Investigation of Print Quality in Newspaper Printing using Web Offset Printing Machine based on Computational Intelligence

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Abstract- Currently print production in newspaper industry is automated, except in print quality assessment and control. Mostly quality assessment is a manual and subjective procedure. For investigating the print quality, it involves colour image to validate the attributes through data mining and colour image analysis with the help of sensors. There are 20 print attributes for evaluating the colour image. Investigation shows the good communication between the subjective observer and proposed print quality evaluation technique

Keywords- Print quality, web offset printing, Newspaper printing, quality assessment, colour image assessment, Digital image assessment

I. INTRODUCTION

Offset printing is the most commonly used commercial printing process in the production of newspapers and magazines (1). Since offset printing is a high quality and cost effective process [8]. According to the paper served in the printing machine, offset printing can be categorized into Sheet-fed offset and Web-fed offset, whereas web-fed offset printing process used for high volume and can run up to 13 m/s speed. Multicolor images in web offset printing are produced by printing cyan (C), magenta (M), yellow (Y), and black (K)dots of varying sizes upon each other having different angles. An image comprised of such dots of one colour is usually called a halftone image. Halftone images are transferred onto printing plates, in the computer-to-plate (CTP) process. There is a separate plate for each printing colour. The plates are mounted on plate cylinders both the non-image area and image areas on the plate are on the same plane. During printing, a thin layer of water (dampening solution) is applied to the plate followed by the application of the corresponding ink. The inked picture is transferred from the plate onto the blanket cylinder and then onto the paper.

Numerous factors affect print quality: paper (ink demand and ink pigment penetration increase with increasing surface roughness, for example [13]),ink, printing press, digital proofing system used in colour management [25], ink-water balance, operator actions, and the quality of printing plates. A large variety of deficiencies and problems may appear during printing: mis-registration of printing plates, paper wrinkle formation [15], improper paper surface, high % of linting due to improper paper surface, web breaks, piling, mottling. Even if all the aforementioned deficiencies are absent, the quality of print can be low.

A printed image may differ from its original or proof, due to various reasons. To make visual assessment on print quality the testing carried out on double grey bar which is printed at the edges of the paper. The resultant values are used for altering the printing process to attain the maximum print quality. These type of attributes can also be used for studying the relation between print quality and print parameters like paper, ink, printing press as well as printing process. Print quality assessment made by collecting the values from various print qualities attributes as well as visual comparison. Since subjective observer is the final evaluator of print quality. Here print quality assessment in web offset printing is based on forests-based technique using objective values estimated on double grey bar considered as a major print quality attribute.

II. FACTORS AFFECTING PRINT QUALITY

Components affect print qualities are: paper, ink, printing press, digital proofing system used in colour management dampening solution, ink-water balance, operator actions, and the quality of printing plates.

Deficiencies appear during printing: miss-registration of printing plates, wrinkle formation, too high linting, piling, mottling and web breaks.

Linting problem in offset printing are: printing pressure variation, printing speed, ink viscosity and paper roughness. It was found that the angle at which the web exits the printing nip has a large influence on lint, with the lint level increasing fivefold when the angle was increased from 27 degrees to 153 degrees [49]. The desired print quality is obtained by maintaining the ink proportion of the four ink dots in the colour image area with constant quality i.e. size & shape of the dot and ink density.

III. SURVEY IN DEVELOPMENTS OF PRINT QUALITY INVESTIGATION

There are many print quality attributes contributing to the overall print quality. Image analysis and computational intelligence-based techniques are increasingly used for assessing various quality aspects of prints. Since the manual procedures are tedious, time consuming, and the results are subjective as they depend on personal skills and mood, automated printing quality inspection systems are highly appreciated. Developments in this area usually concern simulation of the most common print quality defects [26], inspection of one or several print quality attributes, such as the actual size and quality of printed dots [4], mottling [42], CCD camera-based estimation of ink density [56], automatic detection and classification of various printing defects [37]. A recent study used Bayesian networks and genetic algorithms to model the overall print quality assessment by a group of people in electro photography printing. The trained network structure reflected the relation between instrumental measurements, subjective print quality attributes and the overall quality. Guan et al. have recently developed a case based reasoning system for offset print quality control [16]. A variety of print quality cases are stored in a knowledgebase and exploited for decision-making in the printing process. Development of knowledgebase image inspection system for automatic defect detection, classification, and misprint diagnosis in offset printing [37]. A CCD linear camera is used as an image sensor. The system can recognize defects, categorize them into one of 47 classes, including colour drift, and suggest actions for the operator to eliminate the cause of defect. Another image analysis based defect detection tool, assisting the press operator in finding defect in the print and taking appropriate adjustments, was tested on a Flexo gravure printing press [45][46]. The system is supposed to be used on offset printing presses. Ductor streaks, hazing, colour splashes, structural defects, and hazing are the types of defects considered. The defect detection is based on a threshold difference image between the reference print and the sample print. Similar approach of comparing the reference print and the sample print is also utilized in [24]. A print quality inspection system developed by Brown et al. for a rotogravure printing press was tested in the wall-covering printing industry [6][7]. The machine vision-based system uses a spectrophotometer based on holographic grating jointly with a monochrome area scan camera and measures a number of characteristics of the print including colour and the variation of the printed dots. If drift is detected in any of the parameters, the system instructs the operator to make adequate adjustments to the process variables. [10] developed a printing quality control expert system for controlling offset printing dot variations. The system consists of knowledge base, the inference engine, and the user interface. Good correspondence between the model and human assessments of the overall quality was found.

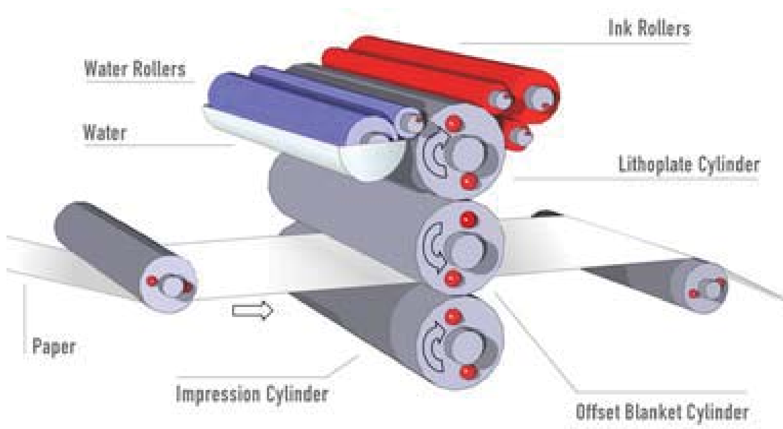

Fig.1 Web offset printing process

IV. PRINT QUALITY PARAMETERS

The various parameters used of assessing the print quality are:

Table 1 Print Quality attributes

S.No.	Measuring Attributes	Measuring Area/ formula
1	Dot deformation	sd – centre & fs- shape
2	Dot Gain	Dot Area
3	Tone value	Tone value - ‘‘black’’ area of double grey-bar
4	Miss-registration degree of printing plates	Registration Mark
5	Estimate of average black ink density	grey bar
6	Mis-registration of C, Y, M	X direction, Y direction
7	Colour Deviation	$\Delta E = ((\Delta L^*)^2+(\Delta a^*)^2+(\Delta b^*)^2)^{1/2}$
8	Ink density deviation from the required density level	Dot Area
9	Edge sharpness	Registration Mark
10	The number of missing dots	Dot Area
11	ΔE	Colour density area
12	ΔL^*	Colour density area
13	a*component	black grey-bar part coloured grey-bar part
14	b* component	
15	Contrast	
16	Noise	Black, cyan, magenta, yellow ink in a grey-bar
17	Mottling	Image area
18	Trapping	$T = 1 - 10^{-Dop} / 1 - 10^{-ðD1þD2Þ}$ (X)100
19	$\sqrt{(\Delta C_k - \Delta C_c)^2}$	ΔC black and coloured grey-bar part
20	The print-through level	print seen from reverse side of print

V. MEASURING PRINT QUALITY

Although there is a great interest in having a print quality measure capable of integrating various quality aspects, attempts to devise such a measure are very infrequent [55]. The same applies to a metric capable of predicting observer responses regarding picture quality [35]. The paper suggested using grey balance, tone reproduction, and overall appearance as printing quality attributes [52]. To assess the overall printing quality level, the quality attributes are combined as a triangular fuzzy number. It was suggested using fuzzy integration to aggregate print quality attributes, evaluated using computational intelligence techniques, into an overall print quality measure. It was demonstrated that print quality evaluations provided by the measure correlate well with print quality rankings obtained from experts [57]. Deviation of the amount of C, M, Y, and Kinks from the desired level, quality of printed dots, variation of ink density, noise level in a printed picture were the print quality attributes used in the study. A system attempting to simulate human print quality assessment for simple prints made by laser and ink jet printers was presented [51]. Using simple print features characterizing noise level, edge sharpness, and tonal contrast the system was trained to categorize prints into the ‘‘bad quality’’ and ’’good quality’’ classes. Another approach to categorization of prints into the two classes was proposed [30]. The categorization was based on moment invariants computed from a colour image histogram.

VI. EVALUATING PRINT QUALITY

Exact and repeatable colour reproduction is one of the main features of high quality printing. To attain repeatable colour reproduction in offset printing, ink density is usually measured and maintained in a predetermined range. [62] One of the ways of achieving exact colour reproduction is to employ spectral techniques for recording, handling, and reproduction of colour. The advantages of using spectral values are the absence of colour metamerism and the fact that nearly all visible colours can be recorded. Rather expensive spectrophotometers are usually used to obtain spectral values. There are many print quality attributes contributing to the overall print quality. Nonetheless of the current practice of using manual inspection of overall quality of complex colour prints in the printing industry [40] image analysis and computational intelligence-based techniques are increasingly used for assessing various quality aspects of prints. Since the manual procedures are tedious, time consuming, and the results are subjective as they depend on personal skills and mood, automated printing quality inspection systems are highly appreciated. Inspection of one or several print quality attributes, such as the actual size and quality of printed dots [4] [5] [10], mottling, CCD camera-based estimation of ink density [9], automatic detection and classification of various printing defects [37], print graininess. Guan et al. have recently developed a case based reasoning system for offset print quality control [16].Perceived colour and tone, print uniformity, ghosting, and leaking are the parameters considered being important regarding print quality. A CCD linear camera is used as an image sensor. The system can recognize defects, categorize them into one of 47 classes, including colour drift, and suggest actions for the operator to eliminate the cause of defect. Another image analysis-based defect detection tool, assisting the press operator in finding defect in the print and taking appropriate adjustments, was tested on a Flexography and gravure printing press [45] [46]. The system is supposed to be used on offset printing presses. Ductor streaks, hazing, colour splashes, structural defects, and hazing are the types of defects considered. The defect detection is based on a threshold difference image between the reference print and the sample print. A camera system measures the print, compares the measured L*a*b⁄*values to the reference image, and generates an error signal, which can be used for ink feed control. For a rotogravure printing press was tested in the wall-covering printing industry [6] [7]. The machine vision-based system uses a spectrophotometer based on holographic grating jointly with a monochrome area scan camera and measures a number of characteristics of the print including colour and the variation of the printed dots. If drift is detected in any of the parameters, the system instructs the operator to make adequate adjustments to the process variables [10]. Developed a printing quality control expert system for controlling offset printing dot variations. The system consists of knowledge base, the inference engine, and the user interface. It was expected that the system will also be used to train the entry-level trainees. A CCD camera is used for image capturing to check the grey value from individual pixel to compare with set value of reference image.

VII. MONITORING INK CONSUMPTION AND FEEDING

To achieve uniform print quality throughout print production an automatic ink feed system is essential to eliminate the inconsistent colour density. Subsequently it reduces the paper, ink and process waste during printing. Consistency & resistance to wear is the main advantage of using the automatic control system. For online ink feed control spectrophotometer or densitometer is used to measure the ink density [21] [28] [39] [50].In addition to densitometers and spectrophotometers machine vision has also been utilized in several of the studies. Colour cameras have been used for both finding the measuring target areas [39] and determining ink density. It has been demonstrated that it is possible to determine ink density with acceptable accuracy from RGB camera measurements [9] [44] [47] [48] [56] [65]. Amongst the advantages of using colour camera-based machine vision for printing process control are: the ability to automatically find the measuring target areas, the ability to store images of the print that can be analysed off line, the ability to detect defects of the print, and the possibility of estimating other print quality parameters from the images. The trained system can be used as an assistant for the novice press operator. The system determines the colour of ink that needs adjustment, the direction, and the amount of the alteration. In all the aforementioned works, ink feed control is based on controlling ink density measured on a solid print area. However, printed pictures are made of halftone C, M, Y, and K inks with an acceptable accuracy and is superior to the integrating controller.

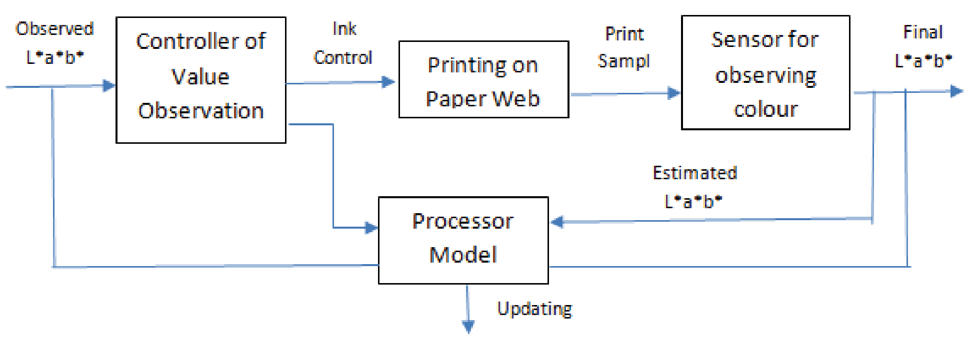

Fig.2 Process Monitoring System control

VIII. CONCLUSION

Nowadays industries are striving to manufacture the quality products to meet the customer specifications. To ultimate goal of the printer is to get the high quality printing by achieving exact colour production and satisfying other print quality attributes. The acceptance and rejection of colour print is mostly based on ink density measurement by subjective observer evaluation. This is based on the difference between the original and its reproduction copy. Investigation performed on the basis of colour image analysis and computational techniques. The effectiveness of the system based on the how resulting system relates the human judgements. It's important to develop more advanced technique to capture the image for evaluating the print quality for high speed printing machine. There is a need for measuring the moisture content of the paper during printing since it involves dampening solution during printing also plays important role while printing the solid colours on the news print paper (less than 80 GSM). The print quality differs because of the larger variety of paper quality, ink quality and other parameters that affects the print attributes in future there is a need for optimizing the printing process that includes plate coating, plate exposure, plate processing, blanket, printing materials and standardising prepress equipment's and printing machines.

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