

Mill experience with gate-roll-coated papers

M. Hirakawa and H. Iwase

Operational factors such as pressure in nips, differences in roll surface speeds, consistency of coating color, and raw stock conditions must be carefully controlled for good quality in paper products and a longer life for equipment.

Jujo Paper's Ishinomaki mill is located about 350 km north of Tokyo (about 220 miles) and has a production capacity of 660,000 tons/year of printing and writing papers. The mill produces more than 550 varieties of paper, in grade, tone of color, and basis weight, with ten paper machines and three off-machine coaters.

In 1981, we began manufacturing gate-roll-coated papers, which have 4-6 g/m² of pigment coating on each side, with a gate roll coater on Paper Machine 8. Today, we run three paper machines equipped with gate roll coaters. Production has reached 75,000 tons/year (Table I) with this grade, which includes wood-free, wood-containing, machine-finished, and supercalendered papers. Here, we will focus on Paper Machine 8 and its wood-containing products.

Development of gate-roll-coated papers at Ishinomaki

In October 1980, a gate roll coater was installed on the No. 8 machine (Fig. 1) to improve resistance to picking of wood-containing paper for offset printing. As we had expected, surface strength was increased satisfactorily, and steam consumption in the dryer section was estimated to be about 20% less than that for the two-roll size press.

In August 1981, we started a project aimed at improving the printability of wood-containing papers. For this purpose, we intended to make the most of the gate roll coater of Paper Machine 8. Trial runs showed us that the production of pigment-coated papers with the gate roll coater was feasible and would be economical.

At first, the No. 8 machine did not have its own color kitchen, so the production of these papers was possible only when the No. 1 coater's equipment was available for No. 8 machine. Eventually, a color kitchen for Paper Machine 8 was completed, in May 1983. At the same time, a sensor for determining the basis weight and moisture was mounted at the entrance of the gate roll coater for continuous monitoring of the raw stock. At present, we have three production lines for gate-roll-coated papers, as shown in Table I. The products have been well received by printers and publishers.

Hirakawa is manager of the coating section, and Iwase is assistant manager of the technology department at Jujo Paper Co., Ishinomaki Mill, Ishinomaki Miyagi, 986 Japan.

Pigment coating with the gate roll coater

Control of coating weight

The weight of coating applied to the paper web depends on several operational factors, including pressure in flooded nips (Fig. 2), differences in surface speed between outer and inner metering rolls (Fig. 3), and consistency of coating color (Fig. 4). Of course, line speed does affect coating weight, but it is impractical to adjust the thickness of a wet coating film by changing machine speed.

However coating weight increases when nip pressure between metering rolls is decreased, it also results in uneven distribution along the length of the press (Fig. 5), because the metering rolls of Paper Machine 8 are not crown-compensated rolls. Nip pressure should be kept constant for fixed-crown metering rolls. Different surface speeds of these rolls could be used for controlling coating weight, but we would have to replace these rolls frequently because of rapid wearing of the roll covering. Consequently, we regulate color consistency in the service tank to control the coating weight (Fig. 6).

Web slipping and wrinkle

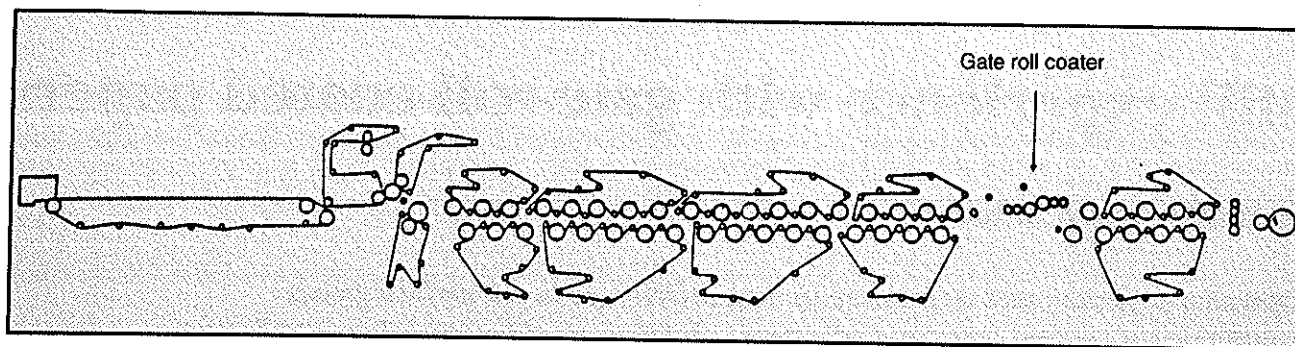
Since the caliper profile of pigment-coated papers tended to be unstable, we made a lot of rejected product during the trial period. We were unable to observe the condition of the raw stock and to determine the coating weight profile along the cross-machine direction (CD), because there was only one sensor for basis weight and moisture just before the reel.

Until another sensor for basis weight and moisture was installed at the entrance of the gate roll coater in March 1983, we had to stabilize the CD profile of the base paper before applying the coat with the gate roll. This unavoidable adjustment work made us waste about an hour or so of valuable time. After that installation, both the reject rate and the time involved fell dramatically.

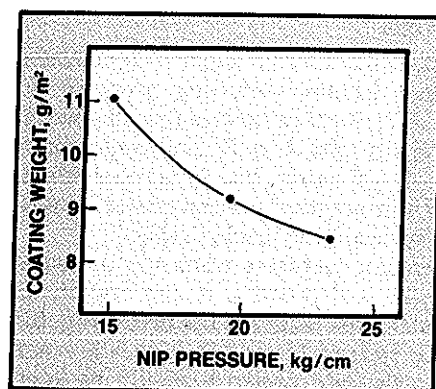
The smoothness increases as coating weight increases, and we observed web slipping and the formation of wrinkle on the reel when the coating weight exceeded 6 g/m² per side in the trial runs. These troubles have been resolved by the regulation of web tension and nip pressure between the reel and drum.

Coating weights are kept below 6 g/m² per side now. More coating not only brings about these problems, but it also causes stains on dryers' cylinders and web creases at the calender.

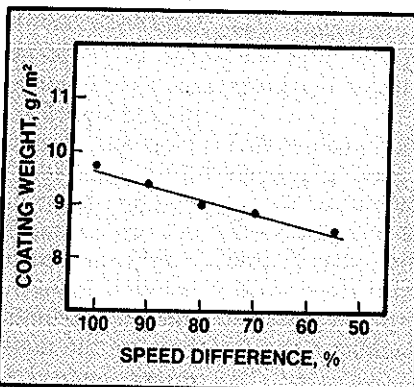
1. Paper Machine 8, with a wire width of 6 m, produces 231.2 tons/day at a machine speed of 650 m/min.



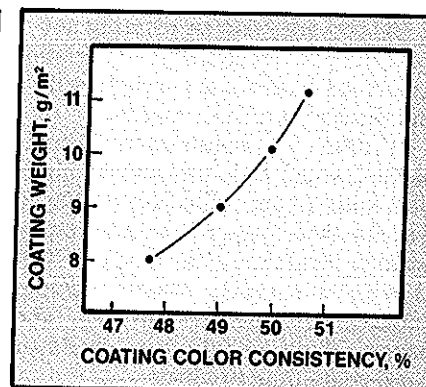
2. The influence of nip pressure between the metering roll on coating weight (on both sides)



3. The influence on coating weight (both sides) of the differences in roll surface speed, expressed as 100× (outer roll speed/appliator roll speed)



4. The influence of coating color consistency on coating weight (both sides)



Coating patterns

Formerly, we occasionally found a pattern we called the "railroad track" pattern, shown in Fig. 7. This pattern results from an undesirable coating film split after the nip. This railroad track pattern has been almost eliminated by decreasing the internal sizing and increasing the moisture content of the raw stock.

Sometimes we find a CD stripe pattern at the edge of the web, which is caused by bounding of applicator rolls. This condition is eased by proper adjustment of the roll jacks. Defects in the applicator rolls or metering rolls can cause coating patterns more readily in pigment coating than in sizing with starch solutions alone.

Other coating patterns that can be encountered with gate-roll-coated papers include MD stripes, caused by ribbing of the coating film on applicator rolls, and the orange peel pattern, which originates in an undesirable coating film split. Coating weight must be kept below a certain level, because coating patterns become more marked and caliper control becomes difficult as the weight is increased.

Since coating color contains a small quantity of luminous dyes, patterns appear when ultraviolet rays are applied to gate-roll-coated papers in a darkroom.

Deposits and stains

A part of wet coated film on the web surface transfers and accumulates on paper rolls, cylinders, and dryer canvases and forms deposits. Unless cleaning is carried out frequently, these deposits will cause serious defects in

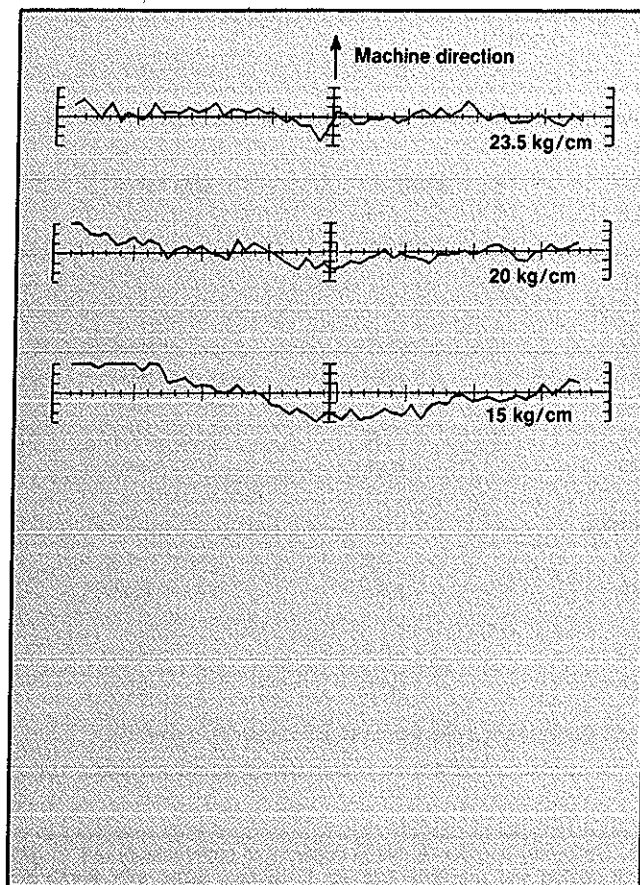
1. Gate-roll-coated papers at Ishinomaki

	Wood-free, matte finish	Wood-containing			
		Matte finish	Matte finish	Super-calendered	Super-calendered
Paper machine	4	8	8	N4	N4
Brightness, %	80	75	70	75	70
Gloss (75°), %	10	8	7	30	25
Production, tons/year	3,000	38,000	4,000	12,000	8,000

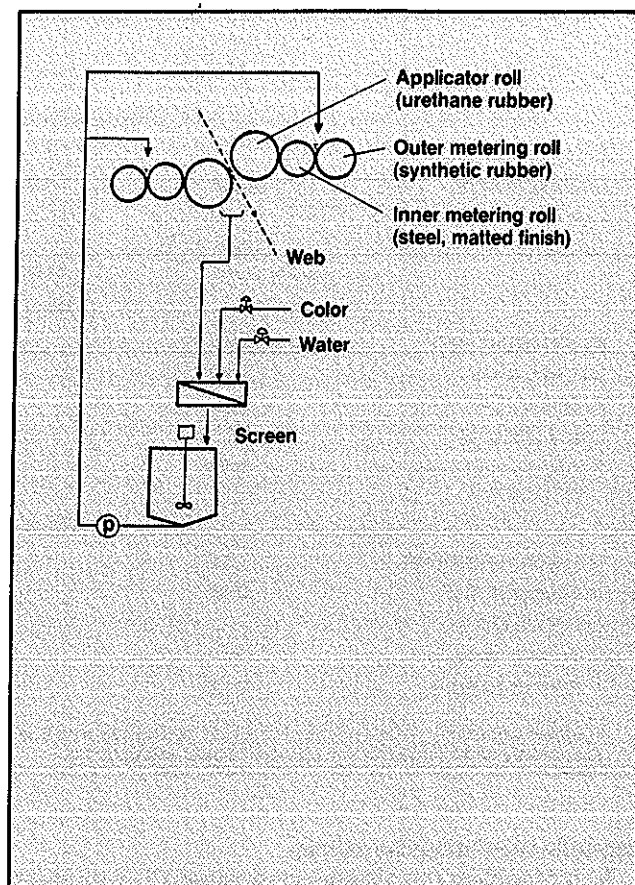
finished paper. Paper rolls and dryer canvases are being cleaned continuously by shower water and canvas cleaner, respectively, and cylinders are swept by hand periodically. Noncontact drying equipment such as air flotation or infrared drying are helpful for reducing such deposits and stains.

We had a problem with rubber latex gumming on the surface of applicator rolls when the quantity of latex binder in coating color was increased. Once such gumming takes place, the paper machine has to be stopped to remove

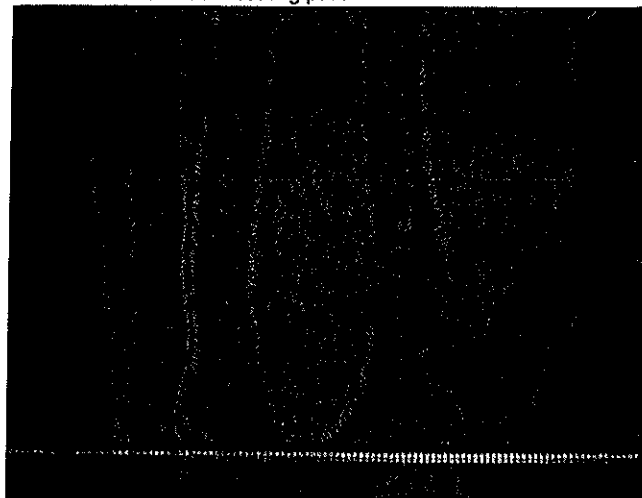
5. These profiles of coating weight show that variations across the sheet increase with a decrease in nip pressure between metering rolls.



6. Schematics of the gate roll coater



7. The "railroad track" coating pattern



the gum, which would otherwise appear as defects in paper.

Necessarily, deposits inside the color-supplying lines lead to dirt specks in the paper. Pigment coating and starch sizing are alternated on Paper Machine 8, and a part of the supply line piping is used for both coating color and starch solution. It takes a lot of time to clear piping carefully between these alternating operations. Since coating color contains a certain amount of starch as binder, which sometimes deteriorates, the addition of preserva-

tives into coating color is indispensable.

Peeling of the rubber cover of the applicator roll

Four years ago, rubber covers of applicator rolls peeled off three times in succession. The junction between the cover and the iron core of the rolls had been broken by penetrating vapor. Generally, the core is cooled by water to prevent the rubber cover from being melted by friction heat. If the temperatures of the core and cover are wide enough apart, the moisture which penetrates from the roll's surface condenses at the juncture, breaking the junction and causing the cover to peel. Therefore, we have made the temperature of cooling water higher, and we have also changed the rubber material into a more durable one.

Extreme wearing of the rubber cover of the applicator rolls can be the cause of uneven coating, especially at the edges, and of creases in the web at the entrance of the gate roll coater. The applicator rolls of the No. 8 machine are replaced every two months to prevent these problems.

Properties of gate-roll-coated papers

Problems of wavy edges and curl

Before we installed the sensor for basis weight and moisture, wavy edges in the sheet pile often occurred, because the moisture content of gate-roll-coated papers on the reel was kept below 4% to achieve a flat caliper in the cross-machine direction. This problem was solved by increasing the moisture content of finished paper by

II. Paper and print qualities of various wood-containing grades

	Grade ^a			
	A	B	C	D
Manufacturing parameters				
Paper machine	N4	N4	8	8
Coating method	Blade	Gate roll	Gate roll	Uncoated
Coating weight, g/m ²	20	12	9	...
Finish	Super-calendered	Super-calendered	Matte	Matte
Paper qualities				
Basis weight, g/m ²	70.6	66.6	64.6	62.0
Density, g/mL	1.20	1.10	0.90	0.80
Brightness, %	76.3	74.3	75.4	73.7
Gloss (75°), %	43.3	28.4	7.6	7.1
Printsurf roughness, μm at 10 kg/cm ²	1.89	2.80	4.28	4.76
Print qualities				
Dry pick resistance ^b	5.0	4.9	4.8	4.3
Ink absorptivity ^c	0.55	0.68	0.32	0.25
Ink gloss (75°)				
Printed once, %	65.3	45.3	17.7	11.7
Printed twice, %	81.5	71.7	41.5	22.1

^aDefined in the text. ^bOn a scale of 1 to 5, with 1 being poor and 5 being good. ^cRelative scale where a small fraction represents good ink absorptivity and a large fraction represents poor absorptivity.

carefully regulating the caliper.

A curl problem was also observed, especially with sheets of small sizes. Curl has been controlled in the drying operation by regulating steam to the various dryer cylinders.

Printability differences between top and wire sides

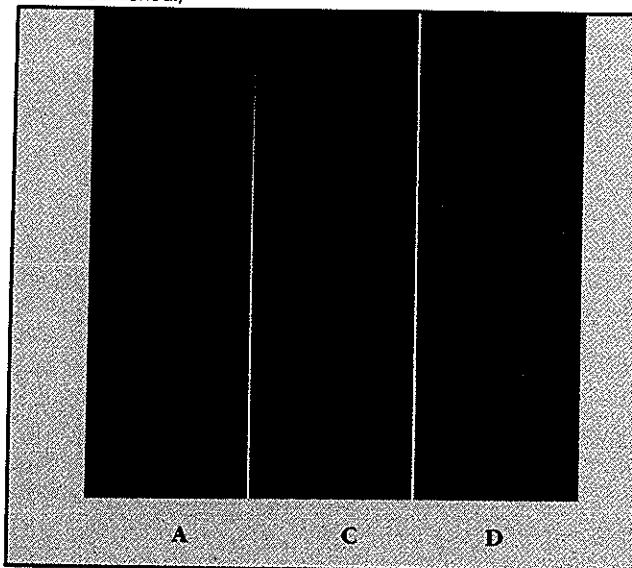
As a fourdrinier paper machine, Paper Machine 8 imparts a different surface quality to wire and felt sides. The underside is of course inferior to the top side in smoothness. Therefore, the nip pressure between the metering rolls for the wire side is kept slightly lower than that for the top side, to apply more coating on the wire side and improve its printability. Two-sidedness scarcely appears in either base paper or gate-roll-coated papers produced with twin-wire formers such as our machine designated in the tables as No. N4.

Comparison of properties between gate-roll-coated papers and blade-coated papers

As mentioned, coating weights of gate-roll-coated papers must be kept below a certain amount, say 6 g/m² per side for our No. 8 machine, to prevent the problems of web slipping, deposits accumulation, and serious coating patterns. Consequently, gate-roll-coated papers are somewhat inferior in printability to blade-coated paper, because blade coaters are able to create a uniform coating surface even if coating weight is increased. Table II shows the qualities of white papers of various wood-containing grades as follows:

- A: blade coated and supercalendered
- B: gate roll coated and supercalendered
- C: gate roll coated and machine finished

8. Uniformity of color (A: blade coated and supercalendered. C: gate roll coated and machine finished. D: surface sized with starch and machine finished.)

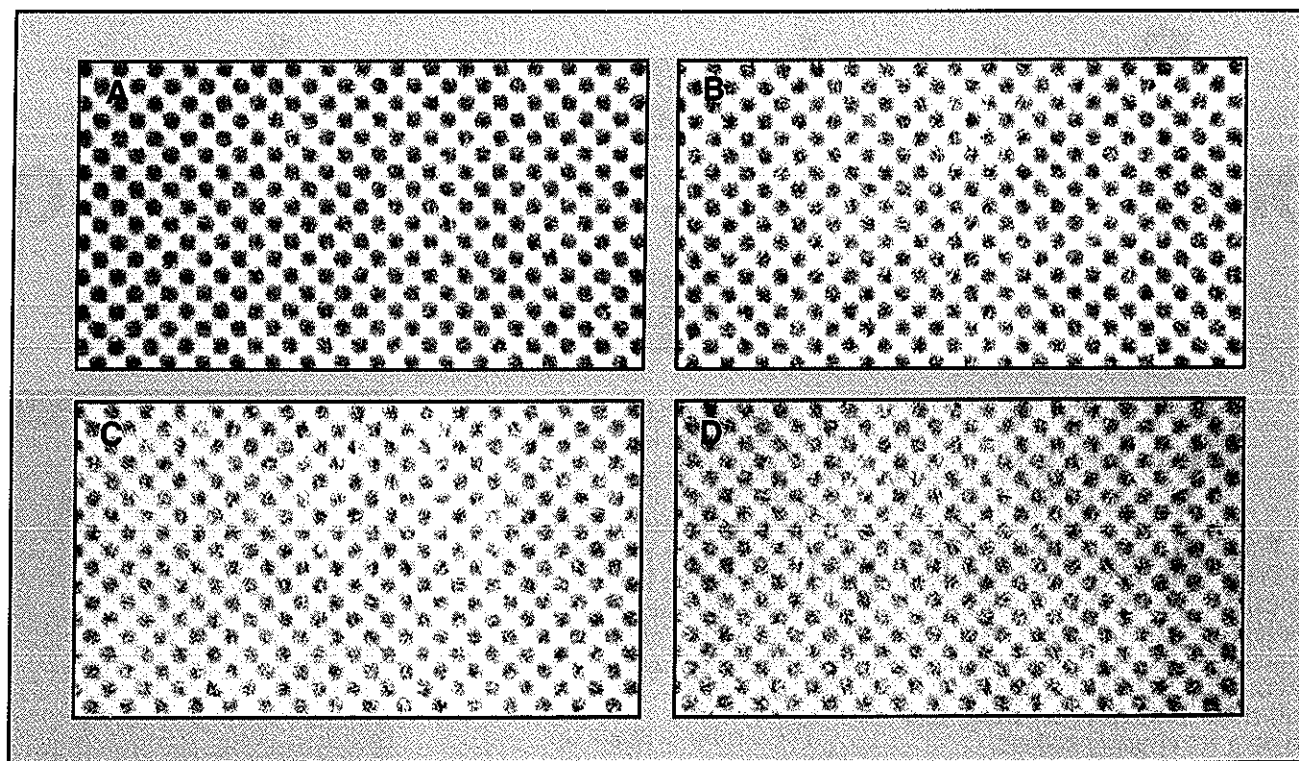


- D: surface sized with starch and machine finished.

(For these papers, the fibrous material is constituted with 10-15% of stone groundwood and 85-90% of bleached kraft pulp.)

As shown in the table, surface properties of gate-roll-coated papers are inferior to those of blade-coated paper; however, these properties are dramatically better than those of uncoated papers. Gate roll coating improves printability substantially. Gate-roll-coated papers are

9. Uniformity of ink transfer and the contrast between the printed and unprinted areas for various papers (A: blade coated and supercalendered. B: gate roll coated and supercalendered. C: gate roll coated and machine finished. D: surface sized with starch and machine finished.)



superior in uniformity of color of the printed areas, in uniformity of ink transfer, and in contrast between the printed and unprinted areas, as shown in Figs. 8 and 9.

Pigment coating with the gate roll coater has to be carried out to improve the resistance to picking. Therefore, the binder ratio of gate roll coating color is about twice that of blade coating color, to retain a sufficient surface strength of paper. This necessity yields a somewhat poorer ink transfer and a lower rate of ink absorbency in the printing process. However, it is a remarkable merit of gate roll coating that gate-roll-coated papers are completely free from streaks or scratches. These features are unavoidable weak points of blade coating.

Since Paper Machine 8 has no supercalender, it produces only matte-finished, gate-roll-coated papers. On the other hand, machine No. 4 has an on-machine soft calender, and No. N4 has two supercalenders. This equipment is useful for imparting various features to slightly coated papers.

Concluding remarks

The gate roll coater is popular in our country as a simple tool to improve printability. Gate-roll-coated papers have been welcomed by printers and publishers, and the sales of these grades have been growing steadily in Japan.

Pigment coating with the gate roll coater improves the printability of paper substantially, though not as extensively as blade coating. A streak-free coat is the most outstanding merit of gate roll coating.

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