Core Competencies...

Understanding the base for quality winding.

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About the Author

Paul Roth, Vice-President and Director – Sales of Appleton Mfg. Division, Productive Solutions, Inc., has been involved in the marketing and selling of core cutting equipment arena for over fifteen years. Appleton Mfg. Division is a leading manufacturer of core cutting and handling equipment.

If you use cores – you should know this

In this article I will increase your core competency by introducing a variety of subjects relating to the cores used to facilitate web handling, starting with a quick overview of why they are used, how they are made, what issues arise in manufacturing, handling, storing, cutting and using them.

Near the end of this article I will cover some of the typical core problems converters face and offer ways to identify and avoid them.

What are cores, and why are they are used

Cores are the tubular paper, plastic or steel forms found inside of rolls. The core provides a foundation for winding and unwinding a web product – non-woven fabrics, tag and label stock, tape, paper, light gauge metals and film… items that typically found in roll form. The core provides a means of starting a round roll, often is used a part of the winder drive system, supports and protects the product during shipment, aids in handling, and finally is becomes part of the unwind mechanism.

You will find cores on virtually all web processes – at the winder, rewinder and unwind stages of the process. They are often forgotten – until they are missing, or cause production problems!

Core Materials

Originally, cores were iron or steel. They were shipped with product and returned when empty. Metal cores fell into disfavor due to the book-keeping and customer relations problems associated with charges, credits and tracking the cores. There are firms using steel cores internally, but you seldom see them in customer shipments.

Spiral wound fiber cores became the core of choice. You may run into convolute cores in a few applications… these cores are generated by wrapping a sheet of paper around a mandrel (similar to the process of starting a web on a core). Convolute cores are distinguished by a single seam parallel to the core centerline. They are used when a very smooth surface is required as they do not have the spiral seam present on most cores.

Plastic cores are also a small factor in the market, again most prevalently in areas where they can be readily reused or in small diameter consumer applications where they function as part of the consumer’s equipment.
How are spiral wound cores made?

A quick look at how cores are produced will help you understand some of the process variables that can affect your operations.

The core making process begins with rolls of kraft paper that are staged in the back stands and fed through tensioning devices and glue systems enroute to the winder. When threaded through the winder, the layers of paper are called plys. The grade of paper, thickness of the plys, and the type of glue all contribute to the core wall thickness and the core strength. Different grades are used to generate cores with different costs and properties. Short fiber, high recycle content, core stock is the lowest cost and weakest paper... kraft linerboard is the strongest and most expensive.

Typically the inner and outer plys are more expensive grades with lower cost plys in the middle. The inner ply is fed onto the mandrel from the side opposite the balance of the plys. The inner ply has its own glue applicator, so you may experience different bond performance on this ply.

Winder designs vary, but they all serve the same purpose, that of creating a spiral wound core by compressing the glue coated plys together over a mandrel. The plys are wrapped around a mandrel and introduced under the winding belt. As the belt moves, the plys are drawn in and compressed, forming a continuous tube that feeds off the mandrel.

Though the winding process has been with us for over half a century, it has become increasingly sophisticated during the past few years. While the core inner diameter (ID) has been, and still is, dictated by the mandrel diameter, manufacturers are now using on-line laser measurement systems to monitor the outside diameter (OD). The operator adjusts the OD by feeding in plys of varying thickness to control wall thickness. This gets tricky as each ply can vary within the process tolerances of the paper makers. Even with laser measurement there is still variation in OD, just less than before. OD is still dependent on operator skill and attention.

Downstream from the winder, the core is allowed to set before being introduced into a device that cuts the continuous spiral cores into discrete lengths to facilitate loading into carts or pallets for transfer to subsequent processes or to the customers. Core manufacturers are increasingly using an in-line knife cut-off device, as opposed to a saw, for better cut quality. There is some concern that the in-line knife cut may reduce chuck tear-out resistance on heavy wall cores by disrupting the ply bond in the adjacent inch of core. Some manufacturers are recommending post cure re-cutting to eliminate this.

Re-cutting is done in part because the cores shrink as they dry (cores come off the winder at about 12-14% moisture and air dry to 8-9%). This shrinkage is hard to predict, resulting in cores that are short. Re-cutting is also done to facilitate core handling, reducing the number of cores being transported. Most cores are re-cut before going on to web processing equipment. Where this re-cutting occurs is a choice the user needs to make. Pre-cut core programs put the re-cutting responsibility with the core manufacturer… sounds great, but there are trade-offs.

You need to determine if you should require oven dried (cured) versus air dried cores. Cores can be cured in forced air kilns to minimize shrinkage and dimensional variation. This adds to cost, but may be necessary to prevent the core from shrinking and spinning or falling out of your roll.
Core Trends

We have seen the following trends developing in core usage:

- Core construction and performance are being improved. First introduced in Europe, hard (denser) cores are becoming a bigger factor in the United States. These high performance cores were designed to raise the critical speed of cores used in wide web applications, minimizing the chance for core burst during unwind. Cores can literally “explode” if their critical speed is exceeded – most often at the very end of a high speed unwind. These high performance cores typically use denser, longer fiber paper in their construction.

- Metal caps are becoming rarer. Stronger cores and special end treatments appear to be reducing the requirements for capped cores. Most of the requirements we see are for caps are for newsprint rolls that are exported.

- Cut core tolerances are tightening. Only a few years ago I had a Swedish machine builder argue that tolerances of plus or minus (+/-) 1/8th of an inch were more than adequate. Now they are touting 1/32 of an inch. We historically provided + 10 to 30 thousandths of an inch. Now we are building machines that meet specs of + 5 to 8 thousandths.

- Film cores are becoming more sophisticated. Treatments include skiving, grinding, and extrusion coating to provide dense, seam-free cores for winding films. This reduces the amount of film lost due to seam patterns telegraphing into the roll of plastic.

- We have recently seen an increase in re-cutting used cores for re-use. This practice is more prevalent overseas, but can reduce costs if quality is properly controlled.

- Core disposal is becoming an issue. Though most paper mills do not want to repulp cores as they slow the digesting process significantly, the Composite Can & Tube Institute can provide a list of recycling facilities (reference appendices).

That’s the short course on core making. The relevant question is how do you know what you are getting? There are some standards you can use. We have noticed increased standard setting activity due to ISO requirements for quantifying product.

Fiber cores

The CCTI (Composite Can and Tube Institute) has and is developing standards for fiber core quality. Some of the basic subjects include:

<table>
<thead>
<tr>
<th>Number</th>
<th>Topic</th>
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<tbody>
<tr>
<td>CT-101</td>
<td>Measuring Wall Thickness</td>
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<tr>
<td>CT-102</td>
<td>Measuring Inside Diameter</td>
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<tr>
<td>CT-103</td>
<td>Measuring Outside Diameter</td>
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<tr>
<td>CT-104</td>
<td>Measuring Length</td>
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<tr>
<td>T-5</td>
<td>Ordering and Storing paper mill cores</td>
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<tr>
<td>T-108</td>
<td>Side-to-Side Crush</td>
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<td>T-121</td>
<td>Measuring Warpage</td>
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More sophisticated, performance related, subjects include:

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<thead>
<tr>
<th>Number</th>
<th>Topic</th>
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<tbody>
<tr>
<td>T-50</td>
<td>Bending and Stiffness</td>
</tr>
<tr>
<td>T-113</td>
<td>End Supported Beam Deflection</td>
</tr>
<tr>
<td>T-114</td>
<td>End Supported Beam Strength</td>
</tr>
<tr>
<td>T-116</td>
<td>Torque Strength</td>
</tr>
<tr>
<td>T-119</td>
<td>Dimensional Stability</td>
</tr>
<tr>
<td>T-148</td>
<td>Determination of Natural Frequency and Flexural Modulus by Experimental Modal Analysis</td>
</tr>
<tr>
<td>T-149</td>
<td>Dynamic Cleavage Strength</td>
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</table>

These standards and many more, are available from the CCTI. For more on the CCTI visit www.cctiwdc.org or call them at (703)823-7234.

There is some controversy surrounding the dynamics of core failure. In the long run this will be positive as it will lead to more refined standards and better core performance. It’s sufficient to say that we are seeing a lot of activity in the areas of core strength, both in terms of critical speeds and chuck tear-out. New core testing equipment has been developed in the past 2-4 years, and its use is spreading.

**How does this affect you?**

Being aware of potential problems and resolving them sure beats looking for answers when you are in the middle of a production run. We see a number of recurring quality issues that directly impact your productivity and your scrap:

**OD/ID Tolerances**

As we have seen from the winding process description, core OD & ID are targets with tolerances. Most core manufacturers use a variety of ply thicknesses to control OD around a relatively stable ID, trying to maintain a uniform wall thickness. Others use a tapered mandrel, moving the winding point to compensate for variation in wall thickness, thereby transferring the tolerance to the ID.

Know the dimensions that are important to you and know the processes being used by your vendor to control these dimensions. Keep in mind that how production variances are handled will affect your core cutting, your winding tension, and any equipment that will subsequently chuck the core. If your winder drives from the core ID, OD variation can cause web tension problems. Extreme ID variation can cause chucking or shaft loading problems. Given the potential negative impact of core problems on web processes, we are constantly amazed by the number of users who have no idea what their core diameters and tolerances should be to optimize their winding performance. How wild can these variations get? We have seen operators applying masking tape to the core ID to ensure chuck grip. What is that again, the process variations we have discussed cannot be that extreme!

True, there is a hidden factor in core diameter variation - your complacency. The core producer has a wide range...
of mandrel diameters varying by as little as 1/100th of an inch. Each time they swap the mandrel for another size, they have to stop the winding process and rethread the winder. If they can supply you with cores in a broader range of diameters they can group your order with others that may be running at any point in time. Consequently your 3.010” ID cores may come in at 3.030” one time and 3.000” another.

If you do not police diameter, the range will increase as vendors find you accepting wider variations in ID. The customer taping their ID’s had a range over 1/4”.

When we encounter a core tabbing or a core chucking problem during cutting – we measure the core ID before taking any remedial action on the equipment.

**Straightness/Warp**

There is not a good standard for core straightness. CCTI’s T-121 tells how to measure warpage, but falls short of establishing limits. As the degree of automation has risen, core straightness has become an increasingly important factor. With manual feeding, the operator could see the warpage and correct for it… discarding cores that were “too bad” to use. Automatic loaders require greater uniformity. We state that the core should be straight enough to roll down a 7 degree incline. Others say that the ends of the parent core should not be more than 1/2” above a flat plane. CCTI’s T5 “Ordering, Storing, and Using Paper Mill Cores” addresses length, diameter, wall, moisture content, crush and torque - but not warp.

Support during storage is a key to minimizing warpage, as is constant humidity. Care should be taken to support the core at its ends and at regular intervals along the length of the core.

We have seen cores so badly warped that they could not be forced onto a core cutter mandrel.

**Roundness**

Ovality, or roundness, is an issue created by core handling and storage. This problem becomes more apparent as core diameter increases. The weight of the stack creates egg shaped cores near the bottom of the rack. They cure in that state, causing problems at the re-cutter and at the winder. Proper storage, stack height and pattern, and humidity, are keys. Your core vendor can help you establish proper storage conditions.

Need another challenge? Try maintaining uniform web tension with an egg-shaped core.

**Ply bond**

Ply delamination causes problems at the re-cutters and at the winder chucks. A loose inner ply will bunch up, jamming the cutter or preventing the cut cores from sliding cleanly onto the winder arbor. Delamination will also show up as tabbing (internal) or “dog ears” (external).

We recognize two sources of ply delamination. They are noted below with the typical cause:

- **Inner Ply** - this is the result of failure of the ply internally (a paper failure). It is evidenced by loose fiber on both sides of the tear. This is a paper quality issue.

- **Inter Ply** - this is where two plys separate at the glue line as evidenced by the lack of torn fiber. Often one surface will show the gloss of the dry adhesive. This is a bonding issue. It is most often seen on the inner ply or liner.
I’ve seen cores where I could easily pull the entire inner ply out of the core, or where the centrifugal force of the core rotating during the cut caused the outer ply to separate from the balance of the core. Typically these were glue problems. Ply bond strength limits the minimum length of core you can cut. We recommend that the cut length exceed the core wall thickness, though I know of cases where users are cutting 1/16th inch slices off a 5/8th inch wall core.

Poor ply adhesion can also contribute to “spin-out” problems on your core chucks (along with improper ID, or too soft a core).

Cutting cores

All spiral wound cores are cut at least once. The first time is during the winding process where the continuously wound core is cut into lengths for handling and shipping. The core industry specification (CCTI’s T-5) notes that the following are normal length variations for parent cores from a winding line:

<table>
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<tr>
<th>Core Length</th>
<th>Tolerance</th>
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<tr>
<td>36” to 72”</td>
<td>+3/8”</td>
</tr>
<tr>
<td>72” to 120”</td>
<td>+1/2”</td>
</tr>
<tr>
<td>120”+</td>
<td>+1”</td>
</tr>
</tbody>
</table>

Our “real world” experience confirms that these numbers are close to what you can expect on parent cores from your core vendor. After drying, the cores are more stable and can be re-cut with closer length tolerance.

Cores are usually re-cut a second time before they are used to provide closer cut length tolerance.

Your cutting alternatives

The user has two alternatives for providing accurately cut cores to the workstations:

- Pre-cut core program through a core vendor.
- Cutting on-site with your own staff.

The factors to consider include:

- Inventory - how much space will you need for core storage and what will the average core inventory cost.
- Procurement cost - the costs for pre-cut cores and for longer parent cores.
- Length tolerance - the cut length tolerance of each cut and effect of summing these tolerances on your process equipment.
- Versatility / flexibility - the frequency of order changes that impact cut lengths.
- Waste - the waste associated with scrapping cores due to damage, ID and length variations due to humidity changes, and obsolete cut lengths.
- Labor - the labor costs associated with handling and cutting cores.
- Floor space - the space required by a pre-cut inventory versus the space required to cut longer parent cores.
Pre-cut programs

Pre-cut core programs have their pluses and minuses. Among the disadvantages:

- requires close communication with your supplier.
- can require frequent deliveries.
- in a rapidly changing environment you can end up with unused inventories (waste).
- humidity changes can make cut lengths unusable after prolonged storage.
- core acquisition costs may be higher than on-site cutting.

Advantages include:

- your capital costs are lower.
- you do not have the cutting process in-house.
- The vendor is responsible for his re-cutting generated core waste. Well, kind of responsible… it will be reflected in your price. Interestingly though, we have seen some precut cores priced so low as to make it more expensive just to buy the parent cores… not to mention the cost of cutting them.

On-site cutting

Conversely, re-cutting at your facility presents a different set of considerations. On the negative side of the ledger:

- You will need cutting equipment.
- You will have to staff the cutter.
- You will be responsible for your cutting related waste.

On the positive side, recutting at your facility offers these benefits:

- provides instant response capability.
- core costs may be significantly lower.
- cutting may be staffed by current personnel with no additional labor.
- set cutting equipment can provide just-in-time cutting capabilities. This further reduces the need for cut core inventory, reduces waste generated by scheduling changes, and gives you more flexibility in core vendor selection.
Cutting processes

Regardless of where the cores are cut, the cut properties will reflect the type of cutter used.

Saws

Saws remove a kerf, a narrow portion of the core, ranging from 1/8” to 3/16” wide. This results in a cut square to the core wall. The downside to saws is that they create dust and noise that need to be addressed.

Typically saws include noise suppression enclosures and dust collection equipment as components of the system.

Knives

Knives do not remove material – they part the core. The result is minimal or no dust, but the wall of the core will have a slight bevel. This bevel is typically just under ½ the thickness of the knife. The type of knife will affect the amount of bevel, appearance of the core wall, and cutting speed. CCTI is working on a specification for measuring bevel, T-151.

Free wheeling, rotating knives cut slower as they are crushing (scoring) and parting the core. The core wall appears to be more porous. A brake can be added to cause the knife to drag, thereby eliminating some of the porosity.

Powered, rotating knives are typically used to cut fibrous materials, like fabrics or nonwovens, and tapes that are heat sensitive. They still have a bevel, but its amount may be decreased by using a single-faced knife that displaces the material being cut to one side of the cut.

Fixed knives slice the core, thereby generating more heat which in turn gives the core wall a varnished appearance. Again, the cut will exhibit a 0.020” to 0.030” bevel on each end. This bevel creates a core that is 0.040” to 0.060” longer on its ID than it is on its OD. Length is therefore measured at the core ID.

Length tolerance

By virtual of design, some cutters provide better accuracy than others. We attribute core cut length variation to three components:

- machine repeatability
- set-up variations
- variations resulting from humidity (post-cutting)

We define machine repeatability as the ability of the cutter to consistently generate the same cut length. This may not be the length that is required, as set-up variations also play a role in the lengths produced. Set-up variations are those that result from the operator changing from cut length A to cut length B. (Most cutter manufacturers offer programmable re-cutters or digital scales that minimize the potential for operator variation.)

Even if the cores are precisely cut, the impact of time and humidity shows up in length variations. Cores that are cut as little as a day in advance of their use can shrink or swell to the point of being unusable.
on a tight tolerance winder set. When we look at the variations exhibited by a set of cores on the winder, we see another factor at work. That is whether the cores are cut as batches of a given length or as individual winder sets.

Set cutting ensures that the set length and OD are most consistent. Set cutting is best described as JIT (just-in-time) cutting. Each parent core is a winder set. This minimizes OD variation and scrap loss (if the winder width and parent core length are equal). Set cutting will give you more uniform tension across your process if you are slitting a single web into multiple widths and winding. The OD variation on any given parent core is less than randomly selected cut pieces from a shipment of cores.

Batch cutting utilizes lower cost equipment, but creates the opportunity for tolerances to build across a winder set in addition to introducing greater OD variation in a set. Batch cutting is the process where all the cuts made from a given parent core are of equal length. Sets are often assembled later using cores from differing length batches. This can result in OD variation, length tolerance accumulation, and waste due to changes in requirements, and excessive inventory.

Cut length tolerances are not quite as important if the cores are going on a duplex or two drum winder. Tolerances become critical when a number of cores are loaded end-to-end to create a set.

Cut quality

The quality of the cut is part of your end product’s image. It will also impact your daily operations. Burrs, dog ears, and ply delamination can all cause problems at the winder. The quality of cut is established by the following factors:

- the type of cutter
- the paper and bond
- core internal diameter

Cutting systems

Core cutting systems should be custom to your requirements. This is your vision of what you need to do and how you would like to do it.

A system can be as simple as a core vendor’s cart for the core supply, a manually loaded and actuated core cutter, and a cart or boxes for accumulating the cut cores. The operator advances the core to a target and initiates the cutting cycle.

The first enhancement is typically automatic cutting. The core is advanced by power to a target, freeing the operator for core handling tasks such as loading parent cores or catching cut cores.
Automatic parent core loading can be added to the system, further freeing the operator for quality checks, packaging and record keeping. This equipment is typically used for batch cutting cores of a given length.

More sophisticated systems have the ability to cut winder sets of varying core lengths. In addition to automatic inbound parent core handling, these systems can print data on the cores and handle the outbound cut cores in a variety of ways. The operator can load the cutting and handling instructions for an extended period of time (typically including a number of differing set patterns) and be free for other tasks.

Virtually all the major manufacturers of core cutting equipment include the capability of interfacing their more sophisticated cutters with winders or production control systems to facilitate the process of downloading cutting instructions.

We have built systems that unload parent core carts, load a parent core onto the cutter, cut to winder specifications, print core number and length, notch both ends, insert metal caps and deliver the completed core to a set cart or directly to the winder - all without the operator touching the core.

A bit about core finishing

Core finishing refers to treatments that enhance the core usefulness. Some of the more common ones are:

- caps / plugs (metal, wood, plastic) - used to maintain core roundness, resize, strengthen for driving and breaking, facilitate multiple reuse
- notches (bridge, through) - used to drive and brake the core.
- burnishing - chamfers - used to facilitate shaft loading, or to create wider contact areas with the chucks.
- slits - used to start wind-ups, or the break-away the core.
- tapes - to start web wind-up
- holes - for vacuum pick-up of the web.

These treatments make the core better suited for specific types of winding and unwinding equipment. Your equipment vendors and core suppliers can provide additional details on this subject.
In summary - to avoid core problems

Before you can avoid problems, you need to know what problems can occur. We have covered a lot of information today to help you understand the variables that affect your core processes.

First, it’s important that you know what matters to your process (and your customers’ processes) and control those variables. What is critical? Is it core ID, OD, or both? How about length? What tolerances do you really need?

Then you need to practice good core handling techniques:

- Store your cores at the humidity of use.
- Make sure your racks support the core adequately, considering both length and diameter.
- Protect the core ends from impact damage.

To protect your bottom line, know what is causing your waste and what it’s costing you. It is amazing how many companies we work with that have no idea what their core waste is… the simple math of how much did you buy versus how much you shipped. The difference between these two numbers is your total core waste.

If you elect to cut your own cores, make sure you have the right equipment. You will want to consider the impact of:

- Production rates
- Type of cut needed
- The work environment (dust, noise)
- The accuracy required by your (and your customers’) equipment
- The skill level of the operator(s)
- Expected equipment service life
- Parent and cut core handling

When you review your core process, considering the points we discussed today, you will minimize the chance that cores will have a negative impact on your operations, and your bottom line!
References:

The following are resources for information on cores:

CCTI www.cctiwdc.org Composite Can and Tube Institute - Source for core manufacturers, equipment manufacturers. Cross referenced to a number of industry websites.

CCTI (703)823-7234 Core standards

Appleton Mfg. www.amdpsi.com Cutter visions

Credits:

Appleton Mfg Div
Cutter Photos

Dunsirn Industries
Slitter/winder photos

Hayes Manufacturing Group
Core Mfg photos

Newark Paperboard Products
MDHS Cutter photos

Perry H. Koplik and Sons
Roll photos
BACK TO LIST