Development of a Filling Sauce Equipment System for Fish Canning Industry

J. Panjamadisorn, P.Kittisupakorn

Abstract- **This work studies development of a filling sauce equipment system for a fish canning industry. A filling sauce process is necessary for fish canning industry. The aim of this work is to design and devise filling sauce equipment; consisting of a filling sauce device and a refill sauce storage tank. This type of the tank when using in a sauce filling step causes fluctuations of sauce flow rate into cans. This leads to the possibility of sauce overflow or deficit. In addition, when the hole sizes of a filling sauce device are inappropriately designed, this results in fluctuating of sauce filling into cans. Therefore, this work introduces an approach to overcome the difficulties by adding another tank to maintain the level of the sauce in the feeding tank first. Then, the filling sauce device is properly designed. With this approach, the sauce loss can be reduced by about 84.2 % per day or the saving of sauce is 24 litres per day. The payback period is less than 9 months. Consequently, this work is applicable to decrease any sauce loss filling into cans in other canning industries.**

Index Terms— **fish canning, canning industry, filling sauce, filling sauce equipment**

I. INTRODUCTION

At present a food canning is effect to lifestyle. Because, having comfortable to eat, low price and can be kept for a long time. Food canning is needed highly for the market, once is fish canning. Therefore, fish canning industry was established mostly in the short time. However, in depressing economy materials are expensive. So the budgets of products also are increasing. If there is not effective in process of fish canning that it would be made the budget highly and certainly make benefit decrease. Therefore, cleaner technology (CT) is necessary to help to reduce the budget of production such as water, electrical, and energy loss of process. For the reducing quantities of sauce loss in fishing canning is very importance. Because, some fish (sardines) canning factory in Thailand have been surveyed a filling sauce process. Found that cans with sardines are filled with sauce using rotary sauce filler and Cans may not be completely filled or overfilled, hence at The factory station, sauce is manually removed or added into the cans by using tablespoons. Because the level of sauce in storage tank cannot be control.

This method of a factory makes a lot of quantities of sauce loss which is very expensive. Therefore, reducing and optimizing quantities of sauce loss is requested.

For researchers to develop a liquid filling system: Process and apparatus for metering and introducing a liquid into packaging containers [1]. Liquid filling system with improved fluid displacement, nozzle and container handing, cleaning, and calibration/set-up capabilities. An improve method and apparatus for a liquid filling system is herein disclose incorporating mean for generating greater overall production rate efficiencies(i.e. number of filled container per minute per filling station) [2]. Apparatus for the simultaneous filling of precise quantities of viscous liquid material to a plurality of containers in a sanitary environment. The invention to provide such an apparatus with working component that are cleanable-in-place (CIP) [3].

The objective of this work to develop a filling sauce equipment system by design a sauce filler and level control sauce in the tank to minimize quantities of sauce loss in the process and to minimize washing-up liquid in cleaning process.

II. FISH CANNING INDUSTRY

Fish canning involves several standard manufacturing process including fish preparation, canning, retorting, and packing. However, several variation exits between tuna canning and sardine canning. For the purpose of this work, the following processes will be focused of discussion with Sardine canning. Sardine canning involves the following processes: receiving, cutting, washing, can filling and pre-cooking, sauce filling, seaming, retorting, and packaging [4]. Figure 1 shows the process flow diagram. In the sauce filling: sauce can either be brine, tomato sauce, tomato sauce with chilli, and oil.

Prior to sauce filling, sauce is prepared by mixing all ingredients in the sauce kettles. Sauce is cooked for 1.5 to 2 hours at around 50°C. One cooked, sauce is pumped into the storage bin of the sauce filling equipment. Cans with sardines are filled with sauce by using a rotary sauce filler. Cans may not be completely filled or overfilled. hence at the factory station, sauce is manually removed or added

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into the cans by using tablespoons. Each can should have at least 6 millimeter headspace to prevent bulging of seamed cans due to overfilling

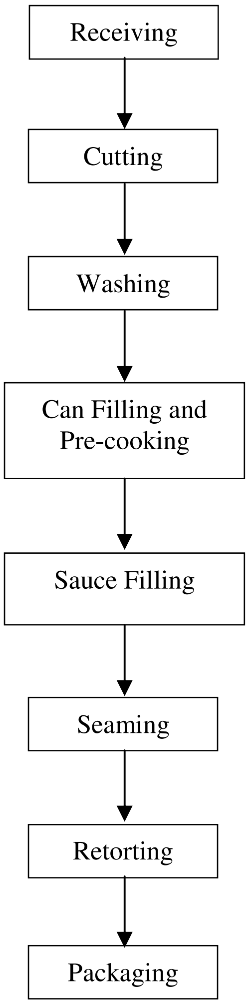

Fig. 1. Sardine canning process flow diagram.

III. BERNOULLI EQUATION

Mathematical models can be derived to predict the efflux time. The principles to be applied are [5]:

A. Conservation of mass
B. Conservation of energy

The equation of continuity for an incompressible fluid can be written as:

$$\frac{dv}{dt} = Q_{in} - Q_{out} = v_a A_a - v_b A_b \qquad (1)$$

Where Q = volumetric flow rate (m^3/s), v = velocity (m/s), and A = area normal to flow (m^2). v_a and A_a represent the velocity and cross-sectional area of the tank while v_b and A_b represent the velocity and area for the tube. In order to predict the behavior of the system under different condition, the energy equation can be used between two point, a and b.

$$\frac{P_a}{\rho g} + \frac{v_a^2}{2g} + z_a = \frac{P_b}{\rho g} + \frac{v_b^2}{2g} + z_b = cons\tan t \qquad (2)$$

Where P = pressure (Pa), z = elevation from a chosen datum (m), g = gravitational acceleration (m/s^2), and ρ = density (kg/m^3). The first three terms on either side of this equation give the pressure head, velocity head, and elevation head respectively at the top of fluid head (a) and the outlet of the tube (b). The

IV. DYNAMIC MODEL OF EXPERIMENT

The purposes of this experiment is to study behavior of liquid flow rate as a function of time at the difference hole sizes of filling liquid device compare with mathematical result. The apparatus, shows in Fig. 2, consisting of pipe cone. The dynamic model and assumption of the experiment can be written as

- The physical properties, density of liquid to be constant
- Pipe is smooth, Friction loss are neglected

$$\frac{dh_1}{dt} = \frac{1}{A_1}[-q_1] \qquad (3)$$

$$\frac{dh_2}{dt} = \frac{1}{A_2}[q_1 - q_2] \qquad (4)$$

From a mechanical energy balance, or Bernoulli equation [6], [7]

$$q_1 = A_1\sqrt{2gh_1} \qquad (5)$$

$$q_2 = A_2\sqrt{2gh_1 + h_2} \qquad (6)$$

and

$h_1\,(t)$: the level in the cylindrical shape;
$h_2\,(t)$: the level in the section 2;
$q_1\,(t)$: the flow rate in the cylindrical shape;
$q_2\,(t)$: the flow rate in the cone shape;
g: the gravitational constant;
A_1: the cross-section area in the cylindrical shape;
A_2: the cross-section area in the cone shape;

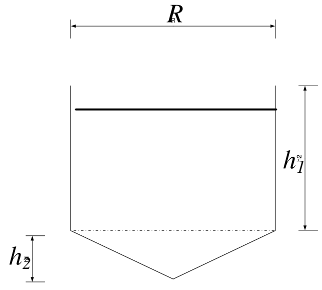

Fig.2. Apparatus of experiment.

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From simulation result the height (h) vs. time (t) plot shows in Fig.3 was exhibited that the time increasing, the height of liquid was decreasing. And the time was increasing; the liquid flow rate was decreasing at the difference hole sizes shows in Fig.4.

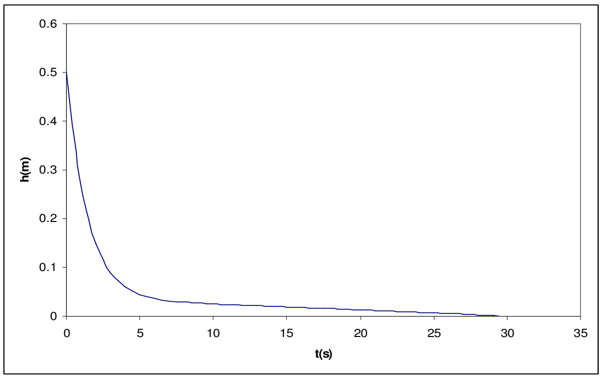


Fig.3. Relation between heights vs. time of apparatus from experimental

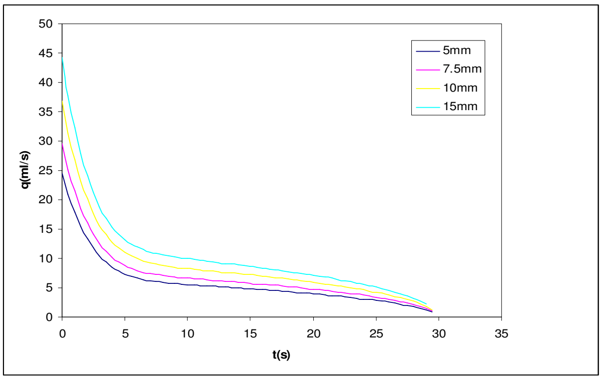


Fig.4. Relation between flow of liquid at a difference hole sizes

V. DESIGN OF FILLING SAUCE DEVICE

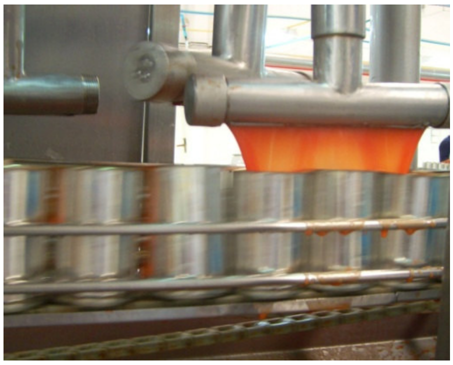
For design of a filling sauce device have to consider and realize of material specific for food and cost.

Procedure for design of filling sauce device

1. Measuring quantities of sauce wastage by random in a cycle shows in Figure 5.(a)
2. Design of filling tomato sauce device. From simulation result by hole size is 7.5mm,10mm,and 15mm shows in Figure 6
3. Measuring quantities of sauce wastage by random in a cycle for new apparatus shows in figure 5. (b)

(a)Before (b) After

Fig. 5. Measuring quantities of wastage sauce



(c)

(d)

Fig.6. Filling sauce device(c) Before (d) After

The new hole sizes of filling sauce device will minimize the sauce loss by 84.2% and also reduce washing-up liquid in cleaning process shows in Table 1

Table 1: Quantities of sauce loss and washing-up liquid

List	Unit	Before	After	Quantity for safe
1.Quantity of sauce loss	g/can	1.9	0.3	1.6
2.Quantity of washing-up liquid	l/can	1/1,000	1/1,500	1/3,000

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VI. SYSTEM OF TWO STORAGE TANK

The normal system of filling sauce step, there is only one tank and 3 filling sauce devices (for 1 line of step) which has been made of stainless steel, that it is very difficult to control the level of sauce in storage tank. To control the level of sauce in storage tank, this work was designed the refill sauce storage tank connection to the normal sauce storage tank to control level sauce in tank.

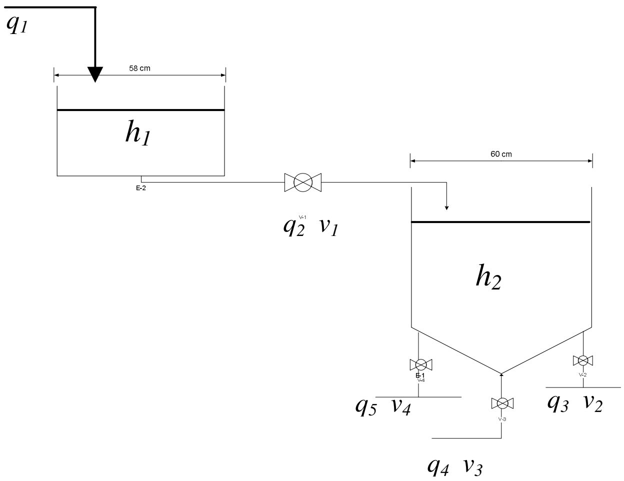

Fig.7. two liquid storage tank systems

The purpose of this study is to control level in normal sauce tank. The apparatus, shows in Fig.7, consisting of normal sauce tank and one more refill sauce tank. The dynamic model [8] and assumption of the experiment for open v_1 and v_2 can be written as

- The physical properties, density of liquid to be constant
- The level of liquid in tank1 is always greater than 0 cm and less than 40 cm
- The level of liquid in tank2 is always greater than 0 cm and less than 70 cm
- The level of liquid in tank 1 is always greater than tank 2
- The desired level of liquid in tank2 is deemed to be not lower than 26 cm (> volume at cone shape) for all t >0
- Pipe is smooth, Friction loss are neglected

$$\frac{dh_1}{dt} = \frac{1}{A_1}[q_1 - q_2] \qquad (7)$$

$$\frac{dh_2}{dt} = \frac{1}{A_2}[q_2 - q_3] \qquad (8)$$

From a mechanical energy balance, or Bernoulli equation [6], [7]

$$q_2 = c_{v1}\sqrt{h_1} \qquad (9)$$

$$q_3 = c_{v2}\sqrt{h_2} \qquad (10)$$

and

$h_1\,(t)$: the level in the tank 1;
$h_2\,(t)$: the level in the tank 2(cylindrical shape);
q_1: the flow rate in the tank1;
g: the gravitational constant;
A_1: the cross-section area in the tank1;
A_2: the cross-section area in the tank 2(cylindrical shape);
c_{vi} : valve coefficient in various valve

Each of valves (v_1, v_2, v_3, v_4) has non-linear characteristic. The valve coefficient depends on corresponding height in tank and the vale coefficients are estimated from flow of liquid and level measurement. Fig.8 shows flow of liquid vs. height plot and Fig.9 shows valve coefficient vs. height plot from experimental data for v_2

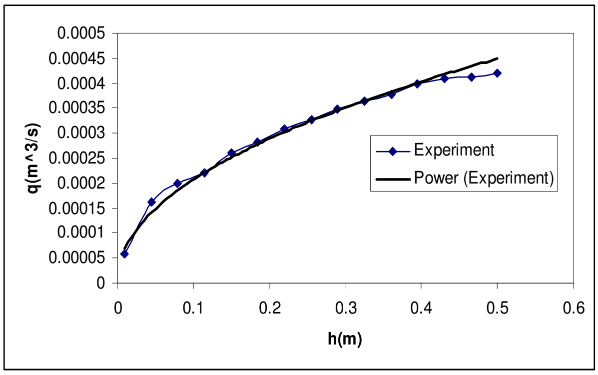

Fig.8. Relation between flow of sauce and height

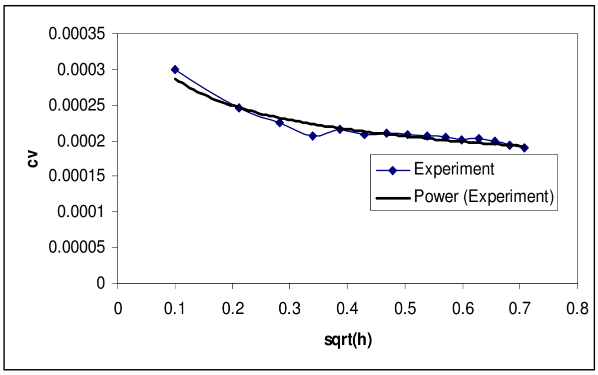

Fig.9. Relation between valve coefficient and height

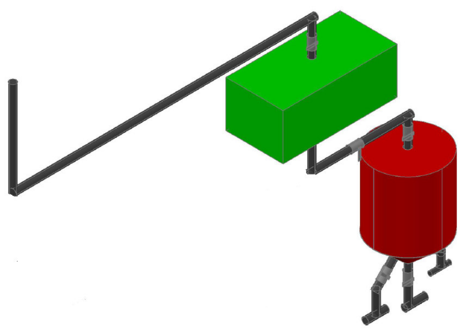

Fig.10. two sauce storage tank systems (3 D)

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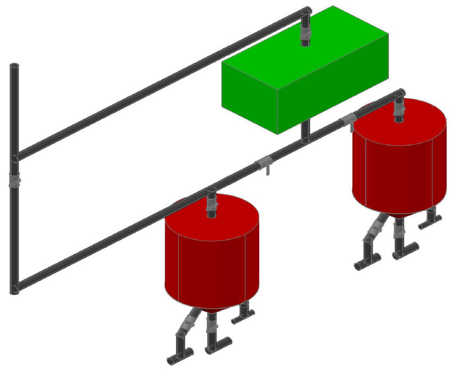

Fig.11. overall sauce storage tank systems (3 D)

VII. CONCLUSION

A normal sauce storage tank is made of stainless steel with the volume of 180 litres. This type of the tank when using in a sauce filling step causes fluctuations of sauce flow rate into cans. This leads to the possibility of sauce overflow or deficit. In addition, when the hole sizes of a filling sauce device are inappropriately designed with respect to the change of level (pressure) in the tank shows in Fig 10-11, this promotes the variation of sauce filling into cans. Therefore, this work introduces another tank to maintain the level of the sauce in the feeding tank first. Then, the filling sauce device is properly designed to give the exact amount of desired sauce filling subjecting to the level defined in the filling tank. With this approach, the sauce loss can be reduced by about 84.2 % per day or the saving of sauce is 24 litres per day and. The payback period is less than 9 months. Consequently, this work is applicable to decrease any sauce loss filling into cans in other canning industries

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