

Progress in Packaging and Paper Physics at IPST

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Figure 1. Roman Popil on the job, (Paper Physics Conference) Helsinki 2008. It was all just mint to be (the ice cream flavor).

Opinions expressed in this newsletter are those of the author (Fig.1) and do not necessarily reflect GT/IPST official plans, policy or direction.

Corrugated box lifetime studies

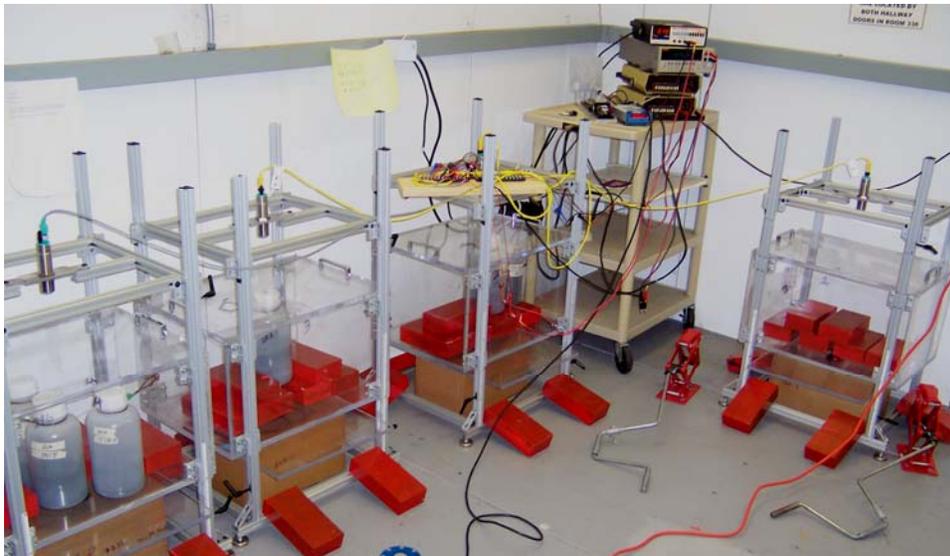


Figure 2. Cyclic humidity environmental chamber with box creep measurement stations.

Results were recently presented at the 2008 Progress in Paper Physics seminar in Espoo Finland. After 2 years of collecting data, we have finally got the story on how medium properties affect the lifetime of corrugated boxes. This was done using a set of RSC test boxes made in our former Corrugating lab which was a set of A flute boxes with the medium basis weight varying from 14# to 42#, the linerboard weight was kept constant at 42#. The end result is a set of useful regression equations which can be used by box designers to optimize the lifetime of their containers based on the physical properties of the medium.

Corrugated boxes with kaolin coatings for waterproof applications



Figure 3. Applying kaolin coating onto linerboard (left) followed by ice pack testing for BCT retention.

They said it couldn't be done, shouldn't be done and won't be done, so of course, we just went ahead and did it anyway. Linerboard was coated with a conventional kaolin coating using a rod coater, followed by an application of aqueous acrylic coating. We tool the linerboard and treated medium and converted the components into RSC boxes which were subject to a simulated end-use ice-pack trial. The findings are that kaolin coatings are economical to apply to linerboard as a base coating to save on polymer costs, provide some strength and vapor barrier properties. We also expect that kaolin coated boxes should display a long lifetime compared to uncoated boxes, that remains to be studied using the set-up shown in Fig. 2.

Electrospun nanofilaments coatings for waterproofing

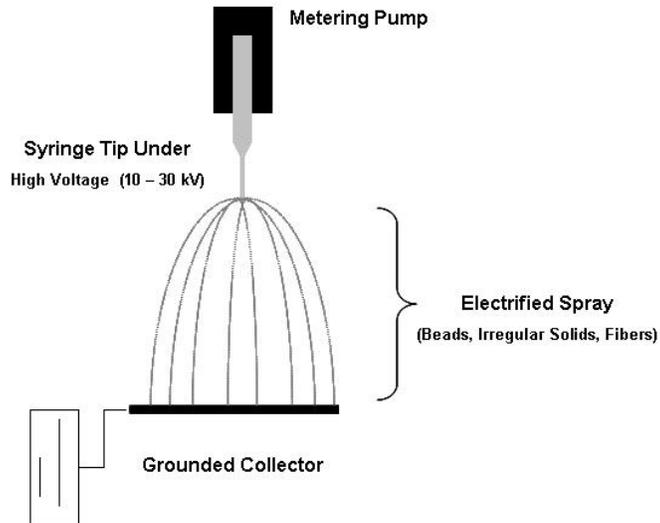


Figure 4. Schematic of an electrospinning or electrohydrodynamic spraying “EHS” concept.

Of course, with all the latest buzz about “nano”-magic we could not leave this one alone. The promise here is that with a very light coating of nanofiber polymer as supplied from an electrospinning concept, waterproofing of containers can be obtained with minimal use of polymer. Moreover, there is no drying of aqueous coatings involved with electrospinning. The technology is currently used in an industrial scale to produce anti-microbial air filters for automobile and hospital use.

We found a unique cost effective formulation and configuration to produce a beaded nanostructure surface which would adhere to linerboard and provide a high WVTR but nonetheless water resistant coating. Results were recently presented and the Tappi Pulping and Engineering Conference by Ericka Ford , a graduate student at the Polymer and Textile School of Engineering at Georgia Tech.

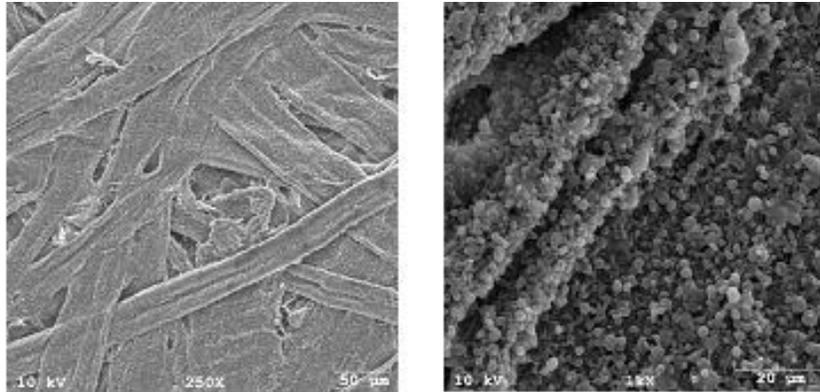


Figure 5. SEM shots of linerboard coated with an EHS applied acrylic formulation. The result is waterproofing with a high WVTR and water contact angle of 120 degrees.

The advantage of EHS applied coatings is the high WVTR, no requirement of external drying capacity but the process is quite slow compared to conventional coating or spraying techniques. Nonetheless, there are known commercial trials currently being attempted using high voltage assisted sprayers using aqueous coating dispersions. Characterization, understanding and optimization of parameters in this process will ultimately lead to widespread utilization of this technology.

New measurements, new measurement technology.

A lot of physical testing these days is being performed by automated in-line testers which preclude the famous and popular Ring Crush test as a strength characteristic for linerboard and medium.



Ring Crush specimen after testing; buckling and rolling edges clearly visible

Currently there is considerable urgent interest from mills to replace this test with SCT developed by STFI in the 1970's. A model initially reported in 1998 relates SCT to RCT along with bending stiffness and caliper. Multiple regression analysis has been performed at IPST on submitted mill and IPST-generated lab data to produce accurate regression models for the conversion of available data from automated testing machines to RCT. Ultrasonic measurements also now widely available can also be used instead of mechanical testing to replace tensile and bending stiffness. Laboratory investigations at IPST have indicated that a

combination of automated in-line testing data can also be used to predict score cracking. Regression models are available for verification with mill data and implementation.

Crushed boards – what does it all mean ??

All corrugated board is subjected to some measure of crushing in the process of conversion of board to printed box blank ready for assembly and shipping. However, much of the effects of the crushing are not measured and neglected in the industry causing an unnecessary loss of strength of the box often compensated by increases in basis weight of materials.

IPST has advocated the use of transverse shear measurement, initially by the in-house torsion pendulum method, now more easily affordable and available with the portable BQM device which was recently characterized and validated by IPST.

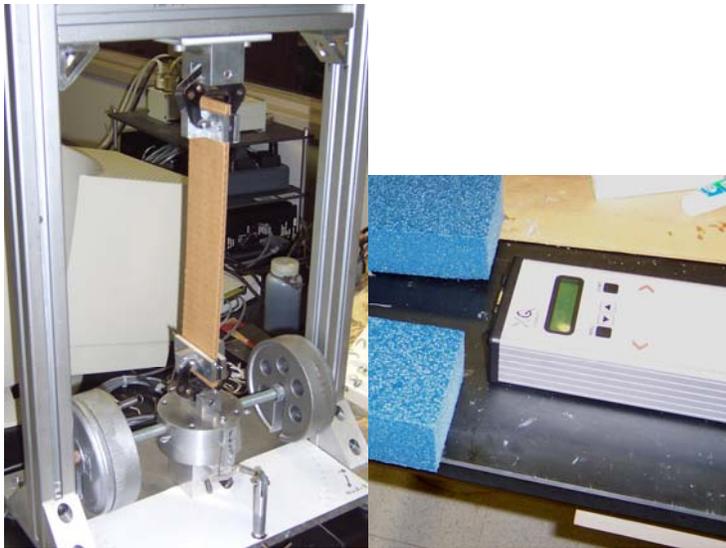


Figure 6. IPST developed torsion pendulum recently described in detail In Appita Journal measures the shear stiffness of the corrugated board medium, essential for optimal corrugated box strength. On the right, the portable BQM measures the same thing but at a touch of a button without the requirement to cut a board sample.

With measurement of the shear rigidity, the objective is to have an improved and more accurate prediction of the stacking strength of boxes exceeding the current limitations of the well known BCT (box compression test) McKee equation (originated from IPC Appleton, back in 1963!!) which does not incorporate losses from box converting. Current investigations of effects of crushing in board will lead to a modified predictive equation which will be useful to optimize strength with no increases in materials or energy but instead, through measurement and control of shear rigidity in box plants.

And so, now what ??....

Immediate plans remain undaunted by the loss of the Langston single facer and Container lab facilities in the 14th St IEC. Michael Schaepe departed in July 2008 for a position with Cargill based in Cedar Rapids Iowa head office and Robert Hall has taken a position with Applied Paper Technology which has moved to new space in Marietta. Perry Arrington who was principally involved in the erection of the DOE lateral corrugator has been retained on a contractual part-time basis to assist with R&D efforts in FY09. The Emerson 7200 box compression tester, the double-backer simulator and other portable transportable equipment have been moved to available space on the 3rd floor of the PTB on 10th street. IPST has lost the capability of manufacturing single face corrugated board but nonetheless will still proceed as follows in the short term:

1) Efficacy of clay coating applications on linerboard.

A clay coating reduces WVTR and so should increase lifetime of boxes paced in a cyclic humidity environment. We have the coated boxes from our spectra-Kote trial work, what is required is a box creep run in the set-up shown in Figure 2.

2) Using the BQM in a modified McKee equation

A series of box blanks have been obtained which will be progressively crushed using a rolling nip rescued from the IEC and their resulting ECT, caliper and BQM measured to formulate an improved form of the McKee equation which will incorporate the loss of compression strength due to loss of shear stiffness that occurs with crushing of board. About 15% in compression strength can be obtained if the effects of crushing are measured in a converting process and corrected.

3) Score cracking research

An old topic that just won't go away but perusing through the volumes of literature, a good portion of which originated from IPC, a common theme that occurs is that cracking arises from the limited strain to failure of surface fibers in a curved geometry. Aha ! So, if we measure the stretch to break of test specimens in curved geometry which should predict score cracking. Such was the thinking behind the invention of the IPC crack angle tester which correlates with MIT fold endurance. However, cracking is more prevalent at higher speeds than bench tests since paper as well all know is viscoelastic and so can be said to be more brittle on shorter time scales. An improvement in this is measure the stretch to break in a tensile test, or calculate the stretch to break in a Mullen test and correlate the results cracking proclivity measured using an AF&PA fold crack tester. Recent results on a limited set of linerboards seems to indicate this is path forward to a cracking predictor test.

4) Thin film metering

Is getting linerboard less wet in corrugating a good thing ? Naturally from an energy savings point of view, the less water and starch adhesive that have to be used the better is the economics situation for a box plant. But how does a thin film metered adhesive application affect the physical properties of the board ? We have the DBS machine now outfitted with a conventional glue machine and a wire rod metered glue machine where we can precisely limit the application of adhesive. A series of board will be prepared

and the physical properties measured to characterize and quantify the effects of thin adhesive films.

5) New ideas, new proposals

Each year requires a new set of ideas to formulate proposals to get funding for the next fiscal year. Where do the ideas come from? What topics of research will likely get industry or other support? Which research proposals are worth the effort (these things are 10 pages) to write-up and distribute? Perusal of journal articles, attendance at conferences provides some idea of what is going on out there and who's doing what, but the best input comes from direct interaction and dialogue with the potential end-user. An example of a new innovation is ultrasonic welding of linerboard eliminating starch use which is being researched and commercialized in Europe. Do we know what's going on in North America in this area? The question for IPST packaging research activity is, where do we go from here with what we got? The bottom line, that occurs repeatedly throughout history, and one that all of us researchers and technical personnel must continually reiterate to our business managers is that those companies/industries/societies that do not engage in research or innovation, ultimately reach the end of their respective product cycles become non-competitive and obsolete. To survive is to do research, to thrive is to implement.

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