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Position Control and Optimization Using the Electronic Circuit Module with the Rotary Encoder

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Control measure the gap between the work rolls is very important in the production of paper boxes. The problem is that the gap and its surrounding is full of the disperse glue and the distance of the rolls as one of the gap characteristics predetermines the amount of the glue that is applied to the paper during the box production. Precise setting the distance that is based on accurate measuring is not possible during the process using the previous mechanism. Therefore electronic measuring devices were applied using the magnetic rotary encoders on both ends of the rolls. Magnetic rotary encoder enables to detect the accurate real position of the rolls at any moment of the process. The processor, as a part of the electronic device, was programmed in assembler to read the values from the sensor MAB28, to recalculate the values into the real size of the gap between the rollers and send the data to be expressed on LCD. The data received using the measuring technique is expressed in the graph. Statistical methods prove the linearity of the mutual dependency that means continuous and accurate method for displaying of the setting options.

Keywords: Control, Rotary Encoder, Electronic Circuit Module.

1. INTRODUCTION

The paper boxes, which are produced in the factory, are made of paperboard cutouts which are then stuck together with dispersion glue. Dispersion adhesive is applied to the board so that it passes through a narrow slot between the rolls. Amount of the glue directly influences the bond strength of the paper boxes, therefore it is very important to determine and set up the proper size of the gap. Control measure the gap between the work rolls is managed using the electronic devices with the application of the magnetic rotary encoders on both ends of the rolls.

The machine for the paper box production that was described in [1] has specific construction in the part with the cylinders coating of the dispersion adhesives. It allows larger opportunity to mount the sensor into the space between the components of the machine therefore it was possible to use the long screw in the function of and

rack pinion to convert the motion into the linear dependency using the electronic device.

The principles and methodology to increase the accuracy and overcome the robustness of CMOS smart magnetic rotary encoder are used in [4]. The principles allow absolute angle detection and high resolution and practically precision construction of small size and also acceptable cost. Hall Effect sensor and its technical application is described in [8] in connection with various kinds of digital transducers.

The algorithms for optimization the processing time is introduced in [6] and power flow in [2]. Optimization with modelling of permanent magnet linear synchronous motor shows [9]. Modelling is based on experiment with the motor testing. Accuracy of calibration system for rotary encoder is solved in [3].

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Rotary encoder from the view point of acoustic signals and the importance of their optimum quality in human-machine-interfaces is investigated in [5]. The rotary decoder is used also in [7] but for a motion of a mechanism of a robotic arm. The system is controlled using a PID controller.

2. METHODOLOGY USED IN OPTIMIZATION OF POSITION CONTROL

Gap size could not be measured from the outside during the operation due to safety and handling problems. Another problem for the measuring process is that both the area around the gap and gap itself are filled with circulating dispersion glue. Therefore and also for another construction practical reasons the solution for determining the size of the gap was only possible inside.

Dimensional and positional reasons predetermine the use of the magnetic rotary encoder MAB28. This magnetic rotary encoder with the installed precise shaft and the return spring are rotated using the Kevlar fiber with the diameter of 0.45 mm. The actual magnetic rotary encoder is placed on a duralumin angle flange which is fixed to additional support made of steel. The design respects the specifics of the internal mechanism of the machine.

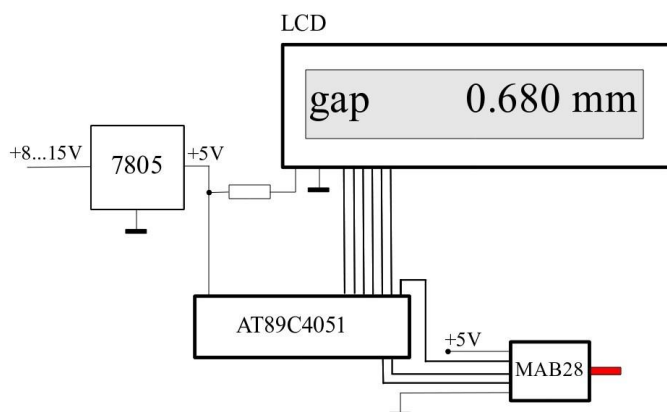


Fig.1. Block diagram

Microprocessor is a major part of practical measuring system for this machine. It reads the data from magnetic rotary encoder MAB28. The data are relevant to absolute mutual position of the rolls. This data are processed and displayed on LCD. Stabilizer type 7805 provides accurate power supply of 5 Volt for all components.

3. MEASURING DEVICE DESCRIPTION

The pulley on the magnetic rotary encoder has a groove diameter of 19mm. That is, with respect to the diameter of Kevlar fiber, the stress of the fiber bending is negligible and therefore it has a great potential for long-term stability and functionality of the device. In this practical application 800 pulses are used from the magnetic rotary encoder on the required stroke of the measuring equipment. This means that in the practical

range of the distance from zero to one millimeter between the cylinders, the resolution is on the 800 steps. So in theory one step indicates $1/800 = 0.00125$ mm. In practice, there was demonstrated satisfactory stability of the measuring device.

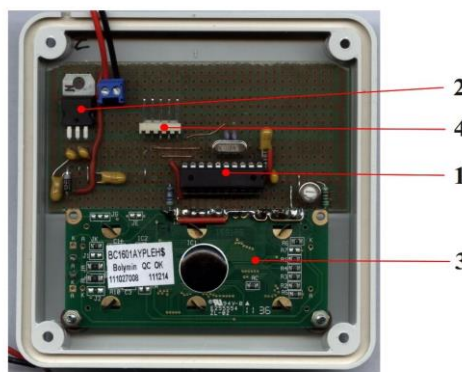


Fig.2. Interior view of the electronics for both signal processing and display from the magnetic rotary encoder MAB28.

- 1 ... Microprocessor AT89C4051,
- 2 ... 5V stabilizer LM7805,
- 3 ... LCD display,
- 4 ... connector for magnetic rotary encoder.



Fig.3. View of the display placed on a covered facility expressed in Figure 2.

Facilities are located in tight dimensional possibilities of mechanical parts at the actual magnetic rotary encoders, so it was important for their choice to use such sensors, which have high accuracy, very good mechanical strength, while the small size. Therefore, the selected sensor was MAB28.

In practice, the spacing for a given machine is usually adjusted in the range of from 0.15 to 0.35mm. Of course during the cleaning of machine is also used setting to zero or opening to 1mm.

Dispersion adhesive is applied through the gap on the paper in the whole width during the manufacturing process. That is, the coating thickness must be adjustable on both sides of the cylinder.

Thickness gauge is used in the form of a control strip. The device provides an indication of real space on each end of the cylinder on the machine.

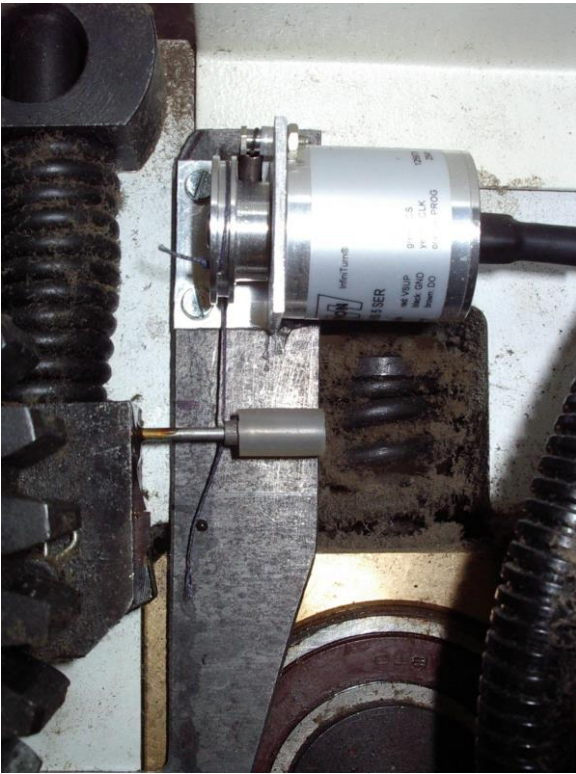


Fig.4. View of the location of the magnetic rotary encoder and its connection to measure movement using the Kevlar fiber.

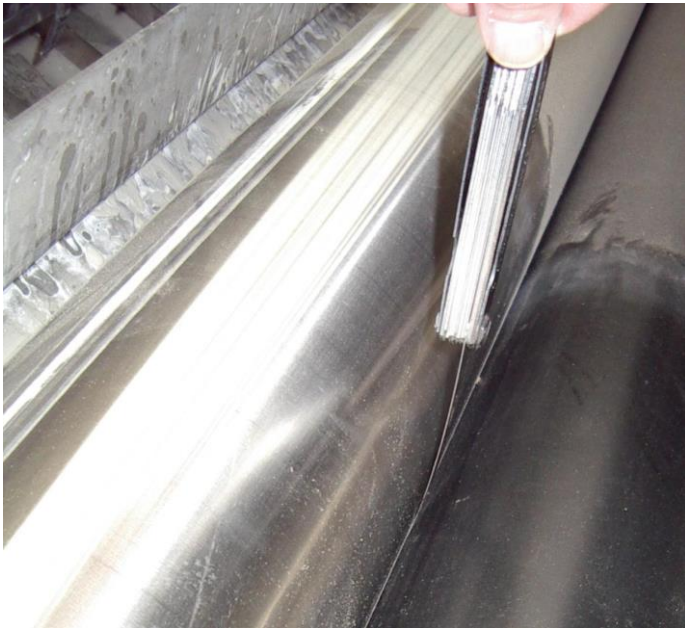


Fig.5. Checking the gap setting using a control strip as measuring instrument.

4 PROGRAMMING APPROACH

The program was written in assembler '51 type for communication of processor with magnetic rotary encoder MAB28.

;reading encoder MAB28
position:

```
mov Ubyte,#0      ;initial values
mov Lbyte,#0     ;initial values
```

```
setb P3.5
clr P3.4
nop                ;micro pause
clr P3.5
mov r7,#8
clr a

pst1:
;first cycle of 8 bites
clr P3.5
nop                ;micro pause
setb P3.5
nop                ;micro pause
mov c,P3.7
rlc a
djnz r7,pst1
mov Ubyte,a
mov r7,#8
clr a

pst2:
;second cycle of 8 bites
clr P3.5
nop                ;micro pause
setb P3.5
nop                ;micro pause
mov c,P3.7
rlc a
djnz r7,pst2
;16 cycles, plus 2 extra cycles
clr P3.5
nop                ;micro pause
setb P3.5
nop                ;micro pause
clr P3.5
nop                ;micro pause
setb P3.5
nop                ;micro pause
;+ zero setting
setb P3.4
;movement
anl a,#11110000b
swap a
mov Lbyte,a
mov a,Ubyte
swap a
anl a,#11110000b
orl Lbyte,a
mov a,Ubyte
swap a
anl a,#00001111b
mov Ubyte,a
ret

;choice of orientation direction of sensor MAB28
jnb P3.0,zac3
clr c
mov a,#255
subb a,Lbyte
mov Lbyte,a
```

```

        mov a,#15
        subb a,Ubyte
        mov Ubyte,a
    zac3:
;limiting the scope
        mov a,Ubyte
        jnb acc.3,zac2
        mov Ubyte,#0
        mov Lbyte,#0
    zac2:
        mov phor,Ubyte
;postponement
        mov pdol,Lbyte
;division two
        mov a,Ubyte
        clr c
        rrc a
        mov Ubyte,a
        mov a,Lbyte
        rrc a
        mov Lbyte,a
;division two
        mov a,Ubyte
        clr c
        rrc a
        mov Ubyte,a
        mov a,Lbyte
        rrc a
        mov Lbyte,a
;[Ubyte,Lbyte] = [Ubyte,Lbyte] x 1,25
        clr c
        mov a,Lbyte
        addc a,pdol
        mov Lbyte,a
        mov a,Ubyte
        addc a,phor
        mov Ubyte,a
    
```

So first, followed by the display on the LCD, and thus generate a small 100 milliseconds pause due to a stable display on the LCD. While micro pause type "nop" is 1 microsecond.

5. ANALYTICAL APPROACH TO THE OPTIMIZATION

Analytical part comprises processing the data obtained during the measurement. The Table 1 shows the three sets of values as experimental results:

Gap in millimeters corresponds to real distance of the rolls obtained in measurement using the control strip as measuring instrument (Figure 5). The parameters for the gap were set from the interval < 0; 1> in millimeters, with the step of 0.05mm. The control strip allows such step as connection of a few pieces according to the purpose.

"Display" as a set of data in Table 1 expresses the values which are obtained using the magnetic rotary encoder. They are also processed by the microprocessor

and displayed on LCD as the result of our research work.

Table.1. Experimental Results.

	Gap [mm]	Display	Indicator
1	0	0	0
2	0.05	0.05	0.9
3	0.1	0.101	1.5
4	0.15	0.145	2.1
5	0.2	0.182	2.7
6	0.25	0.227	3.2
7	0.3	0.301	4.32
8	0.35	0.346	5.88
9	0.4	0.415	6.8
10	0.45	0.471	7.5
11	0.5	0.517	8.2
12	0.55	0.567	8.9
13	0.6	0.607	9.5
14	0.65	0.68	10.5
15	0.7	0.73	11.15
16	0.75	0.79	12.07
17	0.8	0.85	12.82
18	0.85	0.91	13.62
19	0.9	0.966	14.5
20	0.95	0.997	15
21	1	1.003	15.1



Fig.6. Indicator

"Indicator" as a set of the data in Table 1 expresses the distance on adjusting arm in the machine. The adjusting arm is a component, which is situated directly in front of the magnetic rotary encoder. The arm as adjusting screw represents a real movement in the machine. The resulting

value is expressed by the indicator as shown in Figure 6. The indicator, with the resolution of 0.01mm is connected with the machine only during the experiment. The movement of adjusting arm is a basement for the information expressed on LCD after the processing with the microprocessor.

The experimental results are expressed in Figure 7 and Figure 8.

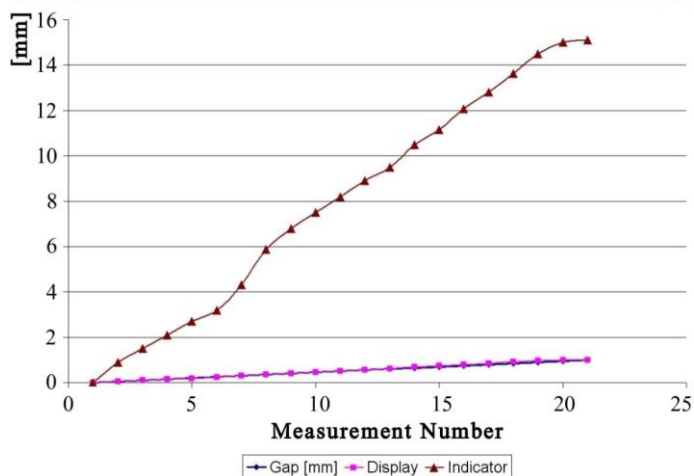


Fig.7. Graphical representation of the values related to Table 1.

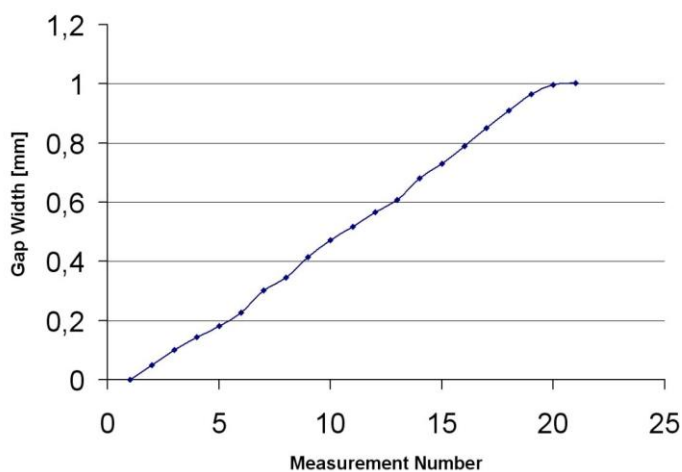


Fig.8. Graphical representation of the gap width as it is displayed on LCD.

The linearity of the values as they are displayed on LCD:

$$y = 0.0531x - 0.0667$$

$$R^2 = 0.9977$$

where

x ... measurement number,

y ... the value of gap width as the rolls distance displayed on LCD.

The index of determination shows the satisfactory value.

6. CONCLUSIONS

The designed system is linked with the finding [1]. It shows the way how to solve the problem with the setting the proper distance between the rolls with the gap for the application of dispersion adhesives on the paperboards during the box production in the specific conditions of narrow space in the machine in comparison with [1]. Experimental testing with the measuring equipment formed the base to coordinate the electronic equipment with application magnetic rotary encoder MAB28 on both ends of the cylinders. The analytical approach with the application of statistical methods proves the linearity of the mutual dependencies, which means satisfactory result of the research.

The individual gap setting is important especially for specific regulations in dependency on the type of the paperboard and the nature of the contract. The invented system guarantees the setting repeatability also after the process of cleaning rollers when they are separated by a distance. So the system allows retrying setting the same adhesive layer and a long-term, stable, accurate effect at an acceptable cost.

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