Effective water cooling systems extend roll covering performance

Win C. Pierce

The methods of internal water cooling for rubber-covered press roll cores can affect the life and performance of the roll itself. This article reviews the importance of water cooling and describes the most preferred systems.

Thermal expansion and contraction of most elastomeric compounds is 10 times that of steel or cast iron, which means that when a rubber-covered roll becomes warm, the cover expands in volume approximately 10 times faster than the metal to which it is bonded. Therefore, if the bond-line temperatures between the metal-to-rubber interface are very high, the expansion of the base, or rubber cover, will be much greater than that of the metal core, which could lead to premature bond failure.

Secondary but also important benefits of water cooling systems include:

- Reducing the temperature of the rubber-to-metal bond line (bonding cements have temperature limitations)
- Reducing the temperature throughout the cover thickness
- Ensuring an even distribution of temperature from the front (tending) side of the roll core to the back (drive) side.

When water cooling should be used

Water cooling might be warranted if any of the following conditions exist:

- High nip pressures generate heat within the cover (hysteresis)
- High sheet temperature
- High ambient temperature
- Mating roll or rolls have high surface temperatures
- Steam boxes or hot air or radiant heat are in use.

Achieving the best situation in a water cooling system: spray/flow

The ideal system would cool the head areas either by spray or flow and have a uniform laminar flow on the inside diameter of the roll core from one end to the other without any "dead" (no flow or spray) spots.

In order to achieve that, the water must rim. Factors that determine rimming are: rpm, amount of water inside the core, and the inner diameter structure of the shell. If the cooling water is allowed to get too deep, it will cascade instead of rimming. Cascading causes turbulence but may not cause good mixing unless large amounts of water flow through the roll, eliminating the possibility of a nonuniform water temperature zone.

The maximum temperature differential between ingoing flow and outgoing flow should be a Delta T of 10°F or 6°C. If you are achieving the proper or specified water flow from one end of the roll to the other, the temperature rise can be used as a control for the water flow.

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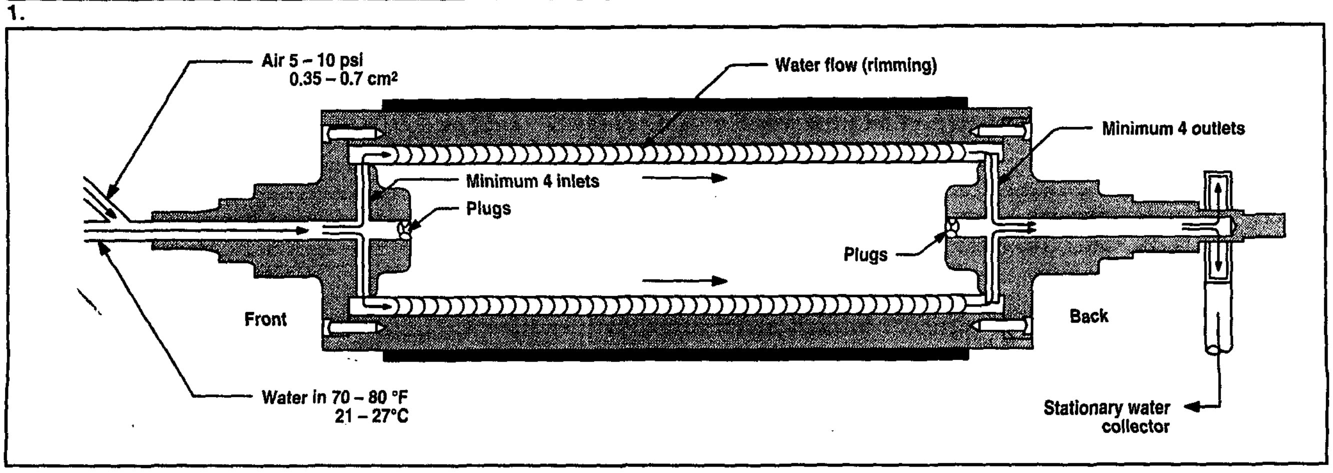

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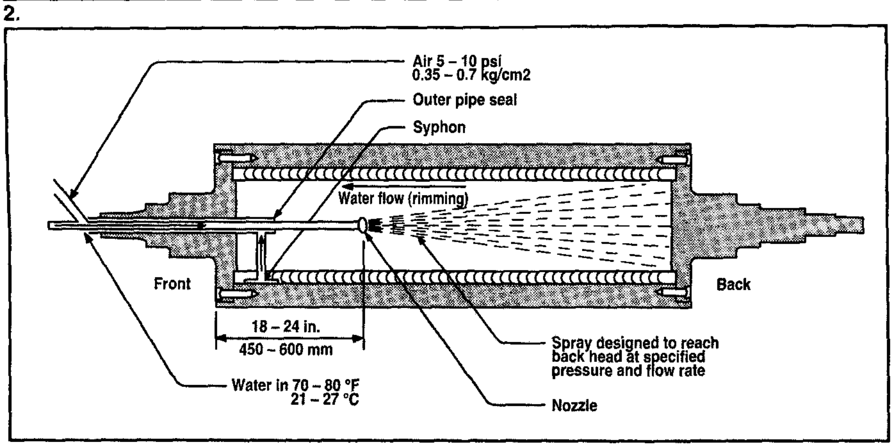

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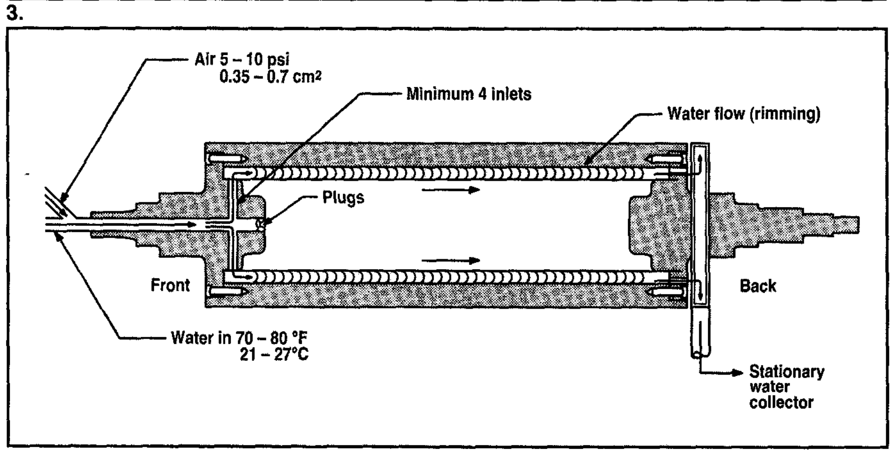

Designing the preferred water cooling system: combining water and air pressure

A well-designed water cooling system would be made up of water and air pressure in the front side journal. The water should exit at the inner periphery of the shell at the back side head junction through a minimum of four ports and then flow directly out of the shell to a collector; or, it should be forced to the journal bore by air pressure and then collected at the back side journal. This type of system should be adequate for most situations.

Water flow in and out of a roll should always be easy to check visually. Flow meters and temperature recorders, when maintained properly, are effective.

Water pressure is usually used in combination with 0.35–0.70 kg/cm^2, 5–10 psi air pressure. Much can be learned by observing the water collector ring on the back side. The air blow-through will indicate when there is too much water in the roll, not enough water, or if the exit ports are plugged.

It is also important that the water supply remains clean. If the water supply contains a lot of minerals, sludge, or other foreign materials, periodic opening of the roll to check for scale and mud should be scheduled. It is important not to let any scale buildup occur because of the effect on heat transfer. High-pressure water or grit blasting will clean up the interior surfaces. It may be worthwhile to paint the interior of the rolls with an epoxy paint.

Minimizing water temperature differentials

Maintaining a constant inlet temperature year round is very important. As you know, in many mills, stream water can vary more than 40°F (22°C), depending upon the season. A heat exchanger can ensure constant ingoing water cooling temperatures. It is important that water cooling temperatures be tailored to cover surface temperatures. For example:

Surface Temp.	*Average Cooling Temp.*
150°F	110°F
140°F	100°F
120°F	90°F
100°F	75–80°F

The primary reason for the above is to minimize temperature differential driven water diffusion and subsequent condensation at the cold metal interface.

In no instance should the average cooling temperature be less than 75°F (in at 70°F, out at 80°F). Using these surface/internal cooling parameters will definitely decrease the condensation level and maintain cover and cover/bond integrity.

Protecting your system with a roll stop interlock

It is recommended that the water flow into a roll be stopped as the roll stops during a shutdown, even if it is of short duration. It is safest if this is automatically interlocked with the press speed control. If water is allowed to continue to enter the roll, depending on water exit port location, a roll could fill with water, which is undesirable because of stratification. In addition, if a roll is partly filled with cool water and the top of the roll remains warm due to cover insulating values, then upon startup you will have a two-sided roll that could cause severe vibration. Also, operating with a very heavily filled or half-filled roll can cause variations in crowns and nip pressure profiles.

In conclusion, water cooling can solve problems, but improper methods can create other problems. Good system maintenance is a must. Accomplishing a temperature uniformity for the entire working surface of the roll and a uniform temperature reduction will maintain and maximize bond strength and overall cover structure integrity.

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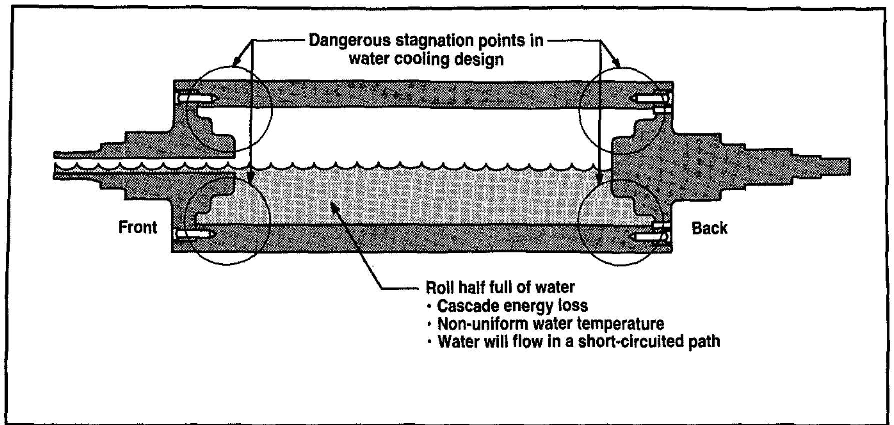

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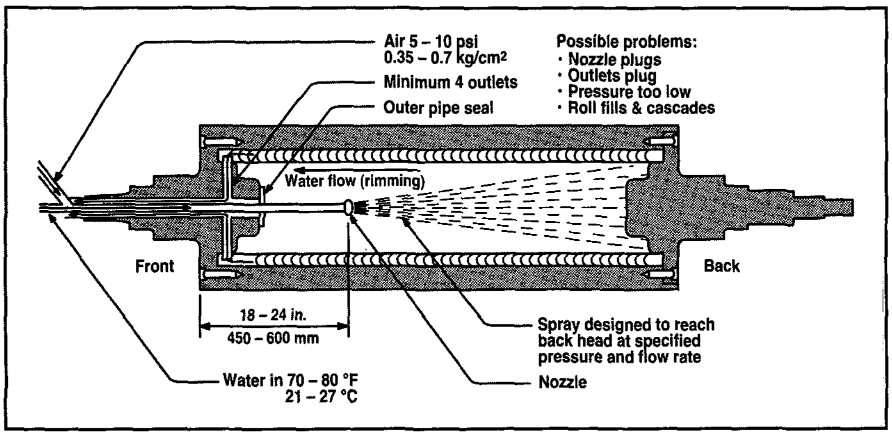

From best to worst

Figures 1–5 show various designs for water cooling systems.

Fig. 1 allows a good balance of air flow conditions, water temperature, water inlets, and rimming.

Fig. 2 is a good alternate design. The siphon design injects a nozzle in the front and the spray is designed to reach the back head at a specified pressure and flow rate. Then the spray is drawn out through the siphon in the front.

Fig. 3 is an acceptable design. Water and air pressure enter the front side of the roll and are drawn out the back side through the stationary water collector.

Fig. 4 illustrates a poor design that might cause several problems, such as nozzle plugging, outlet plugging, low pressure, and roll fills and cascades.

Fig. 5 is an unacceptable design. There are stagnation points, the water flows in a short-circuited path, and the roll becomes half full of water, leading to energy loss. Also, nonuniform water temperatures minimizes bond strength and cover structure. TJ

Pierce is vice president of applications, Stowe Woodward Company Ltd., Southborough Technology Park, 333 Turnpike Road, Southborough, MA 01772-1708.