

Understanding the Mckee Formula for Corrugated Box Compression Test



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Abstract:

The title of kraft to the paper is given due to its intrinsic strength as 'Kraft' means 'Strength'. The kraft paper shows its strength against the different types of external stresses like bursting / compressive stresses etc. Therefore, the kraft paper comes out to be an ideal solution for packing the material and to transport without damaging the packed material against different stresses during loading, unloading & in transport.

A scientific approach governs structural design of corrugated box for which the Ring Crush strength of both, the liner paper and flute paper, works like building block of the compressive strength of the box. Mckee formula is used to predict / design for the Box Compression strength of the corrugated board.

In this content, we are going to discuss only about the RCT, ECT and BCT with an approach to understand Mckee Formula. There may be several other parameters which may be critical to quality factors (CTQ factors) affecting the strength of corrugated box but these are out of the scope of this content.

Keywords: Kraft - Strength , RCT-Ring Crush Test, CTQ, Thickness, Orientation

Introduction

Corrugated board consists of 2 major components, (1) Liner and (2) Medium Flute [Ref. 2]

The liner paper is the outer and flat surface

(Fig. 1). The inner part medium/flute is a wavy type structured paper and it is for absorbing shock / impulsive stresses. The composite strength of the carton is a function of strength of liner paper, medium paper and also of the design parameters.

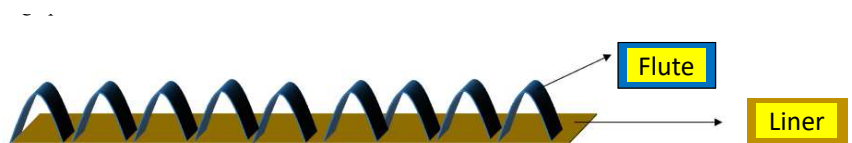


Fig. 1 Liner and the medium

There are some quality tests to be performed for examining the feasibility of performance in real time. Few of them are as:

1. Burst factor/ Burst Strength
2. Ring Crush Test (RCT) /Edge Crush Test (ECT)
3. Box Crush Test (BCT)
4. Water absorbency – Cobb

(The discussion is restricted to RCT, ECT and BCT only.)

Different types of corrugated box wall structures are as below [Ref 2]

Different types of structural design and their printability characteristics are shown in Fig. 3. The improvement in printability is due to improvement in smoothness of the surface because of the support given by flute. [Ref 4]

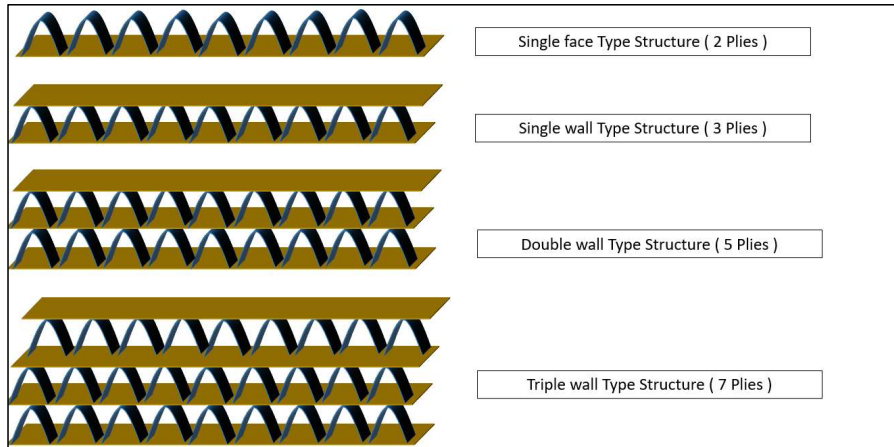


Fig. 2 - Different types of corrugated wall structures

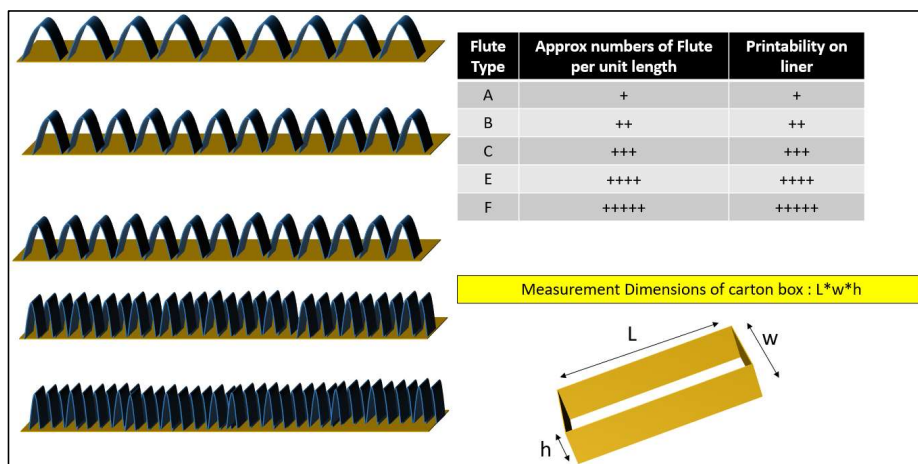


Fig. 3 Different structural designs and printability surfaces

The building block of the compression strength of the corrugated box is the Ring Crush of the paper used in liner and flute structure (Fig. 4). Higher the Ring crush strength, higher is the Edge Crush strength and so is Box Crush/compression strength. Here we are dealing with only stresses parallel to the walls, so Burst strength is not in discussion in this content. The burst strength is resistance to rupture against the perpendicular force to the surface of the wall of box. Burst strength is a planer strength in X-Y plane due to Z directional stresses.

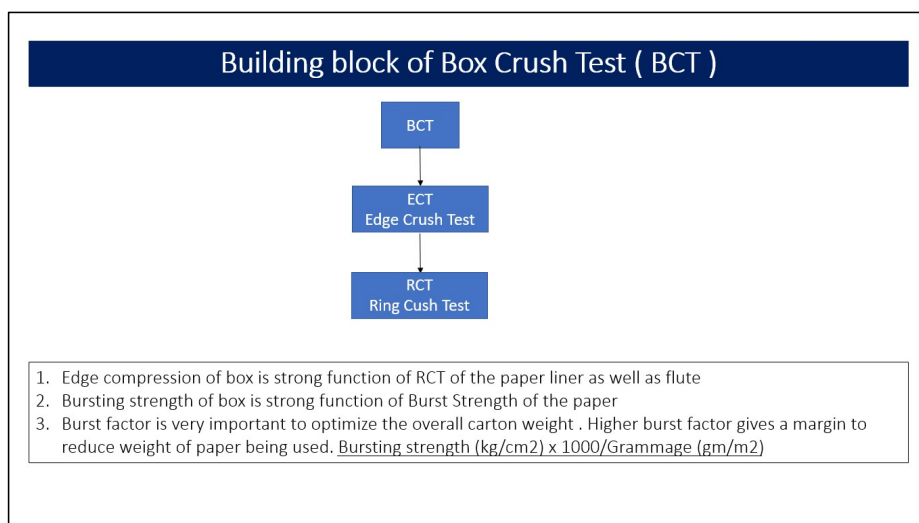


Fig. 4 Building block of box crush test

Ring crush of paper is one of the most important quality parameters. [Ref 5]

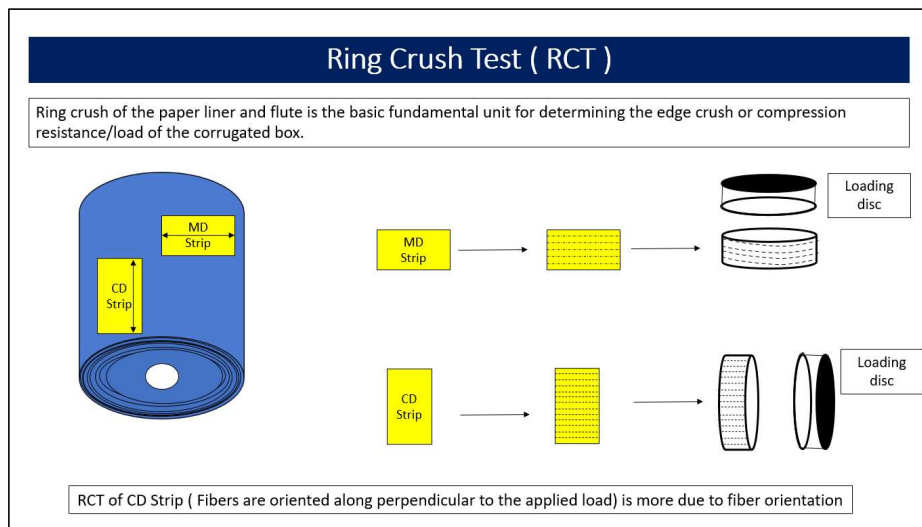


Fig. 5 Ring crush: How fibers are oriented in a sample specimen along MD & CD

Ring crush is actually the crushing strength of a ring made up by paper. There are several factors which affects RCT.

A - Factors affecting the Compressive strength

1. Intra layer fiber bonding,
2. Presence of strength additives,
3. Refining level.
4. Web consolidation in the press part

B - Factors affecting the structural strength

1. Formation / formation index,
2. Draws between the sections / fiber alignment
3. Thickness of the sheet

Point A4 and 3B are to be taken together for the optimization to get maximum Ring crush strength as both of these affects in opposite direction so an optimum value to be decided.

ECT (Edge Crush Test) – Extended form of RCT

Edge crush test involves the force on the cross section of the

wall to crush the edge/wall of the formed carton with the help of liner and flute (Fig. 6). The total load bearing length is the sum of lengths of liner and of flute. The flute is having some extra length as compared to length of liner due to its wavy nature for the same length of wall.

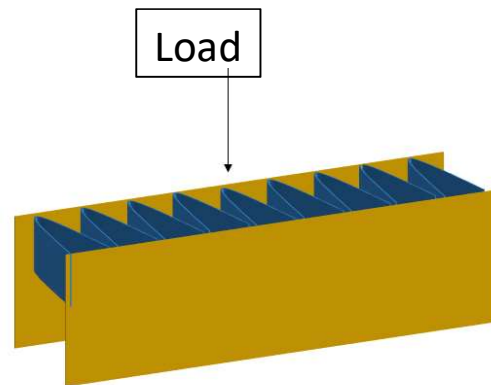


Fig. 6 Edge crush test

Calculation of ECT from RCT

ECT is calculated from the RCT data as shown in Fig. 7.

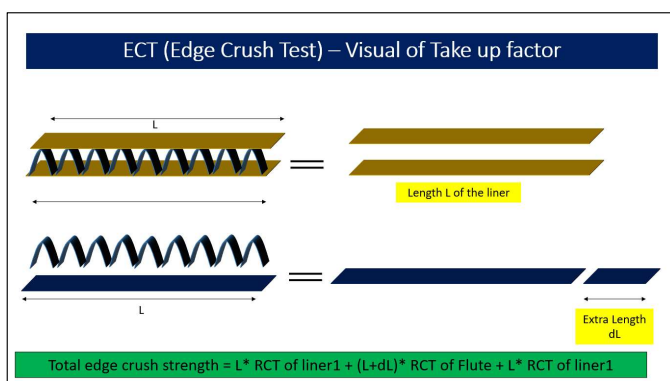


Fig. 7(a) Take up factor used for calculation of ECT

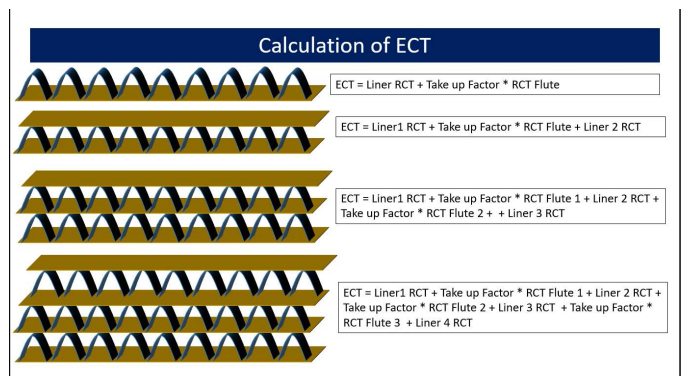


Fig. 7 (b) Calculation of ECT

Calculation of Box Compression Strength with the help of Mckee formula [ref 1& 3]: this formula is used to design the corrugated carton. Firstly, the edge compression load is calculated and followed by the dimensions of box are used to calculate the box compression strength as given below.

Box compression Strength = Constant * ECT (Calculated as above) * Sqrt(Perimeter*Thickness)

The constant varies as per different metric systems.

Conclusions:

Following are a few important design parameters based on which a corrugated box is manufactured.

1. The article to be packed, its weight, its shape & Size and its ductility of the material etc.
2. Once the material to be packed is finalized then other transport factors like distance to be sent, means of transport &

environmental factors like climatic conditions (relative humidity) under which corrugated box will be exposed & also the time of exposure etc.

3. After fixing all the above and a few more parameters which vary from case to case, the corrugated box strength is calculated and converted into real shape.

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