IMPROVISATION OF PRODUCTION METHOD OF CORRUGATED BOX MANUFACTURING MACHINE

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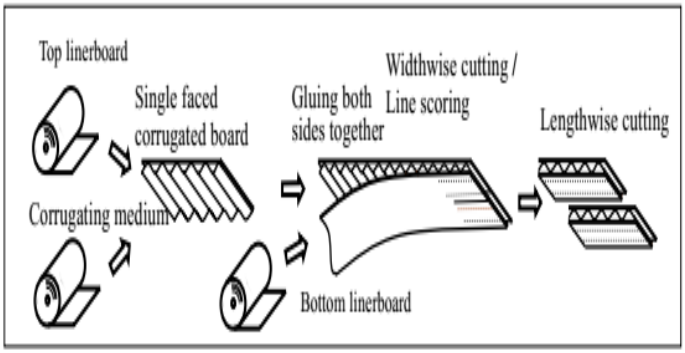
Abstract: The main aim of the project is to improvise the production system so as to improve the productivity and output from the machinery as well as efficiently reduce the time required for the production of corrugated box manufacturing machine As a part of Industrial Project under the syllabus prescribed for Mechanical Engineering, we as a group are working with collaboration of **SUN-UP (INDIA) Paper Board Machinery Pvt. Ltd.** The various types of machineries manufactured in the company include Corrugation Single Facer Fingerless Type, Corrugation Shaft less Mill Reel Stand, Corrugation Reel To Sheet Cutter 2 Ply, Corrugation Programmable Machines and Flexo Printing And Slotting Machine, Corrugation Box Making Machine, Corrugated Board Making Machine, Corrugation Machine, Dual Profile Paper Corrugation Machine, Single Facer Paper Corrugation Machine, Oblique Paper Corrugator, Bearing Mounted Corrugation Machine, Rotary Slotter, Folder Gluer, Semi-Automatic Folder Gluer, Automatic Folder Gluer, Die Punching Machinery.

The changes made in the production techniques tend to improve functionality, longer service life, easy installation, user-friendliness and robust construction thus ensuring proper optimality of resources, optimization of the production speed, cost, material, timing, as well as the prevention of the wastage of the raw material.

Index Terms: Corrugation, Corrugated box, Paperboard manufacturing, Corrugation roller, Corrugation Machine, Flutes, Cardboard Corrugation.

I. INTRODUCTION

Corrugation is the process of formation of parallel groves or ridges on a surface. A corrugator is a set of machines designed to bring together three, five or seven sheets of paper to form single, double or triple wall board in a continuous process. A corrugating medium is pressed into a wave-like shape (flutes), then is glued to both a top sheet and a bottom sheet of linerboard. The corrugatedboards are then dried, scored, cut and loaded.



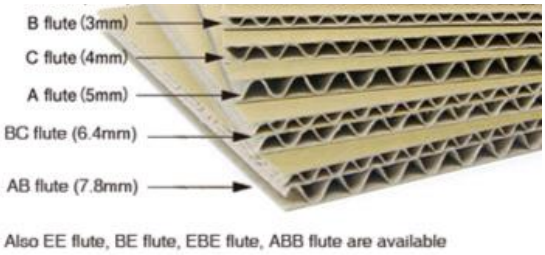


Fig. 2. Standard flute sizes

II. CORRUGATION ROLLER

Corrugation rollers are a set of geared or splined shafts fitted on a machine with a slight clearance between them so as to pass the cardboard paper medium through it. While passing through the rollers a series of parallel ridges is formed on the cardboard sheet. The rollers are generally manufactured in standard size of 52", however sizes also vary with respect to the dimensions and requirement of machinery.

Fig. 3. Rollers fitted on a FingerlessCorrugation Machine

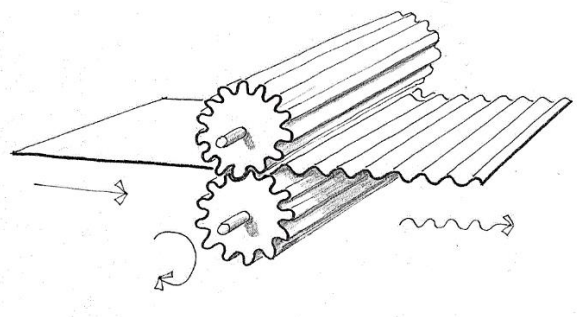


Fig. 4. Diagrammatic representation of corrugation.

III. Problem Statement

These rollers are generally manufactured by general manufacturing methods. The manufacturing of a single roller takes around 31-38

hours right from blank stage to final finished product by the use of old school techniques. This can also be calculated as 4-5 working shifts of the workers, working approx. 8 hours each shift every day.
It marked as a crucial process in the entire steps carried out in the production of system which consumed maximum time under the processes carried out in the company. This marked it as the most important process since the entire time could be drastically reduced if certain changes were found out and alterations were made in the production process of corrugation rollers.
The Corrugation rollers are important of the point of view that the quality of the cardboard depends on the quality of corrugation made, the time required for corrugation process, etc. This directly affects the productivity and the quality of the output from the machine.

IV. Primary Manufacturing Technique

The company used to rely on various old school techniques for manufacturing of rollers which included use of horizontal Milling machine and Hydraulic planer based on the sizes of the rollers required for different machines. The Hydraulic planer was the commonly used machine since the standard size of the roller is 52". The hydraulic planer is quite similar to the shaping machine, and has same working principle.

Fig. 5. Hydraulic Planer

In this process the roller blank is fitted on the machine bed using specially used attachments like spindle steady rests specially designed to hold the long roller blank while machining is done.
This process requires heavy alignment work using EOT since the rollers are made out of solid steel materials mostly EN18 and EN 19 grade. The process involves various processes like holding, loading, unloading, the setting of job on the machine requires high skill since the accuracy of alignment is essential part for use of many different job holding components working together followed by the heavy indexing mechanism similar to that used for manufacturing of gears over milling machine. The machining process consumes maximum time since the process is similar to shaping process and uses a formed tool which cuts one groove at a time and simultaneously cuts teeth over entire circumference. The formed tools of different sizes are required to obtain different flute sizes. However the tool life expectancy is very less due to heavy and constant use.
The process requires stringent measurement checks from time to time so as to avoid errors during indexing and wear and tear of formed tool as it may cause the changes in the size of ridges over the uniform surface of roller
The process may cause extensive cracks on the surface of rollers which may not be visible but ay disrupt the surface over a period of time after constant working after assembly on the machine also the surface finish obtained by this process is not up to the mark hence further processes like deburring and grinding are needed to be carried out. Hence quality control is also prime requirement for this process which needs highly qualified workers.
The overall cost for the entire production of rollers by this process sums up very high due to very high precision working and continuous human intervention. The time required in the entire process may take up from 31 hours to 38 hours which can be concluded as 3 to 4 working shifts of a same worker monitoring the manufacturing. The use of different worker joining at different shift may lead to errors due to lack of information regarding ongoing process or measurements.

V. Improvisation

The problems were identified and various techniques were studied so as to minimize the time along with the cost required for the production of rollers while on other hand improving the productivity, surface finish, and quality of product. The study resulted in the use of hobbing process since the corrugated rollers are similar to the gear but with an elongated lengths. Hence need arised for the use of specialized machine or specialized attachment over any conventional machine for the purpose. After submitting the proposal for abrupt changes in the system, the company observed the differences and decided to switch to the new method of production as it was found to be cost efficient over a long run, so a Special Purpose Machine (SPM) for long length hobbing was brought and the process was implemented.

VI. Corrugated Rollers using Hobbing Process

Hobbing is a machining process for gear cutting, cutting splines, and cutting sprockets on a hobbing machine, which is a special type of milling machine. The teeth or splines are progressively cut into the workpiece by a series of cuts made by a cutting tool called a hob. Compared to other gear forming processes it is relatively inexpensive but still quite accurate, thus it is used for a broad range of parts and quantities.
Hobbing uses a hobbing machine with two skew spindles, one mounted with a blank workpiece and the other with the hob. The angle between the hob's spindle (axis) and the work piece's spindle varies, depending on the type of product being produced. For example, if a spur gear is being produced, then the hob is angled equal to the helix angle of the hob; if a helical gear is being produced then the angle must be increased by the same amount as the helix angle of the helical gear. The two shafts are rotated at a proportional ratio, which determines the number of teeth on the blank; for example, for a single-threaded hob if the gear ratio is 40:1 the hob rotates 40 times to each turn of the blank, which produces 40 teeth in the blank. If the hob has multiple threads the speed ratio must be multiplied by the number of threads on the hob. The hob is then fed up into the workpiece until the correct tooth depth is obtained. Finally the hob is fed through the workpiece parallel to the blank's axis of rotation.

The *hob* is a cutting tool used to cut the teeth into the workpiece. It is cylindrical in shape withhelicalcutting teeth. These teeth have grooves that run the length of the hob, which aid in cutting and chipremoval. There are also special hobs designed for special gears such as the spline and sprocket gears.

Fig. 6. A Hobbing Tool mounted on a machine

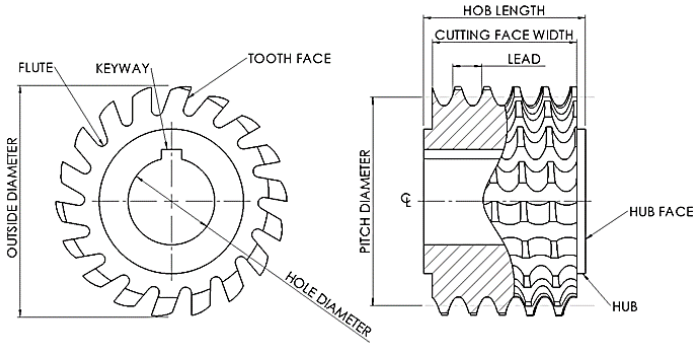


Fig. 7. Dimensional detail of a Hob

The cross-sectional shape of the hob teeth are almost the same shape as teeth of a rack gear that would be used with the finished product. There are slight changes to the shape for generating purposes, such as extending the hob's tooth length to create a clearance in the gear's roots. Each hob tooth is relieved on the back side to reduce friction. Most hobs are single-thread hobs, but double-, and triple-thread hobs increase production rates. The downside is that they are not as accurate as single-thread hobs. Depending on type of gear teeth to be cut, there are custom made hobs and general purpose hobs. Custom made hobs are different from other hobs as they are suited to make gears with modified tooth profile. The tooth profile is modified to add strength and reduce size and gear noise.

Fig. 8. Semi-automatic long length hobbing machine Make: WMW

The SPM for hobbing does not need different tools for holding, the rollers are held between the chuck at the head stock and the tail stock, it can be supported by some means in the centre if required in case of small flute sizes. Hence the alignment and holding is as simple as in case of a lathe machine. The machine being semi-automatic needs a simple adjustments for different feed rates

The gear teeth are cut simultaneously over the entire surface with the help of chuck and tool moving together at different speeds, thus entire roller is machined in a very short span of time. The hobbing tools can be purchased as per size requirement for cutting different types of flutes.

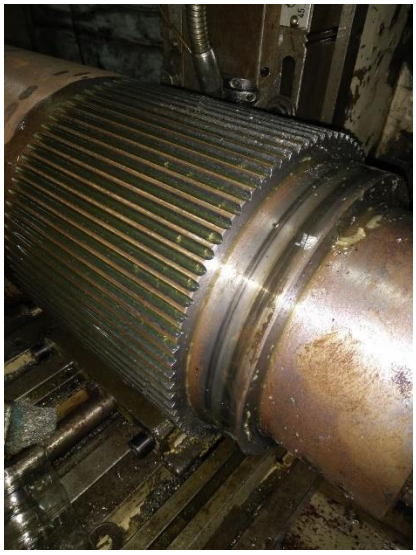


Fig. 9. Hobbing of corrugation roller uniformly over circumference in process

The constant speed ensures the proper surface finish thus reducing the post processes like deburring and surface grinding. The accuracy of measurements is high due to durable tools and hi speed processes, hence there is no necessity for time to time measurements and size checks. Although skilled workers are required for setting up the machine, the time required for production of the standard roller is very less as compared to primary process 21-24 hours, which means 2-3 working shifts would be sufficient for a standard size roller.
The improvisation causes reduction in many pre and post processes which in turn reduces the cost along with the time for production. The high surface finish also reduces the cost for process of hard chroming which provides a smooth finish and a lustrous surface, it provides less frictional surface and good quality of corrugation.

VII. Observations

Table 1. Process Time Chart for Hydraulic Planer

SR. NO.	PROCESS	TIME [IN HRS.]
1	TIME REQUIRED FOR LOADING THE JOB	0.5
2	TIME FOR SETTING ON MACHINE	0.5 - 1
3	TIME TAKEN FOR WORKING OR MACHINING	18 - 20
4	TIME REQUIRED FOR CLEANING	0.5 - 1
5	TIME TAKEN IN UNLOADING JOB FROM MACHINE	0.5
6	TIME TAKEN FOR METROLOGY & QUALITY CHECK	0.5 - 1
7	TOTAL TIME TAKEN	21 - 24

Table 2. Process Time Chart for Hobbing SPM

VIII. Conclusion

On comparison of both methods

1. Conventional process using hydraulic planner requires = **31 - 38 hours**
2. Whereas, improvised process implementing hobbing machine takes = **21-24 hours**
3. Thus the analysis of the working process of machineries and the production system, the time required for the production of the corrugation rollers was efficiently cut down by **10-14 hours**, saving a work time for entire work shift that can be utilised in other works thus improving productivity.

*All the comparisons have been made on the basis of manufacturing of standard 52" roller by both types of machining.

IX. About the Company

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XI. Author's Profile

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