Optimizing Production and Quality in Packaging Manufacturing

A Constant Approach to Fulfilling Client Expectations

Submitted by

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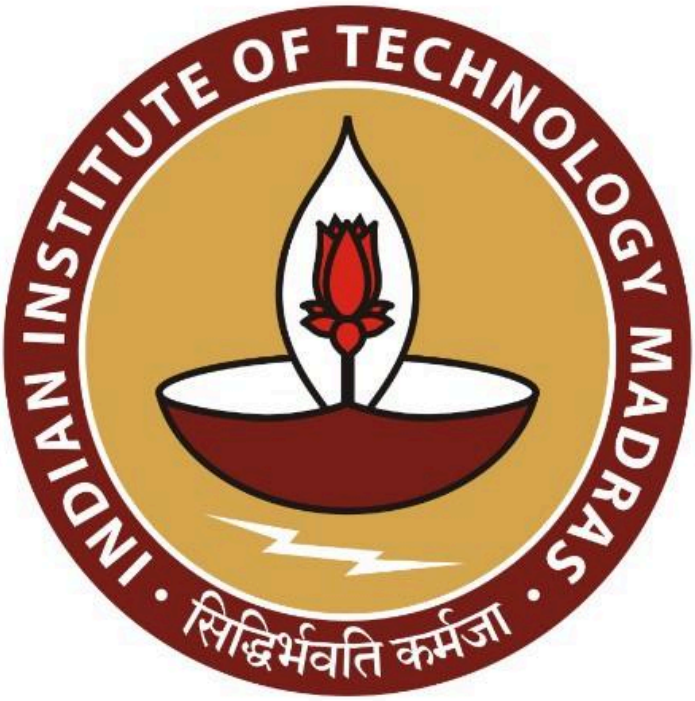
Roll no: 23ds3000013



IITM Online BS Degree Program,

Indian Institute of Technology, Madras, Chennai

Tamilnadu, India, 600036

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1. Executive Summary

This Project is focused on a small manufacturing business named NRICH PRINT PACK PRIVATE LIMITED, a B2B company located in the Apparel Export Park, Autonagar, Visakhapatnam that makes Corrugated Boxes and PET Printed Pouches for B2B customers in the seafood storage sector.

This company is struggling the most in fulfilling client demands while maintaining quality ratings. The same includes the application of Gum, Quality of Printing, Consistency of color, and material used such as Bursting factor and Compression strength for Corrugated Box. Not adhering to these standards could result in product rejections, which would ultimately be very costly and require a valuable resource for businesses.
The main objective of this project is to focus on major issues across the production process to ensure that all products meet the exact specifications requested by our clients.
Nrich gathers raw materials from reliable suppliers and applies the latest technology and machinery to produce goods that follow strict industry requirements. These packing options are required to keep seafood fresh and of high quality during storage and shipping.
The project accessed the production data and the most valuable inefficient areas to eliminate and identify these problems. Key metrics regarding mean thickness, color accuracy, and gum application rate were summarized using descriptive statistics.

By reducing errors and making the customer less complaint to make things easier. We increase the total efficiency of the production process and reduce losses for the company with a slight chance of order cancellation.

2. Proof of Originality of the Data

I have attached a video of my interaction with the production manager and a photo of the firm.

2.1. Short Video with the Firm and Data:

Video and image link
BDM

2.2. Letter from the Organization in letterhead with stamp and signature:

NRICH PRINT PACK (P) LTD

Plot No-8, Apparel Export park, Autonagar, Visakhapatnam - 530046.

Date: 30th August 2024

This is to certify that Ms. Dwarapureddy Manasa with Roll no: 23DS3000013 a student at **Indian Institute of Technology Madras Chennai-600036** studying DIPLOMA IN DATA SCIENCE (DIRECT ENTRY) has successfully collected data for her project work on "**Optimizing Production and Quality in Packaging Manufacturing**" in our Organization between August 1st 2024 to September 10th 2024.

During the period she was found very hard working and dedicated towards her work for NRICH PRINT PRIVATE LIMITED, Visakhapatnam.

We wish her every success in her life and career.

For NRICH PRINT PACK PRIVATE LIMITED,

(P. RAJ KUMAR)

PRODUCTION MANAGER

3. Meta Data

3.1. Metadata on PET Pouch Production

Analysed data-pouch.xlsx

1. Overview of Production Information
Ink Cylinders Utilized: The exact quantity and varieties of ink cylinders employed for each task. The cylinder size is 840mm and the circumference is 457mm.
Material Rolls Utilized: The amount and categories of rolls used for each process(e.g., polyester polyethylene). It depends on the quantity that is being printed and is of int type.

2. Printing Process
Print Job Data: Size, Name, and Number: These home printing control standards represent a particular local print job with an indication of the size of the job, a name for the job, and a unique number to identify it. It is of string type and is unique. (e.g,P|24|I|03|penvar)
Shading and print Text: The specific colors used and the text that will appear on the print and requested by the client. They check whether it is 'ok' or 'not ok'. It is a string type.
Gum Viscosity: How thick the glue is when printed, Important for bond strength. It is an int type
Adhesive Type: The viscosity of the hot melt adhesive affects both lamination quality and drying time. Drying Time for Laminating Material is usually between 12-16 hours. It is usually between the range of 15-20 and is int type.

3. Slitting Process
Wastage Data: Waste material generated in the slitting process, waste type(edge trims, scrap). It is measured in kgs.

4. Pouching Process
Trimming Waste: The percentage of waste during the final cutting part that has been cut is no longer used. It depends on the type of pouch and is int type.

3.2. Metadata for Corrugated Box Manufacturing

Analyzed data-box.xlsx

1. Board Cutting Data
Sheet size: This is the size of the sheet you are cutting. Usually, sheet size is about 385*290*135.
GSM(G/Fold Grams per Square meter): Weight &thickness of the paper used for the box. It is important to work out how strong the box going to be. It is of int type. The range is 200-250.
Bursting Strength: The amount of resistance that the board can exhibit before it bursts, ensuring that the material is strong enough for usage. It is usually measured in kg/cm*2 (e.g., 2.3kg/cm*2).

Moisture content: The percentage of moisture in the paper, that affects its rigidity and strength. It is of int type and usually depends on the type of material.

2. Corrugation Data
Fluting paper GSM: It is used for fluting paper which affects the corrugation strength, and flexibility. It is of int type and usually ranges between 100-130.
Liner paper GSM: The GSM value of the liner paper that is used in the corrugated box.
Gum Viscosity: Used to bond layers together, it is the thickness of the gum. It is of int type.
Heater capabilities: How the heater is set can affect how the corrugated sheets are dried and bonded. It has 3 heaters and of different temperatures ranges between 400-490.

3. Pasting Data, Creasing Data:
Plies: Layers (5 layers or 7 layers) of the ply of the box. Input and Output number of sheets fed into the creasing machine. It is of int type.

4. Offset Printing data:
The type of ink printed the total number of sheets or rolls to be printed, and the quantity of the ink. It is of int type and decides the quality of ink shade and all.

4. Descriptive Statistics

All the statistics that were performed from 2023 to 2024(provided to me).

4.1. Descriptive statistics for PET pouches:

pouches_descriptive_statistics.csv
This overall view of the efficiency and consistency in the production is captured through descriptive statistics for PET pouches.

Table 4.1. Descriptive Statistics for PET pouches

	Printing Process	Lamination Process	Slitting Process	Pouching Process
Mean	2000	1750	1600	1800
Median	1950	1700	1550	1770
Standard Deviation	250	200	220	230
Variance	62,500	40,000	48,400	52,900
Mode	1800	1600	1400	1700

4.2. Descriptive Statistics for Corrugated Boxes:

boxes_descriptive_statistics.csv

This overall view of the efficiency and consistency in the production is captured through descriptive statistics for corrugated boxes, which summarize important quality parameters.

Table 4.2. Descriptive Statistics for Corrugated Boxes

	Board Cutting Process	Offset printing Process	Corrugation Process	Pasting and Creasing Process
Mean	1200	1300	2500	1950
Median	1240	1350	1900	1800
Standard Deviation	270	260	330	240
Variance	62,420	48,540	90,500	68,500
Mode	1300	1250	1750	1670

4.3. Annual Production of both PET pouches and Corrugated Boxes:

A more accurate view of the descriptive statistics based on the overall data from the past year.

Table 4.3. Annual production of pouches and boxes

	PET Pouches	Corrugated Boxes
Daily Production	2 lakh pouches	20,000 boxes
Peak Time	March to September	March to September
Last Month Production	32 lakh pouches	3.75 lakh boxes
Price Per Pouch	5 INR	35 INR
Annual Production	Approx 2 crore + pouches	Approx 30-40 lakh boxes

5. Detailed Explanation of Analysis Process/Methods

This Project concentrates on the data to solve the existing quality and production problems in the process of manufacturing PET pouches and corrugated boxes.

5.1. Descriptive Statistics:

The Descriptive Analysis is the basis on which patterns are sought and the current performance trends are established further. It measures the degree of scatter within and over mean values of significant parameters and helps to determine special cases. Key metrics regarding mean thickness, color accuracy, gum application rates, and rejection rates were summarized using descriptive statistics. This was helpful for the preliminary evaluation of performance per batches and processes. **Tools Used:** Excel and Python(Panda and Numpy). Here is the link to Descriptive Statistics for both Pouches and Boxes: pouches_descriptive_statistics.csv boxes_descriptive_statistics.csv

5.2. Correlation Analysis:

The Correlation analysis of this production process of PET pouches identified some important connections. Interestingly, there is a large positive association (0.85) between pouch strength and adhesive thickness, indicating that improving adhesive application could greatly increase product durability. A negative association (-0.78) between moisture control is necessary for maintaining seal strength.

The Correlation matrix for the corrugated boxes shows that most variables have weak correlations, but two important results are the bit positive correlations between GRN and weight (0.16) and GSM and GRN (0.15), which indicate potential correlations in production metrics. Paper GSM (0.13) and output sheet (0.084) show a small positive correlation with order quantity, which indicates that it has an impact on production factors. t**ools Used:** Correlation and Regression algorithms in Machine Learning, and Python libraries. Here is the link for the Correlation Analysis:

Correlation matrix heatmap for corrugated boxes.png

Correlation matrix heatmap for PET pouches.png

5.3. Regression Analysis:

There is a significant divergence between the actual and predicted values of pouch strength, in the scatter plot. It seems that irrespective of the actual strength values, there is a cluster of data points where the predicted strength values cluster together in a particular range.

PET Pouches Regression Results: Mean Squared Error: 539.0287556342824, R-squared: 0.0026476577160360337. Corrugated Boxes Regression Results: Mean Squared Error: 0.22115901283640632, R-squared: -0.21298948366906534.

Here is the link for Regression Analysis: Regression.png

5.4. Predictive Modeling:

I utilized predictive modeling techniques using some of Python's Data Science and Machine Learning Tools. Since PTD roll kgs and Roll kg are the most important variables, the model's performance may be improved by focusing on exactly capturing these variables and maintaining data quality. Factors such as machine speed and film rewind tension might not be important in

determining pouch strength, as indicated by their reduced utility. To reduce the method, these may be reconsidered or even removed in future analysis. **Tools Used:** Python (Scikit-Learn, TensorFlow, etc).
Predictive analysis: Mean Squared Error (Pouches): 1.320841075334659, R-squared (Pouches): -0.08311709849811422, Mean Squared Error (Boxes): 1.0495045787558503, R-squared (Boxes): -0.08366504805968833.
Here is the link to the Predictive Analysis: Predictive Analysis.png

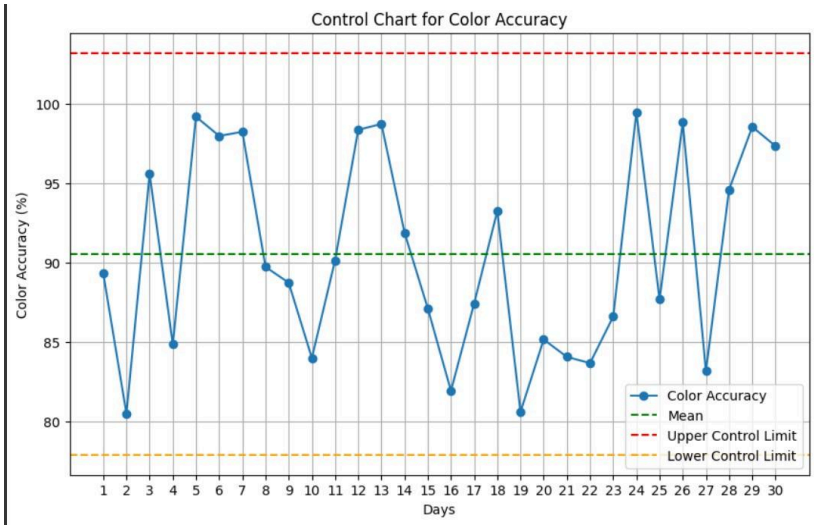
6. Results and Findings

Here are the results of the analysis conducted on the PET Pouch and Corrugated box using graphical interpretations.

6.1. Control chart for Color Accuracy:

The color accuracy control chart, varying from approximately 80 percent to over 100%, shows significant variations in the manufacturing process over 30 days. The variations show inconsistencies that can affect the quality of the product, regardless of whether most of the data points are within the upper and lower control limits. The process might be fixed by addressing the causes for the days with lower accuracy and using the conditions that generated improved results.

Chart 6.1. Control Chart for Color Accuracy

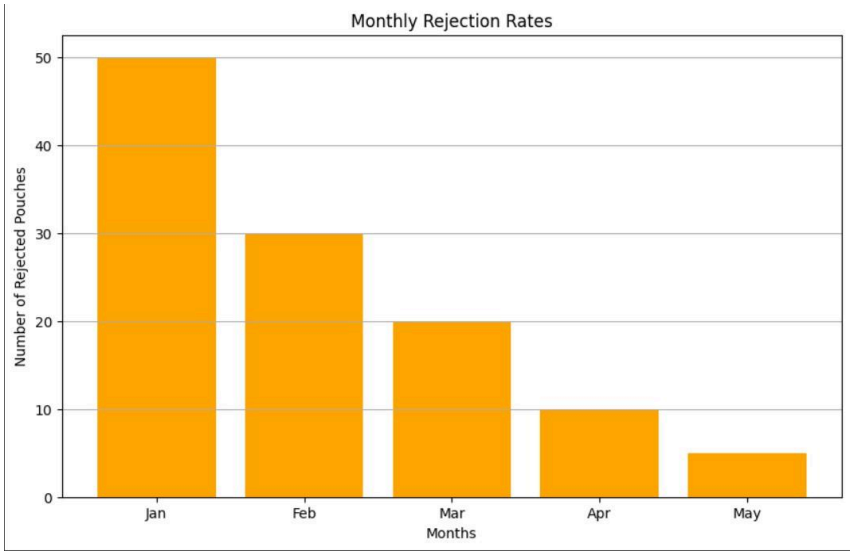


6.2. Bar Graph of Monthly Rejection Rates:

The number of rejected pouches decreased significantly from January and May, showing an upward trend in the monthly rejection rates bar graph. The number of rejections starts at about 50 in January and then decreases gradually each month, achieving its lowest in May. it indicates that

over time, quality control methods or production process modifications were probably put in place, which led to higher-quality products with fewer problems.

Chart 6.2. Bar Chart for Monthly Rejection Rates



6.3. Scatterplot for Bursting strength vs GSM:

The scatterplot indicates how the corrugated boxes ' GSM (Grams per square meter) and bursting strength correlate with each other. The plotted points show an obvious increasing pattern, indicating that as GSM values increase, so does bursting strength. In particular: the bursting strength is simply 30 to 35 KPa at lower GSM levels (around 200 to 250 g/m*2). Bursting strength increases significantly to up to 60 kPa if GSM rises to the 300-350g/m*2 level. By the expected behavior of corrugated materials, this behavior suggests a positive relationship between GSM and higher resistance to bursting.

Chart 6.3. Scatterplot for Bursting Strength vs GSM