CHAPTER - 1

INTRODUCTION

All the facets of nature as a whole comprises with Colours. All living beings are blessed with many virtues. Human being is superior to all others as gifted with ten senses, for actions and perceptions each being five in number. Vision is one out of these to perceive colours.

The bounties of nature are enjoyed with the wonderful organ called as ‘Eye’, with which people feel colour all around their atmosphere. Whatever is provided with nature is colourful whether it were plants, flowers, grains, soils, hills, creatures, sceneries, sunset and sunrise etc. All insects, birds and fishes comprise the world of colours.

Colour attaches the aesthetic value to any object. Different colours are associated with different moods and symbolize sets of meanings. It helps in differentiating products and authenticating them. Colours give an aesthetic identification, attraction, authority and survival values.

In presence of light source, brain of an observer senses and defines colour of the object viewed. There are five original colours – White, Black, Red, Blue, Yellow. However, six basic colours are observed and perceived in which Black and White are achromatic colours (Figure 1.1) and rest Blue, Green, Yellow and Red are chromatic colours (Figure 1.2) [1-6]. In addition to these basic terms of colours some terms like Orange, Mob, Violet, Beige, Lime, Cherry are borrowed from different plants. Emerald, Ruby, Sapphire, Turquoise are borrowed from gems and Canary is a borrowing from bird species.

Achromatic Colours

![Achromatic colours](#)

Figure 1.1: *Achromatic colours*

Chromatic Colours

![Chromatic colours](#)

Figure 1.2: *Chromatic colours*
1.1. EVALUATION OF OLDER COLOUR SYSTEMS FOR EXPRESSING COLOURS

1.1.1. CONTRIBUTION OF ARISTOTLE (384-382 BC)

As per Aristotle, simple colours are the proper colours of the elements i.e. air, fire, water and earth (Figure 1.3) [7]. Black mixed with Sun light and fire makes Crimson. Aristotle believed that Yellow came out of lightness and Blue out of darkness.

![Aristotle’s depiction of simple colours](source: www.webexhibits.org/causesofcolor/1B.html, Date 27/05/2015, 11:19)

1.1.2. COLOUR SCALE

The colour scale (Table 1.1) [6] based on the Light percentage and dark percentage is shown below-

| 75% Light   | 25% Darkness | = | Yellow |
| 50% Light   | 50% Darkness | = | Red    |
| 50% Light   | 75% Darkness | = | Blue   |
1.1.3. CONTRIBUTION OF LEONARDO DA VINCI

First of all simple colours are white. Though philosophers do not acknowledge either White or Black to be colours. White is the receiver of all colours whereas Black is devoid of all. We shall set down white for the representative of all light without which no colour can be seen. Yellow for earth, Red for fire Green for water, Blue for air and Black for total darkness [6].

1.1.4. CONTRIBUTION OF SIR ISAAC NEWTON AND OTHERS

In 1660 Isaac Newton broke the white light into its component colours (Figure 1.4) [8]. He proposed that colour relationship could be best visualized in a circular arrangement and set out his seven colours of the spectrum in their order of proportion. Further, in 1790 Thomas Young elucidated the way of theory. In 1790 Helmholtz also proposed the minimum three primary lights - Blue, Green and Red, to generate all colour appearances. In 1810 Philip Otto Runge designed the first colour containing tints, tones and shapes of colours. In 1839 M.E. Cheverul formulated the fourteen lights of simulation contrast. In 1853 Grassman’s Laws came into existence. In 1854 Maxwell built the first ‘colour meter’ based on rotating disc sinner Black and White. In 1878 Ewald Hering’s opponent colour theory on four psychological /Spectral primaries i.e. Red, Green, Yellow and Blue was evolved. In 1892 Christine Ladd Franklin summarised that the light absorbing molecules of retina which had undergone successive differentiations to give achromatic, dichromatic and trichromatic visions [6,7,8].

There were many attempts to express colours. Most famous and earliest was the Ostawd’s Triangle. Colours were also expressed by Munsell’s Colour System and Natural Colour System.

Figure 1.4: Newton’s experiment with prism

Drawing based on www.spiritualwisdom.org.uk/colours-of-the-rainbow.htm

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1.1.5. MUNSELL’S COLOUR SYSTEM

This system was developed by Albert Munsell in 1905 as a teaching aid for art students [6]. His goal was to have both numerical system and physical example achieved ‘vide’ the Atlas of the Munsell colours. His guiding principle was equality of visual spacing. In the Munsell system, colour relationships are based on three colour dimensions- Hue, Value and Chroma (Figure 1.4) [9]. This system specifies Munsell’s Colour notation system and specifies different hues on circumference value at radius (increasing from center to circumference) and chroma in vertical direction Black to White [10-15].

![Munsell’s Colour System](source.jpg)

Figure 1.4: Munsell’s Colour System

Source: www.dunnedwards.com/colors/specs/posts/classifying-color, Date 27/05/2015 11:38

Value range 0 = 10

Chroma range 0=12

Hue Red, Yellow, Green, Blue and Purple with intermediates YR, GN, BG, PB, RP and scale 2.5, 5 and 10.
1.1.6. NATURAL COLOUR SYSTEM

This system was developed by Hard, Sivik and Toquist in 1979 based on elementary colours Red, Blue, Green, Yellow, White and Black [6]. The guiding principle of natural colour system is ‘defining colours by its resemblance to Herring’s elementary colours expressed in percentage’. The elementary colours in this can be arranged into Hexagon showing possible combinations of the primary colours (Figure 1.6) [16-17].

Figure 1.6: Natural Colour System
Source: www.ncscolour.com/PageFiles/615/NCS_Colour_Circle.png
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1.1.7. QUANTIFICATION OF COLOUR

As we quantify the distance in kms. and miles, weight in kgms. and pounds, volume in liters, there was a genuine need felt to communicate and express colours numerically. As two Red bodies with slight distance is identified as its hue Red but they are not same, therefore, colours are expressed in terms of first Hue (Colour), second Value (Brightness) and Chroma saturation (Vividness). This lead to the scientific approach of quantification of colour which include object which is viewed, light source in which it is viewed and the observer by which it is viewed. Spectral reflects of an object is characterized using a spectrophotometer. Spectral distribution of different light sources are characterized using a spectral radiometer [6].

Let’s discuss some of the following examples-

When on any monitor we fill the other half of the frame with same colour specifically Yellow we observe for a few moments that the Yellow portion that we were looking appears to be lighter and later entire frame appears with the same intensity of Yellow colour.

Sudden difference of Green, Red, Blue and Yellow leaves an after image of opponent colour.

When Yellow lights come suddenly adjacent to the Blue line it seems that it has emerged from background and whole background seems Yellowish.

Considering above examples it is confirmed that visual perception is affected by background, because every colour is seen more dramatic against Black background and subdued and cool against White background. Dark colour looks dark against light colour within any dark colour background. Dark colour can be greatly strengthened by light colour boundary [6].
1.2. PROBLEM STATEMENT

To explore an Optimized Hybrid System through dual measurement approach of Contrast and CIE L*a*b* measurement methods along with visual assessment and judgement of Standard Observer to arrive at a logical inference for achieving the Highest Matching between the Print and Original in sheet fed offset printing through experiments and analysis of the results obtained.

1.3. CHALLENGES

According to the Fogra PSD, colour is the last aspect which is an attribute of the visual perception of human which consists the combinations of chromatic and achromatic contents. The governing factors for the final colour appearance are perceived colours of an object, surface characteristics, texture of a sample and translucency [18]. Generally the colour is defined by three figures such as CIEXYZ and CIE L*a*b*. But all these systems are again dependent on the factors like standard observer, standardisation/calibration of measuring equipments and viewing conditions etc. And at the last the colour print results are presented before the humans and its similarities, accuracy and acceptability is judged finally by humans, so we can say that human judgement system is always at the higher level than any other instrument based measurement system [19].

1.4. REQUIREMENTS

1. Design of proportionate standard master for allowing considerable increase and decrease of colour values in the different colour patches for measurement and judgement.

2. Standardisation of printing machine.

3. Calibration of measuring instrument and measurement of colour patches.

4. Selection of standard observer for final judgement.

1.5. PROBLEM SOLUTION

1. Familiarisation of different standard colour measurement instruments among the users.

2. Selection of standard observers preferably from the work team for critical judgement as and when required.

1.6. NEED FOR THE STUDY

As we know the hue of any object/print gets changed by changing the observing directions and illumination position. This effect increases with trans-lumination and metallic colours. Apart from this several other factors like viewing condition, difference in size, difference in background due to optical illusion and difference of observer due to individual’s difference are also responsible for the change in hue which effect the contrast of the colour prints. The limitation of densitometry in the printing comes up where proof and production differ in materials employed for the different printing, because it works well when same paper and inks are used for specification for results value, print and actual production can be same. To measure the correct hue is resulted with the spectral colour measuring instrument. Because it is capable to measure the colour/hue increasing the perceived colour by the human eyes and as a result setting of printing/prints can be done in accordance of desired colourimetric values of any proof for print production within tolerance.

As mentioned above, the similar factors are responsible for change in hue and any print and the spectral colour measurement also works within a tolerance. Therefore, it is agreeable that spectrophotometer can measure the colours but it has little doubt for the judgment of the colours as with the set rules judgment cannot be given without a judge, likewise there is a need of human judgment for best matching suitable for the human desire and satisfaction. Considering the need of this human judgment the present study is planned to check the instruments measurement suitability and acceptability of same results by the human beings i.e. standard observers.

1.7. OBJECTIVES OF THE RESEARCH

(1) To Study the Contrast Measurement Method.

(2) To Study the CIE L*a*b* Measurement Method.

(3) Comparative Study of above mentioned methods and their limitations.

(4) To explore an Optimized Hybrid System through dual measurement approach of above mentioned methods to arrive at a logical inference for achieving the Highest Matching between the Print and Original in sheet fed offset printing, through experiments and analysis of the collected data.
1.8. MOTIVATION

Colour matching has always been either very simple or very complex task. To explain this a very simple example of our life is, when we go to the shop for matching coloured cloths sometimes we get satisfied with the matching colour very easily from the limited stock because of the limitation of available shades and satisfaction of our mind for the selected colours. But most of the times it is very complex with the vast shades availability and sometimes even after getting the particular shade number our mind does not get satisfied for accepting that particular selected shade is the best match. It may be due to change of colour pigment/dyes, contents, substrates. The similar problems are also witnessed in the printing field and the reasons behind this is, in our small scale printing presses printers totally rely on careful judgment of human observers. While in large scale presses, the judgement taken by the measuring instruments is blindly accepted by humans but sometimes it is observed that due to negligible variations the big stocks had been rejected. This lead me to work on an optimized hybrid system to arrive at a logical interface for highest matching in sheet fed printing to encounter such rejection related problems causing heavy losses.

1.9. METHODOLOGY FOR SOLVING THE PROBLEM

A specially designed test chart was prepared, with a continuous wedge of solids along with dot gain patches.

The printed sheets with different densities from one end to other end keeping the variation with 0.05 densities. The wet densities were measured and sheets were allowed to dry. After eight hours, the ‘Print Contrast’ and ‘L*a*b*’ were measured on each density patches, and the curve depicting different Contrast and L*a*b* values were generated.

To make the analysis more justified with human perception the same sheets were presented before Ten ‘Standard Observers’ and their visual assessments and judgement were compared. While doing the experiment we have intentionally provided a ‘1 minute’ gap in-between observations to completely avoid any involved eye fatigue. All the parameters like paper, ink, measuring conditions and Instruments etc. was maintained in compliance with ISO specifications.

1.10. BENEFITS OF THE RESEARCH WORK

There are two types of human approach for accepting and rejecting the things. The first approach is to accept the things blindly based on the suggestions, recommendations and
acceptability. The second is the fight for rejection in any condition. Both of these relate in form of first and second customers in the printing industry. First customer can accept the slight variation in the colour as an innovation but second type of customers can reject appropriate shade of printed colours by saying that instruments cannot be above to the human judgement.

Nobody has thought and worked in this line. It is hoped that the present study will be a step ahead contribution on this field for achieving the best matching and satisfying all type of customers.

1.1. MERITS OF THE RESEARCH WORK

1. The results of this study are very helpful for the highest colour matching specially in case of critical jobs.

2. This system comprises the benefits of both the aspects, the accuracy of colour measuring instrument and to feel lead judgements of the standard observers.

1.12. THESIS ORGANIZATION

The study is designed to explore an Optimized Hybrid System through dual measurement approach of above mentioned methods to arrive at a logical inference for achieving the Highest Matching between the Print and Original in sheet fed offset printing through experiments and analysis of the results obtained. It is therefore arranged so that the experiments and the logical inference can be followed and understood in better way. The remaining chapters of the study are arranged as follows.

Chapter 2: Literature Survey

Chapter 3: Contrast Measurement and CIE L*a*b* Measurement Methods, other Colour Spaces and Models

Chapter 4: Master Designs and Experimental Stages

Chapter 5: Data Collection

Chapter 6: Data Analysis

Chapter 7: Conclusion and Future Scope

References

Appendix

List of Publications