FALL 2007

CORRUGATING INTERNATIONAL

A TAPPI Publication for Corrugated Packaging Professionals www.tappi.org

Exciting Changes Ahead

TAPPI has announced an agreement with the publishers of *Paperboard Packaging*, Questex Media Group Inc., in which *Paperboard Packaging* is now the official publication of TAPPI's Corrugated Packaging Division (CPD). All TAPPI CPD members (any TAPPI member who checks the CPD as one of their three "preferences" on the annual dues statement) will now receive a copy of *Paperboard Packaging* included with their TAPPI dues from now to the end of their current dues cycle. To continue to receive *Paperboard Packaging*, check the *Paperboard Packaging* space on your next Dues statement and continue to check off the CPD as one of your three preferences.

This move by TAPPI is good news for CPD members and readers of CI. First, there will be a dedicated several pages within each issue of *Paperboard Packaging* with all content provided by TAPPI. Second, the total amount of technical content, technical papers and articles, over the period of a year will be similar to what we had with our three issues per year of CI. Third, our technical content will be back in hard copy form. While distribution via the electronic media is easy, it is questionable as to how many readers the electronic CI actually had. I believe we will have a much larger readership as a part of *Paperboard Packaging*. In addition to CPD members, *Paperboard Packaging* is delivered to virtually every box plant and most of our industry's suppliers offices, factories, etc. Fourth, we will have TAPPI technical content published on a regular schedule, whereas the CI publishing schedule was adjusted each year depending on the date of the annual CPD Conference. As mentioned in TAPPI's press release on the collaboration with *Paperboard Packaging*, I will remain as TAPPI's Technical Editor for TAPPI's technical content in *Paperboard Packaging*. I will continue put out a quality product that has value for the corrugated industry.

There will be TAPPI technical content in this month's *Paperboard Packaging*. The technical paper by Roman Popil that appears in this issue of CI will also appear in *Paperboard Packaging* along with other TAPPI news. The future of CI hasn't been completely decided as we go to press. However, with the opportunities and advantages that partnering with *Paperboard Packaging* brings, I believe that this will be the last issue of Corrugating International.

This issue of CI brings two articles of interest to those corrugating "lightweight" containerboard. These two articles came out of a previous CPD Conference and are typical of the information and education that attendees can take advantage of by attending a CPD Conference. The next CPD Conference is almost upon us. The Conference will be held in Indianapolis on October 29th through November 1st. Two presentations by Joel Weldon, Innovation presentations, Technical presentations, six sessions that include 16 hands-on breakout presentations, a Core Expo Exhibit, and much more are part of the program. One of the Technical Presentations will be the "Shear Measurement of

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FALL 2007 CONTENTS

ARTICLES

Board Crushing Effects" that is published both in CI and *Paperboard Packaging*. This paper presents new research on box compression failure and caliper crush. The trip to Indianapolis will be worth the cost if only to hear the presentation of this research work and to visit with and ask questions of the researchers from the IPST who did the actual research work. One of the short articles proposes skill standards and certifications for box plant employees. TAPPI gave this idea some thought a few years ago. Perhaps it is time to get serious about this proposal.

It is not too late to sign up. Indianapolis is a day's drive for a substantial percentage of the population of the U.S. To see more details about the Indianapolis Conference and registration information, go to www.tappi.org and then go to the "Events" drop down table and click on "Conferences and Symposia". See you there!

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Shear measurement of board crushing effects

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ABSTRACT

Corrugated board in production endures varying degrees of crushing from stacking, transfer, die cutting, printing, and other corrugating and converting operations. Thus, production corrugated board has a measurable loss of shear stiffness from converting operations which reduces its potential buckling load resulting in loss of box performance and lifetime. Yet the level of the impact of crush on board properties and ultimately box performance cannot be accurately detected by the usual measurement of caliper loss which is disproportionately small compared to the loss of shear stiffness. Instead, measurements of flat crush hardness or transverse shear stiffness have been shown to be greatly affected by board crushing. A newly available and convenient non-destructive method using sonically induced shear, Board Quality Measurement (BQM) is compared to a known torsion pendulum technique for validation. The results indicate that the effect of board crushing can be sensitively detected using these methods. Shear measurement can provide clear information regarding the effects of converting operations on board mechanical quality and provide an opportunity to minimize the impact of these operations.

BACKGROUND:

Transverse shear stiffness is the resistance to relative sliding motion of the inner and outside linerboard facings. When a box is loaded vertically, the side panels of the box bulge outwardly in response to the load causing a relative motion of the inside and outside liners principally in the MD or perpendicularly to the flutes. The amount of panel bulging is governed in part the MD transverse shear stiffness. A greater amount of panel bulging for a given load increases the stress concentrations at the corners of a loaded box such that failure will occur sooner in time at a lighter load. Shear stiffness is governed by the strength properties of the medium which is determined partly by material properties and partly by geometry. The material properties of influence are basis weight, fiber strength and fiber bonding. Geometry properties of influence here are flute shape, flute size. Should any measurable amount of board crushing occur, the caliper is usually observed to recover however, the flutings will suffer the formation of a kink at their flanks. These kinks compromise the rigidity of the corrugated medium structure to transverse shear.

APPLICATION OF TRANSVERSE SHEAR MEASUREMENT

Converting operations apply various out of plane loads to the boards in scoring, folding, printing, all of which crush the corrugated board to some degree. To maximize the strength potential of corrugated board it is useful to monitor the impact of the

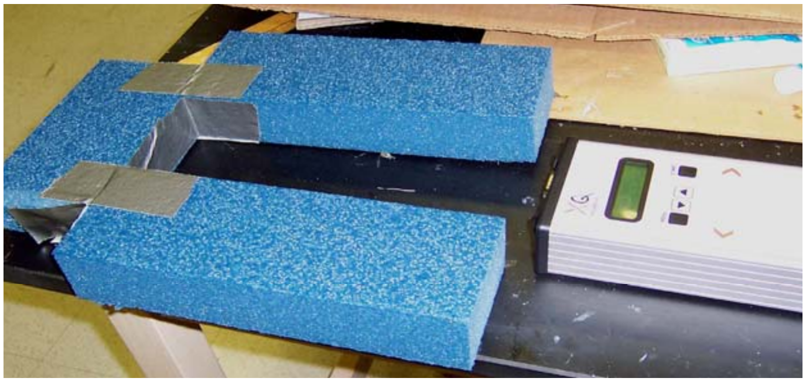

Figure 1: Improvised foam sample support and BQM used in the measurements. Boards are placed with flutes perpendicular to the length of the BQM, the BQM is placed on top of the samples suspended by the foam blocks. Test boards are vibrated along their MD by the BQM, the frequency and amplitude of the test board's sympathetic vibration is converted to a shear stiffness numeric output.

sample	ECT (lbf/in)	MD - 4 pt Bending (Nm)	CD - 4 pt Bending (Nm)	Torsion constant N/m	Average BCT lbs	Shear stiffness R55 (metric)	BQM stiffness kN/m
14A	20.6	18.5	9.2	0.89	614.7	2866	1.2
16A	30.1	20.8	9.4	1.34	679.2	4672	1.7
18A 723D	26.5	19.3	8.7	0.96	670.1	3120	1.4
18A 726E	38.3	17.2	8.8	1.18	720.1	4115	1.5
20A	52.4	17.7	11.3	1.46	931.0	5186	1.9
26A	50.4	19.5	12.2	1.81	1013.8	6742	2.8
33A	61.7	19.8	13.1	2.18	1022.6	8569	3.7
42A	53.6	19.4	9.9	1.24	933.3	4237	2.9

Table 1: List of relevant properties of the A flute set. Linerboards are all 42#, medium basis weight varied from 14# to 42#.

Figure 2: IPST torsion pendulum with specimen mounted between clamping jaws.

converting operations which is realized through the measurement of transverse shear rigidity.

The simplest method to measure this property is through an adaptation of the tensile strength test where opposite faces of the corrugated board are pulled in opposite direction **[1]**. However, an out-of plane displacement complicates this measurement. Other researchers have realized the component of transverse shear in three point bending measurements or have adopted a torsion pendulum measurement to infer the transverse shear rigidity from measurements of the twisting stiffness **[2, 3]**. All of these mechanical measurements require the preparation and mounting of samples in destructive tests and are thereby inconvenient to implement in a production environment.

XQ Innovations **[4]** have recently devised a sonic based method which requires only that the sample under test be placed between supports. The brick sized device placed on the supported sample vibrates along its length through a range of sonic low frequencies. A transducer on the underside of the BQM is in contact with the board and detects the amplitude and frequency of the detected board vibration. The amplitude and frequency of the MD induced board vibration is then computed to an equivalent transverse shear stiffness.

DESCRIPTION OF THE EXPERIMENTS

IPST has developed a torsion pendulum method **[5]** for determining the transverse shear rigidity of board specimens. The system is calibrated using a steel bar which is subjected to known torques using a system of weights and a pulley to twist the steel beam to various angular deflections. Computerized analysis of the detected oscillating twisting frequency of 2.5 x 12" test specimens is converted to a torsional stiffness. Coupled with measurements of the 4 point bending stiffness of corrugated board the transverse shear rigidity of boards is determined. More details of the technique are available in the May 2007 Appita paper physics conference.

A series of boards were prepared using facilities at IPST using the pilot corrugator and manually double-backing as described in reference **[6]**.

One set consisted of a series of lab made A flute corrugated boards where the medium basis weight was varied from 14# to 42#.

Another set of boards used for transverse shear analysis were made by crushing the commercially made or IPST made boards through a rolling nip set at various fraction of the nominal caliper ranging from 90 to 60%. Boards were sent through the rubber/chrome roll nip twice, with the second pass having the board flipped over and rotated 180 degrees from its original direction through the nip.

Figure 3. Corrugated board blank being sent through a double backing glue applicator nip to crush the board to a preset fraction of the original caliper.

RESULTS

The first comparison was made using the A flute series of laboratory made boards where the basis weight of the medium ranged from 14 to 42 lb/msf. Comparison of the transverse shear rigidity obtained from the torsion pendulum and the results of transverse shear stiffness from the BQM are shown in **Figure 5**. The BQM is not calibrated to read A flute so readings were taken using its C flute setting. The one outlying point is the A flute board using 42# linerboard as the medium. In this case, the flutes were observed to be fractured since the corrugating labyrinth is set to accept small range of fluting calipers. Damaged flutes will lead to an anomalously low shear resistance measurement. In **Figure 6**, if we remove the fractured flute specimen the correlation between instruments and methods become unambiguous. Thus we have an indication from this data that medium quality or damage can be detected through transverse shear measurement.

Sample	caliper mm	Torsion Pend. (N/m)	ECT lb/in	Flexural Stiffness (N-m) MD	Flexural Stiffness (N-m) CD	Flat Crush N	BQM kN/m	shear R55
C-flute								
Control	4.15	1.90	41.0	15.5	6.45	15.34	3.65	9219
90%	4.11	1.78	42.1	14.9	6.34	14.55	2.9	8369
80%	4.04	1.28	38.4	14.4	6.08	6.90	2.05	5110
70%	3.93	0.98	38.8	13.4	6.01	5.29	1.5	3545
60%	3.65	0.56	32.3	10.7	5.17	4.25	1.05	1837
Waxed C								
Control	4.28	1.84	49.5	16.5	8.97	15.71	3.5	7676
90%	4.09	1.64	52.0	16.2	8.79	11.05	2.95	6545
80%	4.09	0.95	50.9	14.6	8.12	3.87	1.8	3231
70%	4.02	0.84	46.1	13.5	7.82	2.33	1.4	2787
60%	3.83	0.57	48.3	11.4	7.25	0.09	1.15	1814
A-Flute								
Control	5.13	2.06	49.9	23.7	13.96	18.14	4.05	7565
90%	5.12	1.88	47.5	23.7	13.21	12.53	3.45	6736
80%	4.98	1.13	44.6	20.5	12.88	6.00	1.9	3658
70%	4.92	0.89	47.0	19.6	12.43	4.96	1.85	2784
60%	4.86	0.79	44.1	17.9	12.11	3.01	1.4	2437
B-Flute								
Control	3.02	1.50	52.9	8.0	4.29	40.06	5.5	10079
90%	2.99	1.44	50.7	7.5	4.29	27.69	4.65	9530
80%	2.95	1.25	49.4	7.5	4.14	20.99	4.1	7113
70%	2.85	0.89	45.8	6.9	3.82	11.95	2.7	4045
60%	2.73	0.63	46.7	6.1	3.48	6.72	2	2525

Table 2 . Relavent properties of the crushed board set for comparative transverse shear measurements.

CRUSHED BOARDS

Crisp et al described how changes in the load displacement curve for flat crush occur once a board is crushed. They dubbed the first load peak in the curve as the medium "hardness" and noted that it was the most sensitive measured property that responded to board crushing. Other investigators found that many physical properties are insensitive to board crushing. Recently the studies by Batelka **[7]** and Kroeschell **[8]** show that board caliper recovers within minutes of crushing to 90% or more of its original caliper. However, there is a loss of performance properties (vertical stacking strength and lifetime) when crushed board is converted into a box which goes largely undetected through routine caliper measurements in box plants.

Flat crush test instruments are usually set to set to record maximum peak load value and thus do not detect the drop in the first peak in the

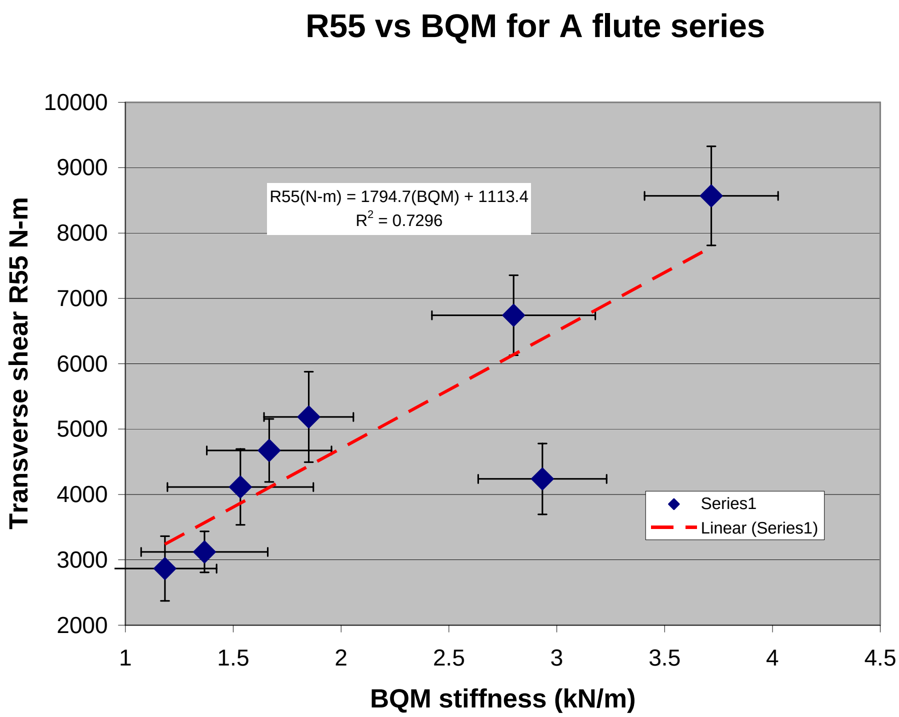

Figure 5. Torsion pendulum determined transverse shear rigidity versus the BQM measurements of stiffness. The BQM was set on its "C" flute setting. The one outlying point is 42A which is a fractured flute caused by the corrugator gap not accommodating this thickness of medium.

load displacement curve. Recording the hardness through a recording compression tester is possible but tedious. Shown in **Figures 7** and **8** below are load displacement curves of uncrushed A flute board and A flute board crushed to 70% of its original caliper. **Figure 8** graphically shows the dramatic decrease in the first peak of the load displacement curve. The alternative to measure the effects of crushing on board by measurement of transverse shear is suggested as a means to conveniently monitor and control crushing effects on board.

Results of the hardness versus permanent caliper reduction are shown for a variety of laboratory crushed boards in **Figure 9**. The permanent loss in caliper for all cases is less than 10% of the original caliper however the corresponding change in the hardness values in some cases as much as 800%! The caveat is however, that the selection of the hardness value if based on load alone

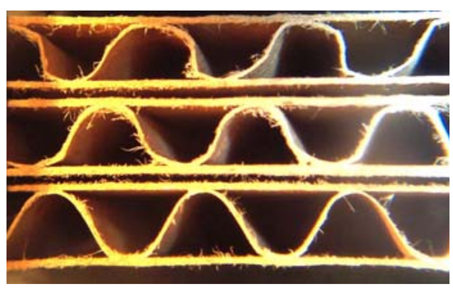

Figure 4. Magnified cross section of C flute boards: bottom board uncrushed, Middle: sent through nip gap set at 70% of original caliper, top board: board sent through nip set at 60% or original caliper. Note that despite the large amount of crushing, the permanent caliper reduction is 10% or less in these extreme circumstances.

involves a subjective evaluation of the load displacement curve and is therefore subject to operator variability. A combination of the curve inspection alongside with a comparison of the displacement value where the first peak was known to occur as found to be the best method to reduce error. However, the care that must be taken to ensure the starting point of the compression cycle for each series of specimens is appropriate to minimize offset is another barrier for making this a routine quality test measurement.

Measurements of transverse shear stiffness or rigidity offer a similar sensitivity to board crush level with a much higher level of convenience and ease of use. Shown in Figure 9 are the results using the BQM device on the series of crushed boards which indicates a good range and correspondence with flat crush hardness. Thus, a measurement of the transverse shear of the medium with the BQM is much more convenient and is comparably sensitive as flat crush hardness to detect and damage to the medium from crushing.

Comparison of the same crushed board hardness results with the torsion pendulum are indicated in **Figure 11**. Here, the transverse shear rigidity R55 is the shear stiffness multiplied by the board thickness. Moreover, the measurement here is influenced by the twisting stiffness of the board which is governed by the tensile stiffness of the linerboards. Hence, in Figure 11 we see a larger separation between the points of different types of board. However, the ranges of transverse shear rigidities are similar to those for shear stiffness as measured by the BQM which confirms the measurements of transverse shear strength to be a sensitive measure of board crush.

EFFECT OF TRANSVERSE SHEAR STRENGTH OF BOARD

The question arises that if crush were to be eliminated in a box plant what would be the potential increase in box performance. Chalmers **[9]** recently has shown preliminary evidence of the influence of reduced transverse shear on box lifetime. The effects of crushing on BCT are expected to be smaller than that on lifetime which can be gleaned from the following considerations.

Recall that the McKee equation **[10]**

for the BCT of the board takes the form:

$$BCT \propto ECT^{0.75}\left\{\sqrt{D_{11}D_{22}}\right\}^{0.25}W^{0.5}$$

with *ECT* being the edge compression strength, $\sqrt{D_{11}D_{22}}$ is the geometric mean of the flexural rigidity of the corrugated board commonly approximated by a 4 point bending stiffness measurement and *W* is the perimeter of the box. Since for a sandwich panel the flexural rigidity is proportional to the caliper of the board squared, the McKee equation is further approximated by this substitution resulting in the more familiar form of the McKee equation which is proportional to the square root of the board caliper.

However, it should be noted that the flexural rigidity term arises for the derived analytical expression for the buckling of a vertically loaded orthotropic plate and as approximated, is neglecting the effect of transverse shear rigidity. Estimates for the decrease in panel critical buckling load can be made from several available analytical and numerical models **[11, 1,** and **6]**. A typical calculation is shown in reference [6] where for the case of 70% caliper crush reductions in ECT are 10% and reductions in bending stiffness are 20% so that the predicted loss in BCT is 12%. But with the inclusion of the loss of transverse shear at this level of crushing, the panel critical buckling load is actually reduced by 32% leading to a predicted BCT loss of 16%. Therefore the neglect of transverse shear will lead to an overestimate in BCT by a few percent by this calculation.

Ultimately, if crush were to be eliminated a gain in BCT of 15% can be expected. Measurement of transverse shear strength is a sensitive method to determine what stages in operations cause the crush.

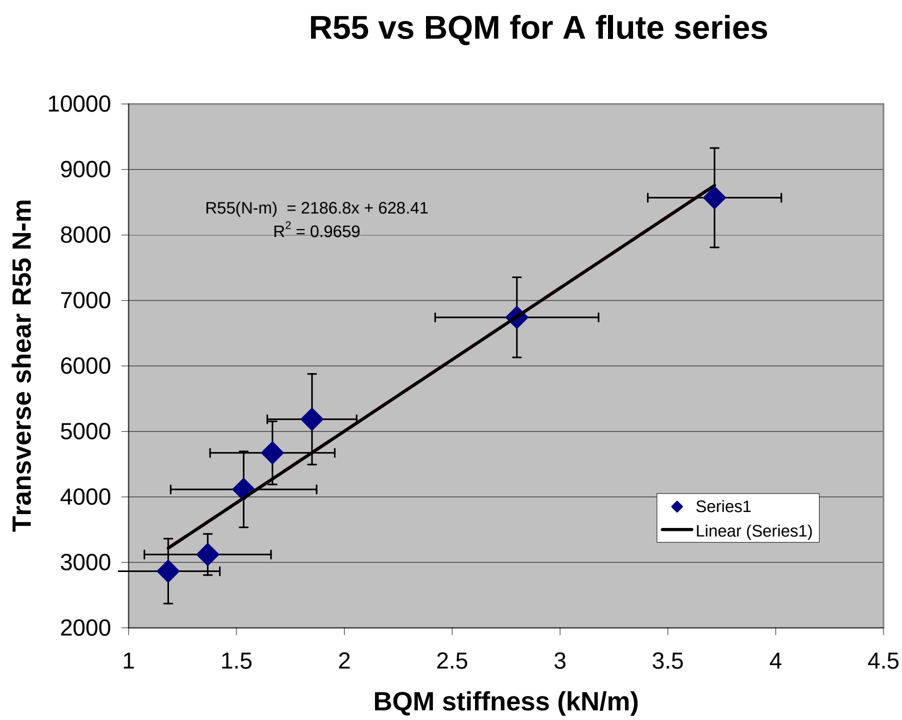

Figure 6. Same as Figure 4 but with the 42A outlier point removed.

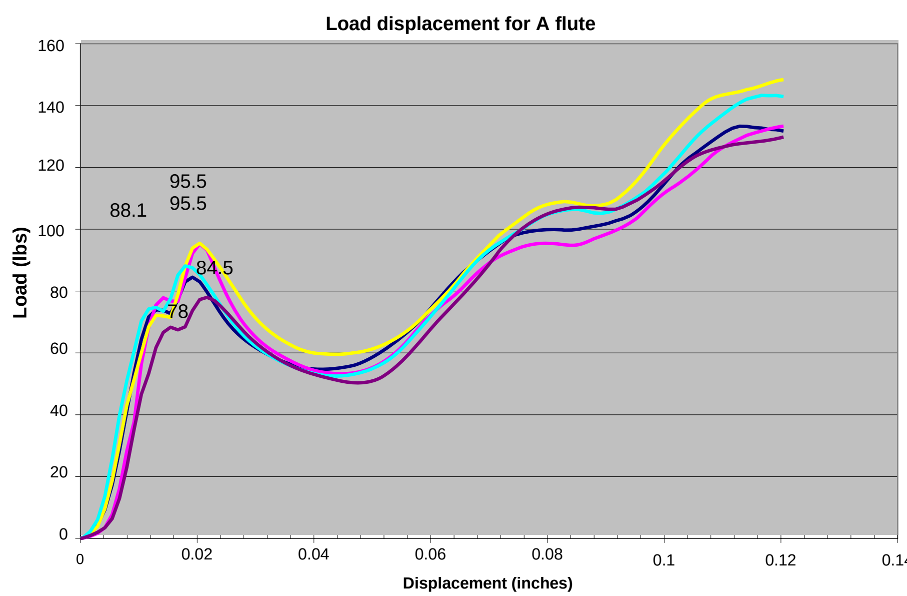

Figure 7. Flat crush load displacement curves for 2 x 2" Uncrushed A flute specimens.

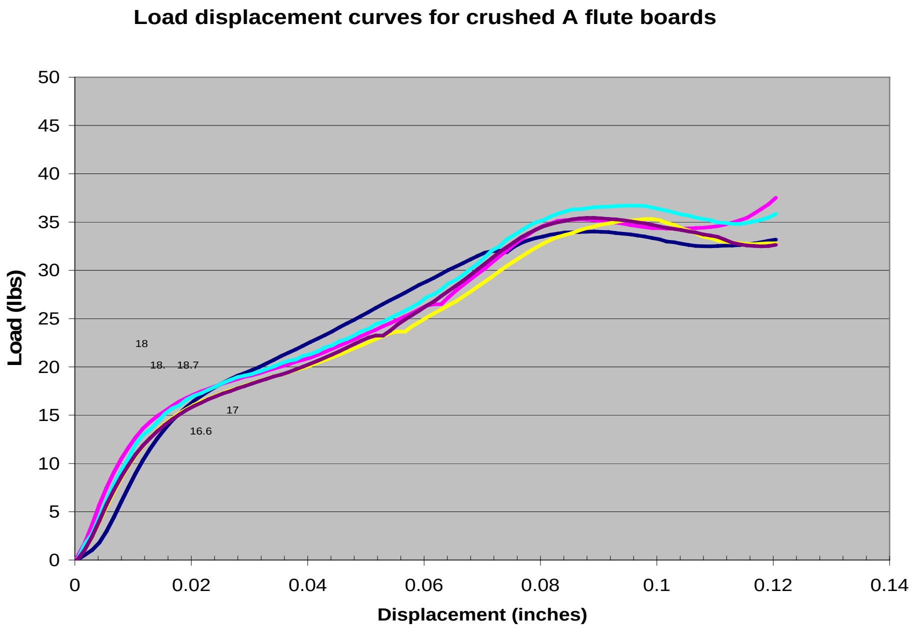

Figure 8. Load displacement curves for A flute boards crushed though nip passage gap set at 70% of the original caliper.

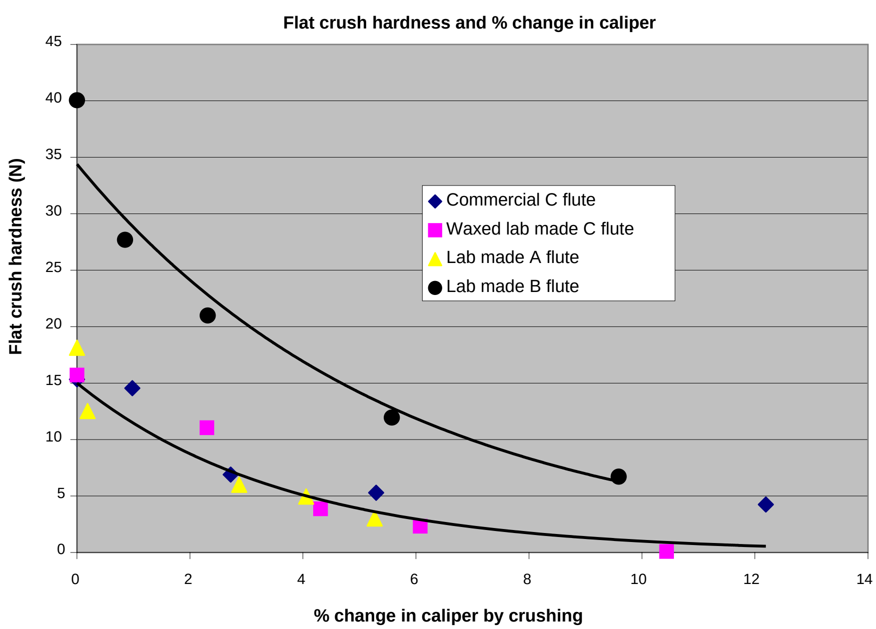

Figure 9. Hardness is the value of the first peak in the load displacement curve in the flat crush test. Although the % change in caliper is about 10% or less, the change in hardness is a factor of 4 to 6 times. The hardness was measured through examination of the load displacement curves using an Instron universal tester and a compression load cell. Thus a measure of hardness is a sensitive detector of board crushing.

SUMMARY

Board crushing occurs to some degree in nearly all box plant operations, however the availability of convenient instrumentation to characterize crush with sufficient sensitivity has been limited. This paper advocates measurement of transverse shear strength as a means to detect board crush. A new non-destructive sonic method was shown to correlate well with measured values of medium hardness and results from a calibrated laboratory torsion pendulum method. These methods have a much greater dynamic range than the corresponding board caliper values thus offer the opportunity to survey box making operations to source and eliminate the cause of board crush. The calculated gains in box compression strength from the elimination of crush is of the order of 15% which should provide an incentive for the industry to incorporate transverse shear measurement of board as part of its regular manufacturing practice.

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REFERENCES

1. Nordstrand, T., Carlsson, L., "Evaluation of transverse shear stiffness of structural core sandwich plates", Composite Structures vol 37, pg 145 (1997).
2. McKinlay, P.R., Shear Stiffness tester, US Patent 4,958,522.
Analysis of the strain field in a

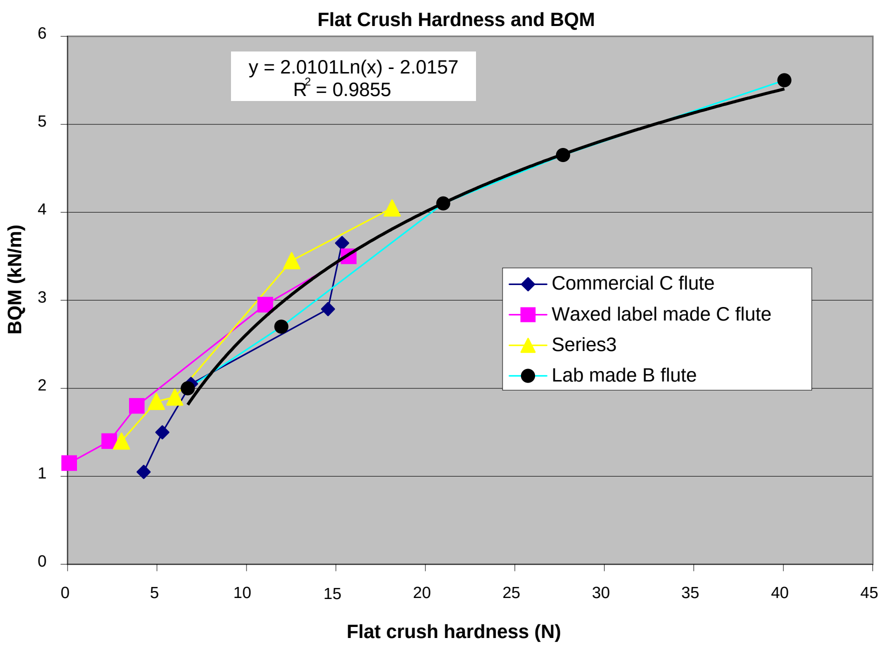

Figure 10. Correspondence of the BQM to the flat crush hardness. A non-linear relationship appears to be the best generalized fit for the data. The large range in BQM values corresponds well to the large range in hardness, thus BQM measurements can substitute for hardness to detect levels of board crushing with more sensitivity than caliper measurements.

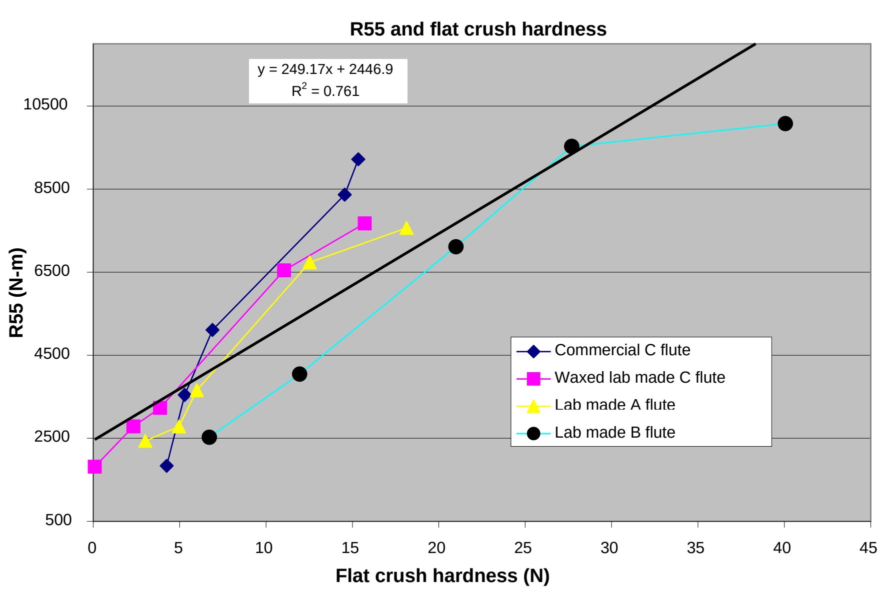

Figure 11. Similar to Figure 11, except the R55 as determined from the torsion pendulum and bending stiffness tester is plotted versus flat crush hardness.

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twisted sandwich panel with application to determining the shear stiffness of corrugated board. *Proceedings of the 10th Fundamental research symposium of the Oxford and Cambridge series*, Oxford, 575 (1993).

3. Chalmers, I.R. "A new method for determining the shear stiffness of corrugated board", Appita Journal, vol 59, no.5, pg 357 (2006).
4. XQ Innovations, "BQM" Box Quality Monitor, 10A The Highway, Mt. Waverly, Victoria, Australia.
5. Popil, R.E.,Coffin, D.W., Habeger, C.C., " Transverse shear measurement for corrugated board and its significance" 61st Appita Annual Conference and Exhibition, Proceedings vol 2 International Paper Physics Conference Papers, Gold Coast Australia 6 -10 May 2007.
6. Popil, R.E., Schaepe, M. "Comparative evaluationof the potential for wax-alternative packaging coatings", Tappi Journal, vol 4, no. 8 25-32 (2005).
7. Batelka, J.J. "The effect of boxplant operations on corrugated board edge crush test" Tappi Journal, vol 77, no 4:193 (1994)
8. Kroeschell, W.O. "Edge Crush Test" Tappi Journal, vol 75, no. 1., 79-82 (1992).
9. Chalmers, I.R., "The use of MD shear stiffness by the torsional stiffness technique to predict corrugated board properties and box performance" 61st Appita Annual Conference and Exhibition, Proceedings vol. 1 Appita Conference Papers, Gold Coast Australia 6 -10 May 2007.
10. McKee, R.C., Gander, J.W., Wachuta, J.R., "Edgewise compression strength of corrugated board", Paperboard Packaging vol 48, no. 8, pg 149 (1963).

Bonding Lightweight Boards

Roman P. Skuratowicz
Corn Products International Inc.

The Lightweight board grades that we're focusing on here are mostly micro flutes that are mostly smaller than E. Some examples are the F, G, and custom flutes.

THE PAPER WEIGHTS THAT WE'RE LOOKING AT ARE TYPICALLY UNDER 17 LBS BUT CAN HAVE A RANGE FROM ABOUT 13-20 LBS. These are very lightweight boards by most practical standards. While combining these grades is typically done with either an Asitrade or a straight corrugator, most of this presentation will be on the straight corrugator as opposed to the Asitrade. However, there will be a lot of aspects that touch both.

One of the predominant growth areas for these lightweight combinations is replacing corrugated or folding carton stock. Examples are cereal boxes or food packaging boxes where basically you're reducing the fiber content while still maintaining the integrity of the package. Another application is clamshell containers; your McDonald's boxes, Big Macs, and the like. High graphic quality is a typical feature of clam shells and usually is a selling point for this application. One of the other applications I've seen is with the coffee cup mugs. You've got single face where they actually make a small flute corrugated sleeve to protect you from burning yourself. It's the environmentally friendly version versus Styrofoam containers.

Runability issues that typically arise when running lightweights are going to be different than those when running normal corrugated grades. We're going to focus on two of the main areas right now. Heat transfer is the first. The main issues here are that you're dealing with a very dense and a very light paper. Now you've lost all the insulation that you normally see with heavier paper grades. You get a very rapid heat transfer with very lightweights. As you get that rapid heat transfer, not only do you have to have very tight temperature control on the corrugator, but now you're going to affect the entire gelling profile of the adhesive. You're trying to do a balance between getting enough temperature to gel the adhesive and, more importantly, to remove the moisture, versus flashing off the moisture and ending up with a very white glue line.

Moisture control is a major concern and warp frequently is the end result when running lightweights and these two issues probably are the principal hurdles that you face with these papers. With very low basis weight boards you get more effect from the adhesive and the moisture that is part of the adhesive. Application of the adhesive and the starch solids in the adhesive become factors to control. The moisture effect, and even more importantly, the adhesive chemistry also become factors. Normally a lot of the room for error that you see with typical grades doesn't apply here. You have much tighter tolerances. How hydrophilic is the adhesive? How well will it hold onto the water? How much will it let the water go again? That balance between too much moisture in the end board versus flashing off the water too quickly during the process is critical to control.

CONCERNS ON THE CORRUGATOR

A critical area that you need to be focused on is the adhesive gap settings. For most machines, unless they're a "state of the art" new machine, you're dealing at the low end of the gap setting. Typically you're going to want an applicator roll gap under .005, where possible. Volume in cells on the glue rolls will impact application and you'll also be limited by mechanical stops.

Tension and tearing become an issue because you're dealing with very light paper. You want to keep good tension on webs to avoid issues with flute formation, but very lightweight liners and mediums are prone to tearing, specifically if the tension adjustment's off or the parallel is off.

Moisture removal and over-drying become a very powerful issue. When you have a very low basis weight and very dense paper, it's very easy to over dry the paper. Many times you're battling moisture removal and over-drying constantly, and you end up with a very small margin for error. Adhesive now requires tighter viscosity and gel temperature control than with typical adhesive. Historically you could have a variance of viscosity by about 5-7%. Adhesive viscosity variation can cause variation in adhesive application. If you continue with these older levels of viscosity variation, the effect of these previously normal levels of adhesive application variation will be much greater on lightweight board combinations. You're pretty much at the low end of what your machine can apply with lightweight board combinations now, so if the viscosity of the adhesive goes up, it can increase your application by 10%, 20%, 30%, all of which will throw off all your moisture balances.

Liner and medium innovation becomes a concern here. The corrugators that are combining with innovative liners and are always getting requests for specialty liners, non-paper liners, poly foil, and other different materials. You're also dealing with the coatings. Grease resistance is a predominant one and water resistance is another.

For normal papers; you can typically coat the one side, the non-bonding side, and you still have a bondable paper. With lightweight paper, coatings are going to completely penetrate. You're going to deal with them on both sides, so you have to adjust the adhesives chemistries accordingly. The main area that get affected here, adhesive absorption into the paper, typically gets restricted by these coatings. Vapor transmission rates in coated papers will basically not allow you to drive off the moisture. These are all factors that have to be dealt with.

The other issue is that a lot of these different liners will have machine issues, typically temperature. Corrugating rolls are what they are. You have the ability to change wraps on some of the rolls, if you've got too much heat there, and get the material to soften up and bond in the hot plates.

Temperatures with coated liners, in fact temperatures in general on these lightweight grades, need to run lower than industry norms. Typically the liner temperature's into the nips should be at about 135°F at the glue tips versus a typical 180° 210°F for conventional grades. Much lower temperatures on lightweight liners brings us back to the balance of moisture.

QUALITY CONCERNS

Warp is probably the predominant quality concern. Very lightweight paper accentuates warp possibilities. With combined board moisture you are typically looking at about 6.5% to 8.5% in the final product for the moisture. You're running very quickly on these machines. You don't have much room for error.

Wash boarding and preprint quality, are other quality concerns. Depending on how the liner is printed, you may have to go with the Asitrade versus a straight corrugator. Caliper is an area which you're also going to be dealing with. By having a very low caliper, scoring is affected heavily by moisture. You don't want the board too wet for rolling score or have it too dry where you get cracked or checked scores.

In conclusion, light weight papers change the machine and bonding dynamics. The solids in the adhesive, the application rate, and temperature control are probably the three most critical areas that specifically are controlling the warp and controlling the quality of the paper. Moisture and tension are primary concerns to make sure you get a good runability. These are the main areas on which to focus. The main message is that all your variances and all your tolerances are much tighter. Everything has to basically run with very little room for error. CI

About the Author

Roman Skuratowicz is a special project manager for industrial sales, having 16 years experience with Corn Products, primarily in paper in corrugating applications and product development and support. Roman has a degree in organic chemistry from the University of Illinois, Champaign and an MDA from DePaul.

Running Lighter Weights

Herbert Kohler, Kohler Coating

I'd like to talk to you about our perspective on running lightweights.

As the industry progresses to higher speeds; smaller flute profiles, better graphics, and tighter functional standards, lighter basis weights become more difficult to manage.

In order to be successful with running lightweights, we also need to reduce caliper loss in the fluted medium. We need to reduce contact time with the glue roll. We need to think about deflection compensated contact rolls. [**fig 1**] These are rolls that are basically designed so that their stiffness from center to edge bows, so that even though it's deflecting under different load and width conditions, the pressure that is distributed across the width and pushing the flute tips into the glue roll is uniform for all loading conditions.

The shell on one of the rolls is actually connected to the inner shaft at the center instead of the end. It allows the shell to bend one way and the journal to bend the other when pressure is applied. You balance the moments of inertia of the two shells in order to achieve that result. Rolls bend proportionally to the amount of pressure applied and then the roll gap is always perfectly parallel, without crowning for any loading or sheet width.

Minimizing moisture also means,

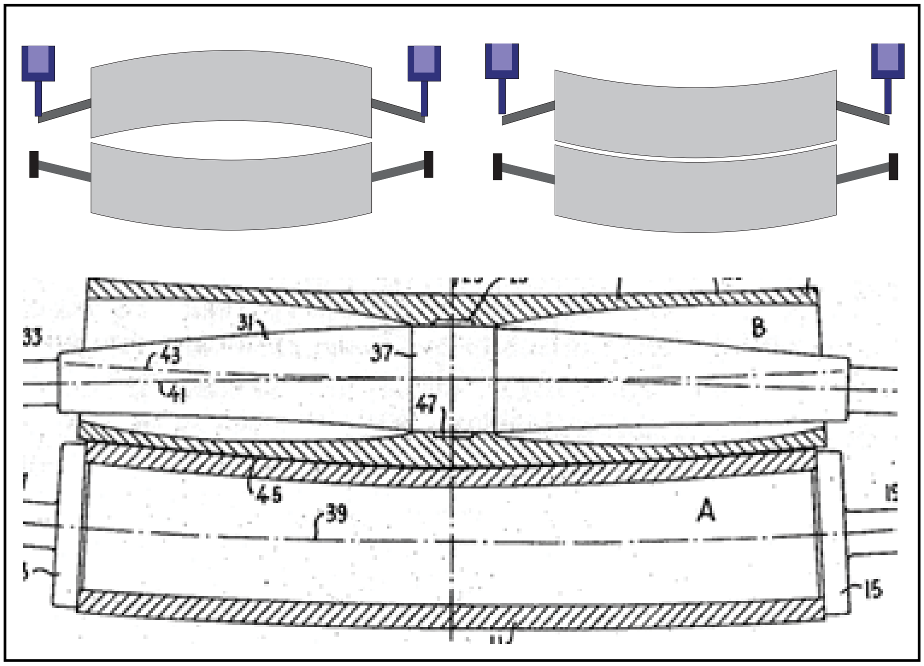

Figure 1: Deflection compensated rolls.

once we reduce adhesive application on the glue machine, we also need to do it in the single facer. **[fig 2]** As an example, a plant having installed a film metering doubleface glue machine formerly had roughly an equal number of batches of singleface and doubleface adhesive. They now make two singleface batches for each doubleface batch. Thus, they are applying about twice the amount of water on the singleface side as the doubleface side. Warp is often the result. The status cries out for an adhesive film metering mechanism to be retrofitted on the singlefacer. **[fig 3]**

In order to be successful, we also need to reduce the heat going into the board. Almost all speakers on the topic of running lightweights stress this operating technique. I certainly think "backwards is better" (an operating technique to have more heat transfer capability downstream in the hot plate section, as opposed to the conventional practice of having higher heat transfer capabilities at the beginning of the hot plate section. ed.) when running lightweight or heavyweight when you're dealing with these kinds of low adhesive application levels. I'm a big believer not only in controlling pressure dynamically but I think that it serves the purpose better across the entire spectrum to put less heat into the board all the time.

Corrugators are definitely running cooler today. I don't know where natural gas pricing is in your area of the country, but it is about $14 per 1,000 cubic feet in Ohio, at the moment (Fall 2005) and it is projected to go up about another 30% in the heating season. Cold corrugating is coming. They will need to be at least one corrugator in the United States running without a boiler.

In order to be successful on lightweights we also need better tension control. One of the things people forget when they take water out of paper is that you lose the ability to stress relieve those three sheets of paper or five sheets of paper when they go into the double backer. So a lot of stress relief that used to go on and a lot of equalization of forces now no longer happens.

The only way to do it is to do what people do in Europe, which is to drive pre heaters, have tension controlled webs into the double backer, and to do what ever other industry that laminates three dissimilar pieces of anything together and that's to control accurately the tension of all of the component parts of the laminate. This is the only industry I've ever seen that doesn't control tension and

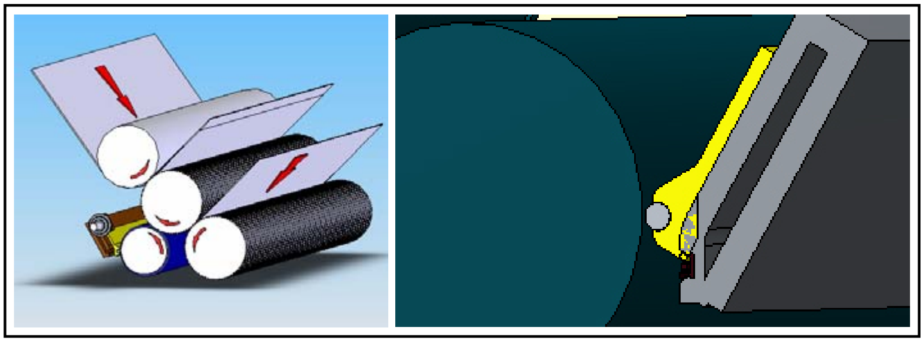

Figure 2: Thin film metering is required on both the glue machine and the single facer.

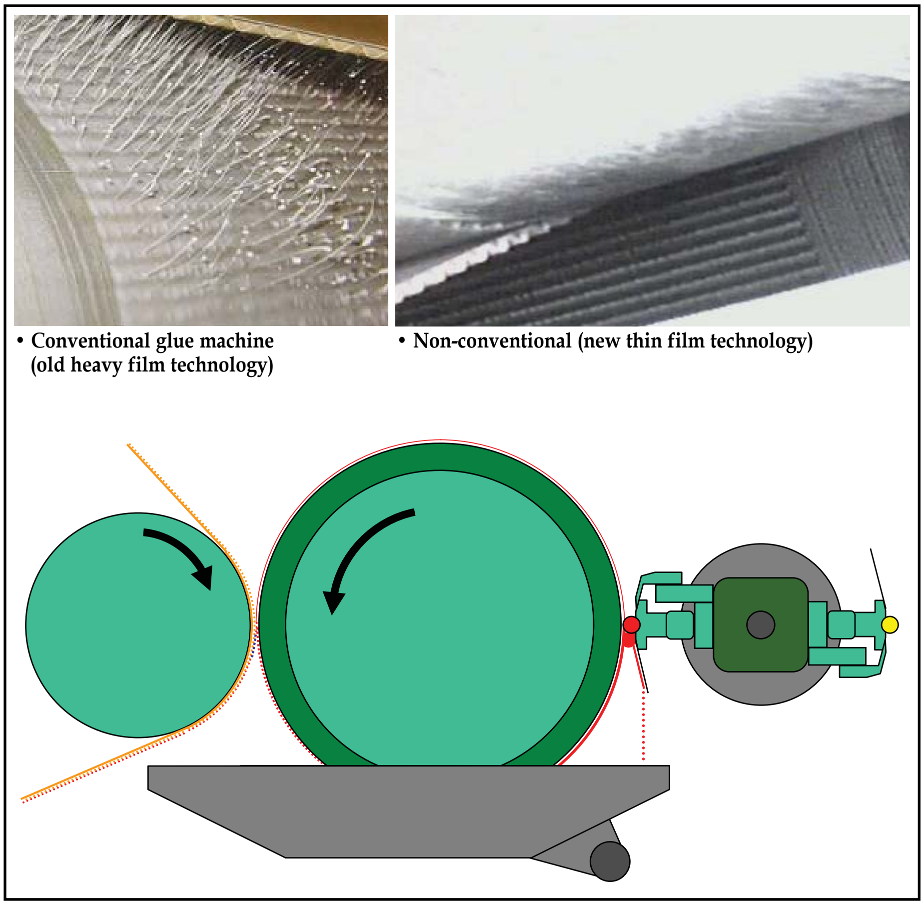

Figure 3: Thin film metering provides the ability to accurately reduce adhesive film thickness below 0.00005 inch/0.0127 mm.

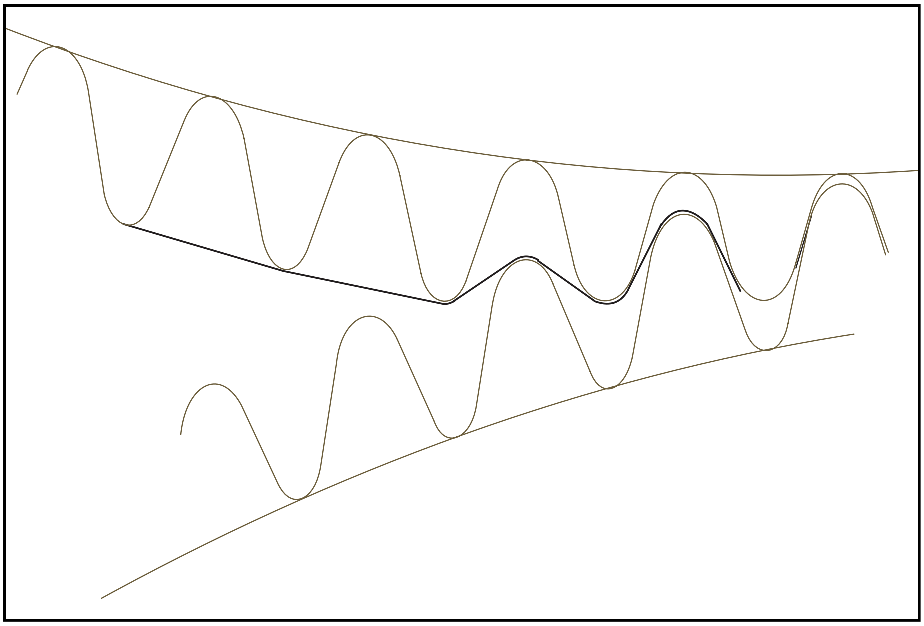

Figure 4: The tension spikes once per flute due to web path changes as the teeth engage.

when water is no longer a dominant variable, tension will become the dominant variable.

Again, all webs need to be controlled with tension. We also need better side to side tension control. It's extremely important, as we take corrugators cooler, not to have 15, 20, 30 degree temperature differentials across the faces of web. That typically means better alignment, anti backlash gearing on wrap control arms, tension leveling rolls and spreader rolls. I don't see spreader rolls very often in the corrugating industry, but I think you're going to see more and more of them as people run lighter and lighter basis weights.

We need to reduce damage to the fluted medium. We need to eliminate the tension spike in the corrugating roll nip, by using belted single facers or deflection compensated rolls. **Figure 4** illustrates the tension spike I am talking about that occurs once per flute, which might be 2,000 times a second, due to changes in the web path as the corrugating roll teeth engage. This has been a historic problem and I'm suggesting a very simple solution.

A device called an air flotation bar that's been around for a long time has one very interesting property, and that is, for very small amounts of storage, it is a massless dancer roll. It is capable of adding and subtracting as much web as needed to avoid the tension spike entering into the corrugating roll that has been present on every single facer since the beginning of time. It'll drop the tension rise from about a factor of four down to about a factor of one quarter. In other words the tension may go up to 1.25%.

As we go colder and as we have increased friction in the corrugating rolls, we have to avoid fracturing the web. This is the way to do it. We'll make stronger flutes and we'll use less adhesive this way.

In summary, running lighter weights requires thin film metering, better tension control and web handling, reduced heat input into the corrugator and reduction in medium damage. CI

About the Author

Herbert Kohler has a background in mechanical engineering and 26 years of experience in the corrugating and paper industries in the areas of adhesive application, coating application, web handling, winding, unwinding, laminating and new process development. He has over 10 patents in these areas. He is the president of Kohler Coating.

Gain Bargaining Power

Brian Deitmeyer

Single-source negotiations often make supply managers feel less than powerful, and sometimes, taken advantage of.

WHETHER YOU ARE NEGOTIATING WITH A STRONG-WILLED MANUFACTURER FOR THE PURCHASE OF A ONE-OF-A-KIND MACHINE, OR WITH A GOVERNMENT-OWNED GROUND SERVICES SUPPLIER AT A LARGE EUROPEAN AIRPORT, SINGLE-SOURCE NEGOTIATIONS DO NOT ELIMINATE THE NEEDS FOR SUPPLY MANAGERS TO ACHIEVE THE BUSINESS OBJECTIVES OF THEIR ORGANIZATIONS WHILE MAINTAINING PROFIT MARGINS.

One-sided capital expenditure negotiations often seem like difficult-to-win situations. However, not every negotiation involves a "fixed pie." The supply manager should consider the consequences for both parties if there is no agreement.

First, what are the interests of the supplier? What are the short- and long-term, hard and soft costs and benefits to the supplier if they do not reach agreement with you?

Supply managers who take the time to estimate their suppliers' alternatives in the front end of a sole-source negotiation may find themselves in a much more powerful position. These supply managers can proactively and diplomatically use their knowledge of the supplier to more equally balance the power in their negotiation.

ARE YOU IRREPLACEABLE?

The supply manager should probe into what makes the organization a great customer for a supplier. In other words: "What does the supplier value greatly in this relationship?"

It is much more difficult for any supplier to lose you as a customer if you are one of their best customers. By making yourself a better customer, you make the supplier more reliant on you, even in a single-source negotiation.

Supply managers who want to make themselves a better customer need to look for terms and conditions that are of great value to their supplier, but that are low cost to their organization. This simple, but not easy concept is the key to changing your value proposition as a customer. For the supply manager who perceives less power in the single-source negotiation, trading interests that both sides value differently in a negotiation is the best way to add truly measurable value to the relationship.

HOW DO YOU RANK?

World-class negotiation results come less from the trading act itself, and more from doing the hard work of prioritizing the tradable items for both sides.

Supply managers who want to focus on understanding tradable items can first consider:

- What specific items does my organization want out of the negotiation?
- What is most and least important to us?
- How will we measure this?

Next, the supply manager should consider the same for the supplier.

- Who is my supplier's best customer?
- What criteria make them the best customer?
- Where does my organization rank in their best customer list?
- How can my organization align with the supplier's best customer criteria?

Best customer criteria usually include straightforward items including price, volume, delivery, length of contract and strength of relationship at multiple levels of the supplier organization. More advanced customer criteria may include information sharing, supply management, warehousing, electronic data exchange, joint revenue targets and process improvement projects.

CASE IN POINT

Take the case of an engineered component purchase, for example. After an initial review of the supplier's business profile on its website, the supply manager initiated the research process with the key supplier contact, and gained a deeper understanding of the supplier's business strategy and direction. The supply manager then used this first contact and understanding to schedule additional research meetings with other supplier contacts to confirm that the supplier's consequence of no agreement (CNA) was losing a referenceable customer in a targeted industry.

The supply manager also discovered that new customer-engineered component sales were a major portion of the supplier growth objectives for the next two years. Based on this understanding of the supplier's CNA, the supply manager was able to position his value more powerfully in the negotiation, and also increase his credibility with his internal customer based on better understanding the goals and needs of the supplier.

In addition, the supply manager, by using the estimation and analysis of the "best customer criteria," identified several wise trades. The highest ranked item for the supplier was access to global markets outside the United States. The supply manager was able to assist the supplier in making key contacts and gaining access to customers in the global marketplace. Subsequently, the supply manager also found it beneficial to obtain a more consistent and high quality supply in the remote regions of the world. The supplier also ranked cost reduction highly in the development of new component products. The supply manager and supplier undertook an intense review of design, engineering, ongoing maintenance and other development costs, which resulted in a more realistic sharing of the costs between the two organizations. CI

About the author:

Brian Dietmeyer is senior partner with Think! Inc., an international strategic negotiation consultancy, co-author of Negotiating Rationally, and a professor at the Harvard Business School. Contact him at 888-99-think or visit www.e-thinking.com.

A Modest Proposal for Skill Standards and Workforce Development

Keith D. Romig Jr., Ph.D.

A coalition of business, labor, education and community establishes standards for production workers

In our industry, the training of production workers has been conducted on an informal basis in all likelihood since its earliest beginnings. When a new worker comes on board, older workers take the new person under their wing, and via instructions, communication and analysis of mistakes, the new worker gains confidence, experience and skill. In fact, until the second half of the 1970s, it was standard industry practice, when a new mill opened, to bring experienced workers from the company's older operations to train the new workforce. In this way a young worker, starting off with no particular skill or training, could learn after a sufficient term of years to move up in the mill to such jobs as machine tender and even beyond.

For many years, this system worked very well for both the employers and the workers. The employers got a skilled, loyal workforce, and the workers got secure jobs that in many cases they could count on until retirement. The unions in the industry supported this system because the experienced workers doing the training were often loyal union members who did not hesitate to convince the new workers of the value and need for union representation. But the unspoken premise of this system was that the paper industry would keep expanding indefinitely, and the number of workers would continue to increase, so that a worker would almost never need to think about finding alternative employment outside the industry.

Until the early 1990s, the paper industry was generally thought of as one of North America's strongest, and considered largely immune to the economic pressures of globalization. "We have the trees," the argument went. "So it only makes sense to keep on making the paper here." But by that time, employment in the industry had begun a slow but steady decline. And then in the late 1990s the world market exploded, throwing decades of conventional wisdom out the door. The Asian financial crisis, combined with unfair trade practices in particular, put strong downward pressure on prices, and many companies were unable to compete.

Plants closed. Companies went bankrupt and closed their doors. Other companies reorganized or sold off large parts of themselves. The one constant theme in this dismal symphony was job loss for the ordinary worker. It became clear as this process got under way and close to 100,000 workers at all levels in the industry lost their jobs, that production workers were being hit hardest. Management, technical and sales personnel had college degrees and formal track records that human resource departments respected. Maintenance workers had craft certifications from union programs or trade schools. But all production workers had were their years of experience and the mountains of skill they had been able to pick up informally on the job.

Although all classes of workers were hurt by this massive job loss, and by the drastic downsizing of the industry, production workers in particular found it difficult to convince employers outside the industry of the very real skills they had learned, and of how much they could do for employers outside this industry. Production workers in other industries had similar experiences. Entire communities were thrown into disarray as unemployment, underemployment and a host of social ills became their lot.

Not only were the lack of formal training, and the lack of documentation of skills adversely impacting production workers in manufacturing, but employers began to perceive a problem of attracting new workers with sufficient skill to replace those expected to begin retiring. Similarly, young workers without experience found themselves unable to demonstrate their skills to employers. A disconnect had grown where workers who had the capacity to take on challenging industrial jobs could not get hired, while employers were concerned they could not hire workers with the skills needed to perform the jobs available.

Fortunately, the National Council for Advanced Manufacturing (NACFAM) and the AFL-CIO's Working for America Institute also saw the problem. They made a massive effort to get major unions, companies, educational institutions and important civic groups together in a coalition to develop a set of standards, certifications, assessments and educational tools to properly verify and certify the skills of current, or recently laid off production workers, and to train and certify new workers. Initial funding was obtained from the U.S. Department of Labor. The coalition named itself the Manufacturing Skill Standards Council (MSSC). It drew leadership and strength from each of the three major stakeholder groups: business, labor, and educational and community.

A set of standards was put together and began to be marketed by the MSSC in 2001. Another intensive effort led to the final development by early 2005 of assessment and certification tools, and a course curriculum with various levels to help both experienced workers and people entering the work force to train for and pass the certification.

In 2004, Harley-Davidson President and COO James McCaslin assumed leadership of the MSSC as its chair and Harley became one of the lead companies involved in the effort. In 2006, Glencoe McGraw-Hill published a first-of-its-kind textbook geared to the MSSC standards.

Now there are more than 50 MSSC assessment and training centers across the United States. Training has begun and the first MSSC Production Technician certificates are beginning to be issued. These will assure employers of a basic level of skill and understanding of production processes for any new employee they hire. The certificate will assure workers that they can take it to manufacturing employers, who will then be assured of their basic qualifications. The MSSC system holds promise of being able to ease and eventually eliminate the disconnect between workers who need family-supporting jobs and employers who need skilled workers.

In addition, the MSSC system is complementary to valuable programs specific to the paper industry, such as (npt)2 and others. The MSSC certificate could well provide the necessary entrée to the more advanced and industry-specific training offered by these organizations. The result for workers will be a more secure job base and substantially more assurance that their job skills are portable. The result for employers will be a more secure sense that their workers have the skills to do the job. It has been clear for decades that production workers in the United States have a great deal of skill. The MSSC system will give workers the piece of paper to prove it. CI

About the Author:
Keith Romig has a doctorate in chemical engineering from the University of Colorado and has been with the United Steelworkers and its predecessor unions since 1991. The United Steelworkers (United Steel, Paper & Forestry, Rubber, Manufacturing, Energy, Allied Industrial & Service Workers International Union) is the largest industrial union in North America and the largest union of paperworkers in the world. Contact him at kromig@usw.org.

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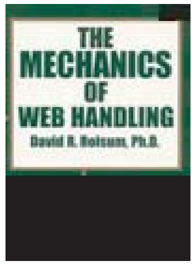

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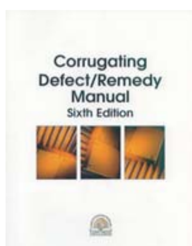

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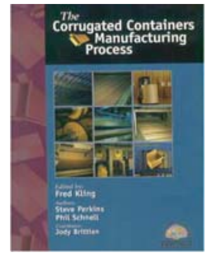

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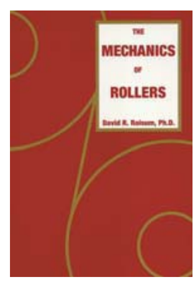

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Written by David R. Roisum, Ph.D.

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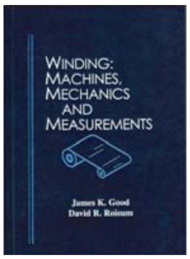

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