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Statistical process control pin adhesion

Scope

The purpose of this Technical Information Paper is to provide a basic understanding of using statistical process control techniques in determining the strength of bond formed during the corrugating process.

Introduction

The pin adhesion strength of corrugated board is a method used to measure the adhesive bond strength between the flute tips of the corrugating medium and its linerboard facings. The test provides a means of determining the strength of the bond formed during the combining process and can be used to detect some manufacturing defects such as poor adhesive penetration and spotty adhesive application. Good adhesion of the medium to its facings is necessary in obtaining high quality corrugated board. It is this property more than any other that allows the components to work together to create corrugated board.

Safety precautions

Use appropriate personnel protective equipment to prevent hand injury when collecting and carrying combined board and /or when cutting pin adhesion specimens

Test method

The preferred test method for pin adhesion is TAPPI T 821 “Pin Adhesion of Corrugated Board by Selective Separation” since this method allows for the selective measurement of the bond strength of both the inside and outside liners. This procedure describes the test instrument, calibration, sampling requirements and the proper reporting procedures.

For some process control purposes it may not be practical to properly condition the samples in accordance with T 821; however, it is recommended that all samples be taken to a conditioned test lab immediately after being collected and conditioned for some fixed length of time before testing.

In addition to the pin adhesion value being recorded, the side failing would have to be noted along with the percent fiber failure to provide complete information for interpretation.

Sampling

Combined board samples should not be taken until the corrugator has reached its intended operating speed and all normal adjustments have been made. Once these objectives have been achieved, then samples should be taken simultaneously across the entire width and identified by position, such as operator side, center, or drive side.

The frequency of sampling should be determined by the program designer's assessment of the process stability. Listed below are some possible process variables that can influence pin adhesion strength and therefore suggest possible sampling frequency. If any of these variables are suspect in causing a lack of process control, that variable should be isolated and studied separately.

- a. New batch of adhesive
- b. Roll change (splicing of either liner or the medium)
- c. Flute change
- d. Resetting of adhesive gaps
- e. Shift Change
- f. Corrugator Speed Change (Single Facer or Glue Machine)
- g. Heat Transfer Change – (Wrap Arm Adjustment or Steam Pressure Change)
- h. Splicer Tension Change

Measurements

On each combined board sample from each position across the corrugator, cut out a minimum of three pin adhesion specimens, according to the procedures outlined in T 821. These specimens should be uniformly spread across the width of the corrugator and should vary enough in the machine direction so that any uneven adhesive application defects due to TIR (Total indicated run out) will be detected as well.

When measuring pin adhesion, it is important that the percent of fiber failure be reported along with the strength value, as well as the component that failed i.e. medium or liner. A high fiber failure combined with a low pin value does not necessarily mean poor bond strength since this condition can reflect low fiber-to-fiber internal bond strength of one of the components. Conversely, a high pin value combined with little or no fiber failure could mean a surface bond which is considerably more susceptible to shear type forces.

Since many customers still test for bond strength by ripping the combined board apart and looking for fiber failure, a surface bond failure showing little fiber pull could easily be rejected even though the pin value is measured at an acceptable level and an estimate of fiber failure is noted in the comment section of the chart.

Control chart

Several options exist for control charting. Separate charts could be established for each position such as the drive side, center, or operator side, or a simple chart can be used which charts the overall average. The most desirable chart appears to be the $\bar{X}$ & R chart; however there can be several options to this. One very useful option converts the end results into percentages of guidelines which can then be used to handle more than one variable on a single chart such as different flutes or board grades.

Statistical process control techniques can be used to determine the amount of variation of the adhesive bond and whether it is improving or deteriorating. These same methods can also be used to determine the cause of the excess variation. Other statistical tools that can be used to evaluate process capability include histograms and frequency and probability plots. Many computer software packages are available that will allow rapid statistical calculations and will quickly generate the plotted graphs.

Example

In this example a total of five pin adhesion tests were made across the full width of samples of 200-lb test C-flute combined board collected once each shift for six consecutive days with each individual average reading recorded on the attached control chart. The average ($\bar{X}$) and range (R) for each of the 18 sample sets were then used to calculate the grand average ($\bar{\bar{X}}$) as follows: