Predicting the potential print quality of newsprint

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The printability index predicts the potential print quality and has become part of our quality control program.

Increasing demand for higher reproduction quality in the daily newspaper has spurred a quick acceptance of new manufacturing technologies in the newsprint industry. Healthy market competition and new pulping and paper manufacturing processes have considerably narrowed the quality differences among the newsprints available today.

Conventional tests for newsprint quality in the mill monitor optical and strength-related properties. These tests correlated poorly with print quality achievable in the pressroom. Even for the papermaker, most conscious, assessing one run against another run was difficult due to such factors as the time delay between manufacturing and printing and poor feedback from both the pressroom and technical service representatives.

The major underlying reason for the poor feedback from all sources was the subjective nature of the print quality assessment. If an obvious, large problem occurred in a pressroom, it was not difficult to find the cause, inform the mill, and take corrective steps. When the issue was general "printability," however, it was difficult to solve the problem based on personal assessments and necessarily vague descriptions.

Paper manufacturers needed to be able to measure the potential reproduction achievable with the paper as soon as it was manufactured and before it was shipped. This would be vital information for the quality-conscious printer, on receipt of a shipment.

A method for determining this information is now available using "printability indices," tailored for letterpress and offset processes.

Components of the printability index

The quality of the printed reproduction of an image depends on the quality and suitability of the paper for a particular printing method—as well as a number of other factors. Here, we use the term "printability" to identify the effect of paper only, excluding all other factors. The "printability index," then, describes the suitability of the paper to accept and hold printing ink to reproduce the image presented to the paper with the plate or blanket.

Print mottle

Others investigating printability come to the well-known conclusion that whether print quality is judged by experts or non-experts, print mottle is the most important factor affecting printability. We came to the same conclusion in working with two large publishers of daily newspapers (one offset and one letterpress), in the early stages of this work. If the effects of all the factors that affect judgment were taken as 100, the effect of mottle was approximately 50. This figure did not change substantially if the judges were scientists, technologists, technicians involved in printability research, professional printers, publishers, or members of our secretarial pool.

Test for print mottle number

Considering a solid print as the signal and interfering areas of lower optical density as noise, we identified the signal-to-noise ratio when judges were presented with a solid print area of 20 mm × 20 mm and asked to identify a smaller area within it which was different in optical density. The smallest identifiable area was found to be 2 mm^2. The size of this identifiable area was only slightly influenced by the optical density difference between the base and the small area. The time required to point out the smaller area was also measured. Optical density differences of 0.02 and 0.06 were picked up in the same amount of time and at the same size.

The test we developed involved making a solid "print" on the paper to be tested using a flexible steel blade at constant angle and pressure. Excess ink was applied behind the blade on a strip of mylar (to avoid premature loss of ink into the paper). The blade assembly was then run over the paper surface, drawing the ink off the mylar and onto the paper. (The speed at which the drawdown was made was not controlled. The effect was tested and was found negligible within reasonable limits.)

The ink was a process black offset ink, in which the

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carbon black pigment content was reduced so that the drawdown's average optical density would be approximately 1. The drawdown was repeated on both sides of the paper, and the paper was allowed to dry for 5 min. The drawdown was evaluated using a video camera connected to a computer equipped with graphics capabilities and using our own software to calculate a print mottle number.

The matrix was an area 20 mm × 20 mm, divided into 100 2-mm^2 cells. As the scan was made, the optical density of each cell was measured and the average calculated. Within certain limits of difference from that average, the cells are designated "black, "white," or "gray." Gray was considered inoffensive, while both black and white cells were not. The "black" and "white" cells were counted three times using three sets of criteria.

Using the first criteria, if the cell's optical density was higher than the average optical density of the matrix plus 0.02, then the cell was "black." If the cell's optical density was lower than the average optical density of the matrix minus 0.02, then the cell was "white." The remaining cells, having optical densities within ±0.02 of the matrix average, were designated "gray." The second and third counts were performed according to the same criteria, except that the tolerances were increased to 0.03 and 0.04, respectively.

The data was then used in the following equation to determine the print mottle number:

$$PMN = \{[(B_{0.03} + W_{0.03})/100] \times 100\} + \{[(SND \times 100)/13.68] - 100\} + [(B_{0.04} + W_{0.04})/(B_{0.02} + W_{0.02})] \times 100 \quad (1)$$

where

PMN = print mottle number

B = number of "black" cells

W = number of "white" cells

SND = sum of neighboring differences, or the sum of absolute optical density differences among all neighboring cells in the matrix.

The subscripts 0.02, 0.03, and 0.04 represent the tolerances used in the counts, as explained. The constant 13.68 is the SND of a matrix with an optical density difference of ±0.01 among all the cells in the matrix.

The measurement was made five times, and the results were averaged. Approximately six samples could be evaluated on both sides in one hour.

The PMN was evaluated in an extensive program involving pressrooms of both offset and letterpress equipment. Papers from various mills were printed on commercial runs. Pressroom personnel and our research personnel evaluated these papers first for mottle only, then for "overall printability."

Unprinted samples of each paper involved in the experiment were tested for the PMN. The subjective rankings agreed exactly with the calculated PMNs on the best and the worst samples. In the mid-qualities, the judges contradicted each other slightly. The closer the PMN was to the best or worst sample, the better the agreement we found, but the confusion of the judges was never greater than one rank on either side of the PMN value.

Encouraged, we conducted further trials in different pressrooms, and the results were similar. With every new verification of the PMN, we were more and more convinced that the measurement truly reflects what the eye can see, exactly and reproducibly. The same measurement was also used during paper machine startups to optimize top-wire installations, utilizing the new capability to analyze the effect of surface-structure variations.

It is now clear to us why the earlier excellent work of other researchers failed to describe mottle. First, the areas considered in the image analysis were too small, and the overall effect was lost in the details. Second, the "mottle" was generated in either transmitted light or radiation, which may be an excellent analysis of fiber distribution but not a description of the surface, which is what we use, by the way, for printing. Convinced that 50% of the "printability" was now measurable, correlations between the subjective rankings of the original study and other measurable properties of the paper were investigated.

Other properties

On the basis of these further studies, the following four other properties were included in the calculation of the printability index:

- Optical density: During the measurement of mottle, the average density of the matrix was calculated. It was used as an indicator for ink absorptivity.
- Brightness: Paper brightness was included in the index for considerations of contrast.
- Print opacity: Show-through is a straight-line relationship with printing opacity and is used as a measure of show-through.
- Smoothness: Measured by Parker Printsurf (S-10), paper smoothness had the best correlation with printability rankings, except for mottle.

Other measurable paper properties, including formation, had no correlation with printability rankings. Our aim was to combine the PMN, optical density, brightness, printing opacity, and Printsurf S-10 results into a printability index. The following considerations were taken into account:

1. For each of the five components the minimum significant change had to be determined. This was determined by experimentation.
2. Paper requirements are different for letterpress and offset. The relative importance of the five components is also different for the two processes and had to be established. These weightings were determined arbitrarily, based on common knowledge of each process.
3. A base line, to which all results would be compared, had to be created. This imaginary newsprint has properties better than newsprints available on the market today.

The effect of each component was established with the following equations, using Considerations 1 and 3:

$$\text{Mottle effect} = [100(PMN - 130)/130]/30 \quad (2)$$

$$\text{Ink absorption} = [10(OD - 1.0)/1.0]/10 \quad (3)$$

$$\text{Smoothness} = [100(PS - 3.2)/3.2]/3 \quad (4)$$

$$\text{Show-through} = [100(97 - PO)/97]/1 \quad (5)$$

$$\text{Brightness} = [100(60 - Br)/60]/0.5 \quad (6)$$

where:

PMN = print mottle number

OD = average optical density

PS = Parker Printsurf S10

Br = brightness

PO = printing opacity.

For Consideration 2, the effect of each component was weighted with the significance factor of the component in the letterpress or offset process. The sum of the effects was then used as the printability index of that paper for that process.

In summary, this index contains five measurable properties of the newsprint, establishes a position for each of the components through the process of measuring them to a common base and considers the particular demands of either the letterpress or the offset process.

Results

The first test of the validity of this measurement used the original work on mottle. After the judges had ranked samples for mottle, we asked them to also rank for "overall printability." The results of the letterpress printability index comparison and the offset printability index comparison were slightly different. We made a small adjustment in the significance of the *PMN*, increasing for the letterpress and reducing for the offset press. The results were then equal to the rankings.

Discarding the result of this experiment then, since an adjustment had been made, other pressrooms with a different selection of newsprints were tested similarly. Both the letterpress index and the offset index agreed with the rankings of the judges. These indices have continued to be in agreement with the rankings of the judges for the past two years.

Conclusions

The index has become part of the routine testing at our central quality control laboratory. Using the data from all our mills, we established an internal ranking for all our paper machines. This system has helped to improve our distribution strategy by ensuring that we ship the right paper to the right pressroom.

The index has never been contradicted by the actual press performance. Many times, the paper was not as good or as bad as the index predicted, but the relative behavior of the paper on the press was always "as predicted." Finally, we can determine only potential print quality. We are not expecting to find the same results with the same paper in different, and differently run pressrooms.□

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