CHAPTER 2

CORRUGATED FIBREBOARD

Corrugated fibreboard is composed of at least two or three kraft papers, i.e. one or two linerboard(s) and one corrugated medium, as shown in Figure 2.1.

Corrugated fibreboard is normally used as packaging for protecting purpose. Generally, there are three major types of corrugated fibreboard : single-wall, double-wall and triple-wall corrugated fibreboards.

DEFINITION

1. Corrugated Fibreboard. A combined board that consists essentially of two or more flatten parallel linerboards with one or two medium(s) between them. The combined board is held together with adhesive applied to the creats of the flutes.

2. Linerboard or Liner or Facing. A flatten kraft paper with which is adhered medium (see Figure 2.1).

3. Corrugating Medium. A flute-making paper sheet.

4. Flute or Corrugation. Arch of corrugated medium, it is for today classified into four major types : A-flute, B-flute, C-flute and E-flute which are mentioned in another section.

5. Corrugated Medium or Medium. Paperboard which is fluted and used as central part of corrugated fibreboard (see Figure 2.1).

6. Single-Faced Board. A simple combined board which consists of a liner and a medium, as illustrated in Figure 2.2.

7. Single-Wall or Double-Faced Corrugated Fibreboard. A combined board which consists of two liners and one medium, as illustrated in Figure 2.3.

8. Double-Wall Corrugated Fibreboard. A combined board which consists of three liners and two mediums, as illustrated in Figure 2.4.

9. Triple-Wall Corrugated Fibreboard. A combined board which consists of four liners and three mediums, as illustrated in Figure 2.5.

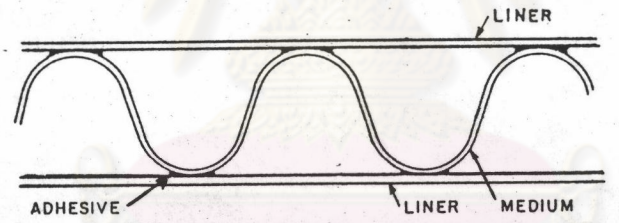

Figure 2.1 Basic Structure of Corrugated Board

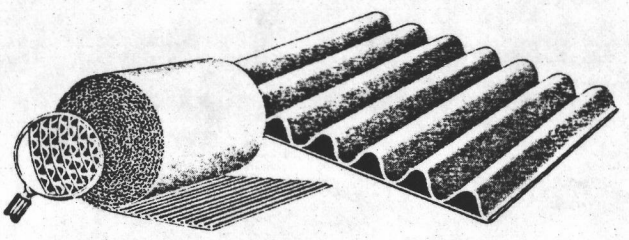

Figure 2.2 Single-Faced Board

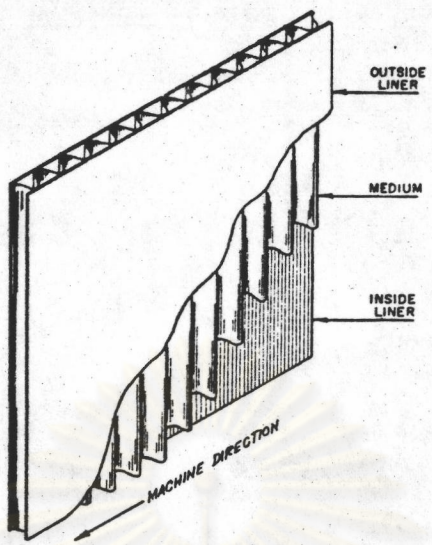

Figure 2.3 Single-Wall Board

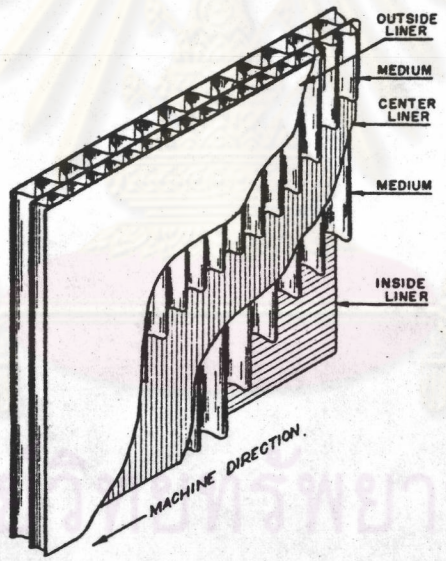

Figure 2.4 Double-Wall Board

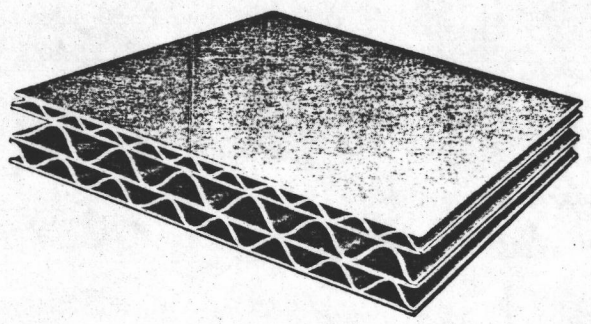

Figure 2.5 Triple-Wall Board

10.Basis Weight. Weight of paper sheet, excluding other components such as glue, coating materials, etc., in g/m^2.

Basis weight of medium, used in Thailand, is in the region of 115 to 135[14] g/m^2 and of 125 to 335[13] g/m^2 for linerboards (Appendix B).

11.Thickness. The height of corrugated fibreboard including the facings.

12.Take-Up Factor or Take-Up Ratio. It is composed of two factors relating the linear footage of linerboard to the linear footage of flatten fluting medium.

Take-up factors are shown in Table 2.1.

Table 2.1 : Flute Types and Take-Up Factors, Used in The Siam Kraft Paper Co., Ltd.

Flute	Flutes per metre	Flute height inclusive of facings	Take-up factor
A	115-121	5.10	1.52
C	135-141	4.10	1.48
B	164-171	3.00	1.36
E*)	-	-	-

Remark : *) not manufactured at present

Source : The Siam Kraft Paper Co., Ltd.

13.Bursting Strength or Mullen Test Value. The ability of corrugated fibreboard to resist the pressure, to which is uniformly applied, until it bursts or ruptures. Bursting values are reported

as kg./cm^2., lb./in^2. or KPa.

14.Puncture Resistance. The puncture test is a measurement of the energy required to force a puncture head, which has the shape of a right-angle triangular pyramid, of designated size and shape completely through a sample sheet of corrugated fibreboard to be tested. Puncture values are reported as puncture units, as inch ounces per inch of tear, as joule, or as kg.cm.

15.Flat Crush Resistance. The ability of corrugated fibreboard to resist force which is perpendicularly applied to the flutes until the flutes collapse. Flat crush resistance is expressed in N , KPa , kg./cm^2 , or lb./$in.^2$

16.Ring Crush Resistance (RCT). The ability of paperboard to resist force which is applied in the same direction of paperboard plane until it collapses. The RCT values are reported as N , kg·f or lb·f.

17.Concora Medium Test (CMT). The ability of corrugated medium to resist force which is perpendicularly applied to the flutes until the flutes collapse. The CMT values are reported as N , kg·f or lb·f.

18.Edgewise Crush Resistance (ECT). The ability of corrugated fibreboard to resist force which is applied in the same direction of the flutes' alignment until the board collapses. The ECT values are reported as N/m , kg·f or lb·f.

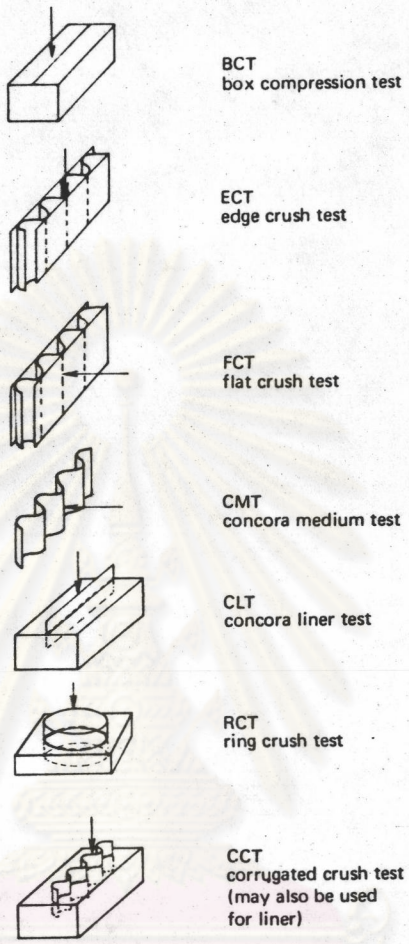

Figure 2.6 : Various Crush Tests Used.

CLASSIFICATION AND STRUCTURE OF CORRUGATED FIBREBOARD.

1. Types and Configuration of Flutes.

There are four major flute types used in the industries as following.

1.1 A-Flute. The height of flute is in the region of 4.25 to 4.75 mm. and of 115 to 125 flutes per metre for the number of flutes per unit of length.

1.2 B-Flute. The height of flute is in the region of 2.15 to 2.65 mm. and of 165 to 175 flutes per metre for the number of flutes per unit of length.

1.3 C-Flute. The height of flute is in the region of 3.35 to 3.85 mm. and of 135 to 145 flutes per metre for the number of flutes per unit of length. Properties and characteristics of C-flute are between A-flute and B-flute.

1.4 E-Flute (or F-Flute, called in Canada). It is the finest flute. The height of flute is in the region of 0.95 to 1.45 mm. and of 300 to 320 flutes per metre for the number of flutes per unit of length. However, E-flute board is used in certain industry in Thailand.

The types and configuration of flutes are shown in Table 2.2.

Apart from those mentioned above, some special designed flutes such as jumbo, or K-flute can be found in specific area.

Table 2.2 : Flute Types Follows TIS.

Flute	Flutes per metre	Flute height exclusive of facings(mm.)
A	115-I25	4.25-4.75
C	135-145	3.35-3.85
B	165-175	2.15-2.65
E	300-320	0.95-1.45

Source : TISI. (Thai Industrial Standards Institute).

MANUFACTURING PROCESS.[1]

The major components of a corrugator machine are single facer(s), mill roll stands, preheaters for linerboards, preconditions for medium, bridge, glue machine, double-facer or double-backer, slitter-scorer, cutoff and sheet delivery and takeoff.

However, the corrugator machine can be divided into two major sections : single facer and double facer (or double backer).

In single facer section, single-faced board is produced. The corrugating medium is passed into the corrugating rolls, then the tips of the flutes are coated with adhesive from a glue roll. The linerboard is passed and is stuck to the flute tips to make sigle-faced board, which is transferred on a bridge to the double facer section where the single-wall, double-wall or triple-wall corrugated fibreboard is made by adding another linerboard to one, two or three single-faced board(s), respectively (see Figures 2.7-2.9).

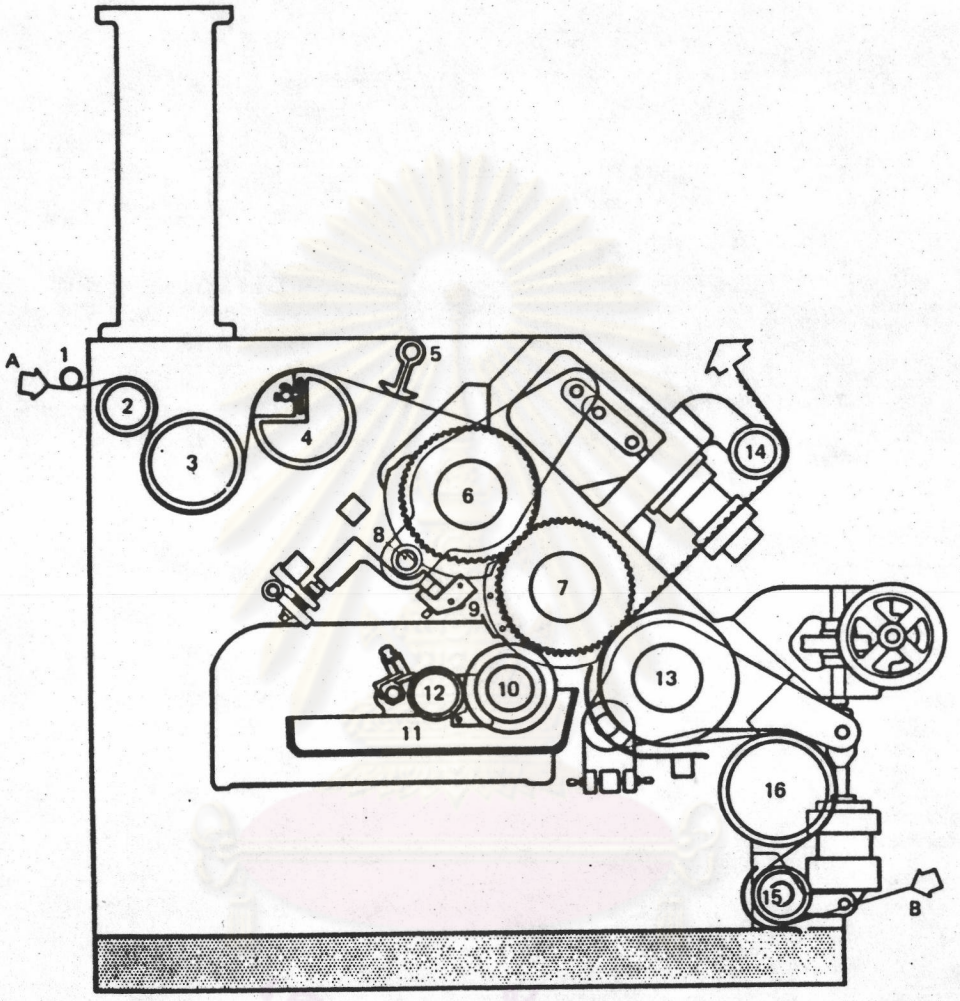

Figure 2.7 SINGLE FACER OPERATION
Outside certain differences in manufacturing features single facers work on generally the same principles. This description may therefore be considered representative of the operation of a heavy-duty unit. Linerboard from the mill-roll stand enters the single facer at **B** and fluting medium at **A**. Fluting medium moves under an adjustable spreader bar or curved bow roll, (1) that prevents sheet-slackness and wrinkles, as the web enters the single facer. It then travels over an idler roll (2), where it can be trimmed by a slitter (not indicated) and under a pre-heater roll (3) onto a Gaylord or pocket-type combination preheater and steamer, which "steams" the bottom side of the medium (4). From here the web passes under a pressure-type steam shower (for top-side steaming) (5) and into the nip of the top and bottom (driven) corrugating rolls (6, 7)—the labyrinth. Fluting of the medium takes place here, and is otherwise referred to as "corrugating". The now fluted medium is stripped from the upper corrugating roll and finger guides hold the medium into the flutes of the bottom roll and also guide it between the bottom roll and the glue applicator roll (8, 9). The glue applicator (10) picks up excess glue from a pan (11), the amount being controlled by a doctor roll with a micrometer remote adjustment (12) using a rubber doctor blade (scraper).

The fluted medium with glue applied to the flute tips is now guided to meet linerboard entering from **B** roller guide (15) and over preheater roll (16) and around pressure roll (13).

The two components **A** and **B** are joined together as they pass between bottom corrugating roll and the pressure roll. This combination produces single-face corrugated board which then passes out of the single facer machine unit and around an idler deflector roll (14) to be transported away by an elevating sandwich conveyor to the overhead bridge.

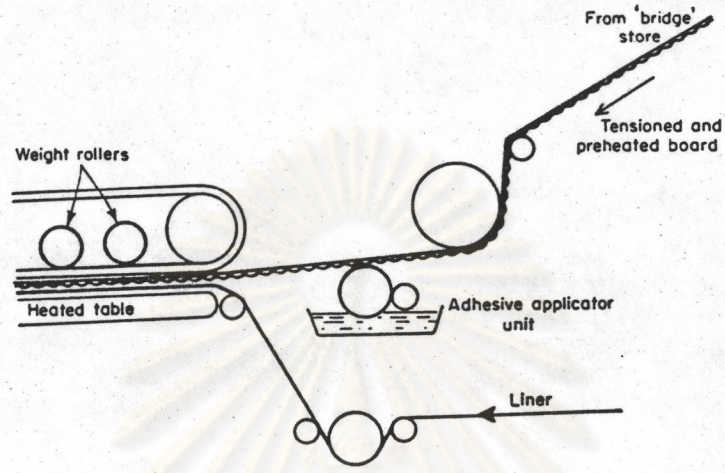

Figure 2.8 The Double Backer

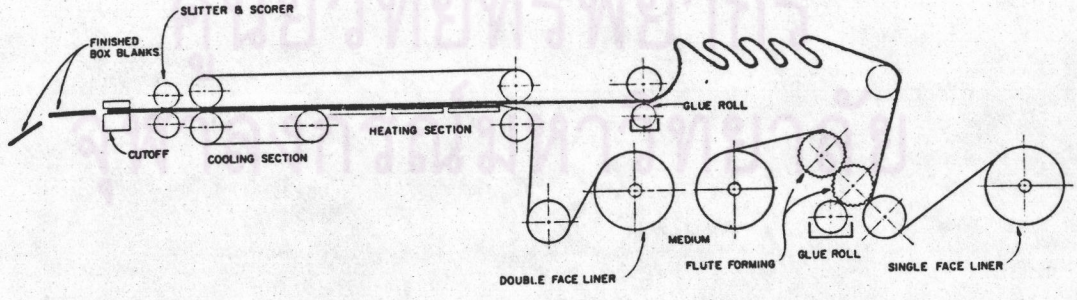

Figure 2.9 Schematic Drawing of the Basic Principle of Corrugating

PROPERTIES OF CORRUGATED FIBREBOARD

1. Flat Crush Resistance.

Flute type is closely related to cushioning ability and the resistance of the corrugated fibreboard to crushing compressive forces. Owing to the arched structure and the engineering principles involved, E-flute, having a greater number of flutes per footage, can support respectively a greater weight than B, C or A-flute when weight is applied, as illustrated in Figure 2.10.

However, laboratory tests have shown that flutes in double-wall and triple-wall corrugated fibreboards generally collapse consecutively or simultaneously. In the former, the flutes having the lowest resistance collapse first. In the latter, the flutes may have approximately the same resistance.

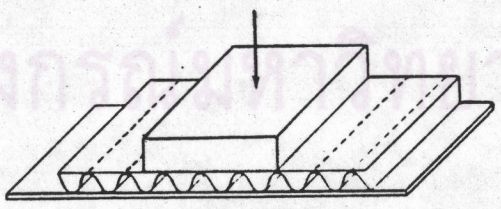

Figure 2.10 Flat Crush Resistance.

2. Edgewise Crush Resistance.

Generally, the flutes are aligned vertically, but rarely horizontally. Flute type and direction are extremely important in so far as the durability and stacking characteristics of a corrugated fibreboard box are concerned.

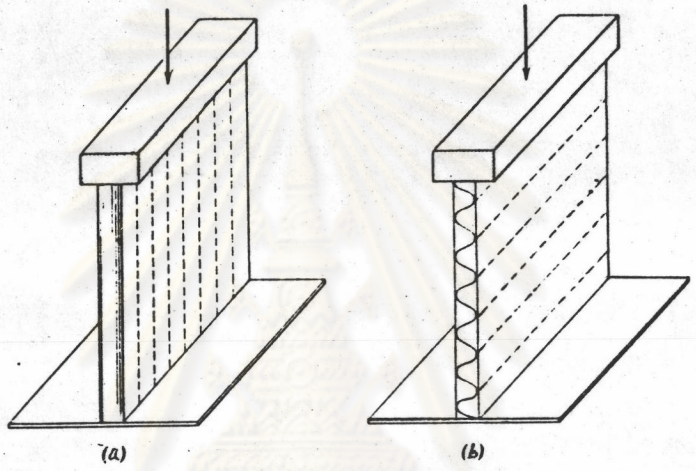

Figure 2.11 Force Application to Corrugations.

2.1 Vertical Corrugations. According to the columnar engineering principles, A-flute, having the largest columns, can support a greater weight than C, B and E-flute, respectively, when weight or force is applied in the direction illustrated in Figure 2.11 (a).

2.2 Horizontal Corrugations. E-flute can support respectively a greater weight than B, C and A-flute, if the weight or force is applied in the direction illustrated in Figure 2.11 (b).

Table 2.3 shows the properties of flat crush resistance, edgewise crush resistance in vertical and in horizontal of

each type of flutes.

Table 2.3 : Mechanical Properties of Each Type of Flutes.

Flutes	Flat crush resistance	Edgewise crush resistance	
		Vertical	Horizontal
A	Poor	Very good	Poor
C	Fair	Good	Fair
B	Good	Fair	Good
E	Very good	Poor	Very good

3. Puncture Resistance. Puncture resistance is influenced by flute height, A-flute has a greater puncture resistance than C, B and E-flute.

At present, puncture resistance is not exactly standardize assigned for the requirement. However, assigning the minimum requirement of puncture resistance for triple-wall board is shown in Table 2.4.

4. Bursting Strength. The most commonly used method of grading fibreboard is bursting strength. Generally, bursting test values depend upon the combined weight of facing materials used. It is believed that the type of flute or the basis weight of medium has little influence on the bursting strength.

In practice, the corrugated fibreboard is tested for either bursting value or puncture value. The former is preferred for single wall and double wall, the latter is preferred for triple wall.

Table 2.4 : Fibreboard Shipping Container Conversion Table Showing Section 3 Rule 41 Uniform Freight Classification, U.S.A.

Maximum weight of box and contents		Maximum inside dimensions (length, width and depth added)		Single wall				Double wall				Triple wall			
				Minimum combined weight of board		Minimum burst of comined board		Minimum combined weight of facings including centre facing		Minimum burst of combined board		Minimum combined weight of facings including centre facing		Minimum puncture test of combined board	
lb	kg	in	cm	lb/1000 ft^2	g/m^2	psi	kg/cm^2	lb/1000 ft^2	g/m^2	psi	kg/cm^2	lb/1000 ft^2	g/m^2	in.oz./ in.of tear *)	kg.cm
20	9.1	40	102	52	254	125	8.8								
40	18.1	60	152	75	366	175	12.3								
65	29.5	75	191	84	410	200	14.1	92	449	200	14.1				
90	40.8	90	229	138	674	275	19.3	117	557	275	19.3				
120	54.4	100	254	180	879	350	24.6	153	745	350	24.6				
140	63.5	110	279					222	1084	500	35.1				
160	72.6	120	305					270	1318	600	42.2				
275	124.7	120	305									264	1289	1100	336

Remark *) 1 inch ounces/inch of tear = 0.30545 kg.cm

Source : Robert R.A. Higham, A Handbook of Paperboard and Board, vol.2 : Technology of Conversion and Usage. (London, Great Britain, 1971.), p.180

USES OF CORRUGATED FIBREBOARD.

A-flute has a good edgewise crush resistance and has the best cushioning property because of its greatest columns and thickness, therefore, A-flute board is the advantage to use when cushioning is desired. A-flute has a great puncture resistance, as well.

However, as its fewest flutes per linear footage, A-flute board has the lowest flat crush resistance. This makes A-flute board the most susceptible to fabrication damage in the manufacturing operation and the most easily damaged in handling. As its greater thickness, A-flute board does not fold or crease as readily as B or C-flute, therefore, the inside dimensions are the poorest control of the three common flutes.

B-flute has the most flutes per linear footage, therefore, B-flute board has the highest flat crush resistance (except for E-flute, for the reasons stated above). B-flute board is preferred for canned products boxes. B-flute board also gives a good looking of printing surface. As its lower thickness giving a better control of inside dimensions, and as its highest flat crush resistance making B-flute board the most resistance to fabrication and handling damage. However, B-flute board has the poorest edgewise crush resistance, therefore, it is suitable for self-supporting products package.

C-flute which its properties and characteristics are between A and B-flute. Today, C-flute is increasingly used for packaging.

Double-wall and Triple-wall corrugated fibreboards are used when greater strength or cushioning than that provided by single-

wall corrugated fibreboard is required. They are used as container for larger and weighty products, such as machinery or electrical appliances.