Development, Installation and Commissioning of an OCR Verification System

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Abstract

Tetra Pak is a large scale organization that provides its customers with a food packaging solution based on laminated carton board in various package formats. The packaging material is produced in more than 50 converting factories represented world wide. The production develops the material in roll form that are loadable in the filling machines. Each roll arrives to the filling site with a barcode label that contains information about the order that was purchased by the customer. In this way the customers are able to identify the product and this process also allows the converting plant to trace the material. Any incorrect information on these labels is obviously unacceptable since the customer needs to be able to rely on that the data that is provided with the material is correct. If the information is not correct and the operator at the filling machine is not observant it is possible that the wrong product is filled with the wrong package design which can have severe consequences. The goal of this thesis was to find a technical solution to visually inspect the product and digitally compare it to the attached label. This solution would act as a barrier system in the downstream process and prevent rolls with the wrong information from exiting the plant and being shipped to the customer. By using lean manufacturing tools along with a team of operators and technicians, a solution was developed based on Optical Character Recognition technology to capture the order number and lane number of the product and compare it to the label. Thereby it will be possible to contain the defect material within the plant and prevent it from becoming a customer claim.

Introduction

Quality is today starting to play an increasingly important role within the supply chain of an organization. In order to maximize the production output and decrease losses, the industry is continuously pushing for a higher quality rate to meet these demands. Once an abnormality oc-

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curs and there is a defect on the product it is important to the company that this defect is detected before it is shipped to the customer to avoid them from claiming the material. When the impacting parameter has been targeted and a tolerated specification has been set, the factory can take further actions on how to make sure that this parameter is controlled within the allowed limits to avoid further quality issues. This project was carried out in the Tetra Pak Converting Process in Denton, Texas, United States. The plant receives raw material on large paper rolls from paper mills which is then printed with a customer design, laminated, slitted and the final packaging material is sent to the customer for filling. The final product is shipped on small/narrow rolls referred to as reels. Besides from the customer design, Tetra Pak also prints the order number of the product at the bottom of the design for traceability reasons. Once the reel is shipped to the customer, a label is applied on the outer wrap containing information regarding the product. This application process is today completely automatic and a label applicator receives data from a buffer, prints this information to the label and attaches it to the reel as it is traveling down on the conveyor toward the palletizing system. Unfortunately there are still ways for the labels to get mixed up due to abnormalities in the process and bugs in the buffers that have not been possible to resolve. If a product has the wrong label it might result in the wrong product being filled in the wrong package which will result in a claim for Tetra Pak. The worst case scenario is if the products are very similar but one of them contains an allergen which could have a huge negative impact on the individual and subsequently the business. Multiple attempts have been made to tackle the issue but it has not been possible to eliminate the root cause. In order to prevent the wrong material from reaching the customer the factory has been forced to have one operator on each shift manually inspect each label that passes and make sure it is correct. However, manual inspection is not always completely reliable and there have still been customer claims. The goal of the label verification system is to automatically inspect the printed order number on the reel using a visual inspection system and compare the result with the label information. If the information does not match the system should alarm the operators and allow them to manually correct the issue before the reel enters the downstream process.

Visual Sensors

The main idea of the solution is to scan the barcode on the label with an existing barcode scanner and then compare this data to the data captured by a visual sensor. It was decided to use cameras with Optical Character Recognition (OCR) compatibility to capture the order number printed on the packaging material. OCR is a technique to read machine printed text using a camera and then extract the text through a computer algorithm. It was necessary to utilize at least three cameras in order to be able to capture the printed numbers since the distance in between the prints will vary depending on the package type that is being inspected. A single camera's field of view was not large enough to compensate for all the sizes that were used. Cognex cameras were purchased to implement the solution since they are the official vision standard of Tetra Pak and contain a very user friendly programming environment. A physical model of the process was developed and can be seen in

Figure 1. In order to comply with the physical

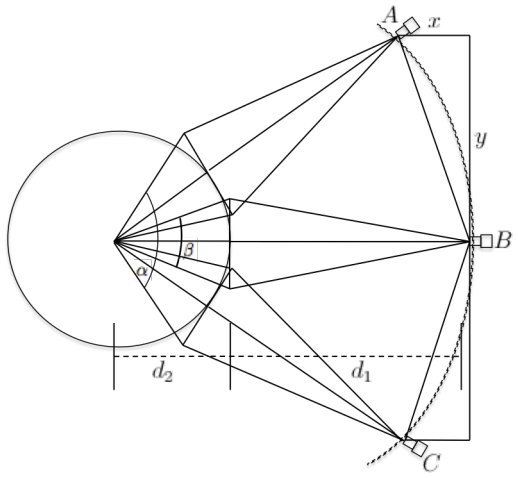

Figure 1: Physical model

limitations of the installation area it was necessary to determine the relationship between the measurement distance and the focal length of the cameras. This relationship can be calculated by the following equations:

$$Fl_{Height} = \frac{D_{Operation} * CCD_{Height}}{Obj_{Height} + CCD_{Height}} \quad (1)$$

$$Fl_{Width} = \frac{D_{Operation} * CCD_{Width}}{Obj_{Width} + CCD_{Width}} \quad (2)$$

where Fl is the focal length, $D_{Operation}$ is the distance between the camera and the product, CCD_{Width} and CCD_{Height} is the size of the sensor chip and the Obj values are measurements of the object. The focal length of the lens is the smallest value of Fl_{Height} and Fl_{Width}. The allowed distance between camera and product along with the recommended focal length were handed over to a automation supplier to allow them to create a complete system implementation for the plant. In addition to building a camera system it was also necessary to update the programable logic controller at the conveyor system to allow the process to listen for the results from the cameras.

Results

The label verification system was a very innovative project in many ways since label verification has never been attempted before within the converting process of Tetra Pak. The OCR vision technology has existed for a long time and is used in many branches within the company already but has never been adapted to serve this specific purpose. It was therefore hard to judge if the technique would be suitable for inspection of the packaging material text. The installation of the project went well and the system was up and running according to schedule but there were some initial issues when the main functionality was tested. Initially the target had been set to a reliability of 99.9% which was not possible to reach at first during commissioning. Once the reel was stopped firmly on the conveyor it caused the structure to vibrate which gave a fuzzy image that subsequently caused the image analysis to fail. The project team solved the issue by allowing for a 1.5 second delay in between the conveyor stop and the image being taken. In this way it was possible to minimize the vibrations. The cameras also utilized the height of the reel as a reference to determine the location of the order number. A contrast issue caused the cameras not to be able to determine the height which resulted in a "no read" when performing the scan. The supplier determined that it had to do with the tolerance settings and reprogrammed the camera algorithm to compensate for the problem. The finished implemented solution can be seen in Figure 2. When all the issues

Figure 2: Implemented Solution

had been corrected the system performed close to the targets and was handed over to the factory slitting department for supervision. Overall the project was a success and it was possible to utilize OCR for inspection on the reels.

Conclusion

A valuable conclusion from the project is that it is important to plan ahead, sit down and do a detailed master plan in the beginning of the project. Although it takes a lot of time and effort, the time that is spent in the beginning will be saved ten times over once the project picks up the pace. It is always important to have a good understanding of the technology that is being dealt with. The Tetra Pak plant in Denton did not have a lot of experience with Optical Character Recognition systems before as this technology had not been used in the factory until now. It was therefore hard to determine which features of our product could cause problems when trying to read the order number and lane numbers. It was found out at a late stage that the OCR technology used in the Cognex cameras is sensitive to manual diversions. Therefore a slight change in the appearance of the numbers can cause the system not to be able to read the information. The order and lane numbers are all machine printed but the orientation and location might vary from product to product since they are sometimes manually changed by the operator. It was therefore necessary to place a framework around the solution that allowed the system to compensate for deviations (a bypass) and a continuos improvement feedback system for the operators to inform the printers that a certain design is not to specification so it will be improved in the future. The statement of this thesis was to develop a vision based system to be able to measure the order number and lane numbers on the package and compare it to the label data and thereby prevent reels with the incorrect label to exit the process. This was achieved successfully by using the combined tools and resources that were granted to the team thereby proven to be possible to achieve using the power of OCR technology.