Improved drying at Recycled Paperboard of Clifton

MUHAMED KOVANGJI

Gas infrared drying system adds capacity to existing steam dryer system

Recycled Paperboard of Clifton Inc. is located in Clifton, N.J., where the 200 tons/day mill produces high-quality, 100% recycled cylinder board products that range from 72 to 260 lbs./1000 ft^2 basis weight. The company processes recovered paper. The mixed waste paper, old newspaper and OCC are converted into various cylinder board grades.

The 128-in. trim-width machine uses nine vats with three presses and 170 multitier steam dryers to form and dry the wide range of paperboard products. **Figure 1** is an illustration of the steam dryer section of the machine. In addition, the mill produces 100% of the steam required for the four-tier steam dryer sections and pocket ventilation air heating system. Natural gas and oil are the primary fuels used to generate the steam. **Figure 2** is a diagram of the steam and condensate systems.

PRODUCTION LEVEL REQUIREMENTS

The plant's long-range plans required a substantial production increase, 7 % or more, in the total board tonnage to meet present and future demands of its East Coast market. However, the cylinder board machine was dryer limited on more than 80% of the grades produced. The limitations were a result of the following:

- Sheet pressing must be kept to a minimum, maintaining a low-density board and the maximum caliper of the board.
- Heavy basis weight grades were steam-supply limited in the dryer section.
- The first section of steam dryers were operated at reduced pressures to prevent picking on heavyweight grades.

Outside consultants recently conducted a study of the steam can drying section that revealed further improvements in dryer system performance and efficiency were not justified. The steam drying section (Fig. 2) was already achieving the highest levels possible for a multilevel dryer configuration in North America.

BASE SHEET DRYING OPTIONS

Mill management began exploring alternative ways to obtain the primary objective—design and install the most efficient and economical solution for the incremental drying requirements. The primary options included additional pressing, incremental steam generation capacity, additional steam dryers, air caps, and infrared drying systems.

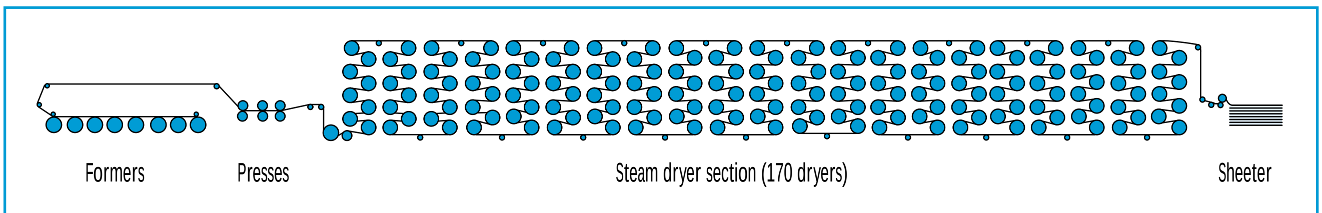
After examining the list and identifying the most feasible and cost-effective options for its applications and the space available, the mill developed two final alternatives:

- Increase steam generation capacity by adding steam dryer cans
- Install a gas infrared drying system in the existing steam drying section.

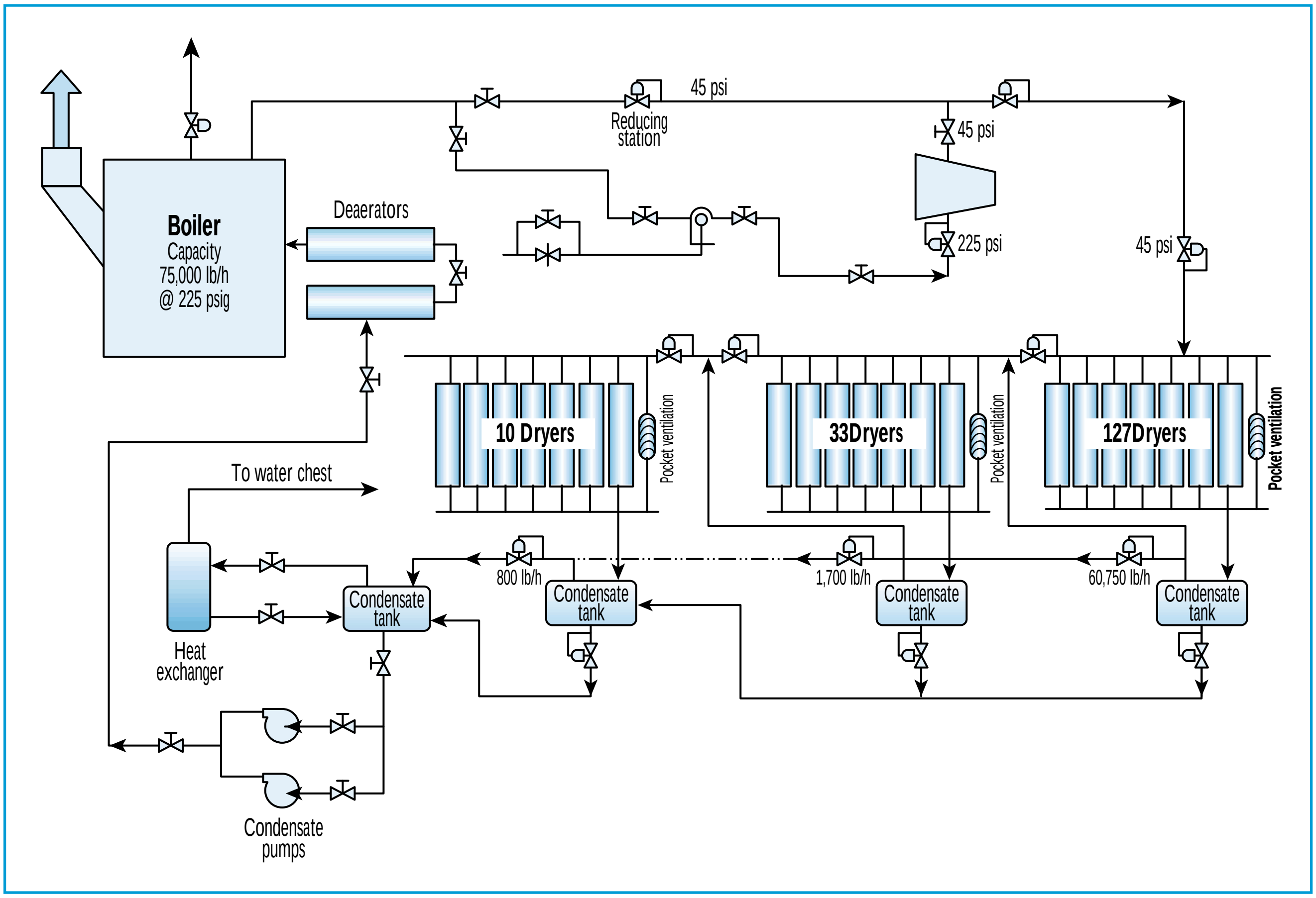
SUMMARY OF THE DECISION ANALYSIS

In order to fully understand, quantify, and decide upon the best solution for the drying application, a set of criteria was established. The criteria included in the evaluation were as follows:

- Drying rates versus space requirements
- Energy recovery
- Total capital cost and downtime



1. Diagram of the steam dryer section of the paper machine



2. Steam and condensate systems

Criteria	Steam can drying	Infrared drying
Maximum drying rates per unit area		x
Maximum energy recovery	x	
Maximum process optimization		x
Maximum improvement to product and sheet quality		x
Lowest installation cost		x
Lowest operating and maintenance costs		x
Minimum space requirements		x
Maximum fire safety	x	
Simplicity of design		x
Minimum support equipment requirements		x
Minimum additional utilities requirements		x
Minimum additional manpower requirements		x
Minimum system emissions requirements		x
Minimum downtime required for installation		x
Minimum additional spare parts required		x

I. Analysis of steam can drying vs. infrared drying

- Total process optimization
- System simplicity
- Fire safety
- Emissions requirements
- Operating and maintenance costs
- Additional utilities required
- Effect on product and sheet quality
- Personnel training requirements.

INFRARED SYSTEM CHOSEN

Based upon the detailed evaluation, the mill decided to install an eight-row, high-density fast-response (HDF) gas infrared drying system after the second press and before the first steam dryer. **Table I** summarizes the results of the analysis.

Figure 3 shows the location of the four frames of infrared dryers that were installed on both sides of the sheet—after the last press and before the first steam drying section.

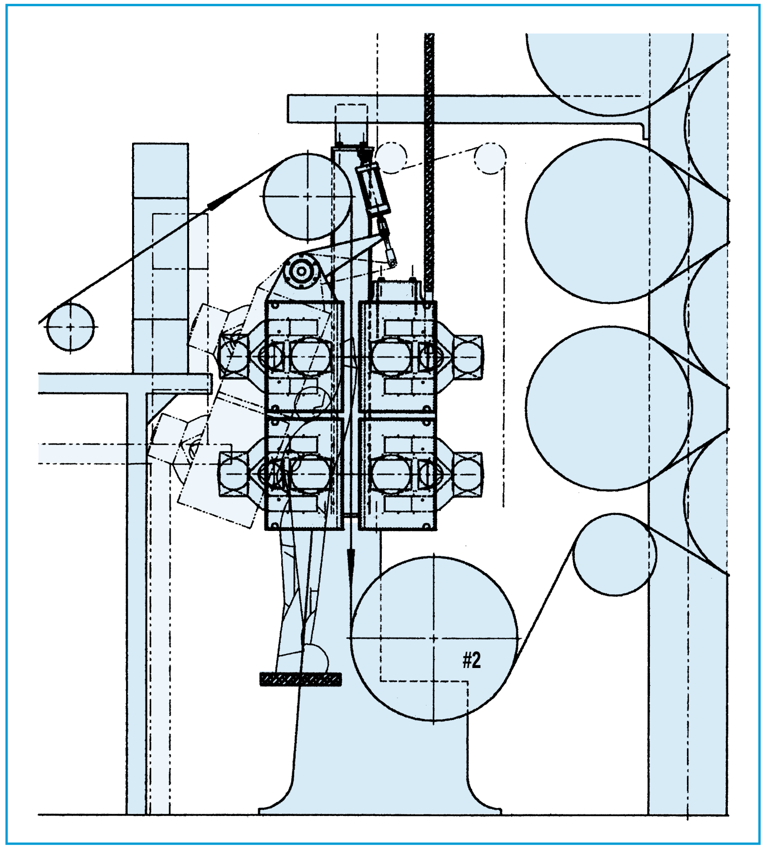
KEY FACTORS IN THE DECISION ANALYSIS

Equivalent drying rates versus space requirements

The gas infrared drying system was able to deliver 10 to 15 times more coupled energy to the sheet than the steam cans for a given surface area, because the infrared system is primarily radiant energy that penetrates the sheet and is uniformly absorbed in the z-direction. In comparison, the steam cans must rely on surface contact and energy conduction through the sheet surface from the dryer can surface. Therefore, when steam pressure is increased to provide higher drying rates, the sheet surface can be overheated, resulting in picking, curl, and generally poor sheet quality.

Also, as the sheet proceeds through the drying section, the paper becomes drier. This reduces the thermal conductivity in the z-direction and adversely affects the drying efficiency of each dryer can, ultimately reducing the effiiency and drying rate of the entire section.

In comparison, the eight rows (two opposing frames of infrared dryers) required only 58 in. of machine-direction space. The equivalent drying with steam cans required 24 additional 42 in. diameter steam cans. In order to accommodate the additional dryers, extensive revisions to the wet end, dryer section, and sheet runs would have been needed.



3. Four frames of infrared dryers were installed on both sides of the sheet—after the last press and before the first steam drying section.

Energy recovery

The infrared air handling system and frames were designed to capture at extremely high temperatures (750º to 850º F) the majority of the exhaust gases that can be easily transported by the exhaust fan to the pocket ventilation system as makeup air. This not only increased the infrared system efficiencies but also virtually eliminated the use of steam to heat the pocket ventilation air. The air system and ductwork were very simple, had no moving parts, and required minimal support equipment.

Conversely, the steam can's condensate recovery system (Fig. 2) required extensive controls, pumps, and piping to return the condensate back to the boilers for reuse in steam generation.

Total capital costs and downtime

The installation of additional steam cans would have required substantial machine-direction space as well as additional steam generation capacity. This scope of supply included additional boiler capacity, steam and condensate pumps, piping, valves, and controls, as well as major revisions and structural changes on the paper machine. New heat removal hoods, fans, and pocket ventilation system additions were also required to support the increased drying loads. The rebuild of the paper machine and revisions to the steam generation capacity would also result in substantially higher engineering and design costs.

In comparison, the gas infrared system required a minimal amount of machine-direction space with minor changes to the sheet run. The gas infrared system was designed to provide only the incremental drying currently required. Additional capacity could be added as necessary without the expensive upfront costs associated with the steam generation system.

The integral gas supply and combustion control system could be located on the paper machine floor. A simple air system was also needed for the supply, exhaust, and combustion air.

In addition, the gas infrared system required a minimal amount of time to install the compact frame, retract systems, and ductwork. The installation, in fact, took only seven days as compared to the several weeks it would have required for the complete modification of the steam dryer section, steam supply and condensate piping, drives, and air systems—not considering all the changes and costs associated with the additional steam generation capacity. The total installed system cost for the steam generation and drying system was approximately four times as much as the infrared drying system. **Table II** provides details of the installed costs.

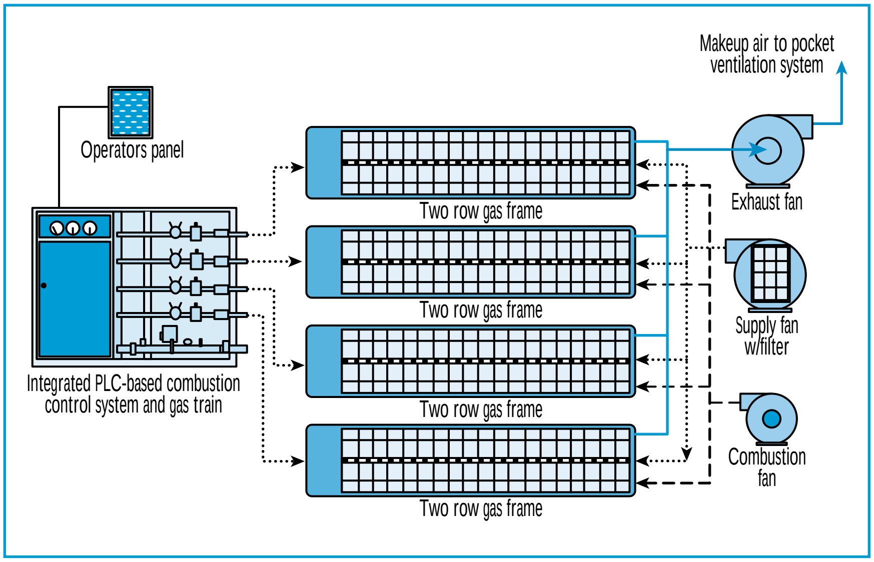
Total process optimization

This part of the analysis determined what would be the best location and resulting total process optimization for each alternative. The design and location of the new systems could have a significant effect on the performance, drying rates, and efficiency of the existing steam cans.

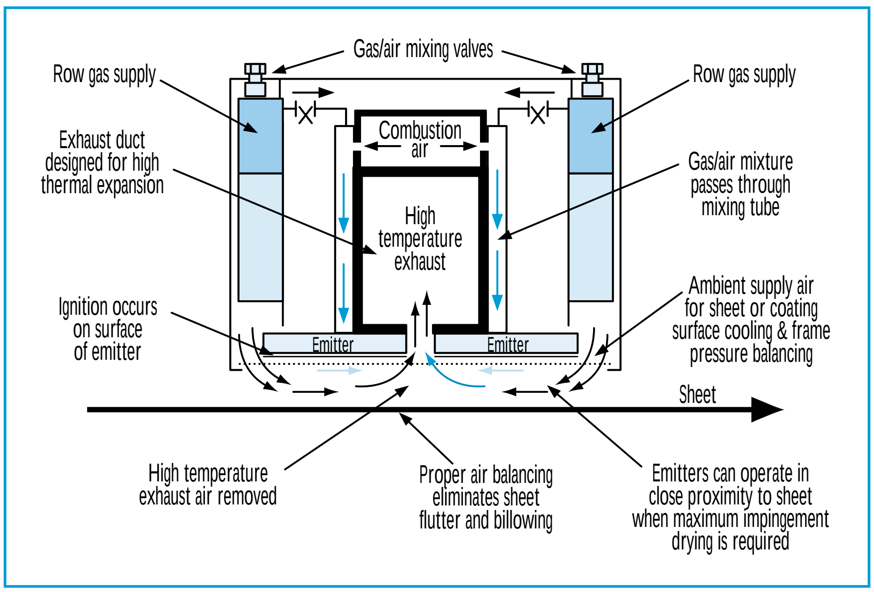
The amount of drying required, wet-end steam can picking, and space requirements determined that the system should be located at the wet end after the presses and just before the first steam dryer.

Typically, new gas- and oil-fired boilers will operate above 90% efficiencies. When the steam cans are included, the total efficiencies can drop off substantially, depending upon the steam can design, type of sheet, and moisture levels into and out of the drying section. This is because a sheet of paper with low moisture levels is a very good insulator. Also, the steam cans at the wet end may exceed 85% efficiency, but the total energy into the sheet would still be restricted on the heavyweight grades due to the previously discussed picking.

Conversely, non-contacting, gas infrared drying systems are not as restricted by sheet moisture and sheet temperatures. Radiant energy penetrates and is absorbed uniformly through the sheet in the z-direction. This allows much higher heat transfer



4. Key system components of infrared gas drying system



5. Main components of drying frames

System description	Cost (US$000)
Steam generation and drying system	
Capital equipment	1,400
Installation cost	150
Total cost	1,750
Infrared drying system	
Capital equipment	350
Installation cost	50
Total cost	450

II. Comparison of installed costs of two systems

rates into the sheet without picking and other quality negatives.

The mill also realized that by elevating the sheet temperatures into the steam dryers at the wet end, picking would be eliminated, and the dryer cans could be operated at higher steam pressures and dryer temperatures. This meant that the total combined throughput from existing steam cans and infrared dryers could be increased.

Another important consideration was that because of the fire-safe emitter design, the infrared dryers could be placed in an opposing frame configuration. This offered the following advantages:

- Any radiation that passes thorough the sheet is captured by the opposing emitter, which enhances the emitters' radiant performance and efficiency.
- The energy is uniformly applied to both sides of the heavy weight board, which eliminates curl and over-drying of the sheet surface.
- Space requirements were minimized, and the frames were located in the optimum process location without fire concerns.

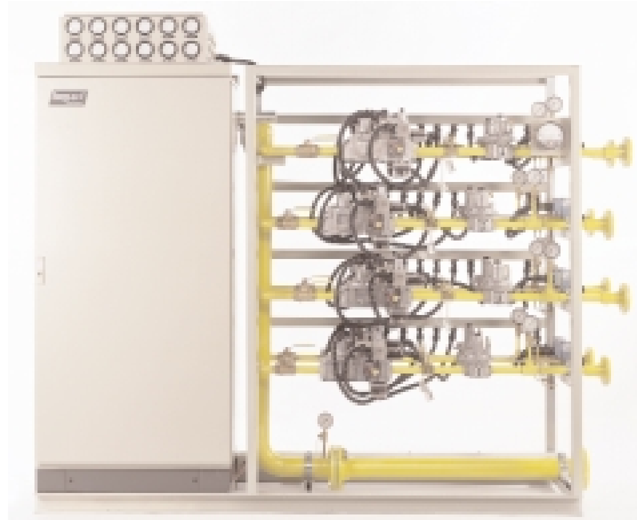
System simplicity

The infrared drying system was very simple compared to the steam drying system. For example, the air system uses separate supply, exhaust, and combustion air fans along with associated ductwork. The design was unique in that no complicated air pressure or flow control schemes and associated moving dampers were required. The air is balanced and set during startup, and the dampers are locked off to ensure they don't move. Key pressures and temperatures are monitored, and the operator is notified if the critical settings exceed established ranges during operation.

The system has a single operator panel that allows the operator to control the entire system, including the fans, ignition system, and control of the gas-firing rate. The integral gas train and combustion control system allow easy access, maintenance, and troubleshooting at one location. **Figure 4** shows the key system components of the gas infrared drying system.

The four two-row, HDF extended drying frames have an integral ignition system, gas supply header, supply air, exhaust air, and combustion air ducts. This makes the units compact and

6. Gas drying frames are mounted opposite each other



7. Integral gas train and combustion control system

easy to install in the limited space available at the wet end. **Figure 5** shows the main components of each frame.

The drying frames were mounted on an independent support structure with a frame retract system for sheet breaks, sheet threading, and maintenance accessibility. **Figure 6** shows the gas drying frames that are mounted opposing each other.

The infrared drying system's electronic control package uses a stand-alone, PLC-based combustion control system with integral gas train. The combined systems simplified installation by eliminating more than 60% of the standard I/O, as well as conduit and wiring required by other infrared systems. The unit is pre-piped, prewired and fully tested at the manufacturer's facilities before shipment. This makes installation easy and reduces installation costs. **Figure 7** shows the integral gas train and combustion control system.

Fire safety requirements

Fire safety was a significant factor in the decision. Since the new infrared drying frames were located on both sides of the sheet for optimum drying performance and space limitations, material could fall onto the hot emitters during a sheet break and possibly catch fire.

The system chosen uses a high-density, fast-response (HDF) emitter with very high-energy output with a very low thermal mass. This combination allows the emitter to operate at 1850ºF and cool down below the flash point of paper within two seconds after the gas is shut off.

The fast cool-down also enhances the life of the emitters and frames because water or steam injection systems are not required when normal sheet breaks occur. Paper machine uptime is also maximized because cleanup after a break is minimal.

The HDF emitter also heats to operating temperature within 10 seconds after ignition. This is beneficial during startup or grade changes because waste and rejects are minimized.

Emissions requirements

System emissions played a significant role in the mill's decision because the steam generation system would use both gas and oil. This required additional equipment and modifications to the existing emissions control and air scrubbing system. Permits would also be required for the additional emissions.

The HDF gas infrared system uses an emitter that produces very low emissions levels. The emission levels produced in the exhaust air of the eight-row system operating at a 100% firing rate (8.7 MM Btu/hr) are as follows:

NOx	0.114 lb./hr
NO	0.099 lb./hr
CO	0.137 lb./hr

Because of these extremely low levels, the exhaust air could be safely sent directly to the pocket ventilation as high-temperature makeup air. This eliminated expensive heat exchangers and emission controls.

Operating and maintenance costs

The steam system would have added a considerable amount of equipment for the mill to operate and maintain: spare parts to support the boiler revisions, new dryer cans, condensate tank, drives, pumps, control valves, and associated controls. The system would also require additional operating and maintenance personnel and associated long-term costs. The addition of steam cans, drives, and controls could also affect the overall reliability and operating efficiencies (uptime) of the paper machine.

The infrared system could operate independently and be maintained without shutting the paper machine down. The infrared drying system maintenance and operating costs were also minimal. No additional personnel were required, and the existing personnel absorbed the increased maintenance needs. Few new inventory spare parts were necessary, compared to those needed for the steam dryer cans.

Grade category (Basis weight)	Speed increase realized (%)
Lightweight grades (58 to 80 lbs./1000ft^2)	2.0 to 5.0
Middleweight grades (82 to 144 lbs./1000ft^2)	5.0 to 12.0
Heavyweight grades (146 to 260 lbs./1000ft^2)	12.0 to 20.0

III. Speed increases for various grade ranges with the use of infrared drying prior to the steam dryers at the wet end of the paper machine

Utilities requirements

The steam drying system would have required substantial increases in gas, oil, water, electricity, and pneumatic instrument air capacity as a result of the following:

- Increased steam generation capacity
- Additional water and condensate pumps
- Boiler and steam system controls
- Additional electrical drives
- Additional ventilating requirements.

In comparison, the infrared drying system needed an additional 90 kW/hr for fans and electrical controls. Also, a maximum of 8700 ft^3/h of natural gas was needed to operate the system at 100% capacity. All of the other utility requirements could be supported by the existing utilities.

Personnel training requirements

Training and technical support was a crucial factor because of the long learning curve for operators and maintenance personnel involved in a major millwide upgrade. This process includes learning how to operate, maintain, and technical-troubleshoot the multiple-function systems being considered. The infrared gas system was simple and easy to integrate into existing equipment. The most complex part was the PLC-based combustion control system. Otherwise, only basic mechanical, operating, and safety skills were needed.

The upgrade was accomplished without expensive or extensive in-class and supplier training offsite. The operators and maintenance personnel were trained easily during the installation and startup phases. The training consisted of two hours of classroom training for the operators, with on-the-job training after startup.

Effect on product and sheet quality

Maintaining and improving product quality is extremely important. The addition of the infrared drying system enhanced product quality and uniformity in several ways:

- Surface defects and poor quality associated with dryer picking in the wet end were eliminated.
- The caliper and density of the product could be better controlled because moisture removal was increased without overpressing and underdrying the sheet.

SYSTEM RESULTS SINCE STARTUP

Increased production and reduced picking levels

The system was started up in July 1995. Overall, it has exceeded all expectations in both production capacity and system reliability. The mill has increased overall production by more than 9% as a direct result of the gas infrared system. In addition, the waste associated with picking at the higher drying levels has been substantially reduced.

The infrared dryers increased drying capacity and allowed the existing dryers to be operated at maximum operating pressures and surface temperatures. This is a primary reason for the substantially higher paper machine speeds, as seen on the grades outlined in **Table III.** This table shows the speed increases realized on the grades, which range between 58 to 260 lbs./1000 ft^2.

System performance compared to existing steam dryers

The new infrared dryers have performed at levels comparable to the steam dryers. This part of the long-term study revealed that the infrared gas drying system is providing energy costs that are comparable to the existing steam drying system. Gas usage was increased by less than 3% from what it was before the infrared drying system startup. This does not take into consideration the overhead costs and additional power requirements of the steam generation, recovery, and steam dryer systems. Detailed gas consumption and costs per ton are not available because of the confidential nature of the information.

System maintenance and long-term reliability

The system has been in operation for more than four years, with minimal maintenance and technical support required. The system is turned on continuously for weeks at a time, with normal shutoff only during paper machine outages. The special alloy HDF DuraGlow™ emitters are still in operation and are performing at full firing rates. As these emitters require replacement in the future, the mill plans to install Dual-IR™ emitters, which have a secondary grid. These emitters will enhance the radiant energy performance and provide additional drying capacity to the existing Voith Sulzer Automation Spectrum-IR™ HDF System.

SUMMARY

In the final analysis, the high-density fast-response (HDF) gas infrared drying system has achieved the maximum return on investment for Recycled Paperboard's particular application. The analysis and long-term performance have proven the infrared drying system's viability as a practical substitute or replacement for steam dryer systems. In addition, the system has been proven to be very safe and reliable for the highly demanding application.

The integration of the two systems has also demonstrated that when properly designed and applied, the two types of drying can enhance total paper machine drying performance. Therefore, the gas infrared and steam drying system combination will be considered in future mill expansion plans. TJ

Kovangji is technical director/plant engineer, Recycled Paperboard of Clifton Inc., Clifton, NJ.