FINAL TRANSLATION

HIGH-PRECISION CONTINUOUS VOLUMETRIC POWDER FEEDERS

KAWATA MFG. CO. LTD.

1. Introduction

Volumetric powder feeding is an essential operation used in powder processing. There are various types of powder feeders, such as screw feeders and table feeders, as well as oscillating feeders and rotary feeders. However, the range of powders that each type of feeder can accommodate is narrow, so a feeder must typically be selected according to the various powder characteristics such as particle size, adhesion properties, and shape, as well as the desired precision. Thus, there has arisen a need for high-precision powder feeders suitable for powders having a broad range of characteristics.

Particularly in recent years, increased functionality of powder materials has been sought in fields such as electronic materials and pharmaceuticals, and there is now a trend toward "atomization." However, there is now an increasing number of cases in which conventional dosing feeders cannot accommodate the greater agglomeration of particles and other issues that result from "atomization." This has the effect of further narrowing the leeway for selecting a feeder.

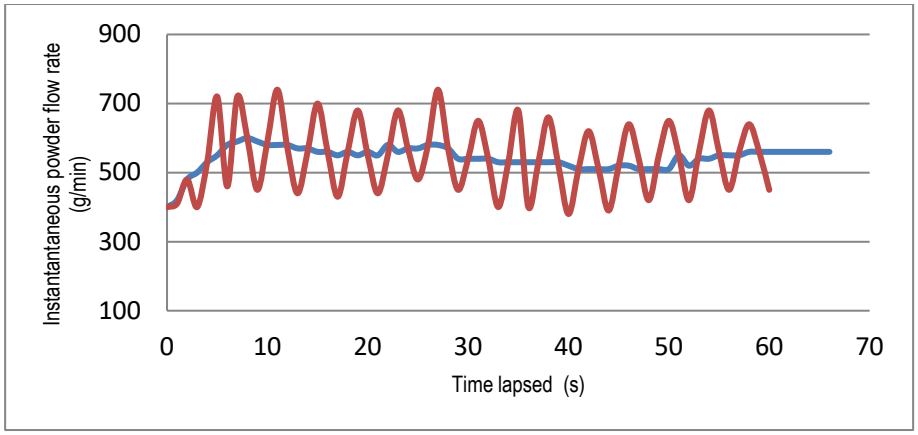
At the same time, enhancing productivity is a crucial technical issue in all industrial fields, and companies are now undergoing the process of converting from the conventional batch dosing and batch mixing systems to continuous dosing and continuous mixing systems. For that reason, there is a need for feeders having a greater degree of instantaneous dosing precision. However, the fact is that a variety of factors affect continuous dosing precision, including the intrinsic pulsation in the case of screw feeders and heterogeneous filling in the case of table feeders, for example. Accordingly, conventional dosing feeders are unable to satisfy the needs of the market.

In order to meet the needs of our customers, KAWATA has surmounted the various technical problems described below, and has developed screw feeders and table feeders that are able to accommodate powders possessing widely differing characteristics. Each of these feeders is described below.

2. The Non-Pulsating Screw Feeder "WINGSCALER"

The WINGSCALER eliminates intrinsic pulsation during screw feeding.

Screw feeders are the most commonly used volumetric feeders, and their use is not limited to powders, but they can be used for particles as well. It is well known that conventional screw feeders exhibit periodic pulsation, as shown in **Graph 1**. Pulsation cycles are in sync with rotation cycles, and the pulse amplitude can be as much as ±30-40% of the average flow rate. In the case of batch dosing, there is no particular problem, because the periodic pulsations are averaged out. However, huge problems arise in cases where precision is required in continuous dosing.



Graph 1 Periodic Pulsation of a Conventional Screw Feeder

Pulsation is thought to be due to the following reasons. Even when the base of the screw is sufficiently filled with powder, while the powder is pushed forward by the screw, the force of gravity breaks it down in the forward direction so that the front barrel portion is never filled. The position of the screw flight periodically changes due to the rotation of the screw, and consequently, when the screw flight approaches the lower discharge outlet, the discharge decreases until the next screw flight arrives. In other words, the discharge volume undergoes pulsation at the same cycle as the rotation cycle of the screw. The barrel must be filled with powder in order to eliminate such pulsation. Thus, some means of control must be provided at the front end of the barrel, so as to prevent the powder from being broken down by gravity.

To achieve this, KAWATA has introduced a blade having multiple wings at the front end of the screw. The powder reaches a state in which it is able to fill the inside of the barrel, since it is subjected to resistance by the blade. Moreover, due to the rotation of the wings, the powder can be finely sheared off, thereby making it possible

to discharge the powder in a more dispersed state, even if the powder is highly agglomerated (see **Fig. 1**).

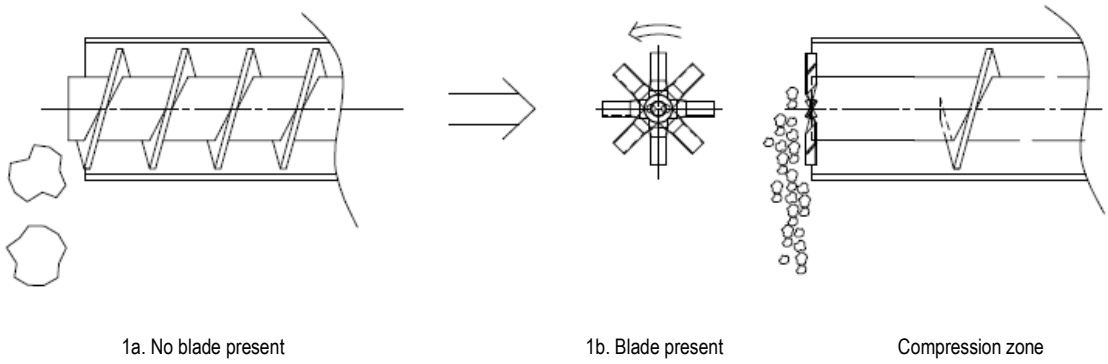


Fig. 1 Image Showing Powder Shearing
1a: Variability occurs. **1b:** No variability

The WINGSCALER makes powder bulk density uniform.

Another factor that affects dosing precision is the non-uniformity of powder bulk density. It is well known that powders differ from fluids and particulate materials in that they exhibit variability in bulk density. Variability in the delivery weight of powders naturally results if there is non-uniformity in bulk density, because a constant volume of powder is always output downstream due to rotation of the screw.

In order to solve this problem, KAWATA has configured the front-end portion of the screw so that there is a space called a "compression zone" in which there is no screw flight present (see **Fig. 1**). The powder is subjected to resistance by the blade, as mentioned above, and then compressed once before being cut off and discharged. This compression makes it possible to eliminate variability in bulk density.

The WINGSCALER eliminates the effect of powder surface pressure.

In the case of screw feeders, filling of the base of the screw is affected by the height of the surface of the powder inside the hopper. That is to say, when the height of the powder is great, the base portion is subjected to a high degree of powder pressure, which enables filling at a higher density, thereby resulting in more powder being fed. As powder is fed toward the downstream side, the surface of the powder within the hopper keeps getting lower, so the filling pressure gradually decreases, resulting in a continual decrease in the amount of powder that is actually fed.

For that reason, KAWATA changed the conventional U-type agitator to the basket-type agitator shown in **Fig. 2**. While the powder rotates within the agitator, it fills in the direction of the screw, and at the same time, the upper part of the agitator is subjected to pressure by the powder, which makes it possible to maintain a constant filling pressure at the screw filling portion. This eliminates the problem of reduced feed volume due to changing powder surface pressure.

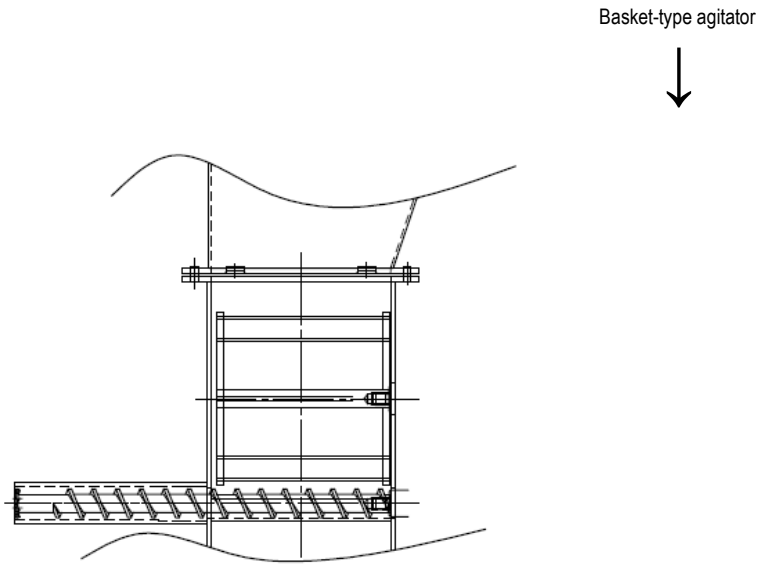
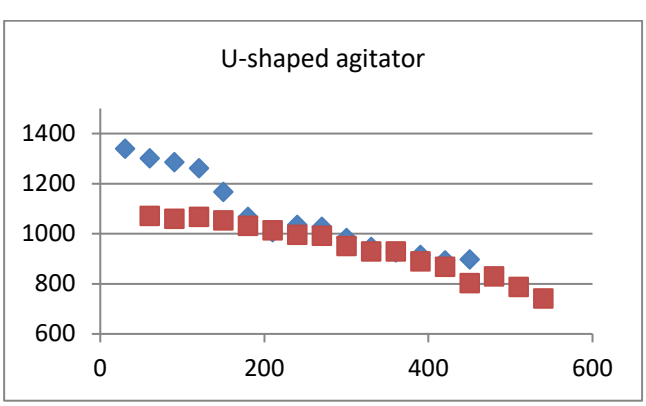
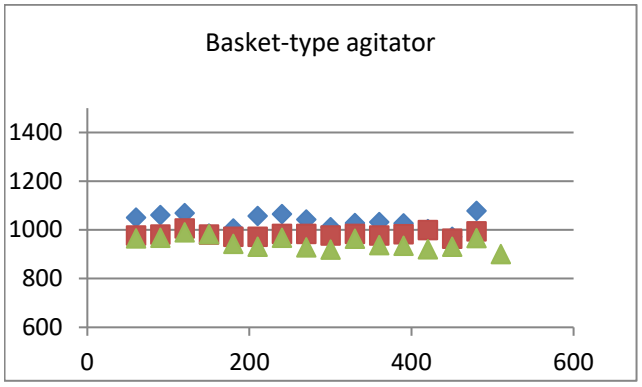


Fig. 2 Basket-Type Agitator

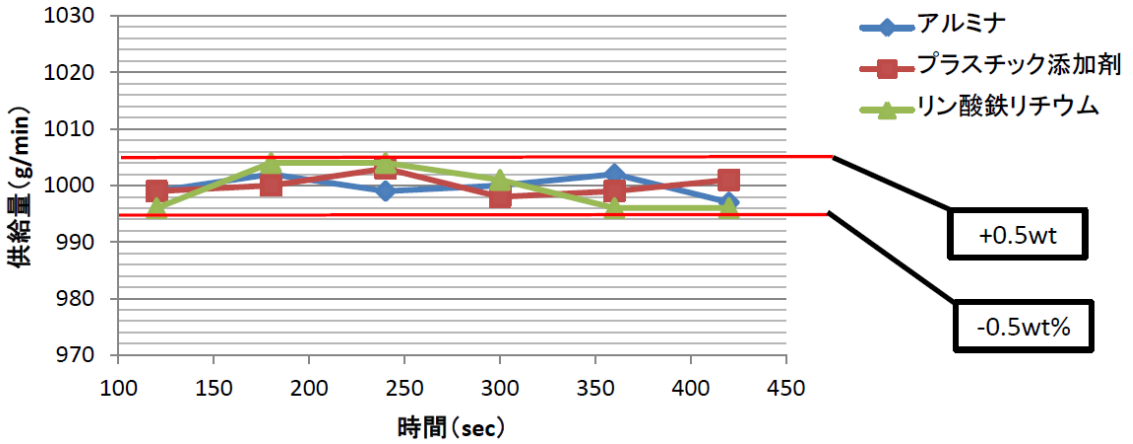
Graph 2 shows changes in the amount of powder fed over time when a typical agitator is used, as compared with a basket-type agitator. One glance is enough to see the marked improvement resulting from the basket-type agitator.





Graph 2 Effect of Powder Surface Pressure and Variability Elimination Effect

The above-described technical means makes it possible to eliminate variability in the bulk density of powder, as well as the cutting pulsation that is intrinsic to screws, thereby achieving a marked increase in instantaneous cutting precision. Moreover, it is possible to offer loss-in-weight specifications for this device, as well as more reliable stability in volumetric feeding. **Graph 3** illustrates examples of volumetric powder feed for several types of powder.



Horizontal axis: Time (sec)
Vertical axis: Feed rate (g/min)
Blue: Alumina
Red: Plastic additive
Green: Lithium iron phosphate

Graph 3 Results of Continuous Volumetric Feeding (set at 1.0 kg/min)

Structure of the WINGSCALER

1) Main Unit (**Photograph 1**)

The main unit includes ① a powder retention hopper; ② a basket agitator; ③ a screw; ④ a barrel; and ⑤ a load cell (loss-in-weight type).

2) Control Panel

A touch screen control panel is a standard feature in the loss-in-weight specifications.

Photograph 1 Main Unit of the WINGSCALER

The WINGSCALER comes in 3 types: Microscale feeder (capacity of 0.1-1.0 kg/h), Small-scale feeder (capacity of 1-10 kg/h), and Medium/Large-scale feeder (capacity of 10-100 kg/h), which makes our product line able to adapt to a broad spectrum of our clients' needs.

Table Feeder "FINESBIT" for highly agglomerated powder

Like screw feeders, the current table feeders are widely used for volumetric feeding of powders. There are two types of table feeders: The type that uses a scraper to cut the powder inside the table feeder after the powder is evenly spread on the surface of the table which rotates utilizing the angle of repose of the powder, and the type that buries the powder in pre-set grooves and uses a scraper to scrape the powder. The latter is the predominant type. Although such table feeders are simple in structure and can be adjusted within a wide range, they exhibit a number of problems. Since continuous filling of the grooves in the rotating table and continuous scraping are performed, there is no intrinsic pulsation as there is in screw feeders. However, as shown in **Fig. 3a**, powder that is impeded by the scraper and spills over the outer wall and drops down, highly agglomerated fine powders drop in large chunks, resulting in poor precision in instantaneous cutting.

Conventional scraper ↓ Rotating scraper ↓

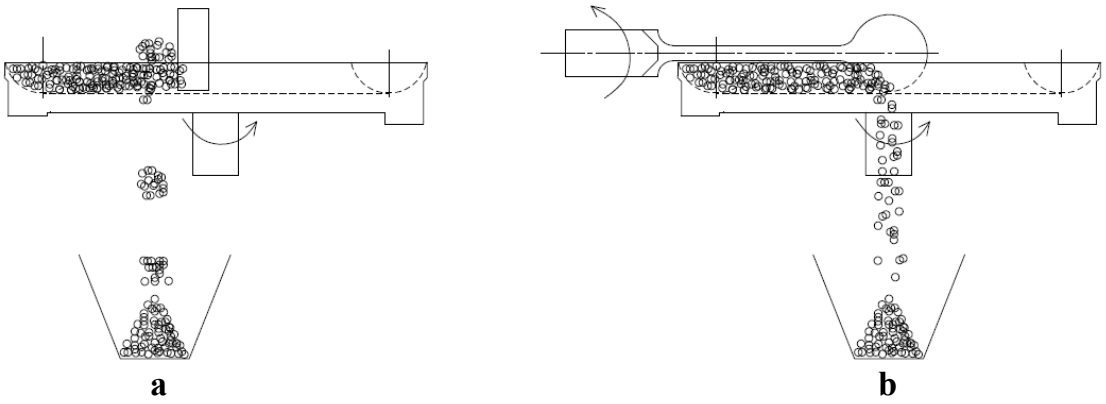


Fig. 3 Comparison of Conventional Scraper and New Rotating Scraper

In addition, it is difficult to fill the table grooves with highly agglomerated fine particles, and when only an agitator and the powder's own weight are used, it is impossible to achieve uniform filling, thus making high-precision volumetric feeding unattainable.

In order to solve these problems, KAWATA introduced a new groove-filling mechanism and a new powder-scraping mechanism (a rotating scraper). These innovations made it possible to achieve high-precision feeding on a microscale, even with highly agglomerated microparticulate powders.

Improved instantaneous cutting precision using a forced scraping mechanism

The FINESBIT employs a rotating scraper to forcibly scrape powders (see **Fig. 3b**). This mechanism makes it possible to prevent powder from sliding inside the filled grooves due to scraper resistance, and also dramatically improves the instantaneous cutting precision.

Improved filling uniformity through the use of a filling roller

Uniform filling of the table grooves is a prerequisite of a high-precision volumetric feeder. However, when the particles readily agglomerate, filling caused by simple gravity easily results in uneven feeding, and bridging readily occurs. For that reason, KAWATA has provided a built-in filling roller in its FINESBIT. This greatly improves even feeding.

The structure of FINESBIT

1) Main Unit (**Photograph 2**)

The main unit includes ① a powder retention hopper; ② an agitator; ③ a grooved table; ④ a rotating scraper for scraping the powder; ⑤ a filling roller; and ⑥ a load cell (loss-in-weight type).

Photograph 2 Main Unit of the FINESBIT

2) Control Panel

A touch screen control panel is a standard feature in the loss-in-weight specifications.

Working Examples

Table 1 shows feeding results for Kanto loam (JIS class 11) and fly ash (JIS class 10) which are ultrafine particles. High-precision feeding was achieved in a range of 100 g/h to 1,000 g/h.

Table 1 Feeding Results

No.	Raw Powder	Output Capacity (Ave) g/hr	Standard Deviation σ (Output volume/min)	Coefficient of Variation σ/Ave (%)
1	Fly ash	78.6	0.0236	1.8
2		152	0.0378	1.5
3		418	0.0731	1.0
4		809.4	0.2870	2.1
1	Kanto loam	120.8	0.0356	2.1
2		229.3	0.0499	1.3
3		561.1	0.0922	1.0
4		1001.3	0.4594	2.8

3. Conclusion

In the foregoing, we have introduced KAWATA's new products WINGSCALER and FINESBIT. These products provide high-precision continuous feeding, and can be used in applications that require feeding of highly agglomerated fine particles. Moreover, since these products are able to output powders in a more dispersed state, users will find them of interest not only in the food, cosmetics, and electronics materials and equipment industries, but also in the pharmaceutical and chemical fields. We would be very pleased if the use of these products serves to solve our customers' problems and increases their productivity.

THANK YOU FOR YOUR INTEREST IN OUR PRODUCTS!