NDE Helps Extend the Life of Paper Mill Steam Drums

An up-to-date NDE program to check the health of individual components can lead to an extension of the service life of the entire plant

BY GORDON E. SMITH

In the United States, as well as elsewhere in the world, regular testing for in-service degradation of the steam drums in paper mills is required at fixed time intervals for safety reasons. In today's industry, the pressure and the rotation speed of paper production machines are often increased to produce a higher output, which means that all safety aspects — from the design to the materials used — will be used fully. One difficulty is that the material these steam drums are made of, cast iron, is not an easily tested material.

Because the size and the wall thickness of these paper and pulp drying cylinders are utilized to the limit, it's impossible to perform repetitive inspections using hydrostatic testing because the drums lose their roundness and go out of balance. Driven by global commercial pressure, it's now financially unacceptable for the paper industry to perform annual qualification tests (i.e., visual (VT), ultrasonic (UT), magnetic particle (MT), acoustic emission (AET), and eddy current testing (ET)) because it would extend plant shutdown times and costs significantly. In the United States, these plant equipment integrity qualification test requirements for paper and pulp mills can be found in OSHA CFR 29, 1910.261, and its associated industrial standards from the American Society of Mechanical Engineers (ASME) and the Technical Association of the Pulp & Paper Industries (TAPPI), etc.

Paper Machines

Following is a brief description of what a dryer is and why it's important to the paper mill. Basically, a dryer is just what its name implies: a device for drying the moisture out of paper as it's being processed from the wet pulp stage to the final, ready-for-market paper stage. The dryers are cylindrical, rotating, cast-iron pressure vessels heated with saturated steam, typically at a pressure of 30 to 60 lb/in.². There's usually somewhere between 30 and 100 dryers in a single paper machine. As the wet paper sheet successively passes across the heated surface of each dryer, it loses moisture along the way.

The amount of paper a paper machine produces is governed by its drying capacity, which in turn is governed, among other things, by the number of dryers and how hot they are. Dryer temperature is determined solely by the operating steam pressure. Operating one or more dryers at lower pressure, speed, or temperature greatly affects productivity because it reduces the throughput of the entire paper machine. That naturally has a negative impact on the company's bottom line. So what can be done? That's where the combination of nondestructive examination (NDE) and physical metallurgy come in.

The same paper machine line can be used to produce a hundred different kinds of paper, depending on the kind of pulp, thickness, and line speed. Paper can vary from very thin, high-quality “Bible” paper to very heavy, low-quality box or Kraft

Table 1 — Defects in Dryers Reported over a Ten-Year Period

<table>
<thead>
<tr>
<th>Location of Defect</th>
<th>Percentage of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head, around journal</td>
<td>44%</td>
</tr>
<tr>
<td>Head, shell interface</td>
<td>22%</td>
</tr>
<tr>
<td>Shell, midspan</td>
<td>3%</td>
</tr>
<tr>
<td>Miscellaneous/unknown</td>
<td>22%</td>
</tr>
</tbody>
</table>

GORDON E. SMITH (GESmithNDTIII@sbcglobal.net) is manager, technical support services, Professional Services & Information, Westerville, Ohio.
Paper used to make cardboard boxes. Typically, mills are broadly separated into two classes: high-quality papers or kraft mills. Kraft mills make the same paper all the time, with small variations for basis weight or coatings. Quality paper mills tend to make a variety of papers that mostly serve the printing industry. Newsprint falls someplace in the middle of the most common types of paper making machines. Today's paper machines are very long to allow for faster line speeds. The dryer section may include more than 100 steam drums. Line speed is almost always more than 500 ft/min, and may exceed 1000 ft/min. Machines have also become wider. The average width exceeds 100 in.

Paper machine dryers can develop several types of flaws during operations. These flaws can influence safety or eventually lead to failure. These failures can be catastrophic ruptures, which can cause injury to workers, machine damage, and extended downtime. Other failures may be less severe and can be corrected. This article covers methods that can be used to detect potential problem areas and help prevent failures. The majority of dryer failures result from the following:

- Failure of the head in the area around the journal,
- Failure of the head in the area of access openings, or
- Failure of the shell at the head-to-shell flange corner.

Table 1 shows industry statistics on defects in dryers reported over a ten-year period. Typically, plant operators place a lot of emphasis on the cylindrical shells, but in fact the dryer head castings may pose a greater problem.

Bolt failure, a closely related problem, should also be a concern. Steam leakage at the head-to-shell interface causes corrosion and leads to stress corrosion cracking. Product moisture can also cause corrosion. Machine vibrations, uneven or overtensioning, and uneven shell-to-head mating surfaces are also conditions that appear to have contributed to bolt failures. Some bolt failures have been attributed to the use of bolts with inadequate strength. This cracking can affect several bolts, making failure of the entire head joint or loss of seal possible.

An additional concern is dryer cylindrical shell thinning due to internal or external wear. Whether the thinning is general in nature or restricted to areas of grooving, from internal wear from an object loose inside the dryer, a decrease in thickness results in dryer failure. Table 2 shows NDE technologies that can be used to help prevent failures.

Table 2 — NDE Technologies for Dryer Inspection

<table>
<thead>
<tr>
<th>Method</th>
<th>Typical Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrostatic (Pressure Testing) (LT)</td>
<td>Leakage and proof of stress capability</td>
</tr>
<tr>
<td>Acoustic Emission Testing (AET)</td>
<td>Crack growth detection with hydrostatic</td>
</tr>
<tr>
<td>Visual Testing (VT) Direct and Remote (Borescope)</td>
<td>External and internal conditions</td>
</tr>
<tr>
<td>Magnetic Particle Testing (MT)</td>
<td>External conditions</td>
</tr>
<tr>
<td>Dye Penetrant Testing (PT)</td>
<td>External conditions</td>
</tr>
<tr>
<td>Ultrasonic Testing</td>
<td>Local shell thickness</td>
</tr>
<tr>
<td>Digital Thickness Gauging</td>
<td>End-to-end shell thickness profile</td>
</tr>
<tr>
<td>Line Scan Thickness Gauging</td>
<td>Material and possibly fatigue identification</td>
</tr>
<tr>
<td>Eddy Current (ET)</td>
<td>In the shell wall defects</td>
</tr>
<tr>
<td>Radiography (RT)</td>
<td>These are used to provide</td>
</tr>
<tr>
<td>Hardness Testing</td>
<td>assurance of NDE results. It is</td>
</tr>
<tr>
<td>Impact Devices</td>
<td>important to calibrate on a cast</td>
</tr>
<tr>
<td>Tele-Brinnell</td>
<td>iron sample tested on an NIST traceable</td>
</tr>
<tr>
<td>Accelerometer Devices</td>
<td>hardness tester.</td>
</tr>
<tr>
<td>King Brinnell Testers, etc.</td>
<td></td>
</tr>
</tbody>
</table>

A view of internal corrosion on a drum.

Here localized thinning of a drum wall was discovered.

A pole-type automated UT probe.
in increased stresses on the shell. General thinning produces a
general increase in vessel stress, but a pit or groove produces a
stress concentration. Periodic shell ultrasonic thickness sur-
veys are one way to ensure that the shell thickness is consistent
with the maximum allowable working pressure.

Regular Nondestructive Examination to
Ensure Dryer Equipment Integrity

The conventional NDE methods for inspecting cast iron com-
ponents are UT, MT, penetrant testing (PT), and ET. Eddy cur-
rent testing also gives some indication on the material structure,
erosion, and corrosion, and RT can give indication of residual
stresses. These tests are suitable for indicating defect location
and extension. However, they are not suitable for helping us
understand the causes of the defects, which is very important to
repairing and replacing the components and extension of a
plant's service life. Other NDE methods, such as visual exami-
nation by borescope, hardness testing, and chemical analysis,
are used for estimating plant equipment life. Table 2 shows the
various NDE methods used for dryer inspection.

The aim of this article has been the description and analysis
of some significant application of these tests for plant life
extension.

Recently, several paper mills have encountered concerns
from their insurance companies about the continued operation
of their old, noncoded, cast iron paper machine dryers. In most
of these cases, the mills have been operating the dryers for
many years without incident, but it seems there's been an
increased awareness about the potential hazards of continuing
to operate these older pressure vessels and, as a result, the
insurance companies have begun to require that the mills dras-
tically reduce the operating pressure.

This author has found that a more reliable procedure to
ensure material strength is to utilize an external surface based
nondestructive evaluation of the material in combination with
hardness tests. Internal visual and external ultrasonic technolo-
gies are primarily used to evaluate damage due to objects or
corrosion.
Of course, these types of engineering assessments need to be done in conjunction with thorough nondestructive inspection of the dryers to determine their present condition. These inspections are done in accordance with 20-year-old, well-established TAPPI (Technical Association of the Pulp & Paper Industries) guidelines and entail ultrasonic thickness testing of the shell (and sometimes the heads), magnetic particle inspections of the shell and heads for cracks, and ultrasonic inspection of the head bolts. Almost all of these test methods start with a good power washing and visual examination of the surface. Today, many specialized coatings for dryer shells exist and make visual examination impractical except when recoating. A few recent dryer evaluations have shown how good the physical characteristics were on the old cast iron dryers. As a result, these mills were able to utilize the full value of the estimated strength over the assumed service reduced strength, giving these old workhorses a new lease on life with improved productivity. However, most paper and pulp mills use specialized cast iron for their dryer vessels. The ASME Boiler and Pressure Vessel Code stopped recognizing this cast iron material more than 30 years ago. Today, many paper and pulp mills are successfully operating cast iron dryer vessels in excess of 50 years and sometimes as much as 70 years old.

Repairing or replacing the damaged component is the easiest way of maintaining production. Since avoiding repeats of failures is especially important for controlling costs, it is necessary to diagnose the cause of the failure initiation, which could be due to material defects or incorrect operating conditions.

Plant facilities change over time and components age until they are no longer economical to operate. In order to ensure reliable service for the aging plant population of machines, advanced material damage and remaining life techniques, as well as diagnostic NDE and physical properties monitoring, are necessary to anticipate when components must be scheduled for repair or replacement. An up-to-date maintenance program that considers the health of single components can lead to a life extension of the entire plant.

---

**Instructions and Suggestions for Preparation of Articles**

**Text**
- approximately 1500–3000 words in length
- submit hard copy
- submissions via disk or electronic transmission — preferred format is Mac but common PC files are also acceptable
- acceptable disks include floppy and CD.

**Format**
- include a title
- include a subtitle or “blurb” highlighting major point or idea
- include all author names, titles, affiliations, geographic locations
- separate paper into sections with headings

**Photos/Illustrations/ Figures**
- should be glossy prints, slides, or transparencies
- black and white and color photos must be scanned at a minimum of 266 dpi
- line art should be scanned at 1000 dpi
- photos must include a description of action/object/person and relevance for use as a caption
- prints must be a minimum size of 4 in. x 6 in., making certain the photo is legible
- do not embed the figures or photos in the text
- acceptable electronic format for photos and figures are EPS, JPEG, and TIF. TIF format is preferred.

**Other**
- illustrations should accompany article
- drawings, tables, and graphs should be legible for reproduction and labeled with captions
- references/bibliography should be included at the end of the article

**Editorial Deadline**
- Winter issue deadline is November 1 (mailed January 1)
- Spring issue deadline is February 1 (mailed April 1)
- Summer issue deadline is May 1 (mailed July 1)
- Fall issue deadline is August (mailed October 1)

**Suggested topics for NDE, inspection, examination and testing articles**
- case studies, specific projects
- new procedure
- personal experience, how it was handled and steps to consider
- basic information on a method
- tips from the field
- code concerns
- questions for Q&A section
- suggestions for profiled person

Mail to:
Mary Ruth Johnsen
Editor, Inspection Trends
550 NW LeJeune Road
Miami, FL 33126
(305) 443-9353, x 238; FAX (305) 443-7404
mjohnsen@aws.org