine, IV Bags, Non-PVC Material, Scrap.*

INTRODUCTION

The scrap from the Kiefel Non-PVC machine is part of the manufacturing plant's most offending scrap metric. This Kiefel machine has the capacity to produce six different codes. Where each code has a different volume and port configuration. For this project, a specific code will be evaluated, as it has the highest production volume for the year. The machine manufactures the bags in 10-unit patterns for this code. However, it is capable of producing the bags in 8-unit patterns. In addition, it is the code with the highest economic impact on the machine, as it is the most expensive code produced on the machine. Therefore, the scrap from this machine directly affects the department's account. For this study, data was taken for six days in two shifts and different types of roll material. Due to the design of this study, the implementation actions apply to most of the machine codes. It is important to know that the manufacturing plant has different codes to identify discarded scrap units. Each defect has a classification, and in this way, it is possible to measure the major impact of defects for scrap. This machine represents 15% of the scrap in the department.

BACKGROUND

Kiefel machines are used in the bag-making process in different plants globally. The machines are designed and manufactured in Germany, with automatic operation [1]. These machines can operate to manufacture various types of bags; they can vary in size, material, and components and therefore differ in operating parameters. The plant has ten Kiefel machines; nine operate with PVC material, and one works with Non-PVC material. The Kiefel Non-PVC machine was designated for this project. The machine runs two shifts of 8 hours, Monday to Friday. The machine operates with one mechanic and three assemblers per shift. The mechanic is responsible for feeding the machine, making process tests, and solving any situation that the machine presents during the shift. The assemblers are responsible for visual inspection, defect categorization, process testing, production packaging, and documentation. It is essential to mention that our customer currently accepts units in complete patterns or two-up units.

For the 2022 year in the Bag Making Process department, scrap was directly affected by the Non-PVC machine. The scrap from the Kiefel Non-PVC represents 15.1% of the department scrap for 2022. Figure 1 explains a scrap for Kiefel machine on 2022 that Kiefel Non-PVC represents 15.1% for 856,543 units discarded.

According to this data, the information for this machine was broken down, and 45% of the machine scrap corresponds to the high corridor code (247). In 2022, 361,655 units were discarded.

For the high runner code (247) with the discarded units, the data of the defects for which they were discarded was taken. Figure 2 shows that the greatest impact during 2022 was with the Non-defect found defect. For this defect, the number of units discarded was 98,546 bags. This represents

27.2% of the scrap for code 247 see Figure 3 for detail of each defect code.

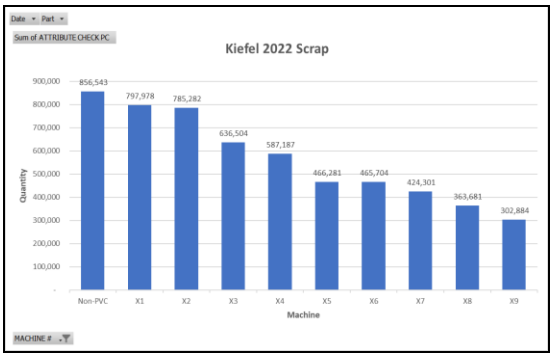


Figure 1
Kiefel Department Scrap 2022

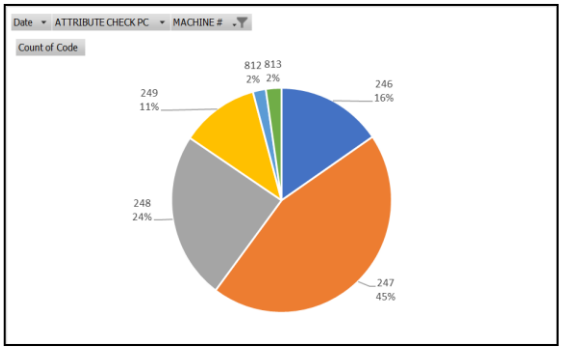


Figure 2
Kiefel Non-PVC Scrap 2022 per Code

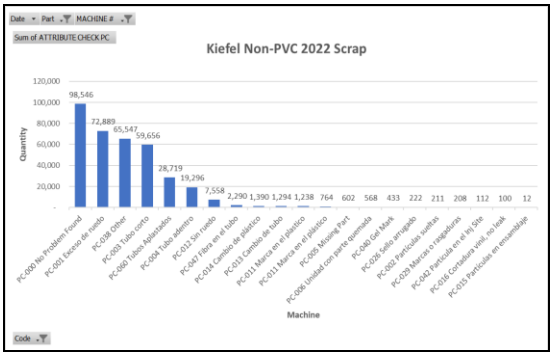


Figure 3
Kiefel Non-PVC Defect Scrap 2022

METHODOLOGY

The project methodology included collecting data for 2022 to determine the project's focus.

The study was performed on six days, two shifts each day. It is essential to mention that every day that data was collected, the same personnel of mechanics and assemblers worked on the machine. This is to avoid the people variable in the study and thus only consider the machine and raw material factors.

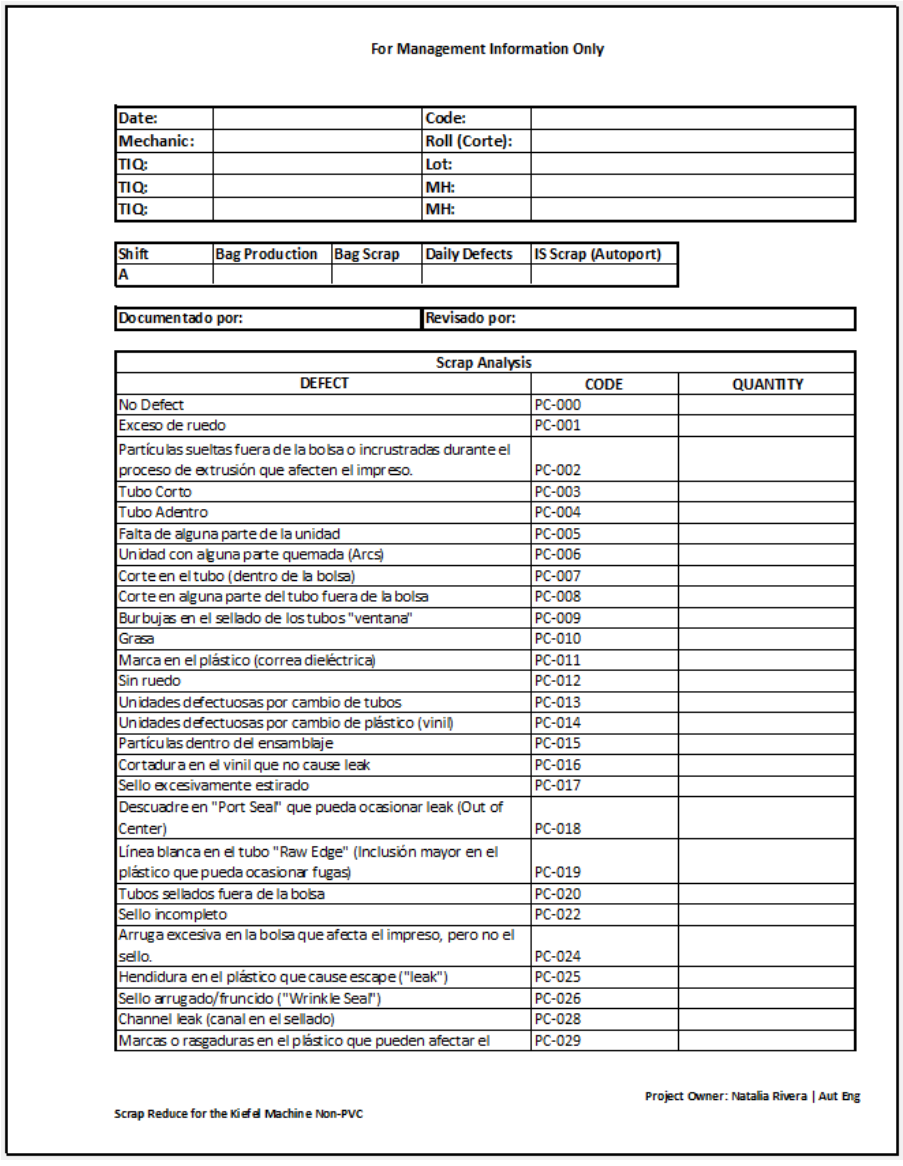
A characteristic of the material used in this machine to manufacture the bag is that the cuts of the vinyl rolls can have tension variations. Being a Non-PVC material, it tends to lose tension during the process. For these vinyl rolls, the manufacturer works with three roll cuts. It is very common that of the three cuts (cuts A, B, and C), the most problematic one is C. So, as part of the project, all three cuts were taken. Manufacturing two days, two shifts each day with each roll cut. What it means that there are three different vinyl roll cuts is that the vinyl manufacturer works with one giant roll that is divided into three. The center slit is slit A, and the corners are B and C. As mentioned, the cut categorized by the manufacturer as C is the most stressful problem it causes on the machine.

As mentioned above, the study was run six days during two manufacturing shifts each day. As part of the project methodology, a form was generated to document the data collected during the six days [2]. Part of the project analysis was that units discarded as scrap had to be saved for re-inspection by another assembler. This confirmed that the discard and inspection were performed correctly. During manufacturing, the assemblers are responsible for visual inspection and discarding the units with defects. The data collected during the six days included the scrap per daily defect, the scrap caused by the units automatically rejected by the machine, the number of good units produced during the shift, and a scrap of the injection site component. In addition, the date, shift, mechanic, assemblers, and the corresponding vinyl lot were documented. For the documentation, it was of utmost importance to document everything at the end of the shift and the next manufacturing shift to support the re-inspection of the categorized scrap.

The re-inspection was a key part of the analysis of the study since it confirmed that the defects categorized in the manufacturing process are indeed present. With the reinspection, the factor of discarding miscategorized or uncategorized units was ruled out.

It is worth mentioning that the staff orientation was of great impact. The personnel must know their work's impact on the manufacturing plant, particularly where the work of the manufacturing line personnel can be aligned with the goals and projections of the plant. In addition, if the manufacturing personnel have the support of the leaders, they will complement each other better, and the goals will be accomplished more effectively. The form was kept simple to avoid confusion during data collection and interpretation.

The data collected through the form (Figure 4 and Figure 5) was entered into Excel by one engineer and reviewed by a second engineer to validate that the data entered was real, not manipulated, and to avoid any errors in the calculations that would come out of this data.



For Management Information Only

Date:		Code:	
Mechanic:		Roll (Corte):	
TIQ:		Lot:	
TIQ:		MH:	
TIQ:		MH:	

Shift	Bag Production	Bag Scrap	Daily Defects	IS Scrap (Autoport)
A				

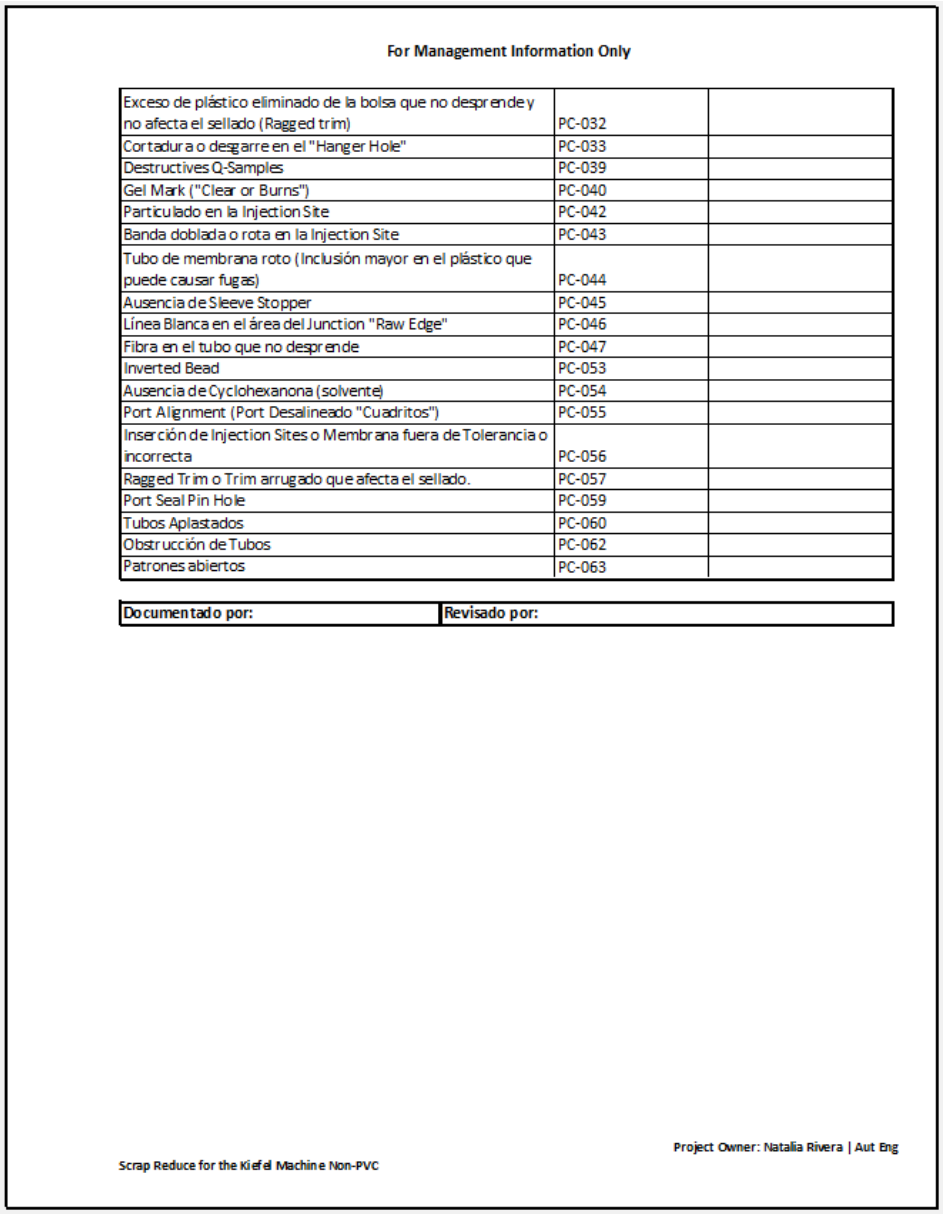
Documentado por:	Revisado por:

Scrap Analysis		
DEFECT	CODE	QUANTITY
No Defect	PC-000	
Exceso de ruedo	PC-001	
Partículas sueltas fuera de la bolsa o incrustradas durante el proceso de extrusión que afecten el impreso.	PC-002	
Tubo Corto	PC-003	
Tubo Adentro	PC-004	
Falta de alguna parte de la unidad	PC-005	
Unidad con alguna parte quemada (Arcs)	PC-006	
Corte en el tubo (dentro de la bolsa)	PC-007	
Corte en alguna parte del tubo fuera de la bolsa	PC-008	
Burbujas en el sellado de los tubos "ventana"	PC-009	
Grasa	PC-010	
Marca en el plástico (correa dieléctrica)	PC-011	
Sin ruedo	PC-012	
Unidades defectuosas por cambio de tubos	PC-013	
Unidades defectuosas por cambio de plástico (vinil)	PC-014	
Partículas dentro del ensamblaje	PC-015	
Cortadura en el vinil que no cause leak	PC-016	
Sello excesivamente estirado	PC-017	
Descuadre en "Port Seal" que pueda ocasionar leak (Out of Center)	PC-018	
Línea blanca en el tubo "Raw Edge" (Inclusión mayor en el plástico que pueda ocasionar fugas)	PC-019	
Tubos sellados fuera de la bolsa	PC-020	
Sello incompleto	PC-022	
Arruga excesiva en la bolsa que afecta el impreso, pero no el sello.	PC-024	
Hendidura en el plástico que cause escape ("leak")	PC-025	
Sello arrugado/fruncido ("Wrinkle Seal")	PC-026	
Channel leak (canal en el sellado)	PC-028	
Marcas o rasgaduras en el plástico que pueden afectar el	PC-029	

Project Owner: Natalia Rivera | Aut Eng

Scrap Reduce for the Kiefel Machine Non-PVC

Figure 4
DOE Form to Collect Data



For Management Information Only

Exceso de plástico eliminado de la bolsa que no desprende y no afecta el sellado (Ragged trim)	PC-032	
Cortadura o desgarre en el "Hanger Hole"	PC-033	
Destructives Q-Samples	PC-039	
Gel Mark ("Clear or Burns")	PC-040	
Particulado en la Injection Site	PC-042	
Banda doblada o rota en la Injection Site	PC-043	
Tubo de membrana roto (Inclusión mayor en el plástico que puede causar fugas)	PC-044	
Ausencia de Sleeve Stopper	PC-045	
Línea Blanca en el área del Junction "Raw Edge"	PC-046	
Fibra en el tubo que no desprende	PC-047	
Inverted Bead	PC-053	
Ausencia de Cyclohexanona (solvente)	PC-054	
Port Alignment (Port Desalineado "Cuadritos")	PC-055	
Inserción de Injection Sites o Membrana fuera de Tolerancia o incorrecta	PC-056	
Ragged Trim o Trim arrugado que afecta el sellado.	PC-057	
Port Seal Pin Hole	PC-059	
Tubos Aplastados	PC-060	
Obstrucción de Tubos	PC-062	
Patrones abiertos	PC-063	

Documentado por:	Revisado por:

Project Owner: Natalia Rivera | Aut Eng

Scrap Reduce for the Kiefel Machine Non-PVC

Figure 5
DOE Form to Collect Data

An important part of this project is that production during the six days of data collection was kept from being held up under any consequence of the project. Instead, the machine operated as normally as it always does. In this way, the data collected is more accurate than if it had been taken on a non-production run for manufacturing. So, the units produced during this project were released to the customer.

In addition, in the manufacturing department, at the end of each shift, the staff documents the production of the machine in a database, the scrap, and the daily defects found. This data was also taken during this project for comparison purposes. The daily defects reported in the database were compared to what was re-inspected. In this way, it was confirmed that what the operators report as scrap is scrap on the machine.

An important factor for this project was that even though the machine produces six different manufacturing codes, defects and scrap situations behave similarly for all codes. Therefore, by taking

their high runner as a prioritized problem, the actions taken could be implemented on at least four manufacturing codes.

ANALYSIS

The production runs for this study were followed by the data analysis. This analysis was performed in Excel, where all the essential data of the project was entered. As it was: the cut of the vinyl roll that was used, the quantity of bags produced, the quantity of scrap, and the daily defects found during the inspection and re-inspection.

A pie chart was created with the data to present the defects found during this six-day run. Similarly, for 2022, the top offender is Non-defect found, with 6,213 units discarded, followed by the excess roll and short tube. Actions from other projects are being implemented for both situations to reduce this scrap. Figure 5 tabulates all the defect data found in this run.

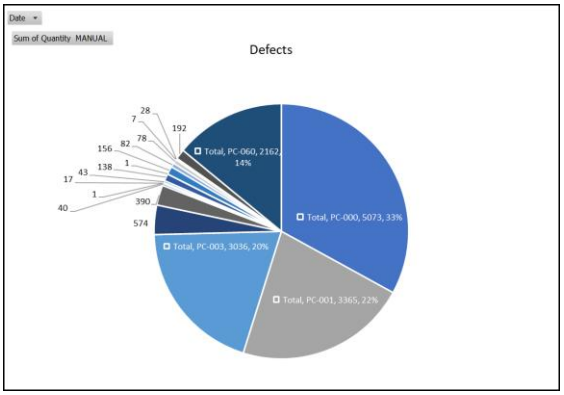


Figure 6
Defects

Figure 6 shows that 33% of the scrap for the study is Non-defect found in the scrap bags.

Once this first analysis was completed, the problem was broken down to find the prioritized problem (Figure 7).

The problem to be worked on was the Non-Defect Found. To have a projection of what assemblers discard under this defect, the 5-Why's Exercises were performed. The 5-Why's Exercise was conducted in manufacturing and focused on the priority problem: Non-Defect Found (Figure 8).

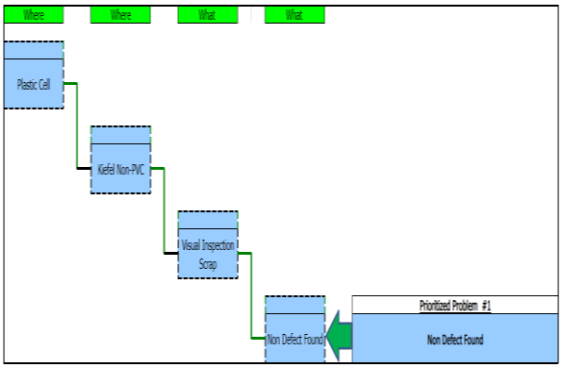


Figure 7
Breakdown Problem

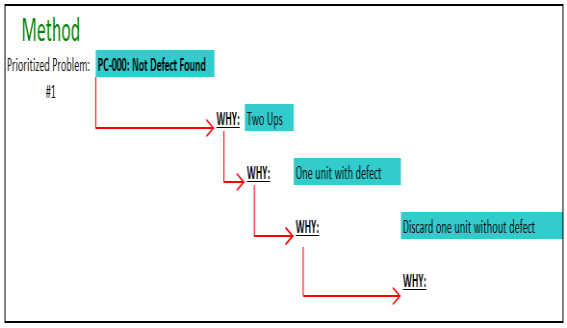


Figure 8
5 Why's Exercises

Explaining the 5-Why's is that the production line inspectors must discard a defective unit, and even if the cavity next to it has no defect, it has to be discarded. In other words, a good unit is discarded because it has a defective unit next to it. This is known as the sister cavity.

A second data collection was performed after analyzing the data collected in this experimental run. This new study was carried out on a manufacturing day during two shifts, using the same people who participated in the first study. The purpose of this new study was to determine if, in fact, the units discarded as Non-defect found were accompanied by units with defects. The same DOE form was used for this run as the first study, and the discarded units were also re-inspected.

The data collected were tabulated and analyzed in Excel. It was found that a defective unit indeed accompanied the units categorized as Non-defect found. Refer to the graphic for details of this characterization.

Row Labels	Sum of Quantity
PC-000 - Non defect	279
PC-060 - Tubos Aplastados	131
PC-024 - Arruga excesiva en la bolsa que afecta el impreso, pero no el sello.	127
PC-056 - Inserción de Injection Sites o Membrana fuera de Tolerancia o incorrecta	86
PC-003 - Tubo Corto	47
PC-016 - Cortadura en el vinil que no cause leak	28
PC-040 - Gel Mark ("Clear or Burns")	25
PC-004 Tubo Adentro	8
PC-005 - Falta de alguna parte de la unidad	8
PC-013 - Unidades defectuosas por cambio de tubos	2
PC-020 - Tubos sellados fuera de la bolsa	2
Grand Total	743

Figure 9
Scrap per Code Classification

RESULTS

After analyzing the data from the experimental runs, it was determined that the priority problem for a scrap of this Kiefel machine is the Non-defect found defect. This means that they are units (bags) that have no defect and are being discarded and directly affecting the scrap of the machine and, therefore, the scrap of the manufacturing department. Figure 10 shows the significant impact that this defect has on the machine.

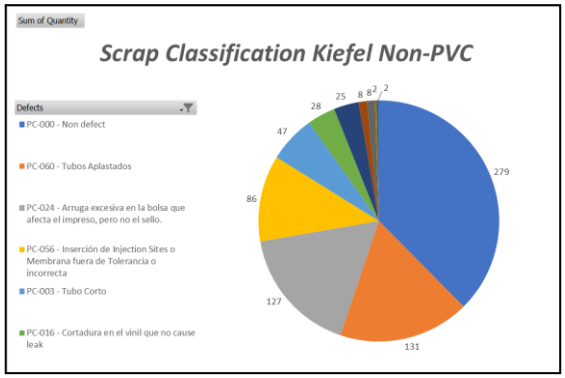


Figure 10
Defects

Figure 10 shows graphically that the Non-defect found defect represents 37.5% of the rejected units during two days of the experimental runs. This means that this defect directly impacts the machine.

From these results, a second offender for a scrap of this machine could also be determined. This is the excess skirt in the bag. As mentioned above, this raw material tends to cause tension problems in the different vinyl rolls. Therefore, this tension problem causes the excess skirt defect. This problem encountered under this project will be addressed under a new Project.

As a result of this project, we evaluated the possibility of working the one-up process for codes 246, 247, 248, and 249. This means that, instead of discarding a unit with no defect, under No Defect Found, this unit will be shipped categorized to the customer as a single unit. Since the process currently in place allows units to be shipped in pairs or complete sets (eight or ten units). This will significantly reduce scrap. Because the most significant impact of this machine will be the defects not found, and, as this is declined, it will reduce scrap. As mentioned above, these units discarded as Non-defect found are the units which the unit next to it is affected by any other categorized defect. The scrap is reduced slightly by having the possibility of two-up (cutting the pattern in two and discarding the units with defects).

IMPACT ANALYSIS

Each bag manufactured for this code, high runner, costs $0.4080. The production per year for this code is approximately 5,060,044 (based on 2022 data), where the machine scrap for this code was 361, 655 units, and the scrap for the Non-defect found defect is 1.91% on the year. This means that with the implementation of this project, the machine scrap for Non-defect found will be reduced by 50%. This machine ran four codes for the client in 2022. The other code has a different cost per bag. For code 246, the cost is $0.3682. For code 248, the cost is $0.5334, and for code 249, the cost is $0.5252. The relation between codes and cost is presented in Figure 11. The overall production for the machine in 2022 for all codes is 9,515,436 bags. The scrap in 2022 is 824,237 bags counting all daily defects reports per lot. This scrap is for different codes, but the most impact is for Non-defects found, representing 26% of the scrap of 2022, having 218,400 bags. The goal of the project is to reduce 50% of the defect PC-000.

Code	Cost
246	$ 0.3682
247	$ 0.4080
248	$ 0.5334
249	$ 0.5252

Figure 11
Cost per Code Per Bag

The projection for the machine for the year 2023 is presented in Figure 12. This projection can be changed with the client requisitions for the medical areas globally. For the codes impacted by this project, the quantity for the 2023 year is 11,666,925 units.

Code	Volume 2023
246	2,009,382
247	6,339,946
248	2,610,220
249	707,377

Figure 12
Kiefel Non-PVC Volume 2023

The projection for the 2023 year is to make 11,666,925 bags on this machine Non-PVC. For the year 2023 and its production volume with the implementation of one up to reduce 50% of Non-defect found, the estimated savings are $56,734.03. Thus, considering all codes of manufacturing previously mentioned.

IMPLEMENTATIONS ACTIONS

As with all projects, this one has a set of actions. The first action was to make a call to meet with the customer of codes 246, 247, 248, and 249 to evaluate the possibility of accepting units in one-up (one at a time). This would meet the project goal of reducing machine rejection by 50% of the PC-000 (Non-defect found) defect. The customer accepted the new shipping process and reached the necessary agreements. The first batch will be manufactured in June to observe the improvement and reduction of scrap. In addition, this plan will be implemented on all non-PVC codes for this customer. To implement the use of one-up, the use of two-up will be eliminated, and only one-up will be used for these manufacturing codes. [3] It is important to note that patterns and integral units will be sent to the customer in one-up. To implement this, a change must be made to the bag packaging manual for these codes and the standard manufacturing procedure where the manual will explain how to pack in the Gaylor and its dividers. The standard procedure will explain how to perform the inspection and packing in the tray for the one-at-a-time units. The customer requested that these units be shipped in separate Gaylors to produce integrated patterns and identified on the label as one-up units. These specifications will be included in the PVC-free packaging manual and standard manufacturing procedure. A very important part is to train certified personnel to operate this machine and explain the importance of the project and its implementation. For the manufacturing plant, the target for the metric scrap is 3% for all departments. This reduction represents 0.41% of the metric of the manufacturing plant.

CONCLUSION

After analyzing all the data collected for this project, it is determined that the scrap from the Kiefel Non-PVC machine directly impacts the department's scrap and, therefore, the manufacturing plant's scrap metrics. With the implementation of this project, the plant will significantly improve the scrap of this machine. It should be noted that this project will affect one machine and four manufacturing codes. Therefore, its savings will be more significant at the departmental than at the manufacturing plant level. In addition, with this project, we were able to identify a second offender for the rejection of this machine. This will be worked on in a future project: an excess skirt in the bag. This will also contribute to a percentage of the plant's metrics. As of June 2023, the one-up process will be implemented, and the savings from this project can be measured. With this savings data, we can present it as a significant scrap reduction improvement project and claim its saving as a process improvement project.

REFERENCES

[1] J. Levitt, *TPM reloaded: Total productive maintenance*, Industrial Press, Inc., New York, 2010.

[2] M. Pabón González, Ph.D., P.E., "Completely Randomized Single Factor Design," in MMP 6000: Advanced Statistics and Quality Improvement Course, UPPR, San Juan, PR, 2022.

[3] D. B. Relyea, *The practical application of the process capability study: evolving from product control to process control*, 1st ed., CRC Press, New York, 2011.