LABEL INSPECTION EMBEDDED SYSTEM

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In food, beverage and cosmetic packaging industry important issue for production quality is that the label is present, and that it is positioned correctly (as example on all of the produced and filled up bottles). There are different solutions in order to satisfy this requirement but the basic parts of the label inspection are almost the same. They are the objects of inspection (bottles), conveyor belt, source of light combined with optical sensor, embedded system and interface. The basic operational principle of similar inspection systems is that optical sensor received part of emitted light of the source. Based on the magnitude of the received signal the inspection system is possible to decide if the label is present and that the label is in correct position. In proposed embedded system TSL230 sensor has been used together with PIC microcontroller to detect label presence.

Keywords: Food, beverage, label presence, label sensor, TSL230

1. INTRODUCTION

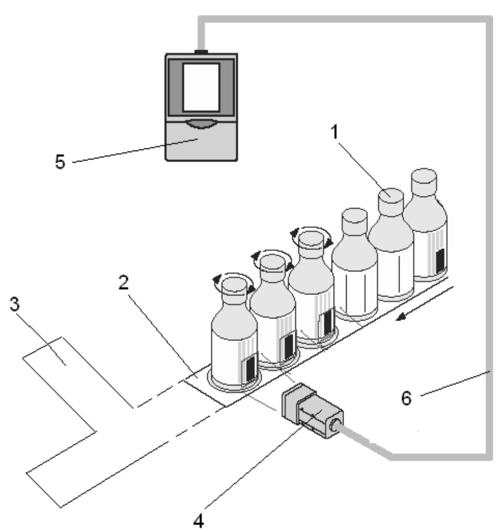

Fig. 1. Basic parts of the label inspection: 1 – inspected bottles; 2 – conveyor belt; 3 – empty place; 4 – source of light combined with an optical sensor; 5 – embedded system; 6 – interface.

In food, beverage, cosmetic packaging industry an important issue for the production quality is that the label is present, and that it is positioned correctly [7] (as example on all produced and filled up bottles). There are different solutions in order to satisfy this requirement but basic parts of the label inspection are almost the same. They are shown on fig. 1 [9].

The optical sensor for such inspection system is chosen depends on the label material and on color combinations. It may be an especially designed for this purpose sensor [7, 8, 10] or a smart sensor which combined two parts – sensor and microcontroller. The source of light may be infrared or visible light with green, red or blue color [10]. The basic operational principle of similar inspection systems is that optical sensor received part of emitted light of the source. Based on the magnitude of the received signal the inspection system is possible to decide if the label is presented and if the label is in correct position. There it is added additionally a so called 'empty place' in which are automatically put bottles with incorrect position of the label or bottles with a missing label.

A similar system which performs an additionally rotational alignment of the bottle is presented in [1, 3]. It uses a stepper motor with 400 steps for one full rotation.

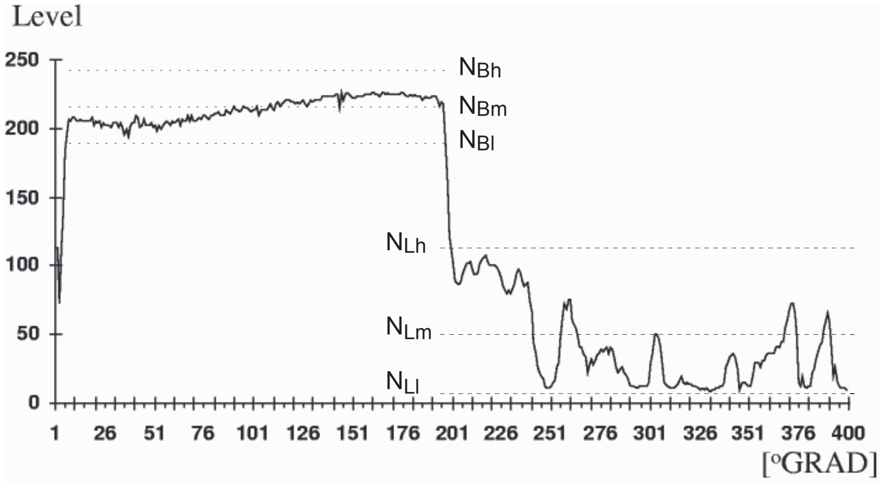

Fig. 2. Result of experiments with plastic bottle containing mineral water.

On the fig. 2 is shown result of experiments with 1.5 liter plastic bottle containing mineral water and with a label in blue color [1]. The light of the source belongs to the infrared area. In this case the label is a part of the whole bottle surface. The received signal from the label part of the bottle has a DC level, which is obviously different compare with signal received from the rest part of the bottle. The difference is due to two types of reflective surface – the one containing label and another one without label. On the X-axis of fig. 2 is shown the circumference l of the bottle in grad ($l = 2\pi r$, where r is the bottle radius). On the Y-axis is shown the level of the received electrical signal using an 8-bit analog-to-digital conversion. Bigger levels on the fig. 2 correspond to the lower degree of reflection. There missing label area is located between 1° and 200° grad. The label area is located between 200° to 400° grad.

2. LABEL INSPECTION EMBEDDED SYSTEM

Based on above mentioned result has been done label inspection embedded system. The circuit of proposed system is shown on the fig. 3.

The building parts of the label inspection system are:

1. D1 – infrared LED which is working in continues mode of operation. Changing the value of resistor R1 varies the irradiance of the emitted light from the LED. There is requirement for a good coefficient of voltage stabilization of the power supply unit in order to ensure stable emitted light irradiance (brown-out protection).

2. IC1 – smart optical sensor TSL230 (TAOS Inc.). Based on the received light irradiance it produces square pulses with exact period (frequency) [3, 11]. The building parts of the circuit is put in a small plastic box with black color (cut-off

visible light) in order to discard influence of the visible light irradiance.

3. IC2 – microcontroller. For experiments is chosen PIC16F88. It is a mid-rage PIC microcotroller [9] with FLASH RAM.

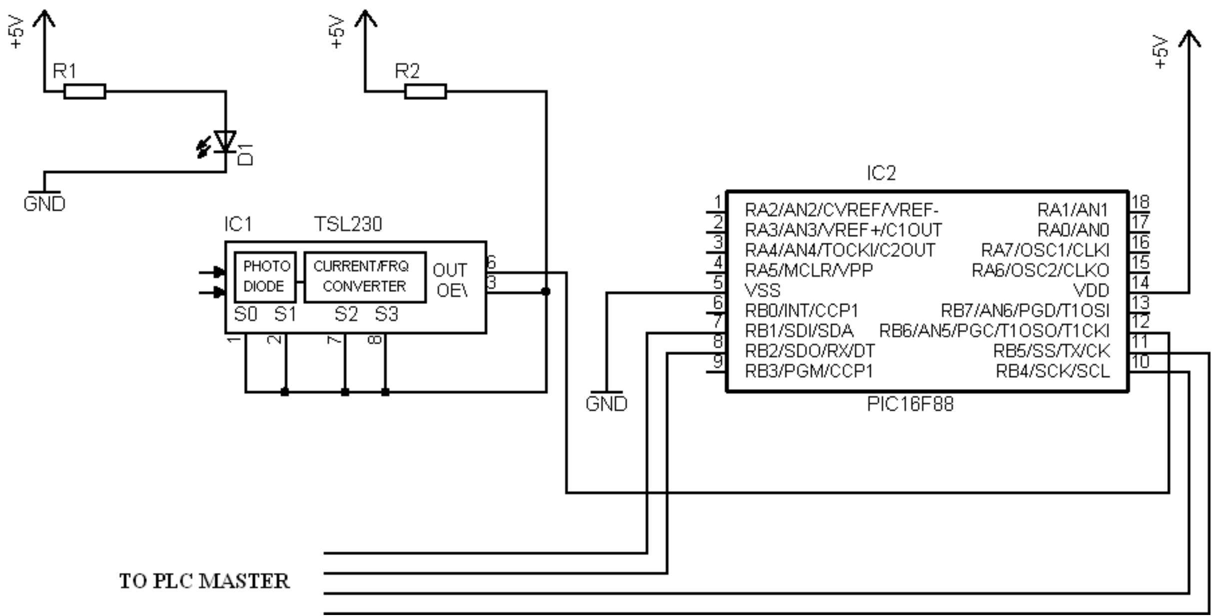

Fig. 3. Circuit of inspection embedded system.

Industrial controller of type SPVMATIQUE-5.X is applied as a master device. It is an advanced version of CONTROLER SPV-3.1 [4]. The communication between PIC16F88 and master device is realized using SPI interface based on four signals – Serial data in (SDI), Serial data out (SDO), Serial clock (SCK) and Slave select (SS) [10]).

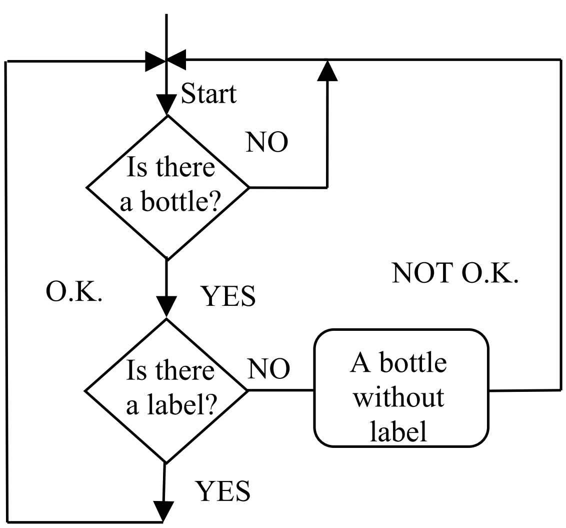

Fig. 4. Working algorithm of the label inspection system.

The working algorithm of the above mentioned system is shown on the simplified block diagram on fig. 4.

The measurement of the current light intensity, received by optical sensor, is done my frequency measuring (counting of number of pulses for a certain period of time). The pulses are registered by Timer1 module, part of PIC16F88, which is configured as a 16-bit counter. The correct number of pulses is determined after finishing of the measurement period, which is defined by Timer2.

On the basis of preliminary experiments for different types of bottles there are determined mean values of reflected IR light intensity for different zones – with label N_{Lm} and without label N_{Bm} (see fig. 2). Mean values are calculated because of some difference existing in reflection ability of zones with and without label. Another reason is that the normalized spectral sensitivity is varied depending of the light length changing [12]. The varying of the power supply also influences on the number of registered pulses.

Based on previously experimentally defined mean values, their limit values also are calculated – N_{Lh} and N_{Ll} for the label zone and N_{Bh} and N_{Bl} for the zone without bottle labels. The parameters N_{Lh}, N_{Lm}, N_{Ll}, N_{Bh}, N_{Bm} and N_{Bl} are stored in non-volatile PIC16F88 memory.

After label inspection embedded system starts work, a continuous IR light reflection measurement is done. Firstly, a check for a bottle presence is performed. The current irradiance value is compared with values, which belong to N_{Bh} till N_{Ll} interval. If a negative result is received, the inspecting system takes a decision that there is no bottle on the conveyor belt.

If the system detects a bottle presence, a new check it started in which the current value of the light irradiance is compared with values of the interval from N_{Lh} to N_{Ll} (zone with label). By this inspection the inspecting system determines if the bottle is with or without label.

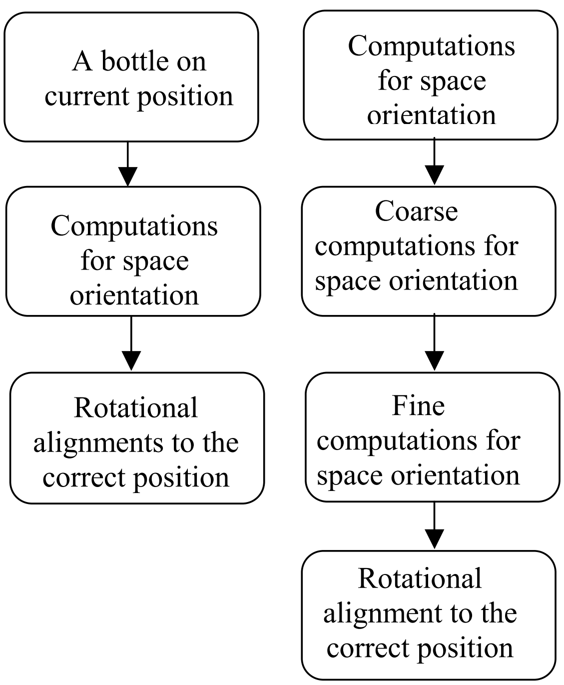

Fig. 5. Algorithm for current position of a bottle detecting and correcting.

If the inspecting system decides that the bottle is without label, it sends information to the master device using SPI interface. From its side master device send a command to the manipulator, which put the bottle without label in, so called 'empty place' (another conveyor belt). Parameters of the manipulator have to be tuned in order to provide a stable and correct work [4].

Together with the check for a bottle with or without label presence, the embedded system is tried to determine the beginning and the ending of zones with and without label. The starting point of the label is find using gradient or threshold [1] method. Lengths of zones are calculated by their corresponding periods of the time. This information is needed in order to correct the bottle position and to orient bottles together with the label in a previously defined direction. For this purpose an algorithm shown on fig. 5 is proposed.

We plan to continue work in this field in order to add additional function to the label inspection system. This function will detect current position of the bottle and eventually (if it is required) will correct it.

3. CONCLUSIONS

The prototype of the proposed label inspection embedded system is working properly. Proposed embedded system is a low-cost technical solution which with small changes is easily adopted for use of different type of bottles containing different types of labels;

We are going to improve the rotational alignment of the bottle using stepper motor. Another improvement we are going to do is to include an algorithm of self-instructing for automatic determination of irradiance level values for different kind of bottles.

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