TITLE- METHOD AND APPARATUS FOR GENERATING AND PRINTING HIGH QUALITY WHITE UNDERBASE USING SCREEN PRINTING ON MEDIA HAVING COLORED BACKGROUND

FIELD OF THE INVENTION

The present invention relates to method and apparatus for generating and printing high quality White underbase using screen printing on media having colored background.

BACKGROUND OF THE INVENTION

There have been tremendous advances in the field of digital printing of colored garments (other than white) using inkjet printing methods and white ink along with color inks. In these methods, the generation and printing of ink separations including white underbase is automated and directly under control of the controller which is typically a computing device like a computer [1]. With inkjets capable of printing variable drop sizes for every ink type the result is almost photographic and beautiful reproduction of the images. Such methods have come to be known as Digital inkjet printing methods or Digital methods in short.

In digital inkjet printing, the screening method commonly used is Frequency modulated (FM) variable dot screening. This results in very smooth lay down of the inks with near solid (constant coverage) in appearance with variations in its opacity. The screen printing on the other hand while benefits from the advances brought about by the automatic generation of white underbase and corresponding color ink separations, but still produces inferior print quality owing to the inherent screening methods involved in printing of the images. The most common methods used in screen printing are Amplitude modulated (AM) screens [4]. This results in lay down that is coarser in appearance and has same opacity throughout. This also results in sharp contrast between background and the inked area which is also responsible for the grainy appearance of the prints.

Recently, hybrid systems that include combination of screen printing and digital printing have appeared in the market due to following reasons :–

1. The cost of print by digital printing is very high due to higher cost of digital inks. Since white ink is the used in most amounts in a print on colored background, methods are explored to combine the screen printing of white underbase in combination with printing of color layer digitally, thereby significantly reducing the cost of the print in total.
2. Having screen capability also allows other specialty garment embellishments like printing of glitters etc.
3. From screen printing point of view, hybrid method bring the image quality close to digital printing by using the combination of white underbase printing by screen and color layer on top of it by digital inkjet means.

Whether hybrid method is used or the screen printing method, the fundamental difference in print quality compared to digital prints is due to the white underbase layer as it is used to hide effect of the colored background of the garment. Due to the nature of AM screening, the white underbase laydown results in high contrast that is primarily responsible for grainy appearance of the prints.

Another factor that affects the reproduction of white underbase is the screen mesh itself. The white ink particles are relatively coarser in size and a single screen can't be used to produce the screens of higher screen ruling. This is overcome by separating the white underbase screen into areas of shadows, mid-tones and highlights and using separate screens of suitable mesh counts. This still doesn't resolve the problem of high contrast and grainy appearance.

OBJECTS OF THE INVENTION

It is therefore an object of the present invention to propose a printing apparatus to improve the print quality of the screen printed white underbase. Another object of this invention is to propose a method to improve the print quality of the screen printed white underbase of articles.

SUMMARY OF THE INVENTION

In case of digital printing, the quality of the white underbase is produced by the way it is laid down. The FM screening tends to reduce the contrast by spreading the white ink coverage. The spread is further enhanced by using drops of various ink volume based on the tone coverage, e.g. in highlights the coverage is provided by the drop with smallest volume, thereby increasing the density of the drops covering the area compared to coverage by large drop. This helps in reducing the contrast that would otherwise result if comparatively few larger drops were used.

In screen printing, there is no control over the drop volume as in digital printing. The white ink of maximum opacity is used to print variations in coverage using AM screens which is binary in nature resulting in areas having full coverage or areas having no coverage of white ink. See figure 4 for example of AM screening. AM screening belong to the class of clustered dot halftoning. There are other variants of this class that are also used and are known as second order stochastic screening, see figure 5 for example.

We propose the printing process based on the use of multiple levels of white ink or various levels of white ink dilutions for printing the underbase using screen printing method. These diluted white inks will have different and less solid percentages of the white pigment in the ink compared to base white ink that is generally opaque. Similar smooth printing effects as achieved by digital printing of white underbase can be achieved in screen printing by using such diluted white ink(s) along with base white ink. So, if the base white ink provides the maximum opacity, one or more diluted versions of the base white ink are used. The diluted version will have less opacity or hiding power in comparison to the base white ink. Each diluted white ink is diluted version of another diluted ink or base white ink. Thus we may have for example base white, light white, light white, very light white etc. Diluted white ink(s) when used with the base white will result in coverage similar to digital printing. Diluted inks can be created from base white ink by adding diluents to it in various proportions to achieve the dilution.

The methods to generate the white underbase for colored background are well defined in the literature [1]. Though, Methods in literature [2][3] exists for splitting a color ink into its diluted components (like Black into Black and gray, or Magenta into Magenta and Light Magenta combination) when printing on a white media/ background, these methods can't be used for white ink. The issue is that the white ink is not a color ink ad when printed on a white media yields nothing but white irrespective of the level of dilution.

Therefore, we present a method to convert the white underbase layer primarily generated for use with base white ink into multiple white ink layers, each corresponding to the white ink type (base/ diluted) to be used.

A method as defined by equation (1) called splitting function, is used. The function f() maximizes an objective function when splitting the white ink. The aim of such objective function could be based on end objective of printing. One such end objective could be to maximize the use of diluted white ink compared to stronger white ink in order to get smooth and less grainy white underbase.

$f(\text{Org White})_{base} = (\text{new white})_{base} + (\text{diluted white})_{diluted1} \ldots\ldots + (\text{diluted white})_{diluted\ n}$ -----------Eqn (1),

Where eqn 1 is subject to the constraint of having components of RHS of eqn 1 when expressed is terms of base white value add up to the Org White value passed to the splitting function on the LHS of the eqn 1.

The method to split original white base into new white base and diluted ink(s) is based on its white pigment solids/particles density or strength. A ramp with variations from 100% to 0% base white is printed on a colored background preferably black as it provides the maximum contrast. The solid (100%) patches of all diluted white ink are also printed on the same colored background as ramp of base white. These solid patches of various diluted white ink are then compared with the ramp to find out the % of base white ramp that it corresponds to. The corresponding value is the solid density or strength of the 100% diluted ink patch in percentage compared to 100% base white ink. Alternatively, if the amount of white pigment solids in base white ink and diluted white ink are known, then the same amounts can be utilized to compute the %wt relative to the base white ink. Based on such computed Solid densities or strengths, a splitting function can be defined that adds up the right hand side of the equation (1) numerically in terms of total white solids density / strength to the left hand side of the equation, where function f() determines percentage value of diluted ink based on input base white ink percentage, while maximizing an objective function (in this case it could be to use maximum of diluted ink). The example output of such a function is shown in figure 1 and 2, where two and three different types of white ink are used respectively, In case of two inks, one ink corresponds to 100% base white and other ink corresponds to dilute white ink at 40% level of base white. In case of three inks, one ink corresponding to 100% base white and other two being diluted white inks at 50% and 25% level of base white respectively.

The objective function in figure 1 is based on maximum diluted ink coverage with diluted ink merging 40% deep into the remaining area of base white ink coverage, where it has to combine with base white to build up the strength.

The objective function in figure 2 is to maximize the coverage of diluted white ink therefore resulting in separations as defined by figure 2, where coverage of 25% white ink (diluted version) is maximized followed by 50% white ink (diluted version)and then finally 100% white ink (base white ink) is used resulting in maximum solid coverage.

User can define any objective function that is based on his requirements. The splitting function takes this objective function into consideration while satisfying the constraint imposed by equation (1).

The screens thus can be generated for each type (dilution) of white ink and used for printing by screen printing method. Most Diluted white ink screen is printed first followed by next level and base white layer in the last so that it is on top of all. This results in white underbase that is close to its digital printing counterpart. Due to the diluted white, level of solid coverage also increases which reduces the contrast between the color background and the white ink. It also reduces the requirement for a higher ruling for printing the white underbase and thus coarser ruling and a coarser mesh count can be used for the screens.

Such separation functions can also be defined interactively by the end user using graphing tools instead of measurement based methods, once some experience is gained in the printing with diluted levels of white ink. Such separation functions eventually have to satisfy the constraints of eqn (1).

As an example, when using the objective function of figure 2, the input value of 100% base white will result in the following –

$$f(100\%)_{base} = (25\%)_{base} + (100\%)_{50\%\ white} + (100\%)_{25\%\ white}$$

The separation function once defined can be stored in the form of a separation table and be used by a controller (computing device) to separate the input base white underbase into separations with diluted white ink(s). These separations then can be transferred to screens for printing by means of an online (computer to screen (CTS) method) or offline (printing on a transparent film and then transferring the image to screen) exposing methods. The multiple screens thus developed then can be used to print the white underbase with base white and diluted white ink(s) on the substrate. Figure 3 defines the apparatus used to generate and print the white underbase for base white ink along with diluted white ink(s).

The method presented here is primarily applicable to white underbase by screen printing and thus can be used with both the hybrid apparatus employing the screen and digital means as well as screen printing apparatus alone.

There can be variations to the present invention possible, which are obvious to the one skilled in art and thus covered by the scope of this invention.

One interesting possibility will also be to apply the diluted white ink separations to all digital printing method by using the digital diluted white inks instead of screen printing method. Such digital methods will however may or may not yield much advantage over current method of printing white underbase using variable drop in an inkjet method. This however can provide significant benefits when using the digital electrostatic technology as in laser printers, where method of printing is same screen printing in principle except that it does not require a physical screen/plate to print. One can think of these digital inkjet/electrostatic printers using virtual printing screens. The ink used by these electrostatic printers is also called toner.

References:

[1] Patent application (WO/2007/099554) - METHOD AND APPARATUS FOR GENERATING WHITE UNDERBASE AND GENERATING SUITABLY MODIFIED SEPARATIONS FOR PRINTING ON COLORED BACKGROUND OTHER THAN WHITE.

[2] Computational color technology by Henry R. Kang. ISBN 0-8194-6119-9.

[3] User manual. Kothari Print Pro – DTP edition.

[4] Modern Digital Halftoning by D.L Lau and G.R Arce. ISBN13 978-1-4200-4753-0

[5] Digital Imaging Handbook by Gaurav Sharma published by CRC Press.

WE CLAIM :

1. A printing apparatus, which is configured from one of the following :-
   i) a combination of digital printer and a screen printer;
   ii) a screen printer; and
   iii) a screen/plate less digital printer employing virtual screens;

   wherein the apparatus employing more than one screen to print white underbase where one or more diluted white ink screen is used.

2. A method to split a given white underbase into a corresponding white base and diluted white ink value/coverage using an objective function while satisfying the following equation and constraint –

   $f(\text{Org White})_{base} = (\text{new white})_{base} + (\text{diluted white})_{diluted1} \ldots + (\text{diluted white})_{diluted\ n}$

   ------------ Eqn (1),

   Where eqn 1 is subject to the constraint of having components of RHS (right hand side) of eqn 1 when expressed is terms of base white value add up to the Org White value passed to the splitting function on the LHS (left hand side) of the eqn 1.

3. The apparatus as claimed in claim 1, comprising
   a controller to generate the base and diluted white ink separations from the given white underbase values in a method as claimed in claim 2.

4. The apparatus as claimed in claim 1, comprising
   an online or offline device to generate the printing screens (physical/virtual) using the separations generated by the controller as claimed in claim 3.

5. Articles printed with white underbase produced in a method as claimed in claim 2, using the apparatus as claimed in claim 1 or 4.

ABSTRACT

TITLE- METHOD AND APPARATUS FOR GENERATING AND PRINTING HIGH QUALITY WHITE UNDERBASE USING SCREEN PRINTING ON MEDIA HAVING COLORED BACKGROUND

The invention relates to a printing apparatus, which is configured from one of the following: a combination of digital printer and a screen printer; a screen printer; and a screen/plate less digital printer employing virtual screens; wherein the apparatus employing more than one screen to print white underbase where one or more diluted white ink screen is used.

{FIGURE 3}

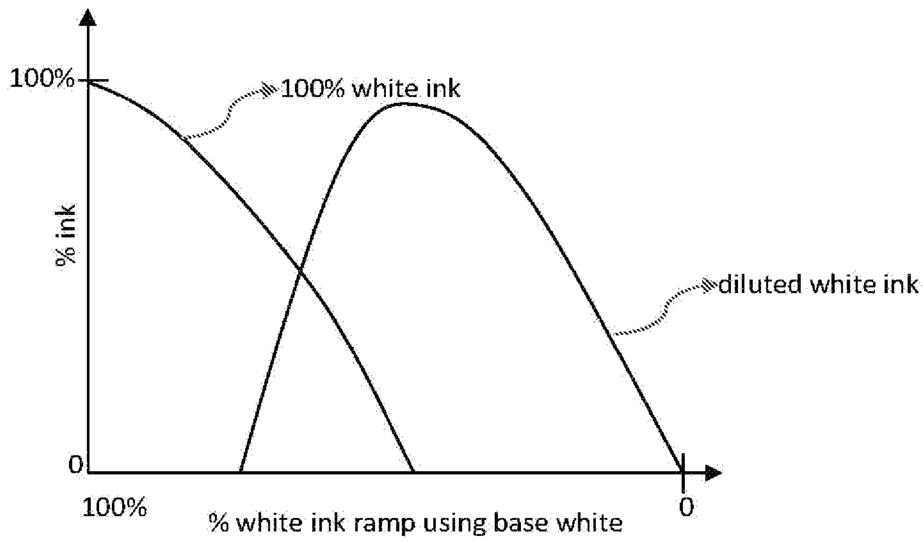
100%
100% white ink
% ink
diluted white ink
0
100%
% white ink ramp using base white
0

Fig. 1

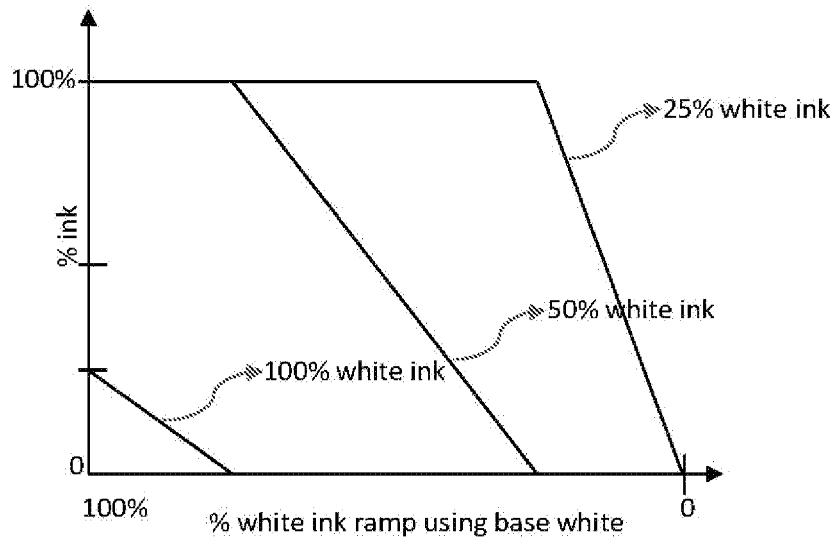
100%
25% white ink
% ink
50% white ink
100% white ink
0
100%
% white ink ramp using base white
0

Fig. 2

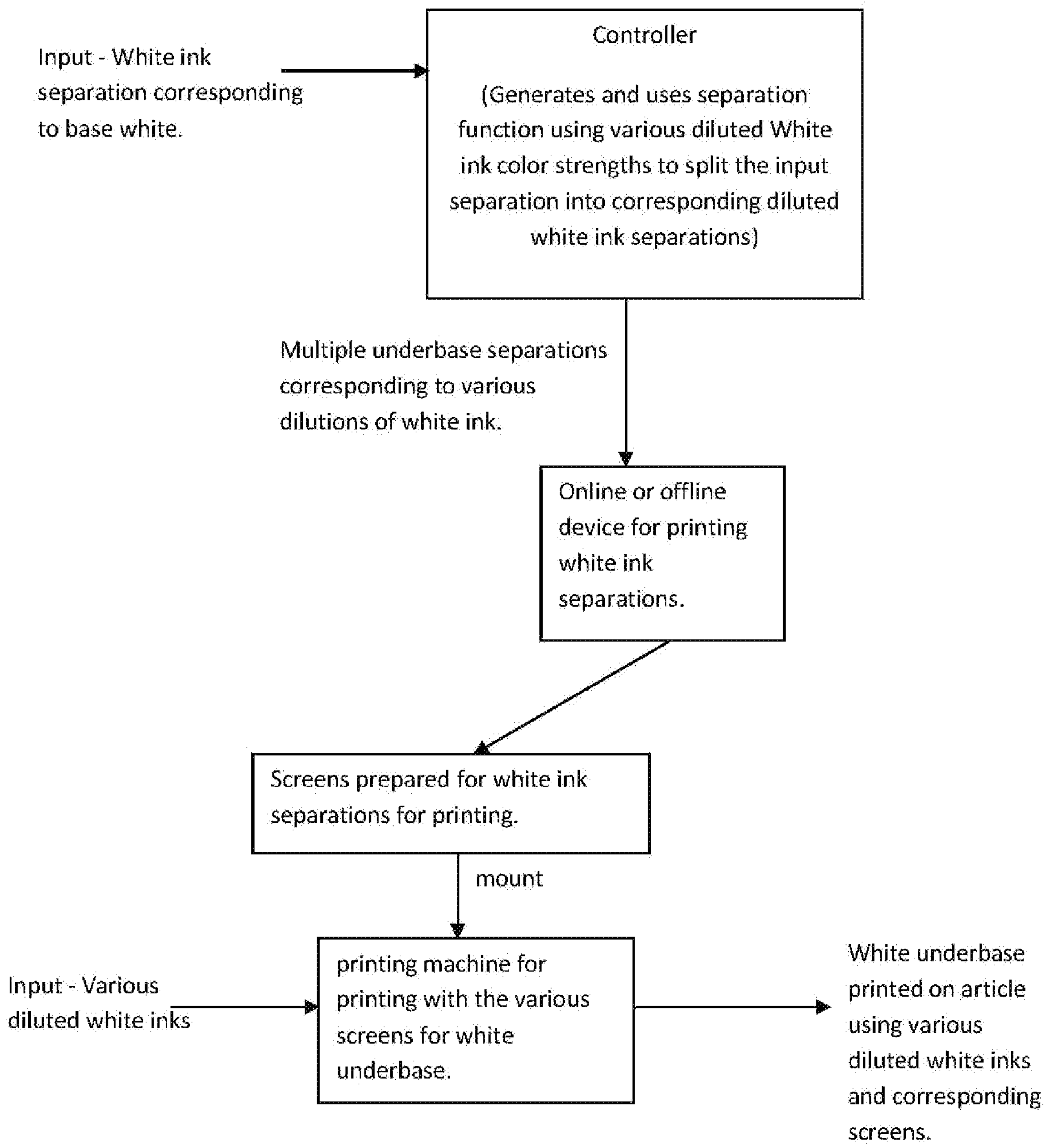
Input - White ink separation corresponding to base white.
Controller
(Generates and uses separation function using various diluted White ink color strengths to split the input separation into corresponding diluted white ink separations)
Multiple underbase separations corresponding to various dilutions of white ink.
Online or offline device for printing white ink separations.
Screens prepared for white ink separations for printing.
mount
Input - Various diluted white inks
printing machine for printing with the various screens for white underbase.
White underbase printed on article using various diluted white inks and corresponding screens.

Fig. 3

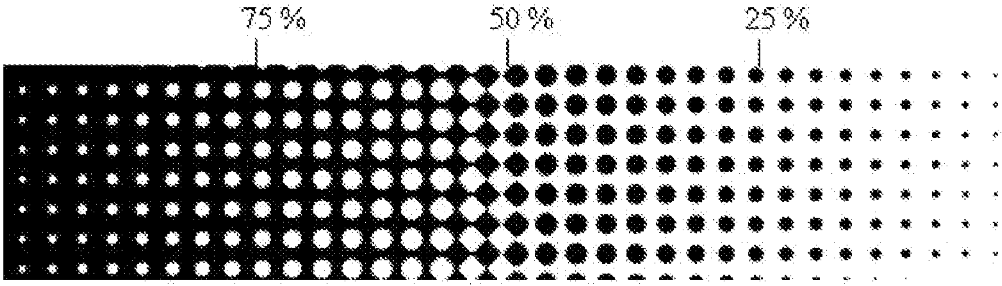

Fig. 4

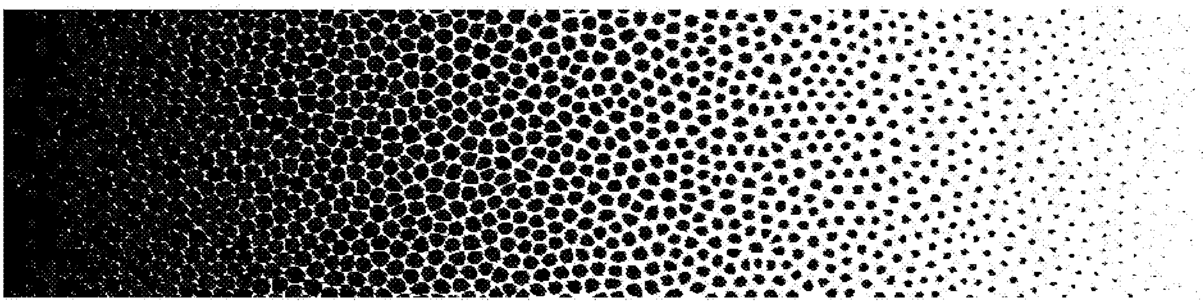

Fig. 5