CHAPTER 3

METHODOLOGY

This section describes the material, apparatus and procedure utilised in the experiment.

3.1 Materials

3.1.1 Substrates

3.1.1.1 Canon PR-101 Ink-Jet Paper

3.1.1.2 Uncoated paper: bond 80 g/m^2

3.1.2 Filters

3.1.3 Ink cartridges

3.1.4 Syringes

3.1.5 Printing Head

3.1.6 *Dye-based inks*

3.1.6.1 Blue: Acid Blue 9, Direct Blue 199 (from Daiwa Chemical Co. Japan)

3.1.6.2 Magenta: Acid Magenta 1 (from BASF A.G.)

3.1.6.3 Red: Acid Red 289, Basacid Red 510, and Basonyl Red 540 (from BASF A.G.)

3.1.6.4 Yellow: Direct Yellow 132, Direct Yellow 86, Acid Yellow 23 (from Daiwa Chemical Co.)

3.1.6.5 Black: Direct Black (Bluish), Direct Black (Reddish) (from Mitsubishi Chemical Co.)

3.1.6.6 Orange: Reactive Orange 13 (from Daiwa Chemical Co.)

3.1.6.7 Green: Zinc Phthalocyanine tetra sulfonate (from Nippon Kayake Co.)

3.1.6.8 Violet: acid violet in Amino anthraquinone group (from Hodogaya Chemical Co.)

3.1.7 Glycerine

3.1.8 Diethyleneglycol

3.1.9 Acethleneglycol

3.1.10 Sodiumhydroxide

3.1.11 *Standard digital image: Wool picture*

This picture is used for the evaluation of colour gamut of ink set.

Number of L*a*b* value: 4800 x 3 values

Illumination/Observer: D65/2

3.2 Apparatus

3.2.1 Bubble Jet Printer: BJ F850 Canon printer

3.2.2 Colour measuring instrument: Gretag Macbeth Color Eye 7000 spectrophotometer

Measurement geometry diffuse/8°

Illumination/Observer: D65/10

Spectral range: 400 nm – 700 nm

Spectral interval: 10 nm output

Specular component included

3.2.3 Orion pH meter

3.2.4 2210J Bransonic cleaner

3.3 Procedure

The procedure can be separated into four parts. They consist of making a test form, preparation of black and white substrate, ink calibration and development of a tool for KM calculations and for the simulation of the colour gamut.

3.3.1 Part I: Preparation of a test form

3.3.1.1 Test form for black and white substrate

3.3.1.1.1 Test form of sized 1 x 1 inch was designed using Adobe PhotoShop. The layout was designed as shown in Figure 3-1

3.3.1.1.2 The square was filled by yellow colour, which consisted of red and green.

Figure 3-1 Layout for black and white substrate.

3.3.1.2 Test form for colour inks.

3.3.1.2.1 Test form of sized 1 x 1 inch was designed using Adobe PhotoShop.

3.3.1.2.2 The square was filled by a yellow colour which was the same as the test form for black and white substrate.

3.3.1.2.3 The position of the next square on the test form was moved slightly after the first square was printed. (Figure 3-2)

Figure 3-2 Test form for colour inks.

3.3.2 Part II Preparation of a black background on substrates for database establishing.

3.3.2.1 The bluish black dye was mixed and dispersed into water, glycerine, diethylene glycol and acethylene glycol. The ink formulation is displayed in Table 3-1.

Table 3-1 Formulation of ink for making a black and white substrate.

Ingredient	(% wt)
Dye concentration 10%	40
Solvent: Glycerine	15
Diethylene glycol	5
Surfactance: Acethylene glycol	3
Water	37

3.3.2.2 The mixtures are printed onto PR-101 inkjet paper and uncoated paper with full area coverage.

3.3.3 Part III Ink calibrations

3.3.3.1 The dye was mixed and dispersed into water, glycerine, diethylene glycol and acethylene glycol to make a dye-based inkjet ink. The formulation is displayed in Table 3-1. Fourteen dyes were carried out.

3.3.3.2 The dye-based inkjet inks were diluted with water in order to produce 7 levels of calibration inks. The sequence of mixture composition is displayed as in Table 3-2. Subsequently, each level of inkjet ink concentration was filtered before it was injected into an ink tank. This was carried out for fourteen inkjet inks.

Table 3-2 Concentration sequence of calibration panels.

Colour ink (%)	Diluent (%)
2	98
10	90
20	80
30	70
50	50
75	25
100	0

3.3.3.3 The mixtures were used to print on black and white substrate using the BJ F850 Canon printer. The yellow print head was used only. These coloured patches then were used for database establishment.

3.3.3.4 The reflectance spectra, the XYZ tristimulus values and the CIE L*a*b* co-ordinates of the printed patches were measured by using the Gretag Macbeth Color Eye 7000 spectrophotometer with an illumination/observation of D65/10 and specular component included.

3.3.4 Part IV Development of a tool for K and S analysis tool and a tool for colour gamut.

The *K* and *S* analysis tool was orginally developed by Katemake.[11] Katemake developed and used the tool for K and S analysis of lithographic inks. In this research,

it was assumed that the optical properties of the inkjet inks can be explained using absolute K and S. Some research [9-10], used the single-constant KM theory to obtain the optical properties for the inkjet inks, however, the inkjet ink layer was semi-transparent that was similar to the lithographic ink, therefore, the two-constant KM theory was applied to the inkjet ink system in this research. Some Visual Basic codes were added to Katemake's spreadsheet tool to make it more easy to use. The spreadsheet was developed using the Microsoft Excel application in order to obtain K and S values promptly from an ink-set database of reflectance values. The K and S values can then be used for further analysis in other tools. The key parts of the tool consisted of two sheets. The first sheet called the 'engine' performs all the calculations and the second sheet called the 'database' was used for storing the database composing reflectance values R_g, $R_{g,w}$, $R_{g,b}$, R_w, and the reflectance spectrum of each ink panel from different concentration levels, R. The essential variables required to calculate R_∞,K and S was calculated systematically (see ***section 2.1***, for the derivation) using the R_g, $R_{g,w}$, $R_{g,b}$, and R_w retrieved from the database sheet. Obtaining the data for a particular ink from the database was carried out by using the INDEX worksheet function of the Microsoft Excel. After determining the R_∞ values, the calculation of K and S by the least squares method was automatically carried out. See ***Chapter 4*** for the application of this tool to the ink sets. The following flowcharts, (Figure 3-3 and Figure 3-4) are the steps of the calculation used in the spreadsheet.

Figure 3-3 shows the step of the calculation of R_∞ and Figure 3-4 shows the steps of the calculation of K and S

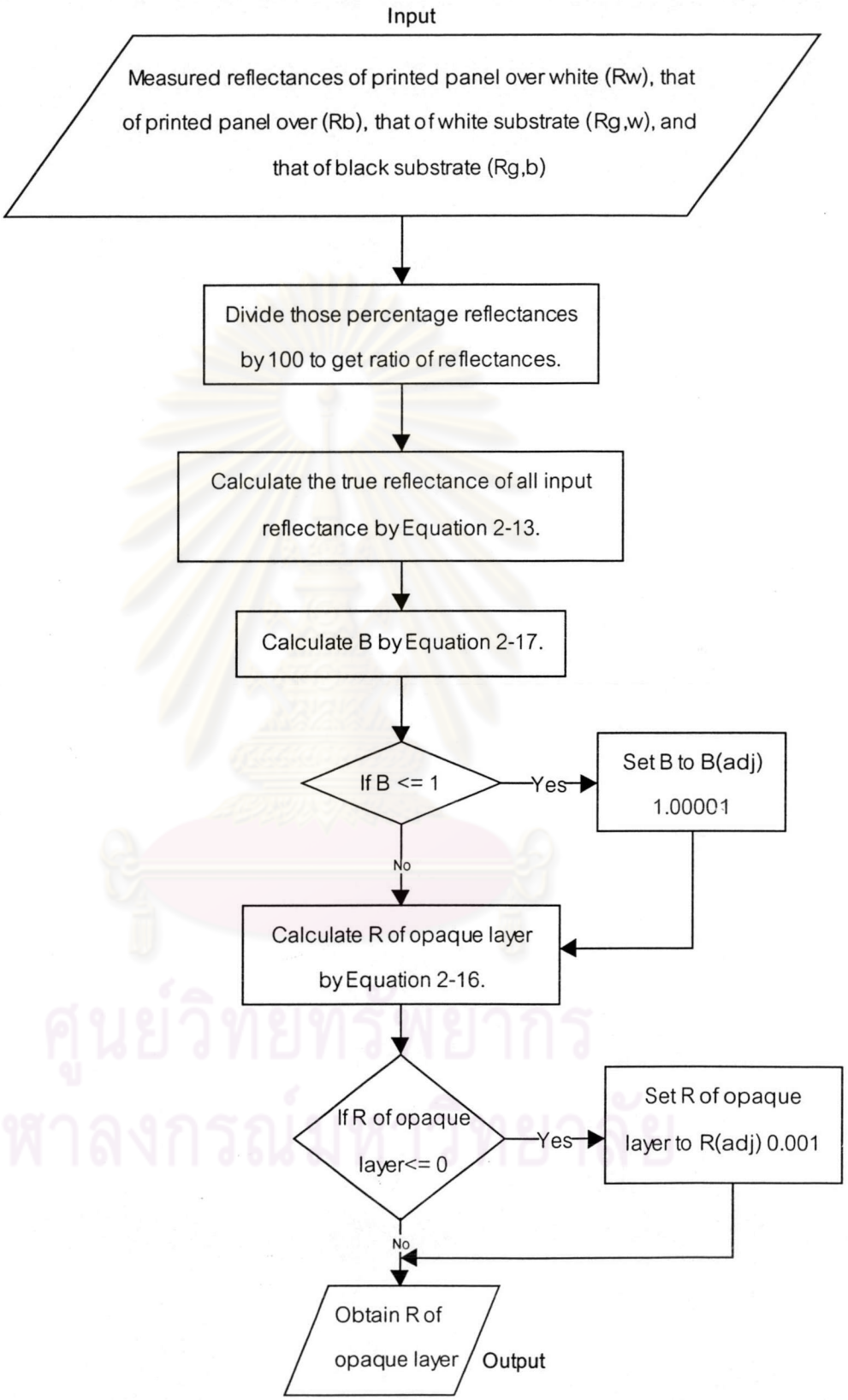

Figure 3-3 Flowchart of the determination of R_∞.

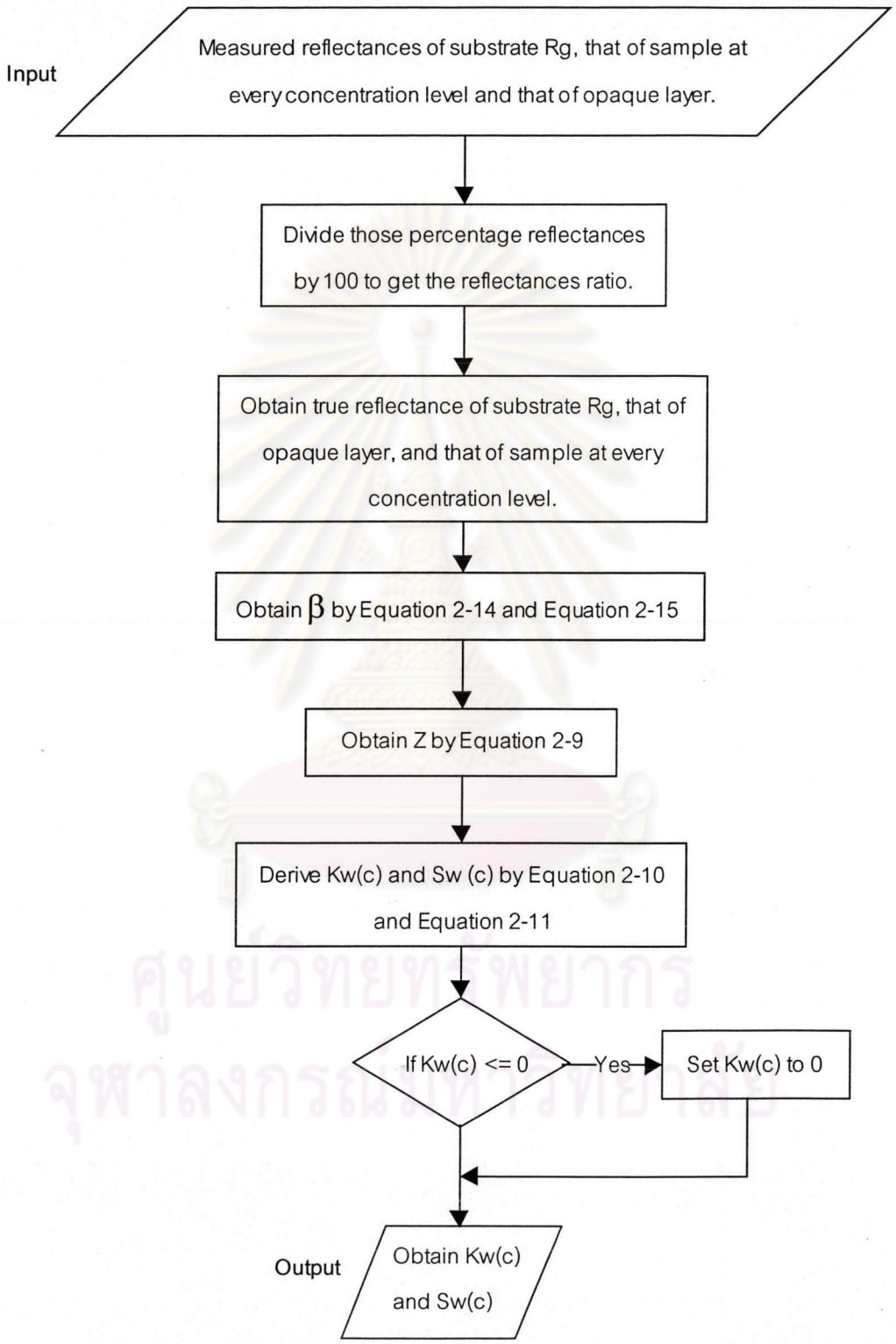

Figure 3-4 Flowchart of calculation of K and S.

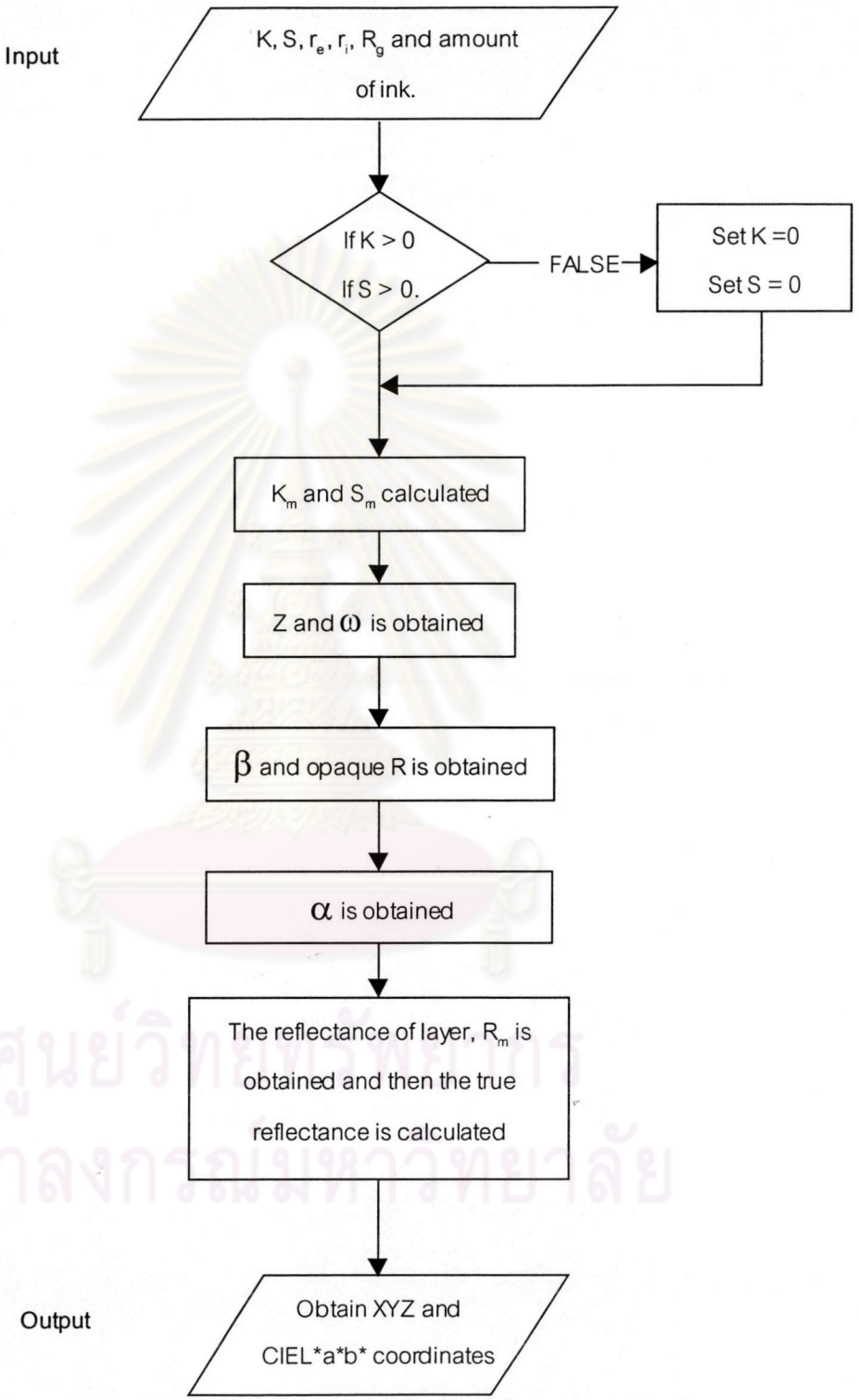

Figure 3-5 Flowchart of the calculation of reflectance spectrum and the tristimulus values from the specified amounts of the components in the formulation.

The absorption coefficients, K obtained were plotted against the volume concentration, C to check the degree of the linearity of water-based inkjet ink. Then the nonlinearity that appeared was characterised by fitting the data to a power series. The coefficients of the power series equation of the relationship of K and C, then were stored as database. When the volume concentration of inks were changed, then K can be back calculated. Figure 3-5 shows the steps of calculation of the predicted reflectance of the single ink and mixture of inks.