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Microcontroller Based Multihead Weigher

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Abstract

Objectives: This paper aims at designing a system of 5 hoppers where sum of weights is calculated for each combination of 3 of 5 hoppers. When any sum equals target weight then hoppers responsible for that sum will be drained to the packaging system. **Methods:** A multi-head weigher is a weighing machine which is fast, accurate and reliable. It is used for packing both food and nonfood products. The multihead weigher continuously feeds product into array of weigh hoppers. The computer system determines which combination of hoppers is matching most closely to the target weight. Then these hoppers release their contents into the packaging machine. **Findings:** Industrial grade microcontroller is used for the decision purpose. The results shows the feasibility of using multihead weigher for fast and accurate packaging operations. **Applications/Improvements:** The proposed technique is useful in the parallel weighing machines. It has wide applications in the packaging systems.

Keywords: Hopper, Microcontroller, Multi-head Weigher, Packaging System

1. Introduction

A multihead weigher is a weighing machine which provides fast, accurate and reliable operation[1]. It is used in the packaging industries for packaging of food as well as nonfood products. In the year 1972 Ishida invented and developed the world's first multihead weigher and launched it into the food industry across the world[2]. The new upgraded models of multihead weighers are suitable for any product type including ready meals, meat, poultry, fish and salads[3,4].

Previously a single-headed weighing machines were used in the packaging industries. Those machines have only one load measurement sensor attached to only one head. The product is collected from the container into the hopper till the target weight is met. Once target weight is achieved, that hopper used to release the product to the dispenser for packaging purpose. In this case, at a time the item is collected only in one hopper and packaging system has to wait for the target weight to achieve. So it is somewhat slow process. Multihead weigher resolves this issue of speed. Probably multihead weigher is used in the batch production process[5]. In multihead weigher the array of hoppers is used. Each hopper is connected with the weight measurement sensor separately[1,6]. A product is fed continuously to all the hoppers in the system. The computer in the system continuously observes the weight of each hopper and calculates the sum of weights of m of n hoppers (m < n). When the target weight is achieved by the combination of m hoppers, at that time those m hoppers will release the product collected by them. The released product is then passing on to the packaging system. The product passed on for packaging has the most possible accurate weight compared to the target weight. After releasing the product for packaging the multihead weigher starts its next iteration. During this iteration, (n - m) hoppers contain product collected in previous iteration. So the time for completing this iteration is very less since very less weight need to be added to achieve the target. In this way the iterations goes on implying the drastic increase in the speed of operation compared to single-headed weighers. Since each hopper is connected with a separate weight measurement sensor accuracy becomes one of the main characteristic of the multi-head weigher system[1].

US Patent No. 6566613[7] describes a high speed control

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system for combinational weighing, compromising of central processing unit that is connected to the weighing peripheral modules through its low speed serial port. US Patent No. 4694920 to[8] describes a control system composed of at least three central processing units which are used to control the acquisition of the data from the load cells, motors and vibrating feeders and the dischargers. This architecture increases electromagnetic interference along with the system cost. US Patent No. 5981881[9] considers a single processing unit which is connected to the weighing modules by Local Area Network (LAN). In this case a high speed LAN is the requirement of the system. But The use of high speed LAN itself increases the system cost. US Patent No. 6830476[10] deals with the provision of simple and low cost distribution unit that eliminates wiring problem. US Patent No. 8076596 to[11] describes the design of weighing cell and a holder for the cell. US Patent No. 8648266[12] describes force measuring module and a method of operation of the force measuring device for the multiple forces measuring device (multi-head weigher). US Patent No. 9217661[1] deals with the correction of errors occurred during the multi-head weighing. US Patent No. 20150051807[13] describes the method for food packaging system in order to optimize the products weighing. It also describes the apparatus and software design for the system. US Patent No US9234787 [14] provides the method of improvement of the sanitary conditions of the weigher[15] provided the method of optimization of the multi-head weighing process with the unequal supplying to the hoppers. The algorithm deals with the minimization of the difference between the target weight and the real weight and maximizing the total priority of the chosen combination[16] focus on the configuration problem of multihead weigher considering the cost functions. It also presents an algorithm to select the average weight for the hopper using Response Surface Methodology and multi-hear simulator[17] describes the method for compensation of environmental vibrations in the load cell measurements of multi-head weigher[18] used the Kalman filter based technique to measure the weights of the object moving with known speed. US Patent No 9194735[19] proves the method of optimal initialization of the weighing machine.

This paper describes simple architecture of the measuring hopper and an algorithm for the system operation.

The complete paper is organized as follows. Section II describes the principle of multihead weigher. Section III deals with the hardware design of the system. Section IV is the main component of the paper that describes the Algorithm for multihead weigher. Section V describes the working of the designed system. Section VI provides the results and Section VII concludes the paper.

2. Principle of Multihead Weigher

Let us consider a multihead weigher system with 6 hoppers A,B,C,D,E and F as shown in Figure 1.Target weight is 500 gm.

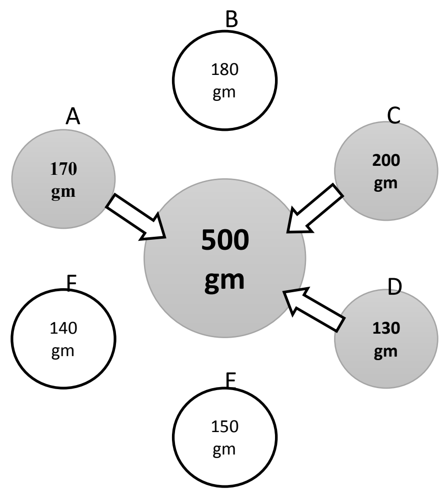

Figure 1. Principle of multi-head weigher.

Here n = 6 and we are considering m is 3 i.e. all the possible of combinations of 3 of 6 hoppers are under observation. Here 20 (6C3) combinations are possible. When system starts product starts feeding to all the hoppers with the help of dispenser. Dispenser is nothing but a vibrator or a rotating disk which provides force to the product to go into the hopper. A separate weight measurement sensor is attached to all hoppers which continuously measures the weight of the product in the respective hopper and provide the measurement result to the computer. Computer monitors in parallel all the 20 possible sums.

Let here consider at some instant of time, after starting the system, the weights of the product in the hoppers A,B,C,D,E and F are 170 gm, 180 gm, 200 gm, 130 gm,

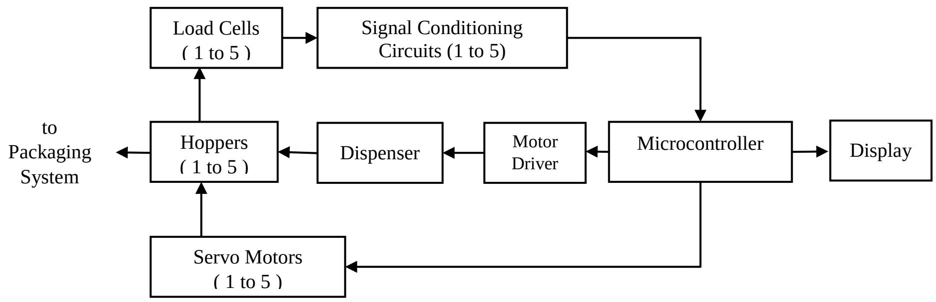

Figure 2. Block diagram.

150 gm and 140 gm respectively. Computer continuously monitors the sums and at an instant found that hoppers A, C and D combine leads to the weight of 500 gm which is the target to be achieved. Hence hoppers A, C and D are to be drained.

3. Hardware System Design

Here we have considered a system with 5 hoppers. Each hopper is connected with the separate load cell to measure the weight, a separate servomotor is connected to each opening door of the hopper. Block diagram of the designed system is as shown in Figure 2.

3.1 Hopper

A hopper is a mechanical structure used to collect the product from dispenser. The designed system consists of five hoppers of equal dimensions and arranged in a pentagonal shape. Figure 3 shows a structure of hopper unit. A hopper consists of two parts fixed structure and rotating structure. Fixed structure is fixed at point E and Rotating structure is just pivoted at point D. A servo motor is providing at the pivot point to provide the motion to the structure. The rotating structure is connected to the load cell as shown by dotted line G. Planes denoted by B, C are open planes of the structure where as others are the closed planes.

Vibrations are provided to the dispenser to move to the product on the dispenser into the hopper. A simple DC motor is used to generate the vibrations. The time for vibration is controlled by the microcontroller. The dispenser feed the product into the fixed structure of the hopper.

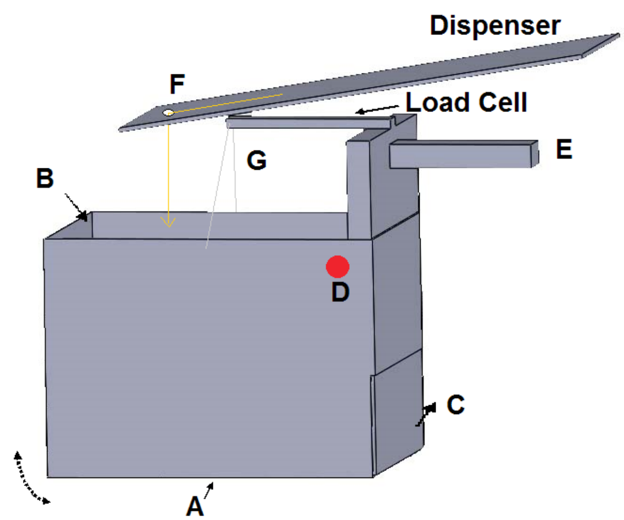

Figure 3. Hopper Unit.

3.2 Load Cell

Load cell is a weight measurement sensor. Beam type load cell is used in this project. A separate load cell is connected to each hopper. An output of a load cell is a voltage signal of very low strength but it is in linear relationship with the weight applied. To increase the strength of the output signal it is passed through the high gain instrumentation amplifier. And then the amplified signal is applied to the microcontroller unit.

3.3 Servo Motor

Servo Motor is used because of its high torque and speedy response compared to other types of motors. It is used to rotate the outer structure. Outer part is connected to the servo motor at the pivot point i.e. point D.

4. Software Design

Software design is an integral part of this project. To perform multi-tasking and the operations with time constrains a real time kernel is used for software implementation. Separate task is used to measure the output of load cell so that output measurement becomes a parallel process. The measured output values are stored in a global variable.

The sum of the weight of each possible combination of 3 of 5 hoppers is calculated in separate task so that sum calculation is also becomes a parallel process. Each sum is monitored in the respective task for the target weight. When the target weight is achieved in any one task then the motors connected to the hoppers responsible to achieve the weight are powered on so the product in the hopper is released to the outlet.

4.1 Algorithm

- Start vibrations
- Continuously read the weights of the hoppers in separate tasks and store in global variables.
- Continuously calculate the sum of weights of each possible combination of 3 of 5 hoppers in separate tasks and in each sum calculating task
    - monitor the sum
    - when it equals the target weight
        - raise the flag if not raised else continue from step 3
        - stop vibrations
        - drain the resulting hoppers
    - when the hoppers becomes empty, close the hoppers and change the status of the flag.

5. Working

A product is fed onto the dispenser panel. Due to vibrations the product starts falling into the hoppers. Load cells continuously read the weights and provide it to the microcontroller unit. Microcontroller calculates the sum of weights of each possible combination of 3 of 5 hoppers using a real time kernel. When the sum in any one task is equal to the target, at that point a flag is raised if it is not raised by any other task before. If flag is already raised by other task then execution will escape from that loop and starts again. And if flag is not raised by any other task then flag is raised and vibrations to the dispenser are stopped so that product stops falling into the hoppers. Motors connected to the hoppers responsible for achieving target weight are powered 'ON' so that the hoppers responsible for achieving target are drained to the outlet line. When the hoppers become completely empty then motors are powered 'OFF' flag is reset and vibrations are once again started and the loop continuous.

6. Results

A prototype of the desired multihead weigher system is designed and developed. A cardboard and plywood is used for mechanical construction whereas a cortex-m series microcontroller programmed using real time operating system kernal is used for software design. With the help of developed system weights are measured and noticeable increase in the speed of weighing is observed compared to the single-headed weighing system.

7. Conclusion

In this paper a brief description about microcontroller based multihead weigher system is discussed. The results also show the feasibility of using multihead weigher for speedy weighing operations. There may be possibility of more than one combination of hoppers that can achieve the target weight but here only one combination is considered; the performance of the system can be increased by considering more than one such combination so that more than one outlets are possible. During the experimentation it is observed that load cell measurement are affected due to the environmental vibrations. Thus the performance can again be improved by designing the filters to counter effect the vibrations on load cell measurements.

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