Abstract: The processes of food industry have remarkably progressed in the quality control and various analyzers are employed in the progress processes. This paper describes how to identify the liquid flowing in the pipeline by multi-sensor fusion method. Here, we present a method that employs three different sensors to identify and discriminate the various liquid and different densities.

Keywords: liquid identification, pipeline, multi-sensor fusion.

1. Introduction

Efficiency improvement of processes by introducing the contentious process strategy has been main interests in the process industry and the various researches associated with this field have been carried out. To improve the efficiency, the automatic inspection of the raw materials and products and automatic control are prerequisite. These automations cannot be realized without using analyzers. The food industry is not out of the scope. The standard HACCP (Hazard Analysis Critical Control Point) and GMP (Good Manufacturing Practices) have been introduced in many food industries. The quality control required to satisfy the HACCP and GMP can be quantitatively carried out by introducing the analyzers. Especially, the washing processes of the plant equipments are prerequisite and the improvement of efficiency of the processes yields total efficiency.

In the conventional approaches, optical sensors and the electric conductivity sensors are independently used to analyze and/or identify the liquid kind and density. However, the sensor is not always sensitive for the objective liquid and to prevent such the situation, many sensors with different gain are set along the measuring site. This fact yields new problem in the cleaning process even the new CIP (Cleaning In Pipe) by chemical method is introduced.

Here we present a method which combines two different sensors, i.e., the electric conductivity sensor and the optical sensor for the purposes. The optical sensor detects the turbidity of the liquid and the electrical conductivity sensor detects the conductivity of the liquid. The kind of the liquid and the density of the liquid are instantaneously identified and estimated in the On-Line manner by these two sensor outputs. The conductivity is strongly influenced by the liquid temperature and thus the temperature compensation is required. Thus, the thermometer is also set.

2. Problem descriptions

The problems considered in this paper are as follows;
(P1) How to acquire the sensor outputs in the wide range?
(P2) How to identify the variety of liquids and estimate the density with very different values?
(P3) Verify the method by experiments?

3. Measuring and Analyzing System

The system is consisted of two parts (1) sensor parts and (2) signal processing part.

3.1 Sensor part

Here we consider Problem (P1).

3.1.1 Optical sensor to detect the reflection from the liquid

Infared optic rays are applied to the liquid and detect thereflected
rare is detected. The amount of the reflection is determined by the turbidity of the liquid. The turbidity is proportional to the particle density and the light reflection rate of the particle. The optimal angle to transmit the light and the receiving reflected light is determined experimentally in the sense that the optical system has maximum gain. The selection of the optimal angle leads to detect the amount of optical refraction in the wide range. Fig.1 shows the optical sensor and its signal processing.

### 3.1.2 Electric conductivity sensor

The electric conductivity changes depending on the materials. The conductivity is measured by the ratio of the electric current flowing in the liquid and the feeding voltage. The amount of the electrical currents changes in the very wide range. In order to adapt to the change, we employed a log-amplifier. The employment of the log-amplifier resolves Problem (P1) in the measurement of the electrical conductivity. The AC voltage is used to avoid the polarization of the liquid. Electrode to detect the conductivity is one which satisfies the sanitary specification as shown in Fig.2 which shows how to the signal is processed.

![Conductivity sensor and signal processing](image1)

### 3.1.3 Thermometer

Since conductivity is strongly influenced by the temperature, a thermometer must be prepared to compensate the conductivity data. Further, the output of the thermometer shows the temperature of the liquid in the pipeline.

### 3.2 Signal Processing Part

Problem (P2) is considered. The microprocessor H8 is used as the hardware of the signal processing. All the data from the three sensors are A/D converted into the CPU of the processor and identified and estimated. The outline of the signal processing is shown in Fig.3. In the first, the liquid is classified into the output signal level by the optical sensor. In the second stage, the roughly classified liquid is precisely classified into the output signal by the electric conductivity sensor.

![Algorithm for identify liquid](image2)

### 3.3 Measurement system

The measurement system is given by combining the two elements above. Fig.4 shows the outline of the system. The set of sensors generates the output signals and are transmitted to the A/D converter and identify the kind of liquid and the density by the signal processing in Fig.3. The system contentiously identifies and estimates the kind of liquid and density in the On-Line manner.

![Experimental system](image3)

Also, to manage RS232c-port in microprocessor H8, transmit the data which detected from A/D-port to PC in order to keep at On-Line. This process make possible to always monitor every sensor at real time.

### 4. Experimental Verification

#### 4.1 Sensor outputs

First, the outputs from the three sensors are obtained for the liquid of the purified water, the tap water, the 100% milk, 20% milk, 40%milk, 60% milk and 80% milk. The outputs for each liquid are shown in Fig.5 and Fig.6. Fig.5 shows the output from the electric conductivity and the optical sensor then all temperature is fixed.
20°. Fig. 6 shows the changes in the conductivity when the liquid temperature changes for each liquid.

From the data in Fig.5, the liquids above can be clearly discriminated and identified. The change in the electric conductivity by the change in the temperature can be compensated by the relation in Fig.6.

### Table 1 Estimation result from 10 to 40 °C

<table>
<thead>
<tr>
<th>Target</th>
<th>Temperature °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purified Water</td>
<td>10 20 30 40</td>
</tr>
<tr>
<td>Tap Water</td>
<td>10 20 30 40</td>
</tr>
<tr>
<td>20% Milk</td>
<td>10 20 30 40</td>
</tr>
<tr>
<td>40% Milk</td>
<td>10 20 30 40</td>
</tr>
<tr>
<td>60% Milk</td>
<td>10 20 30 40</td>
</tr>
<tr>
<td>80% Milk</td>
<td>10 20 30 40</td>
</tr>
<tr>
<td>100% Milk</td>
<td>10 20 30 40</td>
</tr>
</tbody>
</table>

5. Conclusions

The problem considered here is (P1) how to acquire the sensor outputs in the wide range? (P2) how to identify the variety of liquids and estimate the density with very different values? and (P3) verify the method by experiments?

Problem (P1) is solved by the optimal angle selection of the photo-sensor and the employment of the log-amplifier for electric conductivity sensor. Problem (P2) is solved by employment of the microprocessor and developing the proper algorithm. The system with the three above elements was realized and verification experiments were carried out. The milk with 20%, 40%, 60%, 80% and 100%, the purified water and the tap water were clearly identified.

6. References

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