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DYNAMIC BEHAVIOR OF MASS MEASUREMENT SYSTEM USING LOAD-CELL – EFFECT OF PARTIAL LOAD DISTRIBUTION –

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Abstract: This paper discussed behaviors of a mass measurement system with a load-cell type. The goal of this paper was to explore a dynamic behavior of the system with consideration of partial load distribution depending on the place of the product. In this paper, we obtain time responses for step response while the product is put on the place with three patterns on the conveyor. Moreover we analyze the frequency responses based on the step responses with FFT. Consequently, we found that the dynamic behavior may change for the product location on the conveyor.

Keywords: Mass measurement, Dynamic behavior, Partial load distribution, Load-cell type.

1. INTRODUCTION

Mass measurement is significantly important for performing inspection and distribution with good accuracy. Recently a high-accuracy and high-speed mass measurement system of packages moving the conveyor belt operated at high speed, so-called the checkweigher, has been getting more important in the food and logistics industries etc. To achieve the high-speed (continuous) measurement, packages should be moved in sequence. It means that the measuring time for one package is very short. In the near future, the continuous mass measurement for 300 products per minute will be required.

In general, load-cell type system with sophisticated signal processing or mass measurement has been widely used. In order to achieve more accurate mass measurement, strict model for real factory and more effective signal processing with the model are required. Until now, some models and signal processing methods have been proposed [1]-[4].

The method of the mass measurement is divided into two types; namely “Static” or “Dynamic”. Static mass measurement can be performed by sensing the displacement of the system at steady state. After that the mass value can be estimated from the displacement with the calibration of a relationship between the displacement and the mass value. With this method, the measurement time may be long until a steady state is reached. On the other hand, the dynamic mass measurement can be achieved by estimating the mass from the transient response of the system. Since the mass value is estimated from the system response, the measurement time can be shorter. Recently, the dynamic mass measurement is highly required to high-speed mass measurement for the working efficiency.

In the dynamic mass measurement with the previous model, there exist problems to be discussed: weight distribution due to the product position, motor rotation for feeding, and floor vibration. Thus we deal with the weight distribution in this paper.

Typically, the weight distribution is considered to not affect the mass measurement of a system with the Roberval mechanism. However, these factors give an error of the mass measurement. Generally, the Roberval mechanism is achieved by the closed link mechanism with parallel rectangle, then a variation of the displacement by the weight will be able to be vanished. Although this theorem can be applied to only the front view of the system as shown in Fig. 1., the Roberval mechanism is not functioning properly in the depth direction of the system. Thus we explore whether the response of the system depends on the weight distribution. As a result, we clarify that an entirely new dynamic model of the mass measurement system with consideration of the weight distribution is strongly required for dynamic mass measurement with high-speed and high-accuracy.

In the future, we will propose a new model with consideration of the weight distribution. Also we compare simulation results with experimental results to verify the effectiveness of the proposed model.

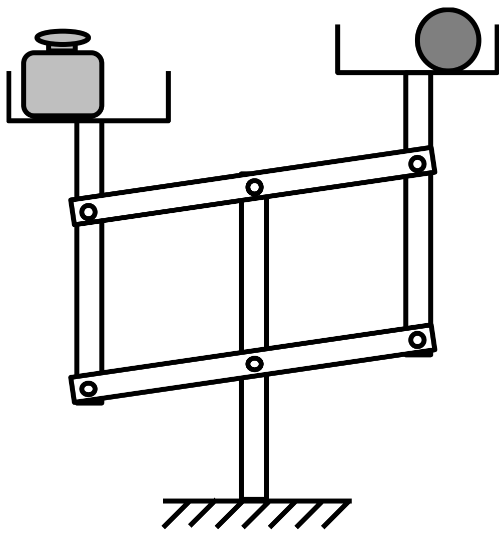
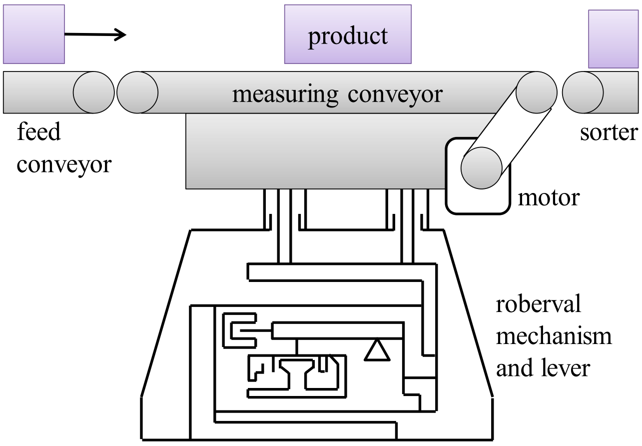
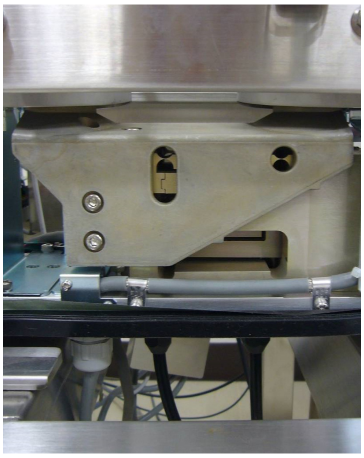


Fig. 1 Roberval mechanism



(a) Overview



(b) Photograph of Roberval mechanism

Fig. 2 Mass measurement system with load-cell type

2. MASS MEASUREMENT SYSTEM

Fig. 2(a) and (b) show the illustration of the checkweigher and The enlarged photograph of the mass measurement mechanism in the checkweigher, respectively. The feed conveyor is located in the left of the measuring conveyor and the sorter is located in the right. The products are moved by the feed conveyor, the mass of product measured by measuring conveyor and the product out of the measurable range is removed by a sorter.

The mass measurement system consists of weighing platform, the Roberval mechanism and the displacement sensor. The mass of the product is estimated from the displacement of the Roberval mechanism. By applying the Roberval mechanism to the measurement mechanism, the mass of the product can be measured even if the product locates in everywhere over the weighing platform. However, the error between the real mass value and the estimated mass value by the conventional method occurs in fact. Consequently, a new dynamic model, which is different model with the previous model (only mass-damper-spring model), is strongly needed. In this paper, we show that the different responses in case of the change of the product location on the conveyor can be obtained in the real mass measurement system as shown in Fig. 2.

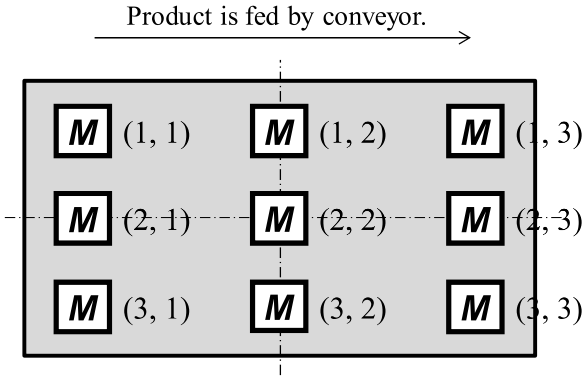


Fig. 3 Experimental condition from top view

3. EXPERIMENT

3.1 Experimental condition

In order to explore the effect that the weight distribution has on the mass measurement system, the time response of the system for the step input is obtained in which the product is puts on the conveyor with 9 patterns as shown in Fig. 3.

Because of the Roberval mechanism, we assume that the effect of the weight distribution in each column is not measurable whereas the effect of the weight distribution in each row is measurable.

In this section, we show the time responses and the frequency responses based on the time responses of the experimental results for the step inputs to the system. Five experiments at each location are executed.

In the initial state, the product (M = 0.5 kg) is put on the conveyor, and the mechanical balance at steady state is hold in horizontal position. At any timing, the product is removed instantly. As a result, the step responses, in which the input is equal to 0, can be obtained.

3.2 Time Response

Fig. 4 shows time responses of step inputs for the system. In Fig. 4, three experimental results are described in each sub figure, and (a), (b) and (c) correspond to each product location (1, 1), (2, 2) and (3, 3) as shown in Fig. 3.

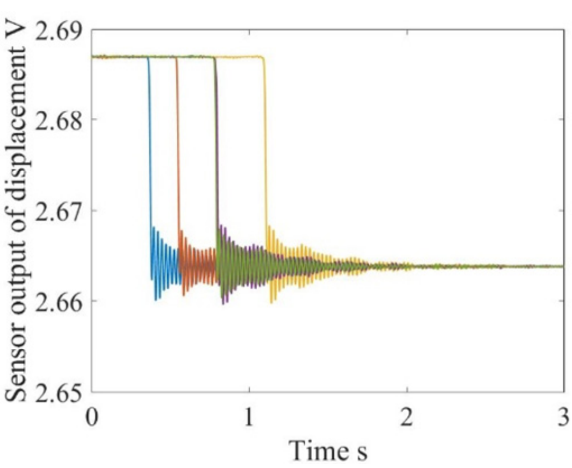
The different step responses for step input to the system can be obtained. In particular, we found that the amplitudes of the responses are different.

3.3 Frequency Response

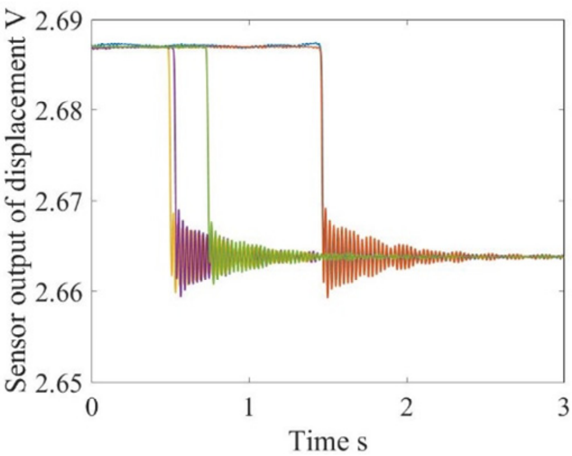
Fig. 5 shows frequency responses based on the step responses as shown in Fig. 4. In Fig. 5, the frequency responses for all experimental results are shown in each sub figure, and (a) – (c) correspond to (a) – (c) in Fig. 4.

From these results, the vibration mode has 2. Especially, the second vibration model is accentuated in third row as shown in Fig. 5(a) – (c).

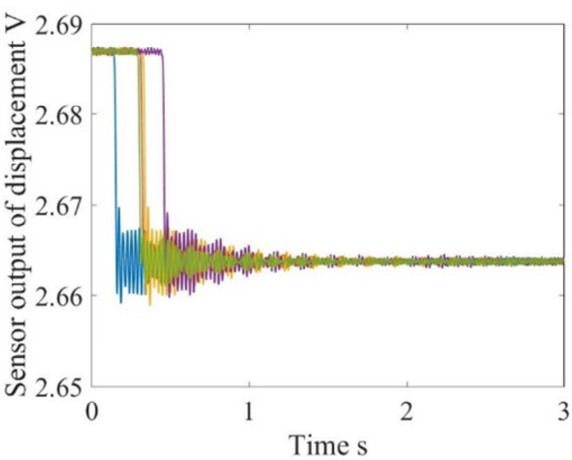
The natural frequency of the system is considered to be about 38 Hz. In addition, the second mode appeared the third row as shown in Fig. 5(c). In Fig. 5(c), the third mode (50 Hz) is considered to be the power electric noise.



(a) (1, 1)

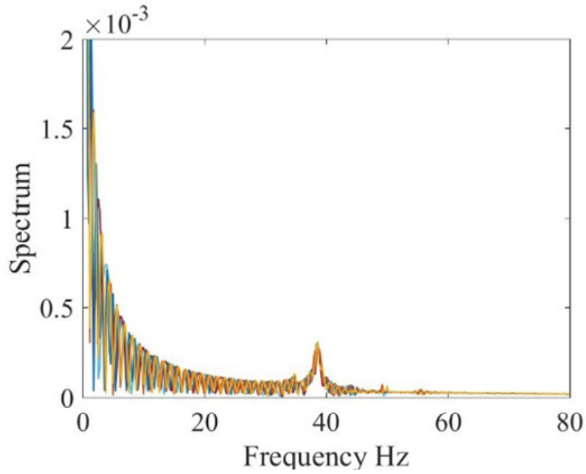


(b) (2, 2)

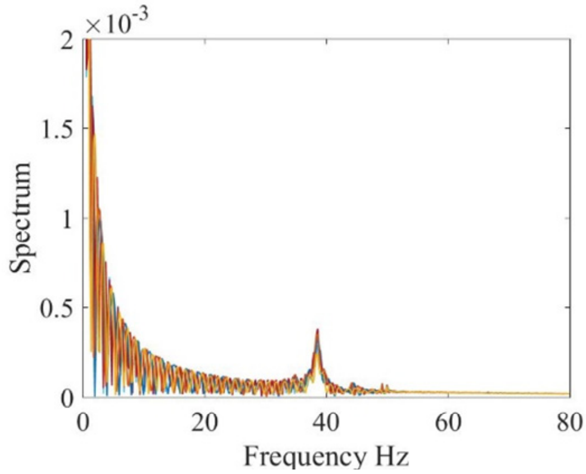


(c) (3, 3)

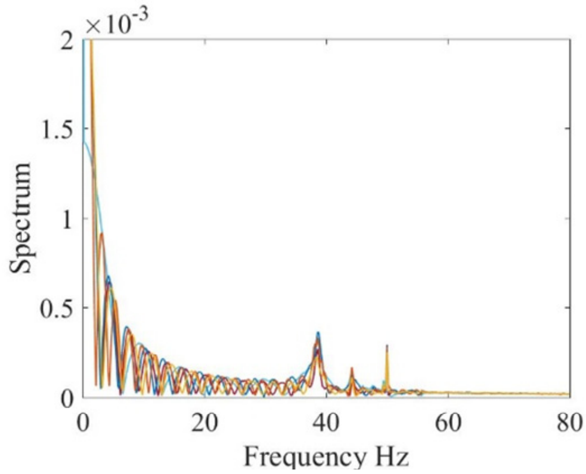
Fig. 4 Time responses of experimental results



(a) (1, 1)



(b) (2, 2)



(c) (3, 3)

Fig. 5 Frequency responses of experimental results

4. CONCLUSION

In this paper, we discussed the reason of the error about the mass measurement due to the product location of the system. Thus we explored the step responses and the frequency responses based on the step responses of our mass measurement system. As a result, we found that the both responses are different in the product location. This means that a new dynamic model of the system with consideration of the weight distribution is strongly required.

In the future, we will propose the dynamic model with consideration of the weight distribution. Then we will compare the simulation results with the experimental results, and we will also confirm the validity of the proposed mode.

5. REFERENCES

[1] Ono T., "Basic point of dynamic mass measurement", Proc. SICE, pp. 43-44, 1999.

[2] Ono T., "Dynamic weighing of mass", Instrumentation and Automation 12, No. 2, pp. 35, 1984.

[3] Lee W.G. et al., "Development of speed and accuracy for mass measurements in checkweighers and conveyor belt scales", Proc. ISMFM, pp. 23-28, 1994.

[4] Kameoka K. et al., "Signal processing for checkweigher", Proc. APMF, pp. 122-128, 1996.