QUALITY PAPER, HIGH YIELDS

By uniformly drying paper during production, electric infrared (IR) helps paper mills and converting operations produce paper with superior smoothness, gloss, and printability. The uniform drying also gives the paper a consistent thickness, reduces feeding breaks, increases machine speeds, and produces higher yields. Paper products dried by IR include:

- Newspapers
- Magazines
- Tissues
- Envelopes
- Books
- Stationery
- Lightweight packaging.

Printers and wholesale customers are becoming more quality conscious. They expect excellent smoothness, gloss, and printability as well as uniform moisture, caliper (or thickness of a single sheet), and coatings—and they hold the papermaker accountable for maintaining these characteristics. Drying paper and coatings with IR processes helps papermakers meet their customers' expectations.

In the papermaking process, paper is formed on a paper machine from a slurry of fibers then pressed and steam-dried to remove moisture. For added strength and printability, clay or latex coatings containing binders are applied to the paper. IR drying is applicable in two areas of papermaking: On paper machines (see Figure 1), IR lamps are automatically turned on over wet spots, drying the paper sheet to a uniform moisture content in a process called moisture profiling. In coating processes, IR sets the coatings instantly, preventing binder migration and producing a smoother coating with improved printability and uniform coating weight. Of approximately 2000 paper machines in the United States, about 400 have electric IR units. Approximately 80% of the remainder could realize significant benefits from adopting IR processes.

ADVANTAGES

For both papermaking and binder-coating applications, IR drying provides many benefits:

Improved paper quality—IR improves the overall paper quality, strength, and printability by enhancing coating uniformity. IR sets the coating quickly and evenly, so the binder concentrates on the paper surface instead of migrating into the base paper. In both papermaking and coating, IR processes also reduce moisture variations to produce more uniform cross-direction (CD) caliper and smoothness. Improvements of 50% to 75% can be expected.

Increased productivity—Paper machine yields increase because IR maintains a consistently low CD moisture level, resulting in uniform thickness, fewer breaks, and 5% to 15% faster production speeds. Reducing moisture by 1% can result in a 4% to 5% increase in machine speed.

Waste reduction—IR moisture profiling can reduce waste on the paper machine as much as 50% per year. Increased moisture uniformity results in fewer caliper rejects, fewer machine breaks, less “off-spec” paper, and reduced machine rethreading. IR drying also reduces rejects by heating the sheet as it comes out of the wet press; this helps prevent the sheet from sticking to the dryer cans—a problem known as “picking.”

When coatings are applied, one IR unit can be used to set the coating and another to automatically level moisture variations. IR controls binder migration, reducing rejects by 30% to 50% for...
Figure 1. IR is used effectively at many points during the papermaking process.
(Source: Impact Systems and Combustion Engineering Company brochures)

yearly savings of $200,000 to $300,000, and possibly even more.

Improved process control—IR microprocessing controls react quickly to precisely level moisture variations. The controls also respond to changes in paper grade, so the paper machine returns to optimum speed and quality production within minutes, reducing waste by 1% to 2%. IR lamps are turned on only where energy is needed to reduce moisture variations. Moisture streaks as small as 3 in. wide can be leveled, minimizing energy usage.

Safe operation—Electric IR operates at lower temperatures than other systems and responds with immediate cool-down. When a paper break occurs, there is no fire or charred paper—two problems associated with gas IR drying.

APPLICATIONS

IR is used in two general areas of papermaking:

Moisture profiling—On the paper machine, IR levels the moisture profile across the sheet (see Figure 2). Achieving moisture uniformity is more important than just reducing the moisture levels. The typical goal in moisture

profiling is to reduce the peak-to-peak moisture variation to 0.5% to 1%.

Typically in a paper machine, the paper at the wet end of the press contains up to 40% water. Dryer cans and steam boxes then reduce the moisture level to about 6%. Throughout this process, it is important to maintain a uniform moisture level across the sheet to avoid uneven caliper and mottling. These problems can be controlled by IR profiling at the last dryer can before the reel, before or after the size press, or at the coating stations.

Process controls monitor the thickness, weight, and moisture levels of the paper and actuate the IR lamps to react immediately to moisture variations. Improving the moisture profile can increase production speeds 5% to 15% and reduce caliper, reel building, and converting problems by 30% to 80%. Profiling also reduces steam requirements.

IR's high-intensity energy is well suited for the dry end of the paper machine, where moisture removal and control are easier and more cost efficient than at the wet end.

Figure 2. IR eliminates moisture streaks, improving sheet uniformity. 
(Source: Impact Systems Company brochure)
Coatings—Applying coatings to paper rewets the sheet from 6% to nearly 30% moisture. A high-intensity IR unit can quickly dry and set the coating immediately following application. The binder remains concentrated in the coating, producing a strong, uniform surface without mottle. IR penetrates uniformly through the sheet, driving moisture from the center. This penetration prevents warp or curl caused when only one side is heated.

A second IR unit at the end of the coater produces uniform CD moisture levels in the final sheet and aids sheet processing for a higher quality final coating.

TECHNICAL CONSIDERATIONS

IR processing is applicable in most moisture-profiling and binder-coating situations. However, many aspects must be evaluated when considering IR processes for a specific application.

Weight—IR effectively profiles paper with weights up to 96 lb/1000 ft². But the amount of IR energy needed to profile weights above 42 lb/1000 ft² may not be economical.

Moisture levels—The difference between the present moisture level and the target level can determine whether IR processing is cost effective to implement. This difference is obtained by analyzing existing moisture profiles and determining the minimum IR processing required to obtain the desired improvement in quality. For example, reducing a moisture profile from 2% to 0.5% peak to peak should result in substantial quality and production increases, without a considerable capital investment or sizable increase in operating costs.

Production increase—An IR system can often be justified by its increased production capacity. In general, production increase is proportional to the quantity of IR energy added to the existing drying capacity of the paper machine or coating line.

Electricity requirements—In papermaking, the average energy consumption of an IR unit is 180 to 200 kW. The electricity demand depends on the drying capacity needed.

When considering IR implementation, the existing process must be evaluated carefully to determine specific needs and the optimal placement of the IR unit. The IR requirements best suited for the application can be determined by discussing the following factors with an equipment supplier:

- Process type
- Moisture variations
- Machine configuration
- Process speeds
- Sheet weight, composition, moisture content, and temperature ranges.

Analyzing this information allows estimates to be developed for energy requirements, waste savings, caliper improvements, and the amount of moisture profiling expected for the cost incurred.
The IR Drying Process

IR energy is produced by heating the tungsten filament of an IR lamp. The emitters operate at 3900°F to produce peak energy at 1.2 microns. This wavelength is effectively absorbed by paper fiber and water. Heat from the lamps is directed at the paper by a series of ceramic reflectors. On the paper machine, the lamps and reflectors are mounted next to each other in a module configuration with quartz plates in front of the lamps to prevent mechanical damage to them (see Figure 3). Blowers circulate air around the lamps to keep the temperature in the module below 400°F for maximum lamp life. The sheet is 1 to 2 in. away from the IR lamps. IR penetrates the paper, resulting in uniform temperature distribution through the paper. IR controls moisture in sections as small as 3 in. across the width of the sheet—which can be as wide as 30 ft.

**Figure 3. Schematic of electric IR equipment.**

(Source: Impact Systems and Combustion Engineering Company brochures)

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Applicable SIC Codes

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**ECONOMIC CONSIDERATIONS**

**Capital costs**—A typical IR unit costs $400,000 and includes one frame and a CD or profile control package. This cost includes the necessary software and operator interface for measuring and controlling moisture. One frame is 18 in. (machine direction) by 21½ in. (high) stretching across the width of the sheet (typically 15 ft wide), and has up to 24 lamps per foot. Installation costs are usually an additional $60,000 to $100,000. The unit's compact size allows it to fit into the existing machine configuration with minimal modifications. With careful planning, the unit may be installed in 16 to 36 h during a routine shutdown. Payback periods are typically 3 to 12 months.

**Operating costs**—Average yearly maintenance cost for an IR unit is $10,000 to $15,000, primarily for lamp replacements; in situ costs include air filters and electrical components. Lamps usually last two to three years or 12,000 to 15,000 h; replacements cost about $70 each. Routine maintenance can easily be handled by plant staff during regular shutdowns—no additional shutdowns are required. Training to operate an IR unit usually requires only about 3 h; complete maintenance training may take up to one week. The IR unit does not require additional labor for operation and should actually reduce the machine operator's workload, because constant adjustments are no longer required to maintain a high-quality sheet.

**OUTLOOK**

IR processing can provide significant improvements in paper quality and process control and can increase yield and production speeds in both papermaking and binder-coating processes. Equipment suppliers continue to (1) improve the design of IR units to make them more universally applicable and economical and (2) provide better integration and system control. A 10% to 15% yearly growth in IR installations is predicted for the papermaking industry as more papermakers become informed of the substantial benefits IR can provide.