Original Research Article

Printing on plastic foil through digital cameras with full inspection in the industry

Abstract

The plastic foil printing company with eight-color machines has requested help from the Faculty of Computer Science regarding the reduction of losses in raw materials. During the study and research in this matter, it was found that the losses in raw materials are caused by the impossibility of controlling the printing through adequate technology. The printing on the plastic film is supervised with a digital camera with the possibility of control in dimension 15[cm]. On the other hand, the width of the printed plastic film is 130[cm]. Therefore, the digital control camera for control is displaced along the x-axis nine times to control the press width of 130[cm]. After each displacement, the digital camera was stopped for a duration of three seconds. Wherever there was a printing defect in the part not monitored by the digital camera and considering the printing speed on the machine for a length of 400 meters of plastic sheet per minute, it caused a significant loss of raw material. This problem has been solved by replacing the 15[cm] wide inspection digital camera with a 130[cm] wide full inspection digital camera.

Keywords:industry,camera,digital, width,inspection

1. Introduction

The "Flexotecnica" EVO XD8 automatic machine[1] located in the production process for printing plastic film at the level of up to eight colors simultaneously at the "Flexograf" factory in the city of Gjilan is the object of research in the said scientific work. Printing on plastic film is carried out according to the customer's request for the packaging needs of food products for mass consumption in the market, plastic or glass packaging labels for water, carbonated and non-carbonated soft drinks, and similar. 100% Inspection Competition in the printing industry is hard, and the requirements are rising constantly. Exact control is the prerequisite both for quality printing products and satisfied customers. BST inspection systems monitor the print easily, comprehensively, and efficiently, for first-class print products[2, 3]. 100% inspection systems use one or more line cameras and constant lighting. The complete web width is captured line by line and displayed as a complete pattern on the monitor[4].

2. An innovative idea for solving the problem

In order to completely eliminate the printing quality control problem, this is possible when the width of the control is the entire width of the printed foil, even in the dimension of 130 [cm]. In this case, the digital camera controlling the printed film does not need to be mobile but fixed. The control of the printed foil in the width up to 130 [cm] at any moment of time will be complete and under the highest possible degree of monitoring. Even if printing defects occur they can be identified instantly and the losses will be minor because the machine operator will immediately stop the machine in order to eliminate the printing defect. In this case, the losses of the foil material would be a maximum of a few meters, while those of the colors would be a few milligrams.

3. Digital technology needed to solve the problem

In order to achieve the realization of the innovative idea, it is necessary to ensure the digital technology, which has the width of the simultaneous control at least equal to the width of the printed plastic film. For this case, the digital technology known as a digital camera or high-performance scanner known as a Full inspection camera - Increasing Productivity and Quality Center (130 cm inspection width) is proposed, which is easily found in the international market[3].
This camera offers various solutions for 100% online inspection and monitoring for quality assurance in narrow, medium, and wide applications such as label and package printing, and is easily implemented in different technologies for image comparison[5, 6].

4. Quality assurance presentation solutions

With the new Q Link editor, machine operators can assess the significance of defects detected on their printing machines in near real-time. Larger areas such as missing colors can be defined as waste areas and cut from the rolls. In addition, the Q Link Editor provides a permanent update function for label yields and performance metrics. This allows overproduction to be easily avoided[7].

5. Context & core problem - Study method

The current state of the printing machine

The printing speed of the machine is up to 400 meters of plastic foil per minute (400 m/min.) in its width of 130 [cm]. The printing design belongs to the designers of the company and according to this design the "Flexotecnica" EVO XD8 machine[8, 9] throws the color on the plastic foil by building product images, text inscriptions of the products, names of the manufacturing companies, and even the responsible bar codes of the product.

During printing, serious defects appear that cause losses to the Flexograf company in Gjilan, despite the digital control through a digital camera or scanner without touch located at the output of the colorful printed sheet. The most frequent defects that appear are lack of any color, the color band along the entire length of the printed film, foreign matter stuck to the color distribution cylinders, and uncontrolled mixing of colors. All of these are the result of technical causes such as the closing of any color injection nozzle due to the inhomogeneity of the color in the material, the partial closure of two of the most color injection nozzles, the adhesion of any plastic particle or insect to the rotating cylinders where the distribution and drying of the color in the plastic film is achieved, as well as the winding through rolls on rolls of printed plastic film and similar.

Even in spite of the continuous monitoring of printing with a digital camera, which conveys the images to the monitor in front of the machine for monitoring by the operator who drives the machine and at the same time for any defect a sound alarm is issued, it is not possible to eliminate the printing defects. These defects are usually due to the high speed of printing and the need of the driver of the machine to avoid the monitor to check the functions of other parts of the machine. On the other hand, the digital camera of the machine that controls the printing is 15 [cm] in size. With this, it is not possible to control the width of the printed sheet of 130 [cm]. Monitoring with this digital camera is performed by moving it in the horizontal plane along the x-axis in the width dimension of 130 [cm] right and then returning to its initial state on the left while the printed sheet moves at a maximum speed of 400 [m/min] in the direction of the y-axis and that from up and down as in Figure 1[10,11].

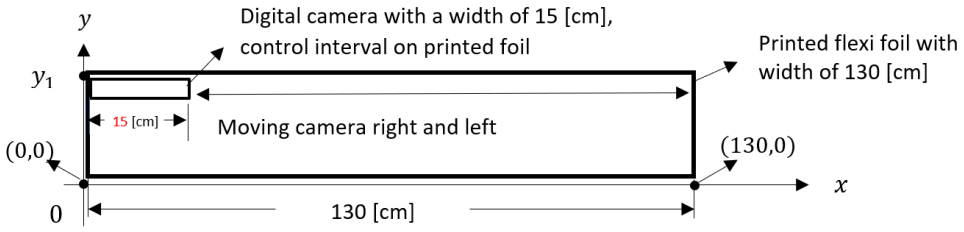

Figure 1. Digital camera shift right with control width 15 [cm]

In this case, if the control with the digital camera is covered in the width of 15 [cm] then the uncovered part of the control when the digital camera is at the zero point (0) of the xy coordinate system then the uncovered part of the control of the printed plastic film will life:

$$130\ [cm] - 15\ [cm] = 115\ [cm] \quad (1)$$

For any distance Δx to the right to move in the positive direction x-axis digital camera with control interval of the printed plastic film, the impossibility of controlling the printed film from the positive side of the x-axis will be reduced and at the same time for this displacement for Δx to the right of the digital camera, but for the

same dimension Δx from the left side of the digital camera, the printed sheet will remain unchecked as in Figure 2[13, 14].

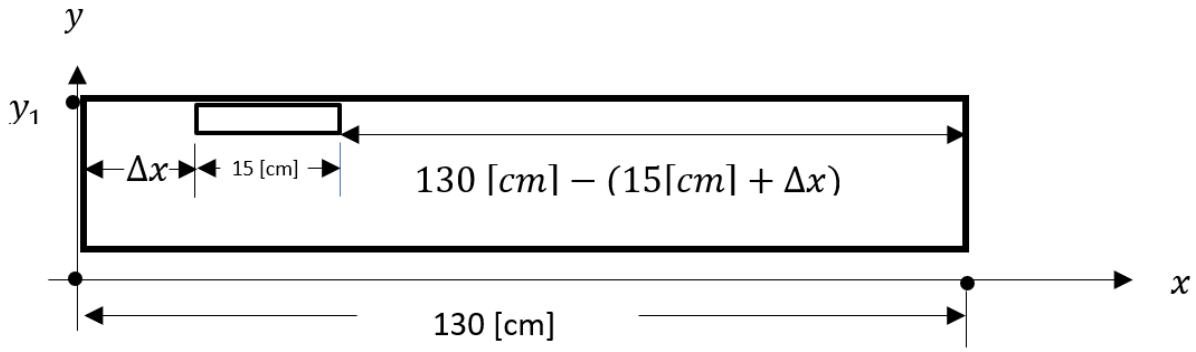

Figure 2. Shifting the digital camera to the right by a distance Δx

Even in this case, the uncovered control width of the printed plastic film remains the same at the value of 115 [cm] as follows:

$$130\ [cm] - (15\ [cm] + \Delta x) + \Delta x = 130\ [cm] - 15\ [cm] - \Delta x\ + \Delta x = 115\ [cm] \qquad (2)$$

Therefore, it is concluded that for whatever distance Δx moves the digital camera to the right or left when it reaches the end of the width of the printed plastic film, the width of 115 [cm] of the printed film at any instant of time remains uncontrolled or unmonitored from a digital camera with a control or monitoring width of 15 [cm].In fact, the digital print control camera in the control width of 15 [cm] is displaced from its initial position, the start of the coordinate system point (0,0) to the right for a distance of 15 [cm] discretely and kept at least 3 seconds for control and thus continues to the far-right end of the monitoring point (130,0) of the perpendicular coordinate system. From this, it can be seen that the current digital camera of the "Flexotecnic" EVO XD8 machine[9, 12] performs nine discrete displacements along the x-axis, respectively from left to right until the end of the width of the printed sheet and returns without stopping in the continuous form at the beginning of the printed sheet to the left as in the figures Figure 3., Figure 4. and Figure 5.

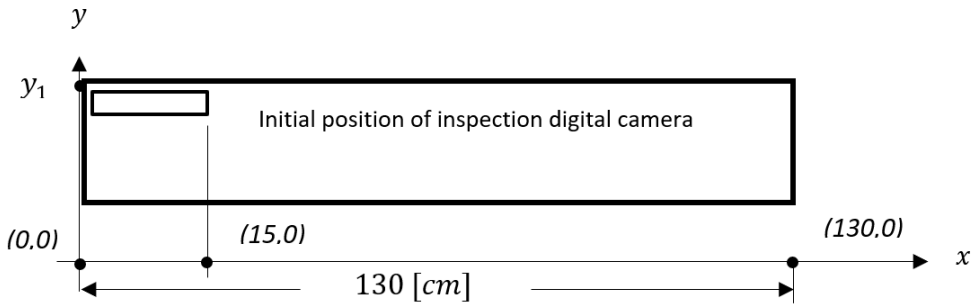

Figure 3. The initial position of inspection digital camera

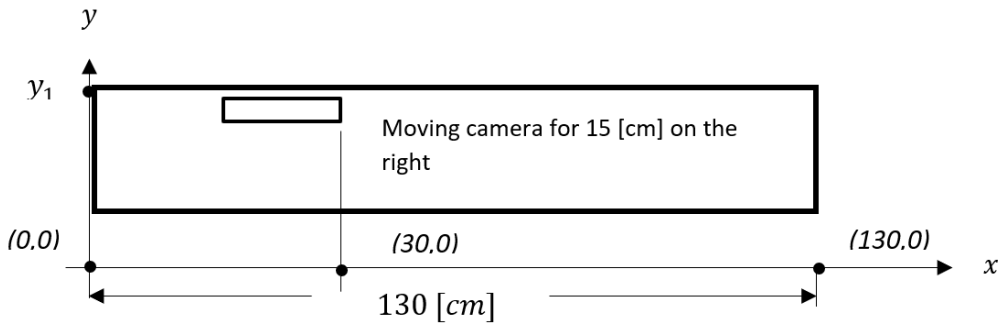

Figure 4. Moving the camera for 15 [cm] on the right

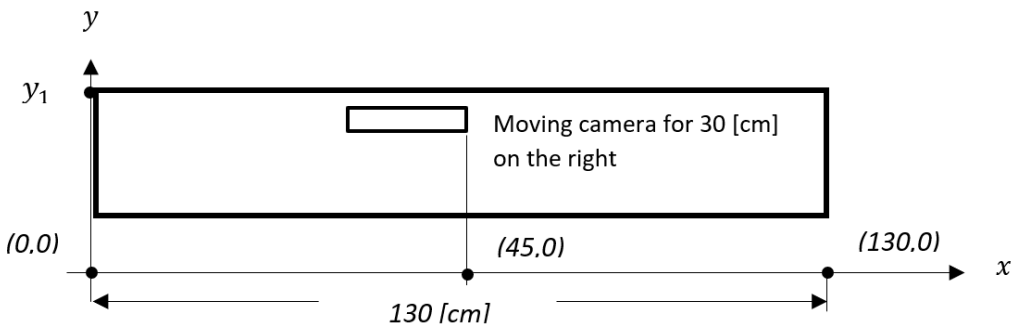

Figure 5. Moving the camera for 30 [cm] on the right

The displacement of the digital camera which monitors the printed film every 15 [cm] in a duration of 3 seconds (3 [s]) occurs from its initial position point (0,0) to the last one (130,0) in the form discrete and returns with non-stop-continuous movement back to the initial position to continue displacement after 3 [s] throughout the printing time of the foil on the "Flexotecnica" EVO XD8 machine. The time of 3 [s] means the control time in the given position of the printed sheet by the digital camera. The position of the digital control camera in relation to the y-axis during the entire time of its movement along the x-axis, respectively right and left, remains unchanged y_1. In fact, this represents the distance of the control digital camera from the printed plastic sheet. This distance is adjusted via the corresponding software to a value of 2 [cm].
For the control of the entire width of the printed film, the digital control camera changes a total of nine positions from 15 [cm] discretely so that the last position again covers 5 [cm] of the penultimate one. He stays in each position for three seconds (3[s]) to be checked. If every 3 [s] changes the control positions, then for the control of the entire width of the plastic film, even that part in a discrete form is needed:

$$9 \cdot 3[s] = 27\ [s] \tag{3}$$

On the other hand, the "Flexotecnica" EVO XD8 machine prints a total of 180 [m] lengths of plastic film for 27 [s] based on the print speed of the machine (400 [m/min.]:

$$400\ [m]{:}\ 1\ [min] = x\ [m]{:}\ 27[s] \tag{4}$$

Respectively: $400\ [m]{:}\ 60\ [s] = x\ [m]{:}\ 27[s]$ (5)

$$x \cdot 60\ [s] = 400\ [m] \cdot 27[s] \tag{6}$$

$$x \cdot 60\ [s] = 10800\ [m \cdot s] \tag{7}$$

$$x = \frac{10800\ [m \cdot s]}{60\ [s]} = 180\ [m] \tag{8}$$

Therefore, it is concluded that, if the printing defect is not noticed in the first 27 seconds, we will have 180 [m] of printed plastic foil lost, while for the second 27 seconds, if the printing defect is not investigated again, we will have to double the losses. In the event that for ten control cycles for 270 [s] or 4.5 minutes, the control camera fails to record the printed defect, then the fines will be multiplied tenfold. This means that the loss will be expressed in 1800 [m] of the length of the printed foil!
This form of printing control on plastic film causes loss in production up to 2000 [m] of printed film length and also significant amounts of printed colors in just one case of a defect within 4 or 5 minutes. Such losses occur in production at least once in an eight-hour work shift. The machine works at least in two shifts so far. The company's losses for this case alone range from 500 to 600 euros expressed in monetary value within one working day. On the other hand, if the printed foil is not noticed at all that has an error on the printed film, but the printed roll continues to be treated further in the company and in the process of its last treatment it is noticed, then the losses go up to 1000 euros/day!

6. Objectives and Research Questions

The effects of new innovative technology on the production process

There is no doubt that the effect of this proposed new technology brings significant losses, maybe significant in the Flexograf company in Gjilan. On the other hand, it maximally relieves the machine operator of stress and the constant psychological burden of what moment in he will identify the defect in printing plastic film.

7. The effect of mitigating losses in raw material during the production process

Not only the mitigation of losses in this production process, but of course the complete elimination of losses in the printing of plastic film for the needs of customers with different requirements. The losses in the plastic mass will be absolutely minor, but also in the colors for printing[13-15].

8. The effect of environmental protection

Since the losses in plastic mass and colors are brought to a minimum, the living environment will not be contaminated by the pollutants of plastic mass, especially chemicals such as dyes.
How to inspect the printed foil at once at a range of 130 cm? How to minimize the loss of materials such as foil and colors? How to do image comparisons in real-time[16-18]?

9. Methodology

With the help of a full inspection camera(100% inspection systems), it will be possible to make image comparisons for colors and printed foil to avoid material loss. This is possible by image comparison while doing it in very high-speed comparison and showing the result if any error occurs in printing[18, 19]. This is possible by using the hardware of the camera/scanner with a full inspection at once in 130cm width which will capture the images and then with software to make image comparison[20].

10. Activities

We should have a hardware full inspection camera that will scan the printed material at a width of 130 [cm] at once. We have analyzed how to implement this camera on the machine, then how to take captures of images to software to make the image comparison on printed material. We have to do research for the best solution for this problem and the best practices. We have observed the process of how it will work practically after all installation and after everything is set up. In all those activities we are insured that finish in six months. Everything went well. Losses in the company have been brought to a minimum, only a few meters of length of plastic film per day. Also loss of color up to several grams per day. This has achieved not only the increase in productivity, profit, and safety of the company but also the ecological protection of the environment from plastic and chemical dyes!

11. Authors' contribution:

The first author of the research is Prof. Assoc. Dr. Ragmi Mustafa-professor at the Public University "Kadri Zeka" in Gjilan, Republic of Kosovo in the Faculty of Computer Science. The first author led the work at the "Flexograf" company in Gjilan. For six consecutive months, at the request of the company's management, it has been worked for two to three hours per working day with the operators of the “Flexoprint” machine and the two co-authors. Second co-author and manager of manufacturing quality, software, and hardware solutions Ph.D. Cand. Kujtim Mustafa, the software developer, has made a significant contribution to the scientific paper in question. The third co-author Ph.D. Cand. Refik Ramadani has been collecting information on similar car companies in the countries of the region all along. He also researched the literature on the global Internet, partner companies, target groups, and beneficiaries.

12. Conclusions

In this scientific work, it was possible to resolve:
1. Elimination of losses in the production of plastic film
2. Elimination of losses in chemical colors printed on plastic foil
3. Ecological protection of the environment in the Republic of Kosovo
4. Increasing production in printing images on plastic foil
5. Increasing the profit of the production company in question

Our partner too is a private company called Flexograf which operates in the city of Gjilan. They are a printing company that is the only one in the region that prints in flexible materials which can be used for

different purposes, for foods and beverages. In the printing inspection, there is a need to solve the problem, we have to make research and try to find the best solution for this problem.
The Target group is staff from the Faculty of Computer Science to learn how the theory can be implemented practically in the industry, so they have learned practical things about the industry how the image learned from computer graphics lectures comparison is made, and how they can implement software for this. The beneficiary groups are of course the academic staff who learn practical things and the private company for which we have found the solution.

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