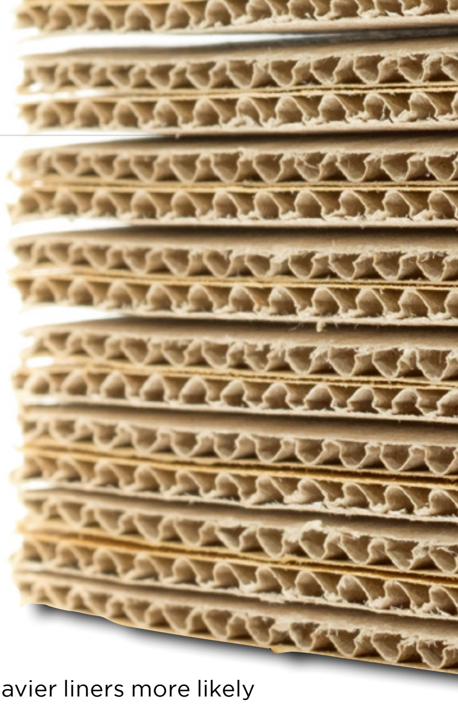

UNDERSTANDING WARP

A DIFFERENT APPROACH TO DEFINING BOARD CONVERTIBILITY.

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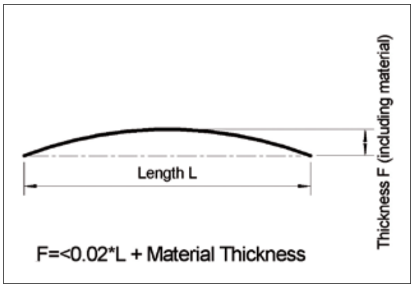
We all understand the term warp as a value for defining how flat corrugated board is. The problems caused by warped board in production do not need explaining and it is also well known that the main source for warped board, in most cases, is a differential in the moisture level between the outer and the inner liner of which the board is made.

In this article we are going to discuss a different approach to defining the convertibility of corrugated board. It was Eduardo Bueno Espinal from EFI who made me aware of the different approach.

Let's first refresh our minds with the definition. The warp definition and target calculation commonly used today is based on the dimensional warp of the board. The image shows the definition principle:



A typically accepted upper limit for convertibility in the corrugated industry is that the warp does not exceed 2%. This means that the maximum height from flat, F, should be:

F = <0.02 x L + material thickness

The Problem

Is the warp definition alone enough to decide if warped corrugated board can be converted?

Let's take a look at warp of different board grades board and the impact on convertibility in practice and ask us the questions:

1. Is, for example, a sheet of BC doubelwall with the same dimensional warp and size likely to give more problems in conversion than a B flute sheet?
2. When we compare two sheets of B flute board having the same size and warp, but a different liner grade combination isn't the one with the heavier liners more likely to give conversion problems?

The answer is two times yes.

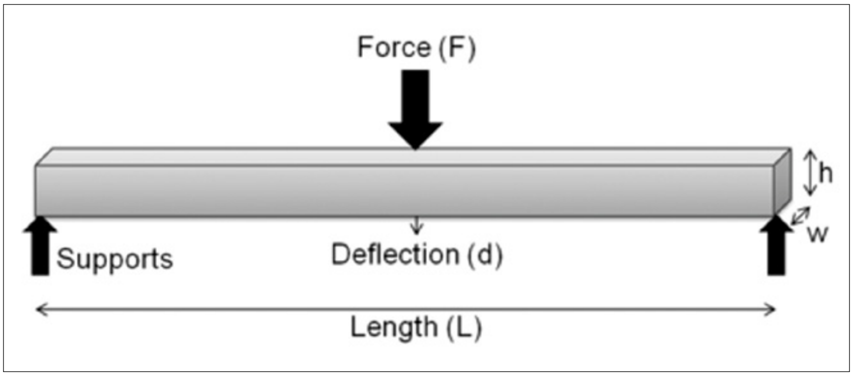
The reason is that when we only look at warp, we only look at a dimensional defect where the board stiffness also has an impact on the convertibility of the board.

Would it be possible to define a different target for convertibility of corrugated board?

The Solution

It is important that in the definition for convertibility of board also the stiffness of the board is represented.

The stiffness of the board can be defined by measuring bending stiffness using the 3- or 4-point bending stiffness test. The next image (Wikipedia) shows a schematically design of the 3-point bending system test.

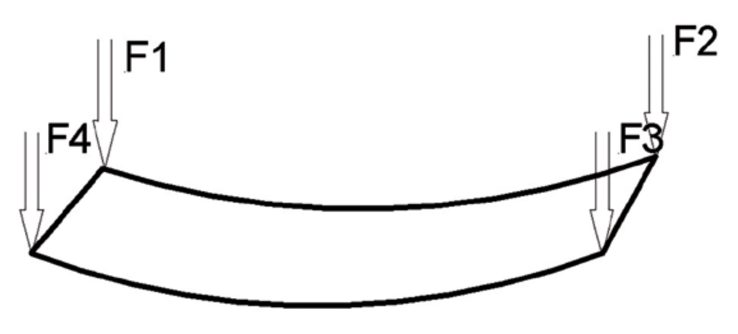


The convertibility of a board cannot be based on only a bending stiffness test before starting conversion. This is because it is important to consider the effect of the warp on the convertibility of a given board stiffness.

The last dilemma we have is that the starting point of a bending stiffness test is a cut board sample of flat board. Mostly we have slight warp in the board.

Can we do a practical, easy to conduct test that combines bending stiffness and warp? One solution could be a test to evaluate the force or load needed to flatten the board by measuring the force that needs to be applied on the four corners of the board to flatten it. In this case the maximum force applied on one of the four individual corners is the key value: **Corner Flattening Maximum Weight** (CFMW).

The sketch shows the Corner Flattening Maximum Weight test setup.

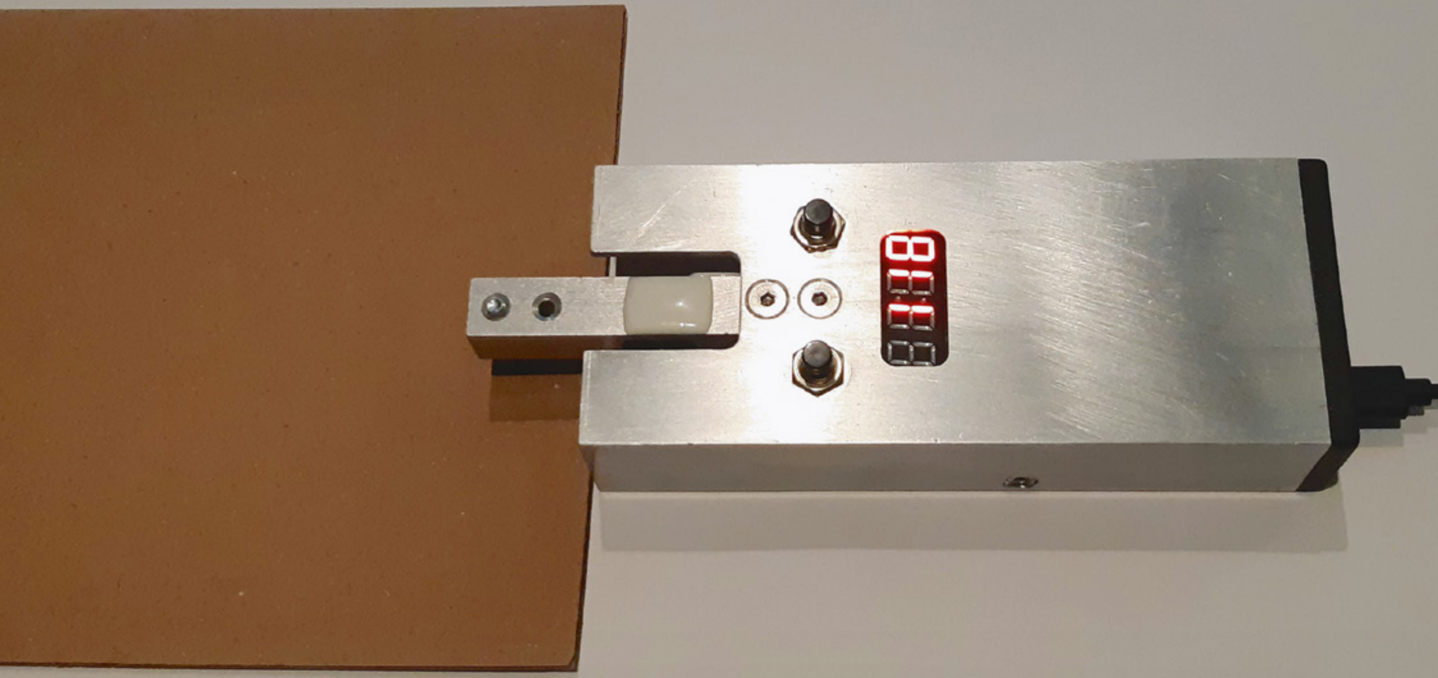


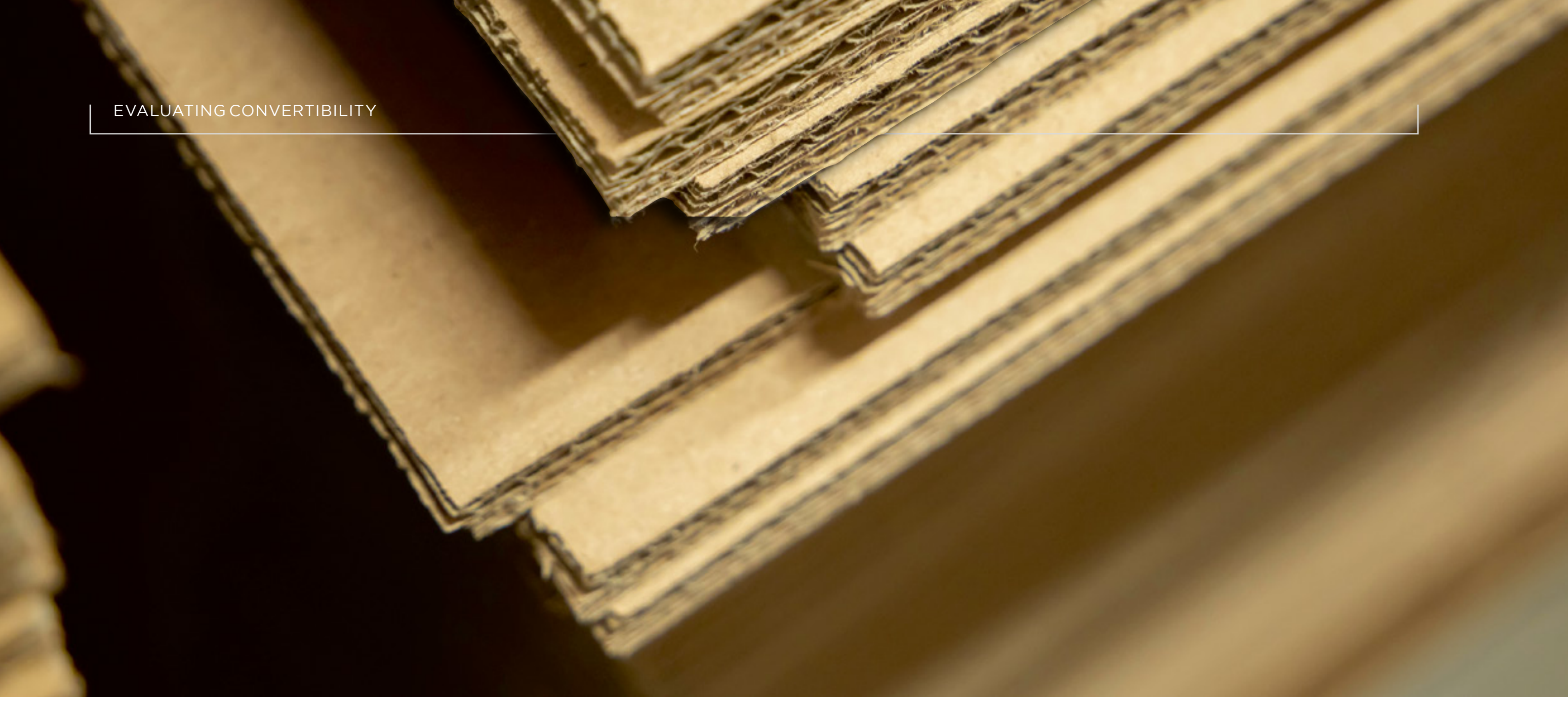
To conduct this test, we build a device that allows to measure F1 to F4 on the board four corners.

The maximum weight of all the corners is the CFMW of the board.

The advantage of the CFMW test is that it is a non-destructive test so you can use the same sample as used for the CFMW test also on the machine transport system.

Is it possible to measure as a percentage the actual force applied by the board transport system vacuum? This can be done if we control the vacuum applied on the transport system so that it is just enough to flatten the board on the transport system and measure the applied vacuum % at the same time. This vacuum % is than the vacuum needed that allows to convert the sheet through the machine.



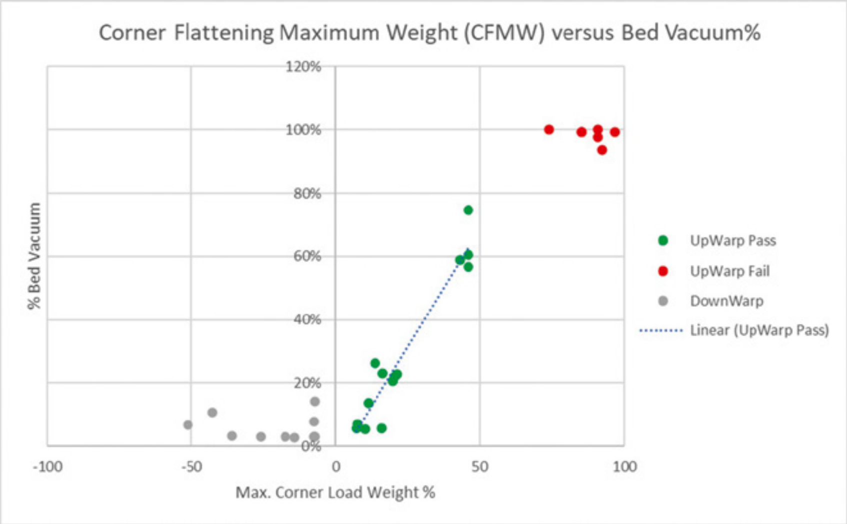


After explaining the theory and test/measuring method, it is time for practical testing. To do so, we used a range of different board grade samples that also had different warp. Some samples had convex (down) warp others concave (upwarp) when putting them on the machine vacuum table with the liner to print on up.

The testing was done in the following order:

1. Measure on the machine board transport system the minimum vacuum percentage needed to flatten an individual board sample.
2. Measure the corner loads of the individual sample. This provided four values per sample for the four corners. The maximum of these values is the CFMW of the board.

The next graph shows the relationship between the CFMW and the vacuum percentage on the machine bed.



The convex warped sheets (left from the 0 load line) are no problem on the vacuum bed.

The red dots are sheets that are not convertible, but we see a clear trend in the green and red dots.

The data in this graph allows to define if the CFMW level of a sheet causes problems during transport through the machine.

The results indicate that we can do a quick non destructive sample evaluation to decide on the convertibility of board.

Points that are important when setting a board deformation specification:

- It is not as straight forward as one might think to simulate the dynamics of air flow under the board on the board transport system;
- How representative is a small sample of a board used for bending stifness for the full board size. The CFMW test has thus clear advantages;
- It is not enough to only define a warp target for the board as the stiffness of the board has also impact on if the board can be hold flat on a vacuum transport system.

It is valid to conclude that using the term Corner Flattening Maximum Weight (CFMW) being a combination of warp and board stiffness is a better way to evaluate the convertibility of board than only using the term warp. ■