In today’s mercurial economy, it is increasingly difficult for any printer or converter to remain profitable. Pressures come from multiple sources: the fluctuating cost of utilities, the rising costs of raw materials and the continuous demand from consumers and vendors for better use of ecologically friendly resources. Therefore, it is important for manufacturers of flexible materials — whether décor paper or metallized film — to keep abreast of available and innovative technologies, which can help satisfy customers while conducting a successful and profitable business.

Why acoustic-drying technology?
Potential benefits of the acoustic-drying technology are not marginal (5 to 10 percent) but considerable. They include:

- Up to a 70-percent increase in web speed — less residence time under the drying station means the press can operate at higher speeds.
- Up to a 75-percent reduction in energy consumption.
- Lower to zero process-air temperature — even with increased speed, the process-air temperature will be less than a non-acoustic-equipped operation.
- Up to 50-percent less plant air for water-based applications. This means additional energy savings because plant air conditioning costs can be high. (Solvent-based solutions are limited by LFL considerations.)
- Up to a 67-percent smaller footprint — generally, the length of the new drying system will be significantly less than the current system.

Fighting the Boundary Layer
A key reason for more residence (drying) time in high-speed applications is the formation of a boundary layer on the material during the printing process. What is a boundary layer? Imagine a large lake. In the summer, the sun comes up and begins evaporating moisture off the lake. After a few hours, a sunny day turns into a cloudy day because as the moisture rises from the lake, clouds are formed. These clouds then act as a barrier, so later in the day, the sun above the clouds is delivering the same amount of energy, but less of the sun hits the lake directly so that less moisture is removed. Similarly, a boundary layer forms on the surface of the material as it moves through the production process and acts like an invisible shield against hot air coming from the drying station. This invisible shield does not allow air to penetrate the surface of the ink and thus begin the evaporation process. Increasing heat and air increases the amount of moisture that is evaporated, but at a lower efficiency until the process flat-lines. Printing-equipment OEMs have used increases in air volume and temperature, along with angle of attack, to deal with this problem, but it has had limited effect.
**Using acoustics for drying**

So, how can sound technology benefit drying? Think of sound that you experience at a loud rock concert — sound that you feel as you walk closer and closer to a large speaker that is filling the concert hall with someone’s definition of music. That feeling is, in fact, a pressure wave brought about by the movement of air created by the speaker. Now, certainly no manufacturing operation is looking to increase the amount of noise; however, that sound power can be harnessed in a very careful way so that it is harmless to human hearing and safe in the workplace.

In addition, you might notice that the pressure as you approach that speaker isn’t constant — it fluctuates. The oscillation of pressure is another important consideration. Think of things where pressure is not constant, for example: a jackhammer, hammer drill and impact wrench. These devices make it possible to achieve a result that the same amount of constant pressure couldn’t achieve. It is the same with drying, the oscillation of ultrasound adds to the effect. Heat and air are more efficient at removing moisture in the presence of sound because the oscillating pressure wave affects the boundary layer.

The acoustic-drying technology developed by this firm had its beginnings with pulse combustion, which accelerates heat and mass transfer by appropriate use of acoustic oscillations with mean flow of the combustion gases. This was successfully applied in water heating, boilers, drying of minerals, sand, sludge, etc. The company’s original technology, however, cannot be applied to flexible packaging, converting and coating because an oscillating flame directly impinges on the material, which creates a fire hazard.

Driven by actual demand for accelerated drying of water- and solvent-based inks and adhesives, the company expanded its knowledge of combining hot-air flow with strong acoustic oscillations and developed a product line of acoustically enhanced drying systems for that specific application. The drying system is an advanced convective or hot-air based system; however in this case, the hot air acts as a skilled massager by providing the boundary layer formed on the material with micro massage to make it more pliable and as a result, it makes drying more efficient. These systems are energy independent and can use hot air derived from indirect or direct heating, as well as pre-heat the air by an in-line electric heater. The most important key element of accelerated drying is its ability to efficiently disrupt the boundary layer formed on the material during the printing process; thus, allowing the process to be conducted with a lower operating temperature of the hot air at advanced web speeds.

The technology has application for both narrow- and wide-web operations as a replacement for existing dryers for various coating applications, between-colors drying sections (usually with heavy ink load or adhesive loads) in flexo and gravure applications, or as a booster section (see Figures 1 and 2) where physical space allowed an installation. In such situations, throughput was shown to increase from 50-85 percent with 17-20 percent added energy. Accelerated speeds have been identified on shrink film, thermally sensitive papers and with use of eco-
friendly inks. Table 1 shows a summary of major operating parameters when acoustically enhanced drying replaced original drying technology in wide- and narrow-web applications.

<table>
<thead>
<tr>
<th>Web width (in. (m))</th>
<th>Dry weight (lb/ream (g/m²))</th>
<th>% of solid (%)</th>
<th>Application</th>
<th>Type of installation</th>
<th>Existing technology Max speed, MMBtu/hr (kW)</th>
<th>Acoustically enhanced Max speed, MMBtu/hr (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>52 (1.32)</td>
<td>1.27 (2)</td>
<td>30</td>
<td>Water-based</td>
<td>Add-on</td>
<td>700 (217) (145)</td>
<td>1,350 (418) (20)</td>
</tr>
<tr>
<td>71 (1.27)</td>
<td>1.27 (2)</td>
<td>30</td>
<td>Water-based</td>
<td>Add-on</td>
<td>700 (217) (200)</td>
<td>1,400 (434) (50)</td>
</tr>
<tr>
<td>16 (0.40)</td>
<td>2 (3.15)</td>
<td>30</td>
<td>Water-based</td>
<td>Replacement, b/c</td>
<td>260 (81) (37)</td>
<td>387 (120) (5.2)</td>
</tr>
<tr>
<td>26 (0.66)</td>
<td>Overhead/tunnel dryer</td>
<td>30</td>
<td>Water-based</td>
<td>Replacement</td>
<td>600 (186) 1.0 (293)</td>
<td>600 (45)</td>
</tr>
</tbody>
</table>

**TABLE 1.** Summary of major operating parameters when acoustically enhanced drying replaced original drying technology, wide and narrow web

Other factors besides press speed must be taken into consideration. Improved drying is possible, but in most cases it was restricted by limiting factors of maximum speed, wind and unwind, sufficient ink laying, etc. Acoustically enhanced drying systems can be adapted by any press, using water- or solvent-based inks or adhesives, where replacement of the drying section is possible or can be added as an extended range and where drying or coating is a bottleneck.

The acoustically enhanced drying systems discussed are very compact and may be of assistance to operators whose production could be improved. Additional savings may apply to the reduction of material waste (scrap) cost due to a more compact dryer and shorter drying path, lower labor cost to produce more material, lower capital expenditures, etc. Maintenance managers become advocates because the dryers are of advanced design but low in maintenance, which is a subtle but noticeable contributor to operational cost.

**Conclusion**
The innovations embodied within acoustically enhanced drying systems can help coaters, printers, laminators and other converters increase profit margins and meet expanding production goals by improving drying-process efficiency, lowering energy consumption, removing drying bottlenecks and increasing web speed on gravure, central-impression and in-line flexographic presses and coaters.

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