WEIGHT CONTROL OF DUAL SUPPLIES USING THE DEVIATION OF THEIR CENTER OF MASS

HP INC
**Weight control of dual Supplies using the deviation of their center of mass**

**ABSTRACT**

The invention disclosure presented here describes a method for measuring the mass of two different Ink/Agent Supplies, or any other supply depending the application, using the displacement of their combined center of masses. This is done using only two separated force sensors, such as load cells, allocated at the sides of the two supplies.

With this invention the number of force sensors is reduced from typically four per Supply to just one, which simplifies design, reduces cost and improves reliability.

1. **PROBLEMS SOLVED BY THIS INVENTION**

   When trying to know the amount of material left in any kind of Supply is very difficult to measure it with precision, especially when considering supplies with liquids such as Ink/Agent Supplies. This is due to the fact that the only way to know exactly the amount of material inside a Supply without requiring access to the interior of the Supply is by measuring its mass. However, this is complicated since typically a good weight measure requires four sensors allocated around the object to ensure the mass is centered. This leads to high cost and complexity.

   Furthermore, the disclosure now described does not require to have access to the interior of the Supplies, which avoids having unnecessary components. Besides, the sensors inside the Supply would be otherwise scrapped when the Supplies are finished. Thus, previous methods increased Supply's costs.

   When the Supplies are measured using indirect methods such as accounting of the material used via software, the error of the data obtained is much higher than previous examples, up to 20% in some cases, meaning it cannot be used to take actions based on that information.

2. **PRIOR SOLUTIONS AND THEIR DISADVANTAGES**

   Prior solutions for detecting the amount of material left in a Supply can be separated in two categories: direct methods and indirect methods.

   Direct methods include those systems that measure a physical property of the Supply to know the amount of material remaining in it. The first one used previously in the industry consist in measuring the mass of the Supply with many force sensors, from a minimum of two sensors per Supply to typically four sensors per Supply. The reason for having many sensors for each Supply is that the center of mass of the Supply must be centered respect to the array of sensors, since the forces supporting the Supply must be distributed to them. As it can be seen, this traditional method of using force sensors require many sensors for knowing the mass of one single Supply, which is expensive and adds complexity to the design.

   Another direct method used in previous printers is to have a level sensor of the Supply inside the Supply itself. This system has been used in several Ink Supplies in the past, especially with electrical level sensors and mechanical switches. The main disadvantages of these solutions are two. Firstly, the sensor component inside the Supply is scrapped when the Supply is finished; hence it increases the cost
of the Supplies. Secondly, they can only detect when the Supply is finished, but are not precise enough to control and monitor all the intermediate states of the Supplies level; in other words, they can only say Supply empty or not empty.

On the other hand, indirect methods try to determine the amount of material inside a Supply using calculations and other metrics with indirect relation to the Supply state. In some printers this is done by using the Drop Counting algorithm. This solution is based on the calculus the printer’s software does to know how much ink has been fired through the PH’s nozzles, which is then subtracted from the Supply ink accounting. Nevertheless, the Drop Counting has a very big error, usually around 20% of the Supply’s used ink.

3. DESCRIPTION OF THE CONSTRUCTION AND OPERATION OF THE INVENTION

The invention presented in this disclosure consists in a system for measuring the mass of two different Supplies using only two force sensors e.g. load cells, this is a single force sensor for measuring the mass of each Supply. This is done by placing a single support holding both Supplies, which is then attached to two force sensors, each one at the side of the assembly. By doing so, the forces of the two Supplies weights are distributed to the sensors.

Depending on the mass of each Supply, the combined center of masses (Weight Total in Figure 1) will be displaced to one side or the other, resulting in a different force measured by each sensor.

![Figure 1: Forces diagram](https://www.tdcommons.org/dpubs_series/1359)

With this information the displacement of the combined center of masses can be analytically modeled in order to determine accurately the exact weight of each individual Supply, as seen in Figure 2. The equations shown in Figure 2 describe the balances of forces and momentums needed to calculate the Supplies’ weights, where W1 stands for Weight of Supply 1 and W2 for Weight of Supply 2.
5. ADVANTAGES

The main advantages of this invention are the following ones:

- Only one force sensor per Supply is needed to know exactly the mass of each Supply.
- High precision. The force sensors allow to know the weight of the Supply, which is a very precise solution for detecting how much material is left inside the Supply at any given moment. Compared to Drop Counting that has 20% error, this invention has an error below 5%.
- Low cost. Compared to other solutions where typically four force sensors are required to measure the Supply's mass, this invention uses much less sensors, reducing the cost of the system.
- Versatility. The solution presented in this disclosure has been initially developed to detect the amount of ink/agent in a Supply, but it can be used for any other Supply e.g. powder, cleaning water, waste material, etc., widening the spectrum of applications.
- Improved diagnosticability and reliability. Since less sensors are needed, the system is easier to diagnose and less likely to have faulty components compared to more complex solutions.

$W_1 + W_2 = R_1 + R_2$

$W_1 + W_2 = \frac{R_2 \cdot l}{l_T} \quad l_T = \frac{R_2 \cdot l}{R_1 + R_2}$

$W_1(l_T - l_1) = W_2(l_2 - l_T)$

$I_T = \frac{R_2 \cdot l}{R_1 + R_2}$

$W_2 = \frac{(R_1 + R_2)l_1 - (R_1 + R_2)l_T}{l_1 - l_2}$

$W_1 = R_1 + R_2 - W_2$

**Figure 2: Forces and momentums equations**

*Disclosed by Carlos Chover, Rodrigo Alvarez and David Butinyà, HP Inc.*