

## Manufacturing of Paper Corrugated Packing Boxes

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**Abstract:** The paper corrugate boxes are popularly and extensively used for industrial and domestic goods packaging. These are of different sizes, thickness and strengths depending on the goods to be packed. Besides this a study in details if the cost and the wastage can be further curtailed is also one of the objectives. One more purpose of this project is to protect and enhance the eco friendliness and pollution free manufacturing process.

The manufacturing process involves a series of operations and the machines, tools and tackles used are user friendly and safe to handle. Sequence of process can be made easier by placing different machines & tools by a very meticulous work and motion study to avoid unnecessary wastage or over use of energy, time and manpower.

**Keywords:** *Corrugated packing, Thickness, Strength, Pollution and Machine*

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### I. INTRODUCTION

Corrugated box is a container most extensively applied in goods packaging and transporting. It is made from paper, and machine-shaped from corrugated box board with hollow structure. Since 1903 when corrugated box was first accepted by legal freight classification organizations as the containers for freight transportation, the application history of corrugated box has been over more than 100 years. Because of its light weight, low cost, ease of assembly and disassembly, good sealing performance, certain cushioning and anti-vibration ability and easy recovery and waste treatment, corrugated box is widely applied in various fields. In the dynamic competitive market the needs and expectations are always changing. It is very difficult to maintain and execute actions against other organizations. The process of an industry such as corrugated boxes production has to focus on ways to make more efficient processes in order to deliver high quality product while at the same time reducing costs. The organizational perspective is examined by focus on “who” performs the different tasks and how operators are related. Process manufacturing aims at extracting process knowledge from event logs, which may originate from all kinds of information systems. The event logs contain information about the start and completion of activities with reference to related context data (e.g. workers and resources). Process manufacturing is a very broad area both in terms of applications and techniques. The process mining methodology is also called as workflow mining methodology. This is been developed for filtering a structured process description from a set of real executions. This research paper provides an insight about corrugated boxes manufacturing industry, since not much work is done in this regard. Current research paper focuses on the applicability of process mining in the corrugated boxes manufacturing unit. Process mining can be applied for obtaining new approach related to organizational flows.

“Identification of organizational paths and the comparison between different workers to minimize the work load and the cost of production are the focal point”. The interaction between the workers can be calculated from the occurrence of handing over of work from one operator to another. The research paper describes a case study based on raw data of the corrugated boxes manufacturing unit, located in Nagpur. Raw data contains details about different size and thickness of corrugated boxes. The data has been recorded in the system to analyze the workers work flow. Application of Business Intelligence tools focuses on performance indicators such as the number of jobs to be performed i.e., manufacturing the particular size and thickness of boxes as per the requirements of the customers. Process mining looks “inside the process” at different abstraction levels. In the context of a corrugated box, unlike Business Intelligence tools, we are more concerned with the organizational paths followed by individual workers, where certain procedures are followed or not.

### II. CORRUGATED BOXES MANUFACTURING PROCESS

Overwhelming demand of the customer forces the manufacturer to manufacture very strong corrugated boxes in order to stand out in the competitive world. The boxes are made up of corrugated paperboard that is different from the rigid paper called as cardboard. The boxes are used to hold things to protect it from damaging and keeping it from leaking. Boxes are printed with important information on them about what is inside or how to carry or move them. It is carefully designed to insert, hold items in place so they won't spill or be damaged.

#### Steps in Box Building

Corrugating machine is designed to do continuous process which brings together three, five or seven sheets of paper to form single, double or triple wall corrugated board. Strong

boxes can be made from different layers like 3 layers or 5 layers of flutes. The first work is to mix dry corn starch with water and other chemicals and push it into the corrugators to spread on the corrugated medium as the layers of liner are added. A box can be made by the corrugated board on a sequence of connected machines called a corrugating line.

**1) Corrugation** -The corrugators are fed with reels of paper as shown in figure. The paper is hardened with heat and steam which is passed between corrugating rolls. This process gives the paper a flute shape (wavy layer) in the single facer. The roll of paper is pulled between a pair of gear like cylinders called corrugating rolls as shown in figure. This forms the paper into a series of particular waves. Glue is applied to the tips of the flutes on one side at the right places and the flute tips are pressed against a flat liner. This creates a corrugated board, i.e., a continuous sheet of flat paper with fluted paper glued to it. The corrugated board is so stiff that it cannot be rolled up; this is cut into flat sheets as per the required size to make the boxes which has been ordered. The corrugated board are then arranged and set aside so the glue can dry properly and after that it is sent to the next process.

**2) Printing** - A printing machine is used to print with bright colour ink. Use graphic designs for self supporting display feature like company name, logo, product information, etc.

**3) Die-Cutting** – Die cutting is used to cut or punch out the size and shape of corrugated paper desired

**4) Stitching** - Stitching is used to connect the lap and the end of the sheet of a corrugated container with a metal wire.

**5) Gluing** - Gluing is like stitching but resin adhesive is used instead of metal wire. Finally the packed or bundled boxes are ready for dispatch.



Horizontal Creasing

Vertical Creasing



Slotting

Stitching

### Quality Control

Quality assurance and quality check are the part and parcel of every sub stage of the process. The process starts with the supplier who supplies the Kraft paper which is used to make corrugated cardboard. Kraft paper should be smooth and strong. The main process starts from the corrugation where the paper is passed through the corrugators and is made into box boards. The individual boards are pulled from the heap and checked. The quality check measures the moisture in the liner and medium. In the manufacturing process, quality test is determined by ensuring the glue strength, bursting strength, compression, and highly accurate dimensions. The flatness of the box board is tested by warp test which assures that each board will travel easily through the machines. The workers run batches of box boards through the machines where individual boxes are pulled for quality check, i.e., for trimming, cutting, printing the colour, and bundling. In this section, we will see the applicability of process manufacturing in corrugated boxes manufacturing unit. The in-built information systems used in corrugated box manufacturing units need to provide an integrated package to assure about the different size, thickness and colour of the boxes along with minimum processing time with reduced work load. Researchers have selected leading corrugated boxes manufacturing unit located at Nagpur to showcase the applicability of process mining. Raw data contains information about the box size, thickness, flute type, colour, and quantity as recorded by the unit. In these logs, information is stored about activities as they are being executed. This information can include the times at which events were executed, who executed these events. The process mining has extracted event logs from the corrugated boxes manufacturing unit, where each event refers to a



Reel Decal Inventory

Printing



Corrugation

Gluing/Pasting

different process. The event logs will show the process dynamics. The log contains real world data about the corrugation box manufacturing process, where the applicability of process in manufacturing unit is portrayed. The log contains 4 cases and 58 different events to represent organizational flow process. The study is focused on the discovery part of process manufacturing.

#### Simple Random Sampling Methodology:

In a simple random sample ('SRS') of a given size, all such subsets of the frame are given an equal probability. Each element of the frame thus has an equal probability of selection: the frame is not subdivided or partitioned. Moreover, any given pair of elements has the same chance of selection as any other such pair (and similarly for triples, and so on). This minimizes the biased chance of sampling error and simplifies analysis of results. More than 95% surety is achieved in this method.

#### Systematic Sampling :

In this method, the first object of a sample is taken randomly and then a systematic pattern is followed to draw a sample from the lot. Though a bias is created but as the first object is random, it can serve the purpose.

#### Stratified Sampling :

Where the lot embraces a number of distinct categories, the frame can be organized by these categories into separate "strata." Each stratum is then sampled as an independent sub-lot; out of which individual sample can be randomly selected. There are several potential benefits to stratified sampling. A stratified sampling approach is most effective when three conditions are met

- Variability within strata are minimized
- Variability between strata are maximized
- The variables upon which the population is stratified are strongly correlated with the desired dependent variable.

The sample size, in this case, refers to the number of independent and dependent variables to be included in the survey.

#### Step 1: Base Sample-Size Calculation :

The appropriate sample size for a corrugated sheet boxes industry having man machine system is determined largely by three factors:

- Estimated prevalence of the variables of interest
- Desired level of confidence and
- Acceptable margin of error.

For a survey design based on a simple random sample, the sample size required can be calculated according to the following formula.

Formula:

$$n = \frac{t^2 \times p(1-p)}{m^2}$$

Description:

**n** = required sample size.

**t** = confidence level at 95% (standard value of 1.96)

**p** = estimated prevalence of variables of interest

**m** = margin of error at 5% (standard value of 0.05)

#### Example

In the corrugated sheet box industry having man machine system, it has been estimated that roughly 50% (0.5) of the variables i.e. independent variables in the manufacturing process has more effect on response i.e. dependent variables. Use of the standard values listed above provides the following calculation.

Calculation:

$$n = \frac{1.96^2 \times 0.5(1-0.5)}{.05^2}$$

$$n = \frac{3.8416 \times 0.25}{.0025}$$

$$n = \frac{0.9604}{0.0025}$$

$$n = 384.16 \sim 385$$

#### Step 2: Contingency

The sample is further increased by 5% to account for contingencies such as non-response or recording error.

#### Example

$$n + 5\% = 385 \times 1.05 = 404.25 \sim 405$$

#### Step 3: Distribution of Observations

Finally, the calculation result is rounded up to the closest number that matches well with the number of clusters (Two Products) to be studied.

Two products are studied. There is no statistically necessary reason to maintain exactly 2 products, and the number can be adjusted if there is a compelling motive for doing so.

#### Example

Final Sample Size: **N = 420 observations**

The final sample size (N) is then divided by the number of clusters (02) to determine the number of observations per product.

#### Example

$$N \div \text{no. clusters} = 420 \div 02 = 220 \text{ observations per product.}$$

### III. CONCLUSION

Process manufacturing is illustrated effectively using corrugated boxes manufacturing unit located at Nagpur. Data from nontrivial process of the corrugated boxes is pooled up into the organization process by organizational perspective. The data is analyzed using effective process manufacturing tools to obtain the results. The process manufacturing techniques enabled the researchers to obtain clear Simple Random Sampling and similar work group with Similar Simple Random Sampling methodologies. It is a scientific approach to analyze all the processes using event logs. Simple Random Sampling emphasizes that all the processes are interdependent and the participation of the workers must be the maximum.

Simple Random Sampling highlights the importance of the quality manager for the overall quality assurance and the quality control. Operator and Helper have scored maximum values highlighting their high workload. Manufacturing for Similar Simple Random Sampling clearly generates the minimum and maximum work flow for the workers. The results are as per the recorded information and the automated mined process which helps the operators and helpers for additional measures to improve the corrugated boxes process efficiently.

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