Paper and Paperboard

Manufacturing and Converting Fundamentals

SECOND EDITION

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9 Corrugating Operations and Raw Materials

From the standpoint of the paper and paperboard industry, corrugating board is the largest single grade of paper produced, and remains a growing grade. The universal use of corrugated containers for shipping manufactured goods makes this grade one of the largest forms of packaging from the standpoint of the packaging industry also. Manufacture of the corrugated board is such that there are a large number of converting plants located throughout the country, close to the users of the containers. The paper for these corrugating plants is made at papermills located in the traditional regions near the forests and water.

The corrugating operation uses two types of product from the paper industry: *corrugating medium* and *linerboard*. The medium is the fluted or corrugated center layer of the board. Standard 26 lb/1,000ft² medium is made 0.009 in. thick, which causes it to be called 9 point board. The linerboard is the material used on the top and bottom of the sandwich. Corrugated board is made in a variety of forms. The most common, that which has two liners and the fluted medium, is known in the industry as *double face*. If there is only one liner, the product is known as *single face*. Single face is frequently used as a liner inside the container to help cushion bottles and other materials. If single face is glued to a double face so that liners are exposed on both faces, the product is called *double wall*. The double wall allows the use of two different-size flutes to give the box added quality. As shown in Figure 9.1, the flutes are made in four different sizes. The largest is A flute, which makes the board the thickest and gives the container the greatest stacking strength. The smaller flutes have greater puncture resistance. By combining both in a double-wall board, we can combine both properties in the container.

It is possible to glue more than two layers together, making more than a double-wall board. The resulting multiwall or multiple-layered material is extremely stiff for its weight and is used as reinforcing at corners to replace wood or can even be used to build skids or other structural pieces. These products are specialized and do not constitute a major portion of the corrugating business.

THE CORRUGATOR

The Single Facer

The first part of the corrugating machine is known as the *single facer*, since it is here that the medium is fluted and attached to the top liner, making single-face board.

Flute	Number of flutes[1] per Lineal foot	Lineal meter	Flute height[2] inch	mm
A	36	118	3/16	4.76
B	51	168	3/32	2.38
C	39-42	128-138	9/64	3.57
E	96	316	3/64	1.19

[1]Approximate
[2]Exclusive of liners

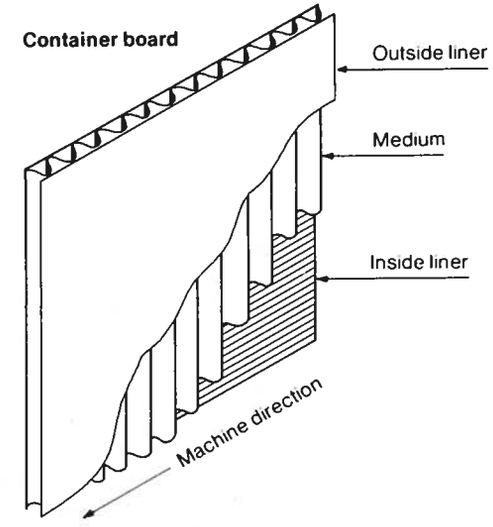


Figure 9.1. Corrugated board flute sizes (Source: Lowe 1975, p.100)

The operation can be divided into four basic sub-operations: (1) the unwinding and conditioning of the two webs, (2) the actual corrugating of the medium, (3) combining and gluing the two webs and finally (4) holding the single face in the bridge to allow the glue to set or dry.

The drawing in Figure 9.2 shows the medium being supplied from an unwind, which is under the part of the machine known as the *bridge*. The top liner is unwound from a position at the outside of the machine. The unwind stands are generally turret unwinds, which allow the use of flying splices so that the rolls can be changed without stopping the machine. Both webs may be passed around heated drums, to heat them before combining. Steam may also be used, especially on the medium to increase its flexibility. If the two webs are at greatly different temperatures or moisture contents before combining, the resultant structure will likely curl. Primary responsibility for the moisture content lies with the manufacturer of the webs, but small adjustments can be made on the machine.

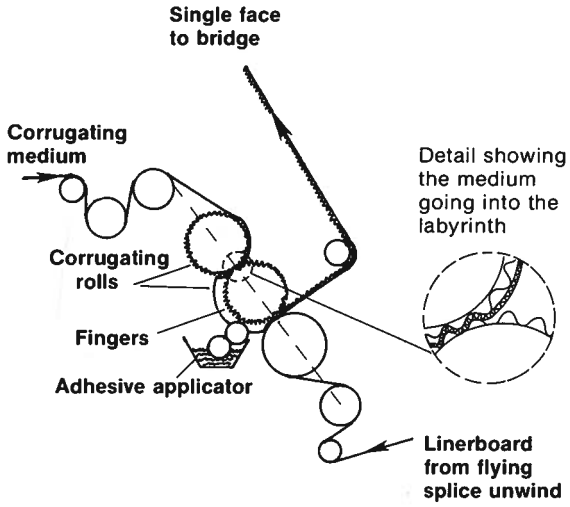


Figure 9.2. Details of single facer

The web to be corrugated is passed between two rolls with corrugated surfaces or intermeshing teeth all across their surface, which force the web into the fluted shape. The web must be made to hold this shape after it passes from these two rolls and the contorted space between them, called the *labyrinth*. As it enters the labyrinth, the web is sprayed with steam to heat and moisten it to make it more pliable. The corrugating rolls are heated to dry the web and make it hold its shape. The inclusion of wax and starch in the steam shower is purported to improve release from the rolls and help to stiffen the medium.

As the corrugated web passes from the labyrinth, it is held against one of the two rolls by a series of thin steel plates called *fingers*. Between these fingers is a set of rollers used to apply adhesive to the tops of the flutes. Before the fluted medium and the adhesive leave the corrugating roll, the top liner is pressed against the glued surfaces. The adhesive is a starch solution of the proper solids and composition to become sufficiently tacky in this short time to hold the two webs together as they pass up to the bridge. This adhesive is generally a mixture of starch granules and pasted or cooked starch in which the granules have been broken down. Higher levels of water resistance require a latex type adhesive and a top liner to which wet-strength resins have been added. As was noted earlier, the board is taken up to the bridge, where it is stored to give the adhesives time to dry and form a permanent bond.

The Double Backer

If double-face board is to be made, the single face produced by the operations just described must be glued to another liner. The back or bottom liner is unwound from a similar flying splice type unwind also found under the bridge. The bottom liner may also be sprayed with steam or heated to increase the similarity between

it and the rest of the assembly, to reduce the tendency to curl. As can be seen in Figure 9.3, the single face is brought from the bridge and adhesive applied to the tops of the exposed flutes. The pressure used in this nip must be controlled to ensure that the flutes are not crushed, but that all flutes receive enough adhesive to bond the board together. The top of the single face may also be sprayed with steam to help equalize the board moisture content and prevent curling.

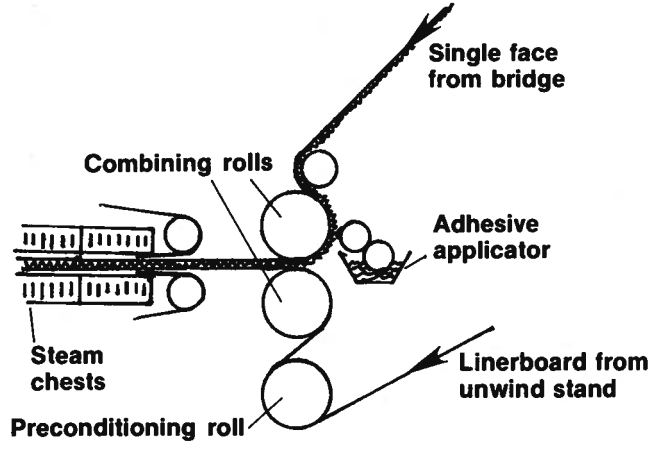
Shortly after the adhesive is applied to the single face, the back liner is brought into contact with it and the assembly is fed between two continuous belts into the steam chest. The adhesive used for this operation is similar to the first, but need not be capable of developing the quick or green tack, since these layers are held together under pressure and heat to dry and cure both glue lines. The pressure is sufficient to hold the layers together, but must not be so great as to crush the flutes.

To make double-wall board, another single facer, bridge and double backer gluing station would have to be installed on the machine. In fact, most corrugating machines are built with two sets of corrugating rolls and provision for making double-wall board. The addition of the second set of corrugating rolls has value other than just the manufacture of double wall. The two sets of rolls are generally in two different flute sizes, perhaps an A flute and a B flute. Both flutes combined in one double wall give it puncture and edgewise-compression resistance. The use of one size of flute at a time allows the manufacture of either of two different types of double face.

Conversion to Finished Blanks

After the board has been glued and cured into a continuous web of product coming from the drying or steam table, it must be cut into individual sheets, or *blanks*. The corrugated board cannot be wound onto a drum for further processing or it would become permanently curled. As the web comes from the steam chests, it

Figure 9.3. Details of double backer



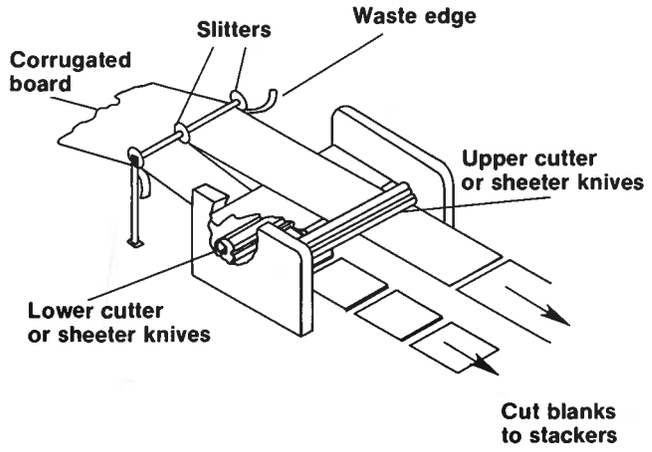


Figure 9.4. Trimmer-cutter details

first passes through a slitting and scoring operation as shown in Figure 9.4. This device has a series of sharp discs positioned above the web that can be lowered into the web to slit it into narrower webs. The slitter knives are movable to allow a variety of web widths to be cut. This device can also be used to score the board in the machine direction by replacing the sharp discs with non-cutting dull discs, which are pressed into the surface of the web. The webs are then cut into sheets by one of two sheeter knives. The machine is normally fitted with two sets of sheeter knives so that two different sheet lengths can be produced. The machine therefore also needs a layboy stacker to accept the cut blanks and stack them in piles of different-size sheets.

CONTAINERMAKING

The actual making of the corrugated board is an important component of the corrugating plant's work, but is by no means the total operation. The plant sells containers, not just corrugated board. The major portion of the plant is occupied by equipment to convert the blanks coming from the corrugator into containers, or some form of saleable package. Profitability of the operation relies on efficient use of the corrugator capacity and also on conversion of the board into printed, folded cartons. As the board comes from the corrugator, it is cut into rectangular blank sheets, which may be scored in the direction perpendicular to the corrugations. Since the maximum stacking strength is in the direction of the corrugations, that will be the vertical direction of the finished container. To be converted to a container, the sheets must be printed, cut and creased to form the folds and tabs that will be glued together to form the container. A large variety of machines are used and it is impossible to describe them all here. A few of the more popular devices will be discussed as examples of the common operations performed on corrugated board.

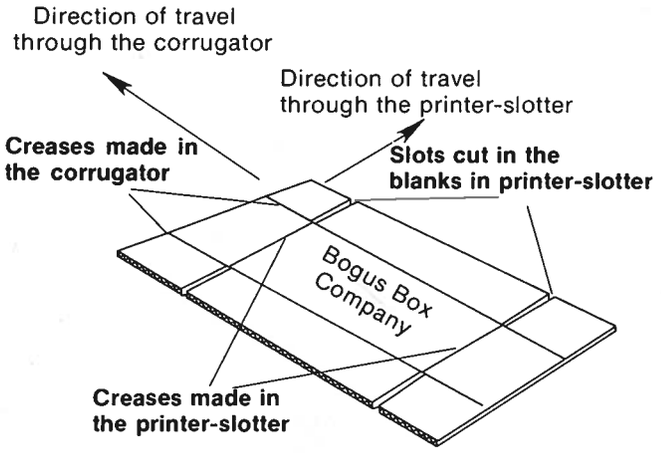
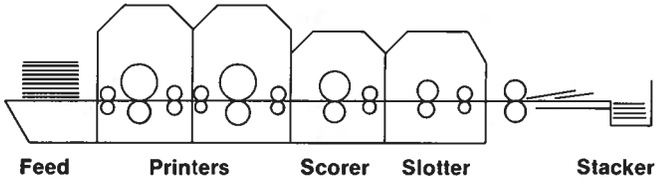


Figure 9.5. Corrugated container blank after printer-scorer-slotter

The Printer-Slotter

A printer-slotter is used to print the blanks and cut the tabs, but will not fold and glue the container. The printing is normally done with a flexible letterpress type plate, using a fairly oily ink of the letterpress type. The sheets are passed through the press in a direction perpendicular to the direction of travel in the corrugator, producing an unfolded container like the one shown in Figure 9.5. If the design of the container is proper, this press can produce a container ready to be folded and sealed. The sheet will have been scored in one direction in the corrugator; by going through this machine in another direction, as shown in Figure 9.6, it can be scored using a pair of rollers on either side of the blank, as shown in Figure 9.7. Small slots can also be cut to create the tabs needed to seal the container. The purchaser of the containers may want them shipped in this condition, intending to fold and seal them in his own plant, or the corrugating plant may need to do the job. The blanks can be folded manually or automatically, and the tabs attached by gluing, taping or stitching with staples. If the boxes are to be glued, the job is more likely to be done on a machine that can print, score, fold and glue all in one pass. Taping and stitching are generally done separately, as they are slower operations and not as readily adaptable to in-line operations.

Figure 9.6. Schematic of printer-scorer-slotter showing the sequence of operations performed on corrugated blanks



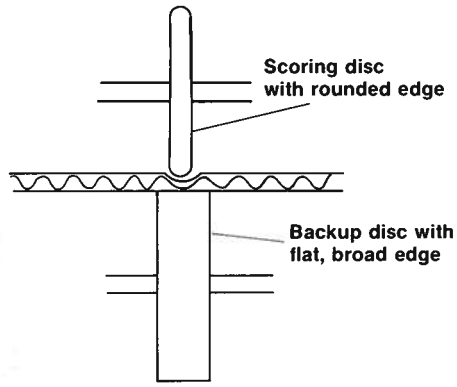


Figure 9.7. Scorer design

Diecutters

If the container design is more complex—requiring slots in both directions, at many different places and at angles to the edges of the sheets or requiring punch-out windows—the container must be cut differently. A diecutter uses a curved diecutting plate, with sharp knives and dull scoring blades extending from its surface. The diecutter may also have attached or in-line printing stations to allow blank sheets to be printed and diecut in one pass. The blanks still require folding and sealing in a separate operation. Depending on the complexity of the folding operation, the folding may be done in a machine or manually, as in the case of store display stands.

Printer-Slotter-Folder

Printer-slotter-folders have become quite complex and sophisticated. Sheets from the corrugator are loaded into one end and finished containers are delivered to skids and perhaps even wrapped and sealed for shipment on the other end. The streamlined, efficient operation of this machine makes it the preferred boxmaking machine, and the most profitable to operate. Designs are fairly flexible, but still limited to scoring and tab-cutting in the direction of the flutes, or perpendicular to the score made on the corrugator.

Printing is accomplished with flexo presses using water-based inks. The press may print up to four colors, although most are equipped for only two or three. The brown color of the container is not well suited to four-color printing, but by properly selecting the colors, some interesting graphics can be created. The flexo plates are stapled to a wooden printing plate cylinder, and can be changed rapidly when jobs are changed. The ink is pumped up to the printing unit from a 5-gal pail set on the floor next to the machine and can also be changed rapidly. The flexo printers use the anilox roll modification and are capable of halftones of fairly good quality. The use of flexo allows the plate to be pressed against the board, conforming to its rough surface, with little danger of crushing the flutes.

The slotter-scorer section has recently gone through a major advance in automated setup to allow faster changeover from one order to another. The scorers are dull discs attached to a shaft above the board, as shown in Figure 9.7, and the slotters are U-shaped dies, which also are attached to a shaft above the board, as shown in Figure 9.8. The slotters and scorers need to be positioned at the right places from side to side on the machine, and the slotters also have to be placed at the proper location with respect to the horizontal travel of the blank through the machine. The positioning is a slow, critical and painstaking task to accomplish by hand. The operator must individually measure and set all slotters and scorers in what is believed to be the right place. A few sample blanks are then sent through, measured and the settings corrected if needed. The newer machines are equipped with servo-motors that can position the scorers and cutters. The position of each device can be dialed in or fed to the controller by card, the devices automatically positioned and the sample blanks run. It may still be necessary to make minor adjustments, but they also can be dialed in and made by the servo-motors. Since most plants operate on small orders requiring frequent changes and must deliver in a hurry, these advances are most helpful.

The printed, scored and slotted blank is now ready to be folded and glued. The adhesive is normally a latex type, which can be applied by rollers or, more frequently, sprayed onto the tabs as they pass through the machine and under the spray heads. The positioning and timing of the spray are adjustable and can be automated. The tabs are folded and pressed into position by metal tabs and rollers. The folded container is generally fed between belts, where it is held closed briefly, allowing the adhesive to set. The container is also fed to a stacker, which keeps it closed until it can be loaded on the skid. More advanced machines collect, count and position the stacks on the skid and prepare the skid for banding, wrapping and shipping.

Figure 9.8. Slotter design