Development of a Fabric Lustre Scale

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Abstract

Fabric lustre is one of those attributes which affects the visual appearance of a fabric. It is the amount of specular light the fabric reflects. So far, there is no simple and satisfactory method for either the subjective or objective assessment of fabric lustre since its measurement is complex. A series of experiments were conducted for the development of a scale for the subjective measurement of fabric lustre. A number of woven fabric samples with varying luster were used for the subjective assessment of lustre by trained assessors. A glossmeter was then used to measure the fabric samples objectively. Simple regression analysis technique was applied to relate the subjective to the objective lustre data and results indicated a high degree of agreement between them. The instrumental data were further used to construct a lustre scale which was assessed statistically for its reliability using larger fabric sample population. Furthermore, the lustre of the fabric samples were measured spectrophotometrically and results showed a good correlation between the delta Y values and the grade values of the physical lustre scale.

Keywords: Fabric lustre, lustre scale, glossmeter, spectrophotometer

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1. INTRODUCTION

The appearance of an object depends on its physical attributes such as color, texture and luster. In textiles, this may greatly influence a customer's choice for the product [1-3]. It is therefore important to be able to assess these textile properties appropriately. Lustre is one of those key attributes which affects the appearance, and hence the aesthetics performance, of textile fabrics. According to the American Society of Testing and Materials [4], lustre is “the appearance characteristic of a surface that reflects more light in some directions than it does in other directions, but not of such high gloss to form clear mirror images”; i.e. it is the amount of specular light the fabric reflects. Fabric lustre is dependent on the characteristics of the fabric such as fibre type, yarn type, fabric construction and woven structures and also on the viewing conditions of the fabric. The phenomenon of fabric lustre may be characterised

by both a subjective and an objective component and therefore its measurement is quite complex. In the textile industry, there is no satisfactory and simple method for either the subjective or objective assessment of fabric lustre. So far, the method for assessing this visual attribute has remained essentially subjective [5] and terms such as dull and matte refer to fabrics with little or no lustre; whereas terms such as shiny and lustrous refer to those with high lustre. Fabrics with smooth, flat surfaces tend to have high lustre because a flat surface reflects more specular light than a surface with contours [6-9]. Therefore, it would be interesting to develop a subjective method based on a visual lustre scale for the assessment of fabric lustre, which may be simple and easy to use. Once a reliable scale has been developed, it may serve as a basis for the development of an objective measurement method using the visual attributes of objects, as measured by a spectrophotometer. The aims of this paper are to (i) develop a visual scale for the measurement of fabric lustre and (ii) assess woven fabric samples visually using the scale and establish a correlation between the lustre grades thus obtained subjectively and the objective instrumental values.

2. EXPERIMENTAL

Sixty fabric samples, 20 x 25 cm each, of variable woven structures and colour were used. The fabric samples were of varying lustre ranging from dull to very lustrous. Three fabric samples (A, B and C) were chosen from the sixty fabric samples such that sample A was chosen to represent minimum fabric lustre, sample B representing maximum fabric lustre and sample C representing mid-range fabric lustre. The remaining 57 samples were then sorted out into groups by three trained assessors using these three reference samples. The lustre groups obtained were numbered 1 - 5, where 1 represented the dull group and 5 represented the most lustrous group.
At least five samples were then randomly selected from each group and a total of 35 fabric samples constituted the sample population for the development of the fabric lustre scale. The fabric samples were then randomly given numbers (1 to 35). The remaining fabric samples were then numbered 36 to 60.

2.1 Subjective Assessment of Woven Fabric to Derive Calibration Lustre Scale Values

An opinionnaire was designed to estimate the magnitude of fabric luster. The three reference fabric samples (A, B and C) were assigned the following magnitude of fabric luster; sample A=1.0; sample B = 10.0 and; sample C = 5.5. Using these reference samples, 25 trained assessors (labeled 1-25) were provided with the 35 selected fabric samples and were required to assign numeric values to the magnitude of fabric luster that was perceived visually in a light cabinet under D_{65} illumination and defined viewing geometry. For normalization of the results, the assessors were also required to assign magnitude estimations (1-10 value) to a verbal scale which served as an external calibration scale, as shown in Figure 1.1 Normalising is usually carried out to improve the sensitivity of the analyses.

The verbal scale had “Dull” assigned a value of 1.0 at the low end of the fabric lustre scale and “Lustrous” a value of 10.0 on the high end.

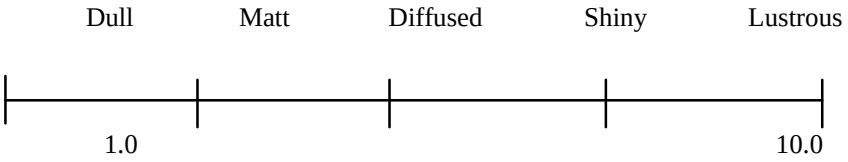

Figure 1.1 Verbal Scale

Statistical techniques were used to retain the data of good assessors and mathematical transformations were used to derive calibration lustre scale values, S, based on a five point scale.

2.2 Instrumental Analysis

A calibrated glossmeter (Erichsen Glossmaster Model 507) set to the 85° angle mode [10-12], was used to measure the gloss values of the 35 fabric samples. Four measurements were taken at three different places on the fabric and the results averaged.

2.3 Construction of the Physical Fabric Lustre Scale

A 5-point physical fabric lustre scale with half-steps was constructed based on the values obtained from the subjective assessment of fabric lustre and the gloss values.

2.4 Assessment of the Fabric Lustre Scale

After the scale has been produced, it was subjected to a trial to examine its reliability. Five assessors were selected randomly from the 25 trained assessors and they rated the lustre of the 35 fabric samples. The test was repeated twice and the results were analysed statistically.

2.5 Spectrophotometric Measurement

The spectral values of the 60 samples were measured using a spectrophotometer (Model SF 600+ Spectroflash). For each sample, three measurements were taken at different places on the fabric and the results averaged. Measurements (Y value representing lightness) were successively taken under specular included (SPIN) and specular excluded (SPEX) mode using D_{65} illuminant. Delta Y, ? Y, values were calculated as follows:

$? Y = Y_{SPIN} - Y_{SPEX}$

3. RESULTS AND DISCUSSIONS

The opinionaire provided estimates of the magnitude of the fabric lustre and these were expressed as lustre scale values, S, Figure 3.1. For example, sample number 1, 19 and 26 had the lowest scale values and represented the dull end of the fabric lustre scale while sample number 7, 11, 17, 25 and 29, with the highest scale values, constituted the most lustrous end of the scale. From the scale values, a number of lustre groups were identified and the results are shown in Table 3.1.

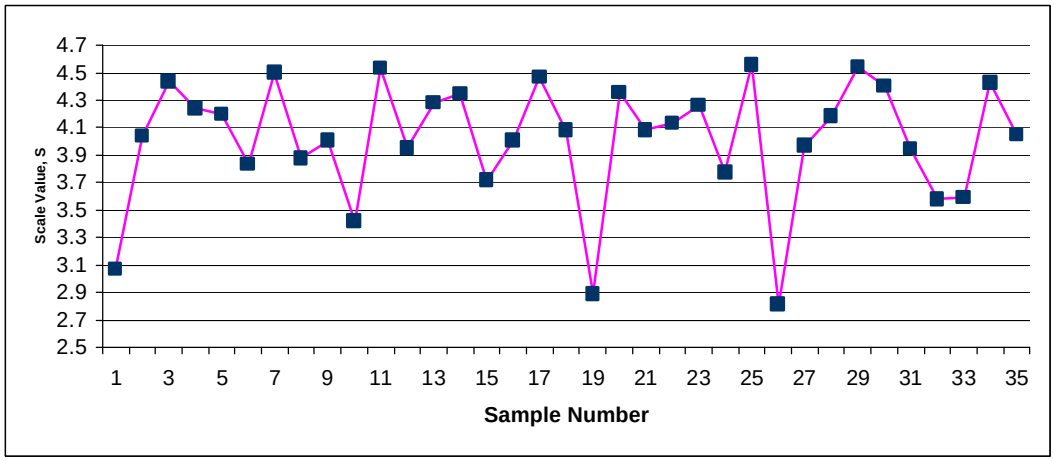

Figure 3.1 Lustre Scale Values, S, Of The Woven Fabric Samples

Figure 3.2 shows the averaged gloss values, G, of the fabric samples as measured by the glossmeter. The gloss values varied from a value of 0.1 representing the least lustrous fabric samples and a value of 3.2 for the most lustrous ones.

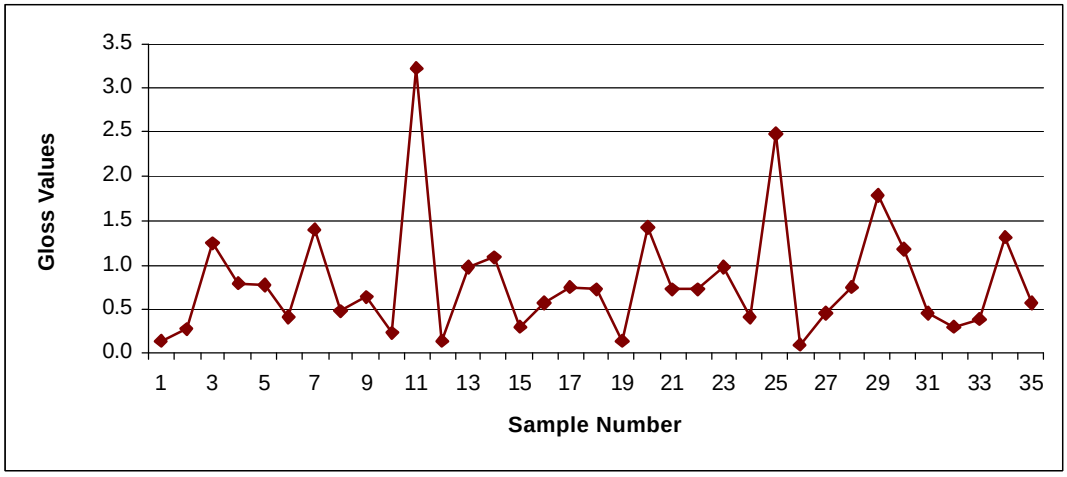

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Figure 3.2 Gloss Values Of The Woven Fabric Samples

Figure 3.3 shows a logarithmic relationship, as expressed by Equation 1, between the calibration scale values and the gloss values of the fabric samples. A value of 0.91 for R^2 (R^2 indicates the coefficient of variation or the goodness of fit), indicated a good correlation between the scale values, S and the gloss values, G.

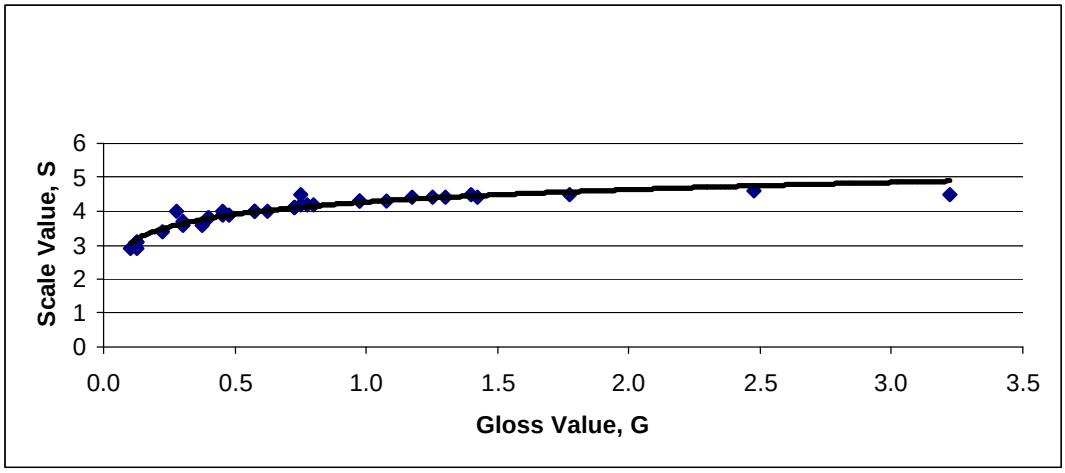

Figure 3.3 Correlation Between Scale Values, S, And Gloss Values, G, Of The Woven Fabric Samples

$$S = 0.525 \text{ Ln } G + 4.227 \qquad \text{Eq. 1;}$$

where S= Scale Value and G = Gloss Value

This suggests that the visual estimation of fabric lustre, expressed as lustre scale values, S, correlated quite well with the results of the objective instrumental measurements using a glossmeter. Thus, gloss values were used to identify the different levels of gloss needed to produce appropriate physical samples (paper of varying level of lustre) for the construction of a nine-step scale. Table 3.1 shows the correspondence between the objective gloss values, the calibration scale values and the lustre grades of the newly developed physical lustre scale, Figure 3.4.

Table 3.1 Correspondence Between Lustre Scale Values, Gloss Values And Lustre Grades

Gloss Value	Lustre Scale Value	Lustre Grade
0.1	3.0	1
0.2	3.4	1.5
0.3	3.6	2
0.4	3.8	2.5
0.5	3.9	3
0.6-0.7	4.0	3.5
0.8	4.1	4
1.0-1.1	4.2-4.3	4.5
1.2-3.2	4.3-4.8	5

Figure 3.4 Physical Lustre Scale for the Subjective Assessment of Woven Fabric Lustre

Figures 3.5 and 3.6 show the relationship between the expected and observed lustre grades. The expected lustre grades relate to the lustre scale values, S while the observed lustre grades are the averaged results of the five trained assessors who rated the fabrics using the physical lustre scale. The coefficient of variation (R2) between the two variables, namely the subjective assessment (observed lustre grades) and the objective assessment of fabric lustre (expected lustre grades) is 0.95 and this indicated the good relation between the observed and expected lustre grades, Figure 3.6. This suggests that the scale was quite reliable.

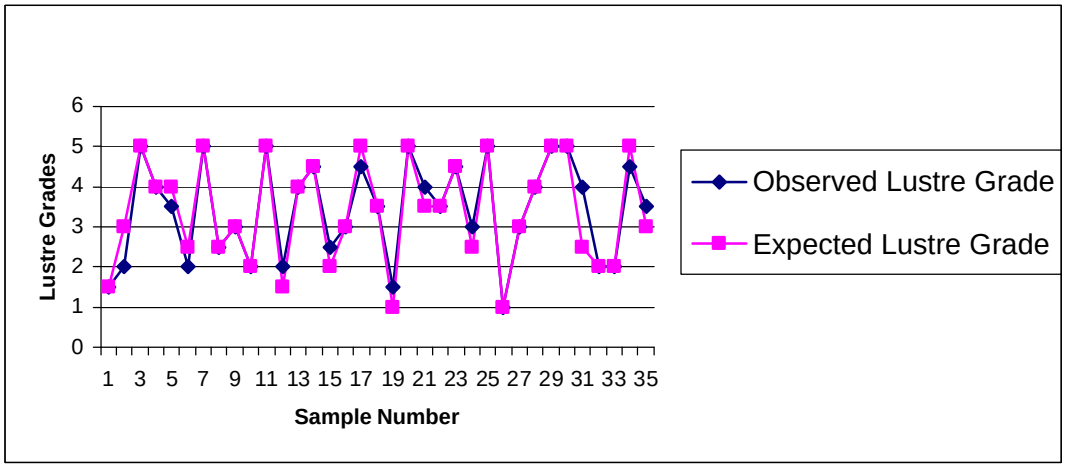

Figure 3.5 Relationship Between Observed And Expected Fabric Luster Grades

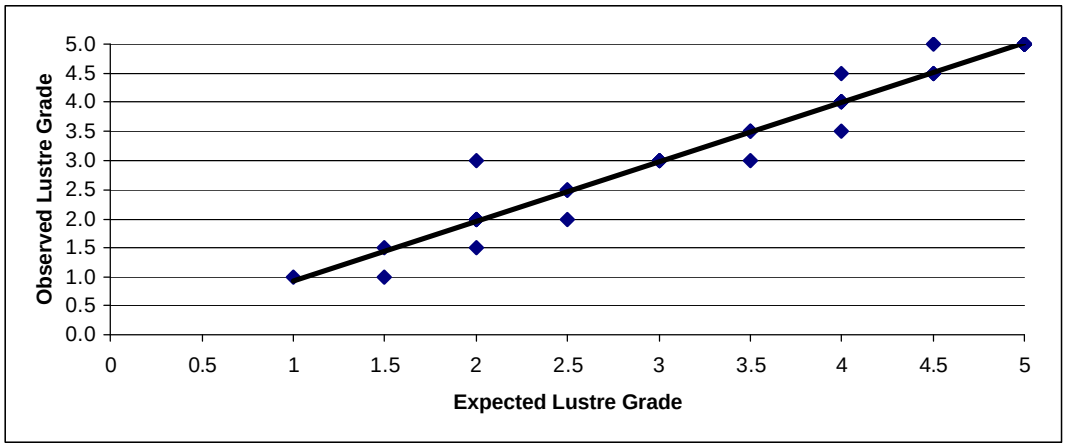

Figure 3.6 The Correlation Between The Expected And Observed Fabric Lustre Grades

3.1 Results of Spectrophotometric Measurement

The XYZ and Lab tristimulus values of the fabric samples were measured under specular included and excluded mode. The difference between the spectrophotometric values as measured under SPIN and SPEX mode were calculated and plotted against the observed lustre grades. Simple regression analysis was used to establish the relationship between the lustre grades and spectrophotometric delta values. It was found that the delta Y values provided the best correlation with the observed lustre grades and gave a Karl Pearson's coefficient of correlation, r equals to 0.84. This indicated that there was a high correlation between the observed lustre grades (using the physical lustre scale) and the delta Y value, Figure 3.7

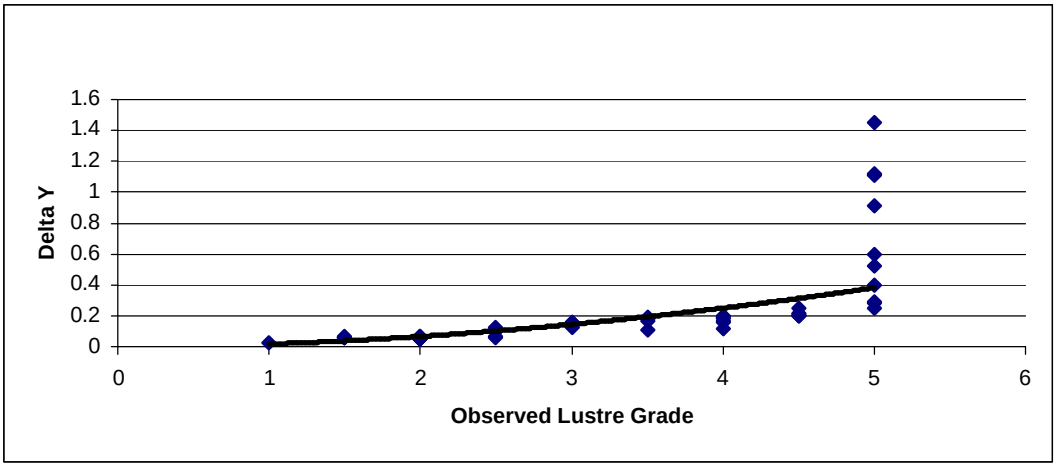

Figure 3.7 Relationship Between Delta Y And Observed Lustre Grades

The observed lustre grades are related to the delta Y (? Y) values by Equation 2,

$$? Y = 0.019 P^{1.82} \qquad \text{Eq. 2}$$

where ? Y = difference in Y values when measured under SPIN and SPEX mode P = Lustre Grade

4. CONCLUSION

The use of both subjective visual and objective instrumental methods for the measurement of woven fabric lustre has been clearly demonstrated and it has been found that there is a strong relationship between the visual estimate of fabric lustre and the instrumental gloss measurement values. The development of a physical lustre scale has been successfully achieved and the scale has been found to be simple to use and quite reliable in the subjective visual assessment of fabric lustre. Furthermore, a useful relationship was found to exist between the lustre grades and the objective values of delta Y.

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