

Development and Implementation of a Semi-Automated Model to Accelerate the Rate of Kaizen in Film Packaging Industry

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Abstract

The need to reduce defects and ability to track frequent activities in a film packaging industry is vital to allow smooth operation. The focus of this paper is to develop and implement a semi-automated model to accelerate the rate of Kaizen in film packaging industry. A study was carried out for process enhancement by improving a nonconformance closure system in order to eliminate scrap rate. Ishikawa analysis and 5 whys were integrated in order to construct a semi-automated model for nonconformance closure. The semi-automated model led to drastic improvements and with this semi-automated model of nonconformance corrective action it was further evaluated that recycle process was consuming a lot of energy and the new quicker recycle method was introduced. Effective nonconformance closure system resulted in good adherence to international quality standards. It was concluded that effective troubleshooting process plays a big role in generating improvements and avoiding frequent occurrences of the same problem. Although the framework has been developed for the film packaging industry, it can also be applied in control of non-conformances irrespective of the industry.

Key words: Kaizen, non-conformance and semi-automated model

1. Introduction

The food film packaging industry is one of the essential manufacturing sectors that specializes in converting plastic granules into thin micron plastic film. However, companies in the film packaging industry face challenges in striving to continually improve their systems in order to maintain food safety and quality standards (León-Bravo et al 2019). This research was motivated by a research gap in implementing Lean methodology, which has been inflexible in terms of complying with international standards, hence a need for effective application of lean tools to comply with International Standards and to accelerate the rate of Kaizen. The case study company in the film industry is a business that specializes on converting plastic granules into a thin micron plastic called film. The business is driven by a Kaizen-philosophy, which acts as a catalyst to accelerate the rate of innovations within the business, and increase productivity rate with zero defects. The problem at the case study organisation was that the total number of nonconformance raised was constantly increasing which resulted in low level of compliance hence lack of innovation. An external audit for international standards was conducted for the case study company and it was found that there is no consistency of closing internally raised non-conformance for operations; hence, lower rate of Kaizen implementation. The audit exposed the challenge of finding a proper method of controlling non-conformance status. The aim of this paper is to develop a semi-automated model to accelerate the rate of kaizen in film packaging industry. It also focuses on the implementation of an effective corrective action plan model to assist with consistent closure of non-conformances and introducing the best lean technique strategy that accelerates the rate of continuous improvement implementation, hence smooth process flow and high compliance level. The following section focuses on similar studies for addressing conformances raised within business operations.

2. Related work

An effective non-conformance system results in good adherence to international standards such as ISO 9001, ISO 14001, and ISO 22000 (Lasrado and Pereira 2018). Various sectors have applied different strategies in order to address non-conformance raised within business systems. Alatulkkila (2018) carried out a study in an electrical motor manufacturing industry to improve quality for non-conformance data system. An interview was performed with different departments to find out problems when investigating non-conformances, and benchmarking with four companies was done to find out different strategies that are used for data collection. The feedback from interviews led to development of reporting tools and creation of a database system for quality complaints (Alatulkkila 2018).

Savino et al. (2014) conducted a study for assessment of non-conformities in quality management systems from both a firm's perspective and customer's perspective. A comprehensive approach for non-conformities analysis was presented to characterise non-conformities from multiple perspectives and prioritise interventions with respect to non-conformities characterization. Failure Mode Effects and Criticality Analysis and a fuzzy inference engine were deployed, and a ranking criticality index was used to address the suitable intervention priorities.

Nováková et al. (2017) conducted a study for analysing and continually improving quality systems in production of spliced veneers, applying 8D Methodology for addressing nonconformities. 8D Methodology comprised of 8 steps (D1- Setting up the team, D2 - Describing the problem, D3 - Proposing temporal measures, D4 - Analysing possible causes and analysing principal causes, D5 - Proposing permanent corrective solution, D6 - Implementing and verification of adopted corrective measures, D7 - Preventive measures and D8 - Acknowledgement to the team. The study led to drastic improvement on handling customer and internal complaints.

Mohsen et al. (2019) applied a data analysis for non-conformance report in a cabinet manufacturing facility, the aim of the study was to improve statistical accuracy of problems that has risen before and also to categorise problems accordingly in order to priorities troubleshooting. A non-conformance system study for clinical technologies was conducted by Kolodyezna et al. (2018) in order to find a better way of solving problems that occur during clinical trials for drugs. An algorithm was constructed using the corrective action preventive action planning procedure during the process of non-conformance correction and prevention when organizing and conducting clinical trials. An algorithm resulted into smooth flow nonconformance system, which assisted into problem classification whether it was minor or major. It was further revealed that trials were not taking long due to an effective corrective action system (Kolodyezna et al. 2018).

Models for process enhancement are constructed in order to solve systematic problems and to predict future risks in order to prevent those risks from happening. Cherrafi et al. (2019) constructed a Kaizen model for sustainability on improving and assisting organizations to decrease their environmental waste in a practical and easy manner with limited resources. This study resulted in drastic improvement of resources consumption and improved environmental impact. Piek (2019) posited that the intent of non-conformance reporting systems is to identify non-conformances and take actions to prevent recurrence and eliminate the causes of the non-conformances, and, undermining the value of non-conformance reporting would result in the auditing process being regarded as incredible.

3. Methodology

The research was conducted in a methodical pattern and Figure 1 shows the research framework illustrating the overall scope of the study and ISO standard requirements. The first step illustrates the problem statement, which is the inconsistency of Corrective Action Plan System (CAPA). CAPA is the plan to address the problem of non-conformances which is followed by the definition of ISO standard requirements (Raj 2016). The third step was to identify the most suitable lean tool that could be used to construct a semi-automated model. The semi-automated model was then applied to close non-conformance and the results were outlined.

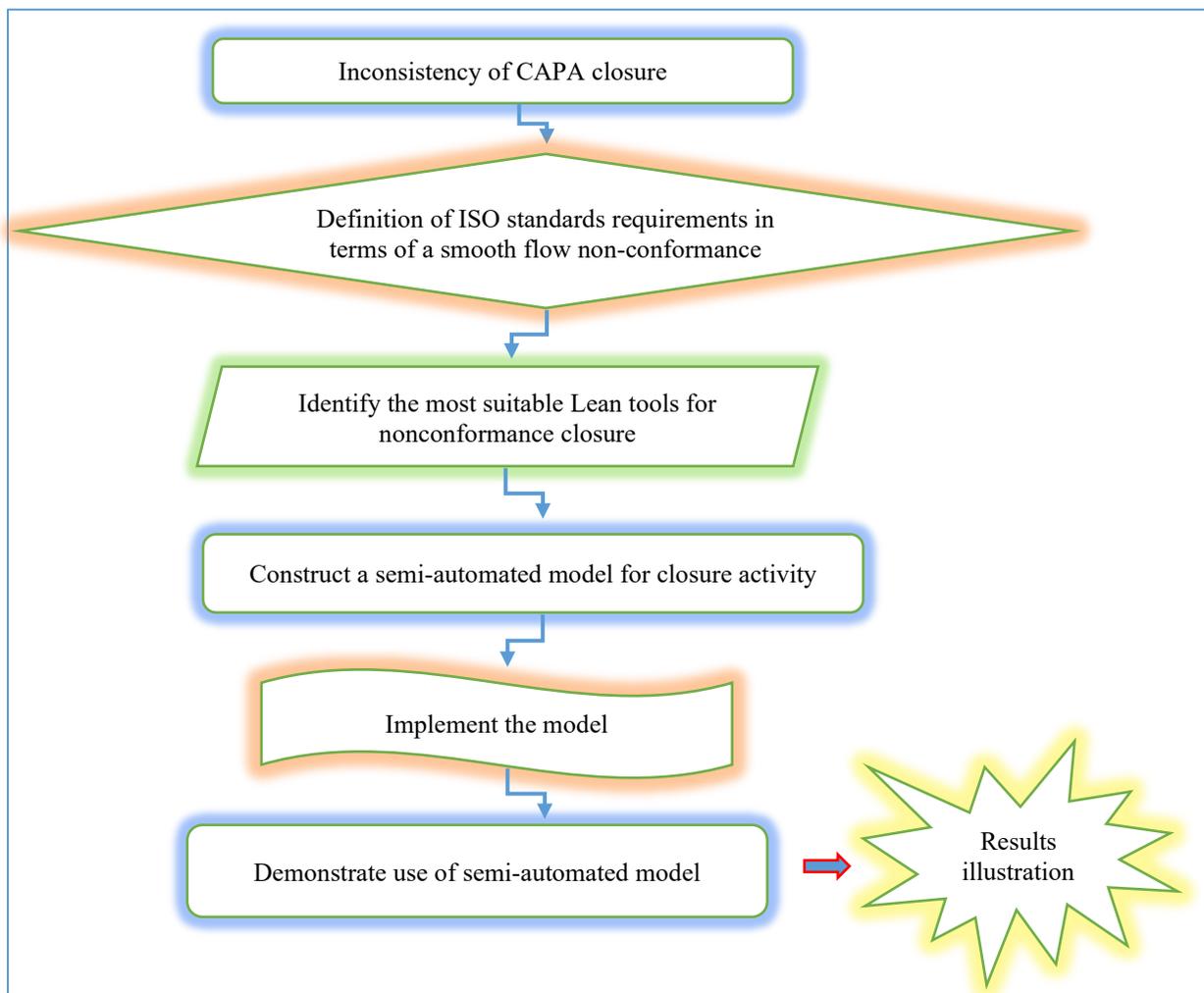


Figure 1. Framework for implementing semi-automated model

4. Results and Discussion

4.1 Scenario before semi-automated model implementation

The scenario before semi-automated model implementation revealed that the investigation method that was used was inadequate due to the lack of alignment with International Standard requirements. According to the previous ISO 9001 audit, it was noted that there is an inadequate procedure of closing raised non-conformances. Figure 2 shows a graph illustrating the monthly follow up closure of non-conformance cases. It was noted that there were 201 non-conformances raised and 61 closed which results to 140 pending non-conformances at the case study company. There was no tool in place to analyze the cause of the problem and there was no consistence in the adherence of the proposed closure dates. It was also noted that some cases had been opened for a period of 10 months, which was almost a year. This was a major problem for the business, which indicates that there is a need to apply lean tool to generate continuous improvement.

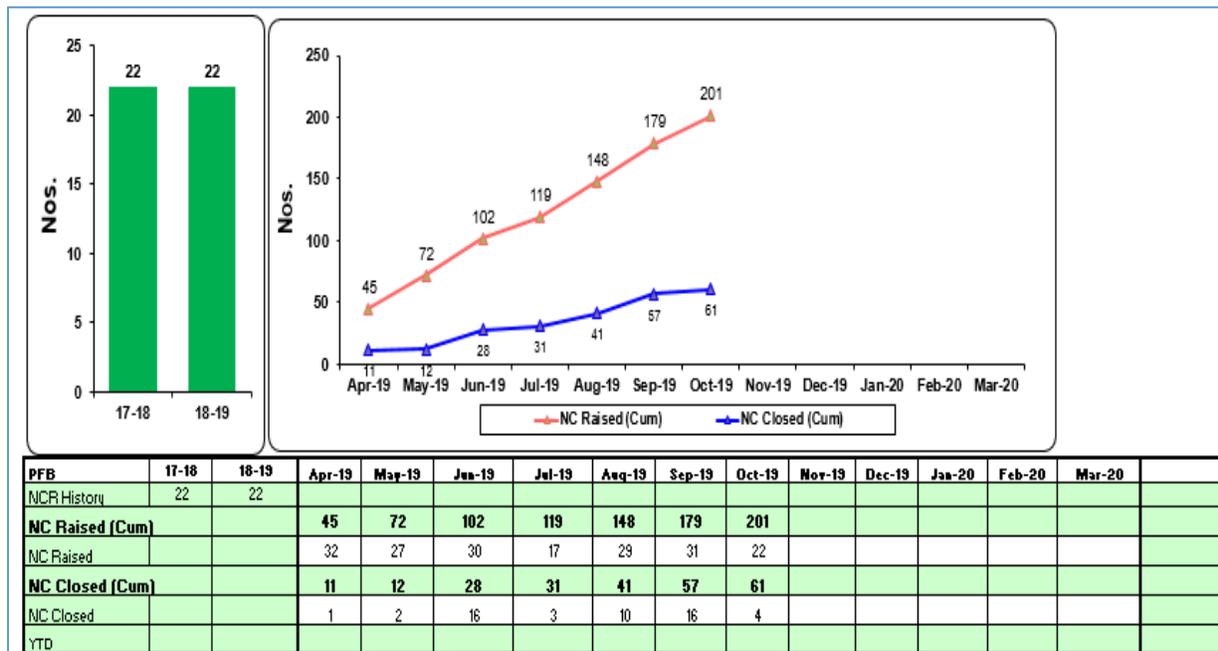


Figure 2. Data for nonconformance raised and non-conformance closed

4.2 Framework for development and implementation of the semi-automated model

The semi-automated model was developed on a Microsoft Excel platform. After development, implementation of the semi-automated model was then demonstrated using the Define, Measure, Analyze, Improve and Control (DMAIC) methodology, commencing with problem definition followed by problem description and subsequent six stages of analysis. Figure 3 shows an overview of the semi-automated model sections from the origin of non-conformance up to the verification, save and transfer section. Stage 1 is whereby the details of the non-conformance are outlined. Stage 2 is deployment of 5 Why analysis to investigate the reasons underlying the problem. Stage 3 is Ishikawa analysis, whereby the main reasons derived from 5 Why analysis are classified into categories of Ishikawa to generate solutions for continuous improvement. Stage 4 is risk analysis to measure the level of risk that the defects have in terms of product or service quality. Stage 5 is characterised by outlining opportunities of improvement and correction, while stage 6 is communication, whereby the analyst saves and automatically sends the completed form to the Total Quality management co-ordinator.

4.2.1 Definition

The input data is the information recorded and code is the colour to categorise information. The oil drop problem originated from Castline working station of the cooling zone process.

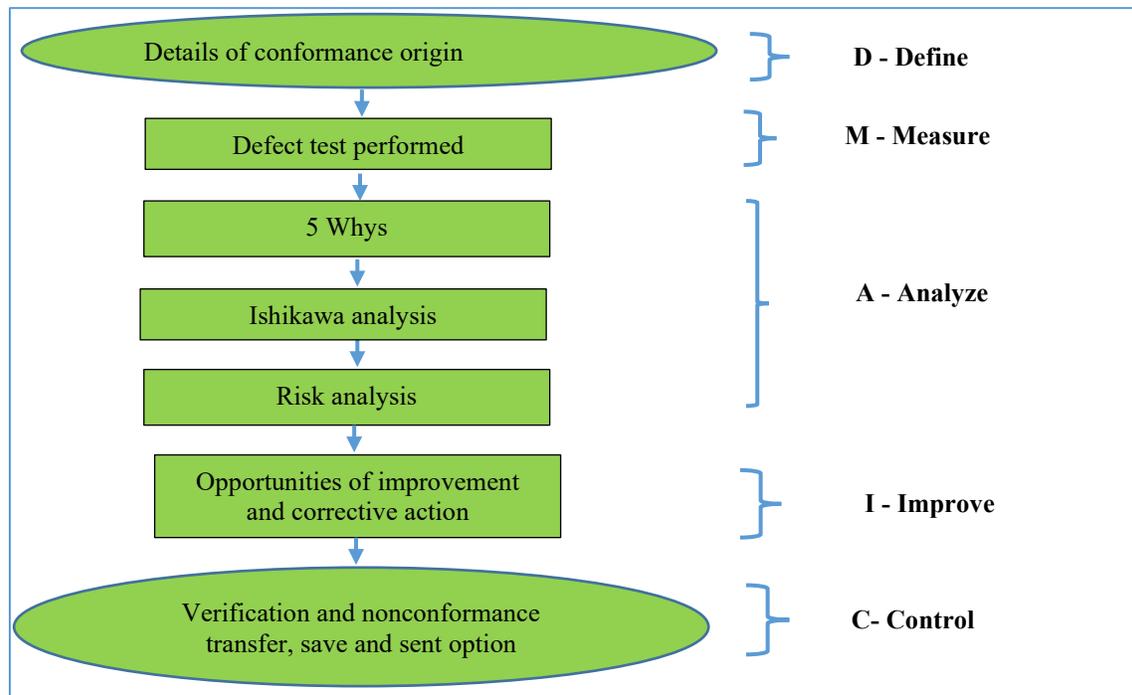


Figure 3. Overview of the semi-automated model

4.2.2 Problem description

After extrusion process, the film is cooled while it is automatically stretching in a vertical closed cooling chamber. The cooling chamber works with chains that constantly pools the film for cooling inside the chamber. There are fans assisting on the cooling process. When the chamber is not cleaned, it accumulates lot of oil stains from the chain which evaporates and condensates on the product. Figure 4 shows a photo illustrating the cooling chamber with tiny oil droplets formed when the chamber is not cleaned and these oil droplets results into product defect.



Figure 4. Photo illustrating oil droplets that results into product defect

4.2.3 Stage 1 - Details of non-conformance origin

Stage 1 is whereby the details of the non-conformance are outlined, the problem statement was the oil drop. Table 1 shows the colour code table illustrating each section on the model, each section has been colour coded and explained accordingly on the table input data. The oil drop problem originated from Castline working station on the cooling zone, Figure 5, 6 and 7 illustrate the full details of non-conformance origin.

Table 1. Semi-automated model illustration

Input details	Colour code	Description
Non-conformance record number		A unique number for the raised nonconformance
Date		The date where nonconformance was raised
Operator name		The name of the person operating the machine
Origin of non-conformance		The details of nonconformance origin
Reel numbers		Each reel where the nonconformance is raised has a specific number for easy traceability
Item code		Each product has a unique item code
Person who found the non-conformance		Details of the quality inspector any due to the nonconformance raised
Quantity rejected		The person or department to handle the nonconformance
Issued to(The person to receive non-conformance)		Film type or product type
Design of the product(Clear, white or metallised film)		The name of the machine where the nonconformance originated
Machine		Classification of the defect issue whether it is a safety issue or engineering issue and specification if other
Classification of defect in terms of departments or area		Indication whether root cause analysis is required or not
Specification of root cause analysis if required		Full details of nonconformance raised
Full details of non-conformance		Specification of the test that was performed on the product
Test validation of the product from quality lab		

CORRECTIVE ACTION/PREVENTATIVE ACTION RCA FEEDBACK FORM - QA-F-44								
NCI	Non Conformance Record Number : (Alert Number if a Defect)	014/07/2020		Date:	27-Jul-2020	Operator Name	Felix	
	Origin of Non Conformance:	Castline		Reel Numbers	SPB200252286	Person who found the non	Thami	
	Item Code	SCL25-TT/A01		Issued to:	Castline Operator	Machine	SP1	
	Quantity Rejected	200.8KG(1 REEL)						
	Design	Clear						

Figure 5. Illustration of non-conformance details

<input type="checkbox"/> FOOD SAFETY	<input checked="" type="checkbox"/> BOPP LINE	<input type="checkbox"/> MATERIAL DAMAGE	<input type="checkbox"/> ROOT CAUSE ANALYSIS REQUIRED ? <input type="radio"/> Yes <input checked="" type="radio"/> No
<input type="checkbox"/> SLITTING DEFECT	<input type="checkbox"/> PACKING	<input type="checkbox"/> OTHER	
<input type="checkbox"/> METALLIZER DEFECT	<input type="checkbox"/> RAW MATERIAL	<input type="checkbox"/> SAFETY	

Figure 6. Illustration of non-conformance origin and specification whether analysis is required

If no Root Caused analysis is required, please give a reason)	
	
Details of Non-Conformance	
	Oil drop observed on the Jumbo roll 650mm from drive side.
Validity Of Non-Conformance complaint (If the Non-conformance is not visible (i.e. Strength of product) list the test/s conducted to determine validity thereof. (TO BE COMPLETED BY THE INVESTIGATOR)	
Test Done	Visual Inspection 

Figure 7. Illustration of details of non-conformance and validation tests for the product

4.2.4 Stage 2 - 5 Why analysis

Stage 2 is based on 5 Why analysis to investigate the reason for the problem. All the possible reasons of the 5 Why analysis were identified and it was found that the main reason of the oil droplets is inadequate cleaning procedure, Figure 8 illustrates a screenshot for the 5 Why analysis on the Microsoft Excel platform.

Validity Of Non-Conformance complaint (If the Non-conformance is not visible (i.e. Strength of product) list the test/s conducted to determine validity thereof. (TO BE COMPLETED BY THE INVESTIGATOR)	
Test Done	Visual Inspection 
Root Cause Analysis - (TO BE COMPLETED BY THE INVESTIGATOR)	
Why? 1	
Oil drop results from the cooling zone	
Why? 2	
Oil condensate and form small droplets during cooling process	
Why? 3	
The cleaning of cooling zone is done when there is a line stoppage	
Why? 4	
Why? 5	

Figure 8. Illustration of root cause analysis

4.2.5 Stage 3: Ishikawa analysis

Stage 3 is Ishikawa analysis, where the main reason derived from 5 Why analysis is classified into categories of Ishikawa to generate solutions for continuous improvement. Figure 9 illustrates the selection of Ishikawa elements whereby the analyst selects the categories from a dropdown menu.

Select from the following root causes associated with the above 5 Why analysis	
<input type="checkbox"/>	MAN
<input checked="" type="checkbox"/>	MACHINE
<input checked="" type="checkbox"/>	METHOD
<input type="checkbox"/>	MATERIAL
<input type="checkbox"/>	MEASUREMENT
<input checked="" type="checkbox"/>	ENVIRONMENT

Figure 9. Illustration of Ishikawa analysis

4.2.6 Stage 4: Risk analysis

Stage 4 is based on risk analysis of the problem. The measurements of the level of risk that characterise the defects in terms of how it affects the business in terms of product quality and quality of service delivery was carried out. The oil drops are likely to happen on the production line, the consequences are minor because once this defect is raised the solution is known. Figure 10, 11 and 12 illustrate the problem ratings.

Input details	Colour code	Description
Risk Identity(How many risks are found related to the defects)		Risk identity option, is for the total counts of risks that has risen from the nonconformance raised
Risk or the treat description		Risk or treat description, requires the user to specify what risks and treat could potentially happened due to the nonconformance that has occurred
Consequences of the defects towards the customer		Consequences of defects towards the customer, is the effect of the nonconformance that has occurred in terms of customer satisfaction
Likely hood of occurrences refers to the frequency of the defect		Likely hood of occurrences, is an evaluation of how likely the problem occur or the frequency occurrence
Consequence if the event occurs refers to the rate of the damage if the event occurs		Consequence if the event occurs is the rating related to the measurement of damage that has been done. For an example, the whole batch has to be rejected?
Likely hood dropdown list with automated values		Likely hood dropdown list is for the user to select likely hood option according to the defect nature
Consequences of the event dropdown list with automated values		is for the user to select consequence option according to the defect nature
Rating Rate (RR), is the product of likely hood of a defect occurrence and the consequence if the event occurs		Rating rate is calculated automatically, it is generated from the product of Likely hood and Consequences
Control, refers to the standards implemented to minimize risks of the defect to happen again		Control refers to nthe principles in place to prevent the event to happen again

Figure 10. Semi-automated model illustration

RISK ANALYSIS - What risk does this pose to the customer. Refer Sheet 2 for guidelines										
Risk ID	Risk/ Threat Description		Consequences		L	C	RR	Control		
1	Poor quality product		Poor service, late delivery to customers		Likely	Minor	8	Cleaning during line stoppage, checking the frequency of oil drop		
Likelihood of Occurrence Lookup Table					Consequence if Event Occurs Lookup Table					
Frequently	Likely	Moderate	Unlikely	Improbable	Insignificant	Minor	Moderate	Major	Catastrophic	
5	4	3	2	1	1	2	3	4	5	

Figure 11. Illustration of risks analysis rating

RISK ANALYSIS - What risk does this pose to the customer?										
Risk ID	Risk/ Threat Description		Consequences		L	C	RR	Control		
1	Oil drop can results to high defect rate		Increase of defect rate results top poor quality hence customers will not trust our product quality		Likely	Insignificant	4	Cleaning schedule has been created and the frequency has been increased		
Likelihood of Occurrence Lookup Table					Consequence if Event Occurs Lookup Table					
Frequentl y	Likel y	Moderat e	Unlikely	Improbabl e	Insignifican t	Mino r	Moderat e	Majo r	Catastroph i c	
5	4	3	2	1	1	2	3	4	5	

Figure 12. Illustration of risks analysis calculations

4.2.7 Stage 5 -Opportunities of improvement and correction

The last two slots of the model are opportunities for improvement from the defect, the action plan for improvement, implementation and the responsible person. The second slot is where an analyst log corrective action that should be taken when a problem is detected. Figure 13 illustrate opportunities of improvements and corrective action of the non-conformance raised.

Opportunities	Action Plan	Due Date	Responsible Person
Improvement on the cleaning procedure	Cleaning schedule has been drafted	13/03/2020	Shift section in charge
Correction (TO BE COMPLETED BY INVESTIGATOR) - What immediate Corrective action was taken to solve the problem?			
The roll was reworked and the cooling zone was cleaned			

Figure 13. Non-conformances evaluation of opportunities of improvements arising after corrective action

4.2.8 Stage 6: Communication

Stage 6 is communication whereby the analyst saves and sends the completed form. The form is sent automatically to the Total Quality management co-ordinator as illustrated in Figure 14.

Figure 14. Validation and transfer of the complete non-conformance investigation report

4.3 Discussion of post implementation results

The semi-automated model led to drastic improvement, hence smooth flow of non-conformance closure system which resulted in high rate of continual improvement implementation. The external audit was conducted in a case study company to evaluate the process for non-conformance closure, the major finding was closed. It was further evaluated that a smooth flow of triggers more opportunities of continual improvement. Hence the case study company went extra mile and used the semi-automated model as one of the tools to generate continual improvement, for adherence to the international standards and for creativity for competitive reasons. Figure 15 shows the status of non-conformance closure which indicates that non-conformances are continually closed and followed up according to the international standard requirements.

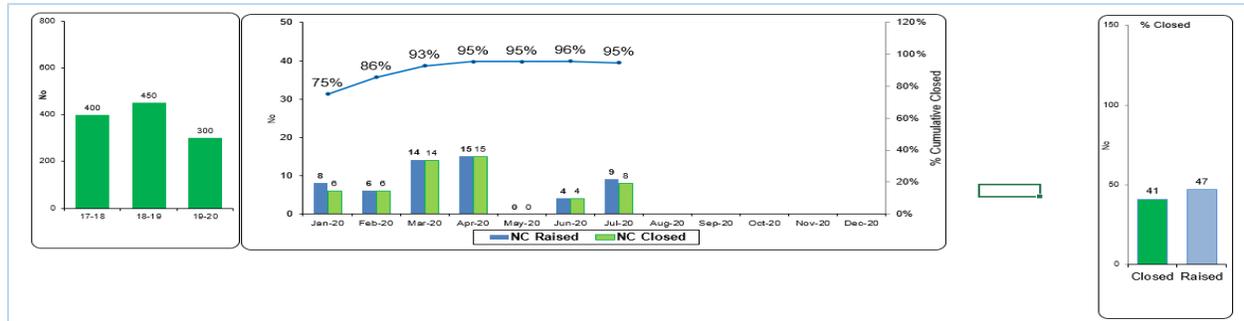


Figure 15. Non-conformance closure after implementing the semi-automated model

5. Conclusion

The smooth flow of a non-conformance closure system results in good compliance to international standards. Organisations are responsible for implementing systems that would accelerate the rate of Kaizen or system enhancement in order to remain competitive. An implementation of semi-automated model for non-conformance closure led to a high rate of continuous improvement in reduction of non-conformances for a case study company. It was concluded that effective troubleshooting process plays a big role in generating improvements and avoiding frequent occurrences of the same problem. The significance of this study is that the framework that has been developed in this study for the film packaging industry can be applied in control of non-conformances irrespective of the industry.

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Biographies

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