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OPTICAL PROPERTIES OF PAPER AND INFLUENTIAL PARAMETERS

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Abstract

The paper deals at length about various optical properties like brightness, opacity, scattering coefficient, absorption coefficient, luminescence, yellowness, dominant wavelength, excitation purity etc. The influential parameters affecting the above properties are studied. The Newsprint furnish consists of both chemical and mechanical pulps. The brightness of the pulp blend is influenced by the brightness of the mechanical pulp. Studies show that the brightness is not an additive property. Slight brightness fluctuation in chemical component has insignificant effect on the resultant pulp blend brightness. The usefulness of 'Yellowness' measurement in fixing the shade of newsprint and cultural varieties of paper is pointed out. The influential parameters affecting printing opacity are discussed. Studies conducted on the influence of brightness, grammage variation, on printing opacity are highlighted. Increasing the grammage and reducing the brightness, increases the printing opacity. The effect of dye additon on opacity, yellowness, excitation purity and luminescence (Y value also called whitness) are studied. Though dye addition increases the printing opacity, by reducing the yellowness, it reduces the luminescence and excitation purity and increases the absorption coefficient. The role of dominate wavelength, luminescence, and excitation purity in fixing the shade of newsprint is

discussed. The interdependency of parameters like luminescence, excitation purity, brightness and yellowness based on the studies carried out on various newsprint samples is highlighted. The use of parameters like brightness, luminescence, dominant wavelength, yellowness, excitation purity in minimizing/eliminating the shade variation of coloured papers, are pointed out based on the studies carried out.

Introduction

Optical properties of paper are as important as the physical properties, since the paper is sold on the basis of its appearance. These optical properties influence the subsequent operations of the product.

Discussions

The following are some of the important optical properties :

1. **Brightness**
2. **Opacity**
3. **Scattering Coefficient**
4. **Absorption coefficient**
5. **Visual Efficiency (Luminescence)**
6. **Dominant wave length**
7. **Excitation purity**
8. **Yellowness**
9. **Shade**

1. Brightness

Paper maker's brightness is based on a measurement of reflectance of light from white or near white papers at a single wave length in blue region of the spectrum, i.e. light that has a dominant wave length of 457 nm.

The 457 nm wave length was chosen as they are most sensitive to change in colour that occurs when pulp is bleached. Brightness is commonly measured using Elrepho, using $BaSO_4$ as primary standard using a trap for eliminating "Gloss". It is expressed as % ISO. The values obtained are one or two units lower than GE.

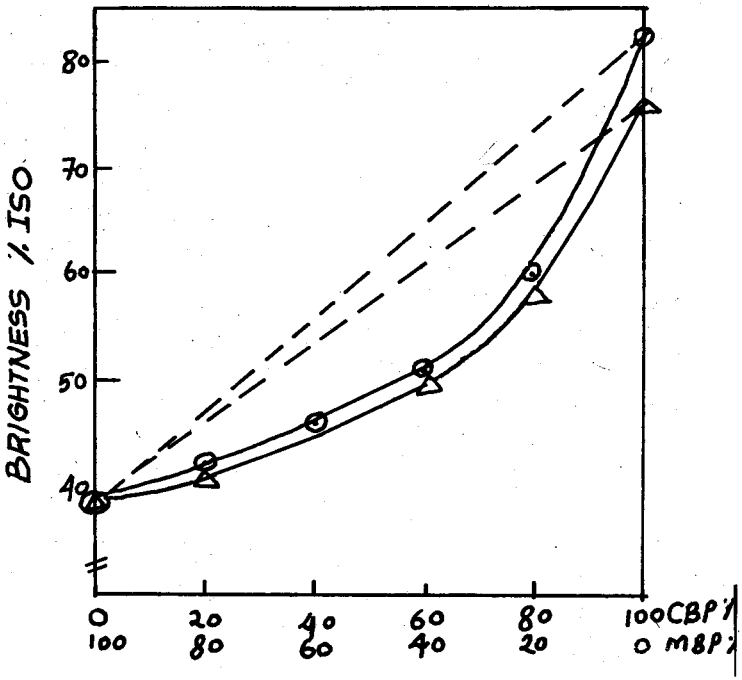

Fig. 1 Effect of Furnish on Brightness of pulp blends.

Brightness of the Newsprint

Newsprint furnish consists of mechanical and chemical components. Brightness of the blend is influenced by the brightness of the individual components. To study the extent of the influence, mechanical bagasse pulp was mixed with chemical pulps of bagasse and hardwood in different proportions. The results are graphically presented in figure (1) and (2).

It is clearly observed that the resultant brightness is more towards the mechanical bagasse pulp brightness. Dotted lines in the graph indicate the hypothetical brightness, if taken as additive property.

Pulp blends were made with lower brightness of chemical bagasse pulp also. The results are included in figure (1). The drop in resultant pulp blend brightness is only marginal. This shows brightness of chemical pulp has no significant effect on pulp blend brightness. The brightness of the blend is influenced by the mechanical pulp fraction. Mechanical pulp has to be bleached to an acceptable level to have acceptable brightness of the newsprint.

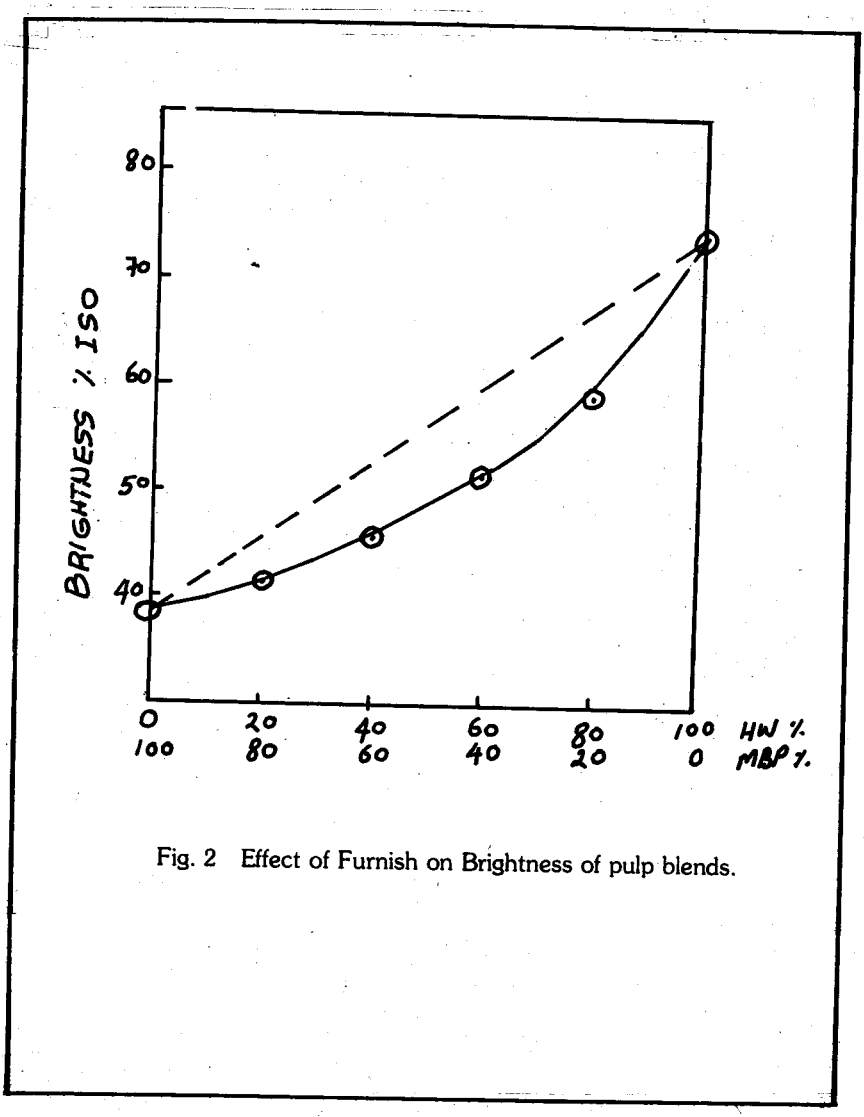

Fig. 2 Effect of Furnish on Brightness of pulp blends.

2. Opacity

Printing opacity is the ratio of the diffuse reflectance from a single sheet of paper backed by a black body to the reflectance of the same spot backed by a pad of same paper. Tappi opacity is the ratio of the reflectance of a single sheet backed by the black body to the reflectance of the same spot backed by a white body that has an effective reflectance of 89%.

Printing opacity,. measures the property that is visually judged as 'show-through' when a number of sheets printed on one side are stacked in a pile.

If R_∞ is more than 89% the printing opacity will be lower than Tappi opacity. If R_∞. is less than 89, printing opacity will be higher than Tappi opacity.

The printing opacity, more nearly represents the degree to which printing would "show-through" from the next sheet in a book. Also it is less subject to instrument error than Tappi opacity. Opacity is measured with the same instrument used for brightness measurement.

Studies were conducted to evaluate the influence of various parameters like, brightness, grammage, dyeing on opacity. For the above studies alkali-extracted pulps from chemical bagasse and hardwood streets were bleached with Hypochlorite to different brightness levels. Handsheets of 60 Gsm were prepared and optical properties were measured. The results are presented graphically in figure (3). It is clearly observed that as the brightness increases, the opacity reduces. The same trend is observed for both chemical bagasse and hardwood pulp. It can also be observed hardwood pulps are having higher opacity than chemical bagasse pulps at similar brightness levels.

To study the effect of grammage on opacity, bleached pulps of hardwood and chemical bagasse of 65% and 80% brightness respectively, were collected. Handsheets of different grammage, varying from 40 to 60 were made. The results are presented graphically in figure (4). The results of mechanical pulp of 56% brightness are also included. Studies indicate considerable improvement of opacity with grammage. Dyes have a pronounced effect on opacity. The blue dye has its maximum absorption at 670 nm. This is where the maximum opacity is obtained. Blue dye has a marked effect on opacity. Yellow dye has very little effect on opacity. In many cases yellow papers have lower opacity than the same grade of white paper. But blue and green papers always have very high opacities. The optical properties of the coloured paper made from same furnish are given in Table 1. This clearly indicates, that addition of blue dye increases opacity considerably whereas addition of yellow dye decreases the opacity. For the same furnish, opacity increases in the order yellow - white - blue. The results confirm, that opacity is influenced by the dye addition.

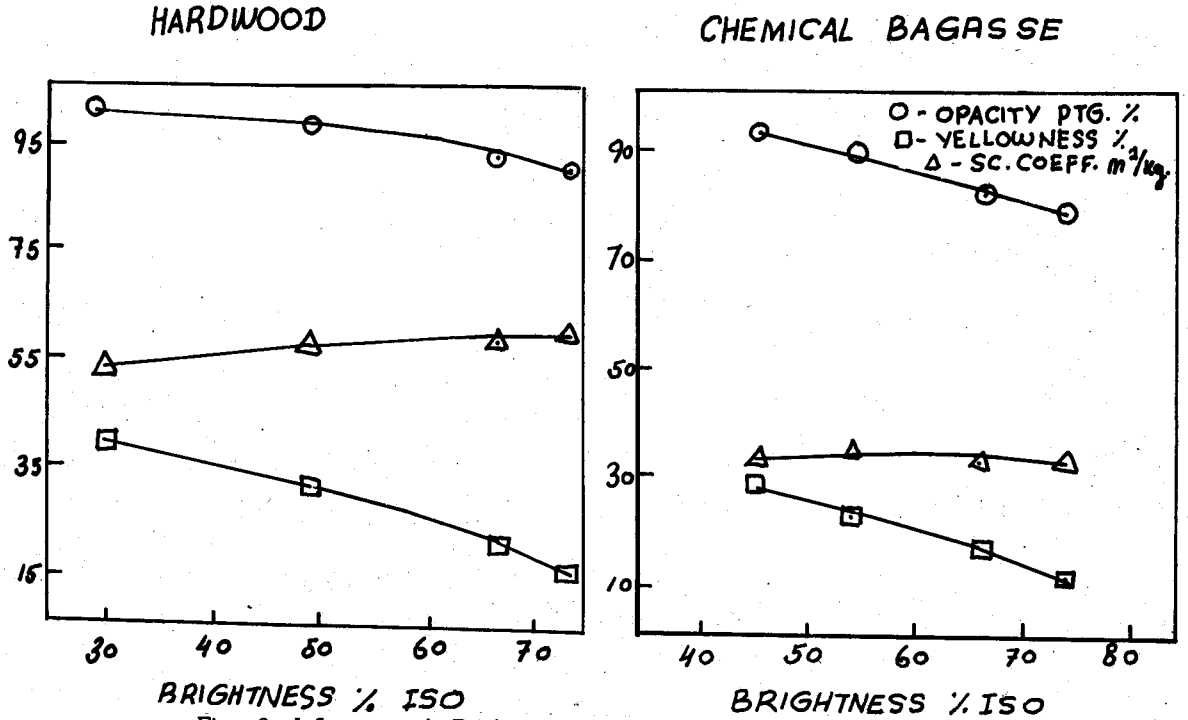

Fig. 3 Influence of Brightnesson Opacity, Scattering Coefficient, Yellowness.

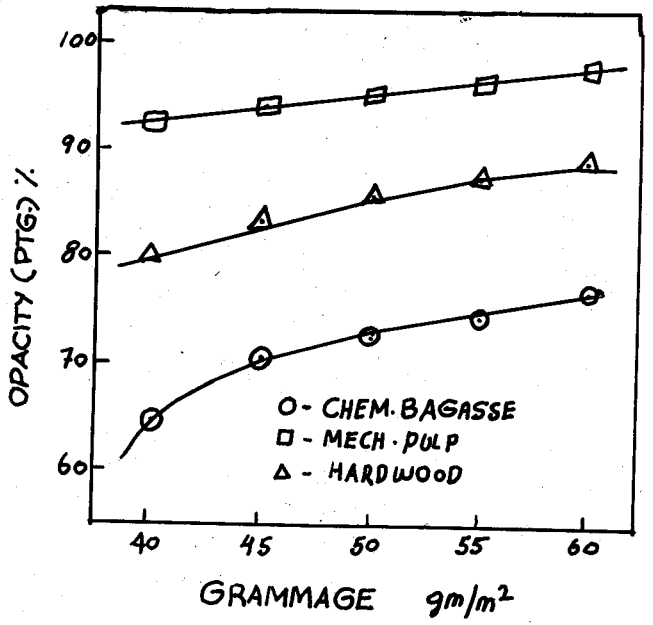

Fig. 4 Effect of Grammage on opacity.

TABLE 1

EFFECT OF DYE ADDITION ON OPACITY

	WHITE	BLUE	YELLOW
GRAMMAGE G/M2	40	40	40
BRIGHTNESS % ISO	60-62	57-58	30-32
OPACITY (Ptg) %	82-84	92-94	77-78
SC. COEFF m²/kg	38-40	36-40	38-40
YELLOWNESS %	9-11	-25 to-30	65-68

It is observed that opacity decreases with refining. Refining increases the area of optical contact between fibres by increasing area of fibre, fibre bonding and this tends to reduce the opacity.

Scattering Coefficient

The scattering coefficient of paper is the ability of the paper to scatter the light. Scattering coefficient is calculated using the formula

$$S = \frac{2300}{W} \times \frac{Roo}{1-R^2_{\infty}} \times \log Roo \frac{(1-Roo.\ R\phi)}{(Roo-R\phi)}$$

where S = Sc. COEFF IN m2/kg
W = GRAMMAGE IN g/m2
Roo = READING OF A SINGLE SHEET BACKED BY A THICK PAD OF PAPER AT FMY FILTER
$R\phi$ = READING OF PAPER BACKED BY A BLACK BODY AT FILTER FMY

The scattering coefficient is the limiting value of light energy scattered backward per unit of thickness.

Mechanical pulps posses high scattering coefficient in comparison to chemical pulps because of fines. Scattering coefficient is not affected by brightness or by grammage (figure 3). At the same brightness and grammage printing opacity and scattering coefficient go together.

Scattering coefficient increases with filler addition. Clay, because of fine particle size, is superior to Talcum, in this respect. Scattering coefficient increases with bleaching for hardwood pulp. Unbleached pulp scattering coefficient is about 30–35 m^2/kg and bleached pulp scattering coefficient is about 50–55 m^2/kg. In the case of chemical bagasse pulp there was no improvement of scattering coefficient on bleaching. Both unbleached nd bleached pulps possess scattering coefficient of 30–35 m^2/kg.

4. Absorption Coefficient

Absorption coefficient is the limiting value of the absorption of light per unit thickness. Absorption coefficient is calculated using the Kubelka Munk equation

$$\frac{K}{S} = \frac{(1-Roo)2}{2\,Roo}$$

where Roo IS THE REFELCTANCE OF PAPER AT
PAPER AT FMY FILTER
S IS THE SC. CO-EFFICIENT m^2/kg
K IS THE ABSORPTION CO-EFFICIENT m^2/kg.

The absorption power is influenced by the chemical constituents of the paper. Bleaching decreases the absorption coefficient. Increase in the absorption coefficient increases the opacity.

5. Visual Efficiency (Luminescence)

Visual efficiency is defined as the ratio of the luminosity of the light reflected from the specimen to the luminosity of light reflected from a perfect diffuse reflecting body. The reading obtained with the green filter (FMY) in Elrepho, closely duplicates the Y value or the visual efficiency.

Mechanical pulp has got a yellow colour because of the chromophores. To make the pulp whiter, we destroy the yellow chromophores by bleaching. Blue or violet dye addition for reducing the yellowness of the pulp will reduce the Y value. To produce more neutral paper with unchanged Y value, we have to bleach the mechanical pulp. The higher Y value of paper, gives better print quality.

6. Dominant Wavelength

Dominant wavelength is the wavelength of the spectral colour component of the shade, expressed in nanometres. Dominant wavelength is determined using the Elrepho by the chromaticity diagram, by calculating the chromaticity coordinates from the Tristimulus filter readings FMX FMY and FMZ.

Dominant wavelength is influenced by Dye addition. For newsprint, it is kept at about 575–580 nm.

7. Excitation Purity

Excitation purity is the percentage of spectral colour component in the shade. 0% corresponds to neutral grey shade and 100% to a pure spectral colour with two grey component. Excitation purity is calculated using the chromaticity diagram.

The addition of complimentary dye reduces both excitation-purity and Y value at approximately constant brightness. The relation between brightness and shade is expressed as below :

Excitation purity = Y value -- Brightness

Excitation purity indicates the intensity of a particular colour.

8. Yellowness

Yellowness is expressed as the difference between the reflectance obtained with amber (A) filter and the reflectance obtained with blue (B) filter divided by the reflectance obtained with the green (G) filter :

Yellowness = (A-B)/G × 100

The three filter readings are measured using the Elrepho.

Yellowness reduces with increase in brightness (fig. 4) Measure of yellowness is helpful in maintaining the shade at a particular brightness.

9. Shade

The shade of the paper can be fixed by the dominant wavelength, excitating purity and Y value. The dominant wavelength will indicate the hue, excitation purity the intensity of the hue and te Y Value the visual brightness. In this way, the shade of the paper can be expressed in absolute terms. The typical optical properties of newsprint are given in Table 2. It is desirable to have low excitation purity with high Y value, for newsprint, to obtain good print quality.

TABLE - 2

OPTICAL PROPERTIES OF NEWSPRINT

	1	2
BRIGHTENSS % ISO	60.4	55.7
OPACITY (Ptg) %	88.9	95.2
SC. COEFF m^2/kg	42.7	51.7
YELLOWNESS %	15.8	13.8
ABSORPTION m^2/kg CO-EFFICIENT	1.50	2.29
DOMINANT nm WAVELENGTH	579	576
EXCITATION % PURITY	8.1	7.6
Y VALVE % (LUMINESCENCE)	67.8	6 23

Conclusions

1. Brightness of pulp blend in newsprint is influenced by the brightness of mechanical pulp.
2. Slight brightness variation in chemical pulp component has no significant effect.
3. Opacity is influenced by brightness, grammage, dye addition.
4. Scattering coefficient is independent of the above variables.
5. Measurement of yellowness, helps to maintain the shade at a particular brightness.
6. Shade of the newsprint can be fixed by expressing dominant wavelength, excitation purity and Y value.

Acknowledgements

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