

## Adaptive bulk material feeding system for extrusion processes

The invention concerns a feeder for bulk material, particularly granules, fed to the mixing chamber from the hopper of an extruder to maintain a predetermined amount of bulk material, particularly granules, in the space above the mixing chamber.

Current technical practice utilizes a variety of devices and systems whose primary function is to ensure the most even and stable feeding of bulk materials, particularly granules, into the working spaces of extruders. There are two basic methods for feeding bulk materials, particularly granules, to the mixing chamber of an extruder: volumetric (volume) and gravimetric (mass) with an adjustable or non-adjustable feeding system. Volumetric systems utilize a specific volume displaced per unit of time. The most commonly used volumetric feeders in processing include drum feeders, screw feeders, belt feeders, vibrating feeders, and disc feeders.

Gravimetric systems utilize the phenomenon of bulk materials falling from the extruder's hopper, located above the mixing chamber. In some solutions, a special additional chamber is located between the mixing chamber and the extruder's hopper, containing a controllable flow control system that regulates the flow and dosing of bulk materials into the mixing chamber.

The feeders used during the processing process fulfil the following tasks: they dose a repeatable amount of material, enable the adjustment of the dosing without the need to stop the feeder and enable the dosing of several bulk materials at the same time.

Patent application EP1445592A1 describes a volumetric feeder with multiple independent measuring cups of a specific volume, moving between the filling and discharge positions, allowing for bulk material portioning and independent control of the dosing paths. Patent application US4781308A discloses a device with a central vibrating table that disperses material peripherally into a series of retention hoppers with individual discharge mechanisms, enabling uniform and selective feeding into the baskets of a combination scale.

Patent application JP2005075548A discloses a screw feeder for powders, in which a feed shaft mounted in a mounting plate provides rigidity, reduces vibrations, and enables stable, long-term material feeding. Patent description PL246230B1 discloses an eccentric feeder with a hopper and a vertical screw that cooperates with a mixer via a rotating sleeve with an eccentric opening, enabling material to be fed directly above the processing screw.

The solution presented in utility model CN208084919U includes a conical asymmetric hopper with a vertical screw and an additional mixing rod to facilitate material flow.

Patent application US20050184103A1 describes a gravimetric feeder with a loss-in-weight mechanism, in which the drive screw is separated from the hopper, protecting the bearing from contamination and ensuring stable, long-term, loss-in-weight controlled feed.

Known solutions, despite widespread use in industry, have a number of limitations, primarily related to the heterogeneity of bulk materials, difficulties in maintaining high dosing accuracy, and the possibility of chute clogging. These problems form the basis for the development of new, more reliable, and universal methods for feeding bulk materials into the mixing chambers of extruders.

The invention concerns a bulk material feeder with a hopper connected at its end to a hopper sleeve, which is connected to the mixing chamber. Its essence is that a truncated cone-shaped throttle stem, with its outer surface parallel to the inner surface of the hopper, is slidable mounted in the hopper.

5 The throttle stem is connected to a linear drive system operating along a vertical axis, which is connected to a position controller mounted in the housing. Level sensors are mounted in the hopper sleeve and connected via signal cables to the throttle stem position controller.

10 A beneficial effect of the invention is the ability to continuously control and maintain the assumed volume level of bulk material, especially granulate, in the space above the mixing chamber in the range between the minimum and maximum level, as close as possible to the nominal level, as well as the ability to dose it in a follow-up manner, adapting to the current operating modes of the extruder and reacting to changes in the material structure resulting from the inhomogeneity of the raw material, as well as ensuring uniform feeding of bulk material to the mixing chamber and the plasticizing system of  
15 the extruder under a set, controlled pressure.

Uneven feeding of bulk materials results in instability in the processing process, manifesting itself through pressure fluctuations in the plasticizing zone, flow velocity disruptions, and the development of deformations and dimensional deviations in the finished products. Using a feeder with  
20 the presented design ensures stable material feeding, even if it tends to settle or block on the processing system components. Implementing the invention not only stabilizes the material feeding process but also has a beneficial effect on the quality parameters and properties of the finished products.

The invention is presented in an embodiment in a schematic drawing.

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The bulk material feeder for the extruder mixing chamber in the embodiment example consists of a hopper 1 connected at its end to a hopper sleeve 2, which in turn is connected to the mixing chamber 3. In the axis of the hopper 1, a throttle stem 4 is slidable mounted, made in the form of a truncated cone, the outer surface of which is arranged parallel to the inner surface of the hopper sleeve 2. The  
30 throttle stem 4 is connected to a linear drive system 5 operating in a vertical axis, controlled by a throttle stem position controller 6. The controller 6 together with the drive system 5 is mounted in the housing 7. The filling sleeve 2 contains filling level sensors 8.1, 8.2 and 8.3, connected by signal cables to the controller 6, which manages the setting of the throttle stem 4. The sensors 8.1, 8.2 and 8.3 detect the current level of bulk material in the mixer chamber 3 and transmit signals to the controller 6. The material  
35 flow through the filling sleeve 2 in order to maintain the assumed filling level of the mixer chamber 3 is regulated by the controller 6, which controls the linear drive system 5 connected to the throttle stem 4.

The position of throttle stem 4 changes between the lower position A (minimum clearance of hopper 2 or its closure) and the upper position B (maximum clearance of hopper 2). The throttle opening and flow

rate are controlled by controller 6. The nominal position of the stem is set in controller 6 for a given process, depending on the type of material (particle size, density, roughness) and the nature of the process being performed.

- Sensor 8.1 controls the maximum level – in this case, stem 4 is set to position A (flow closure).
- 5     - Sensor 8.3 controls the minimum level – in this case, stem 4 is set to position B (fully open throttle).
- Sensor 8.2 controls the nominal level – in this case, stem 4 is set to the nominal position.

If the level drops below the nominal level, controller 6 increases the flow by raising stem 4 until the signal from sensor 8.2 is reached. The flow is then reduced by lowering the stem towards position A.

10    Based on the signals from sensors 8.1–8.3, it is possible to perform self-diagnostics of the system and check the correctness of the dosing process.

The correct flow occurs in two variants:

1. Sensor 8.1 – no fill, sensor 8.2 – fill, sensor 8.3 – fill. This indicates a level above the nominal level and below the maximum level, with throttle stem 4 in the nominal position or adjusted downward.
- 15    2. Sensor 8.1 – no fill, sensor 8.2 – no fill, sensor 8.3 – fill. This indicates a level below the nominal level and above the minimum level; in this case, throttle stem 4 is adjusted upward.

Sensor failures are detected in four ways:

1. Sensor 8.1 – no fill, sensor 8.2 – fill, sensor 8.3 – no fill.
- 20    2. Sensor 8.1 – fill, sensor 8.2 – no fill, sensor 8.3 – no fill.
3. Sensor 8.1 – fill, sensor 8.2 – no fill, sensor 8.3 – fill.
4. Sensor 8.1 – fill, sensor 8.2 – fill, sensor 8.3 – no fill.

The process malfunction also occurs in two variants:

1. All sensors indicate no material in the mixing chamber. If throttle stem 4 is set to position B, this indicates a lack of material in hopper 1 or a blockage preventing flow through sleeve 2.
- 25    2. All sensors indicate no material in the hopper. If throttle stem 4 is set to position A, this indicates problems with material reception by the plasticizing system, its failure, or its shutdown.

The invention can be used in modern, intelligent extruders that automatically and precisely dispense granulate. This solution increases the degree of automation, makes the process independent of material heterogeneity, and eliminates the drawbacks of dosing systems with a fixed feed opening. The movable throttle stem allows for replacement and adaptation to the shape of the hopper and the type of material. Its compact design and installation in the hopper allow for easy transfer of the dispenser between devices, requiring only the use of an appropriate design.

## List of markings

- 1 hopper
- 2 hopper sleeve
- 3 agitator chamber
- 4 throttle stem
- 5 linear drive system
- 6 controller
- 7 housing
- 8.1 fill level sensor
- 8.2 fill level sensor
- 8.3 fill level sensor
- 9 structural elements
- A lower position
- B upper position

## Patent claim

A bulk material feeder for an extruder mixing chamber having a hopper (1) connected at its end to a hopper sleeve (2), which is connected to the mixing chamber (3), characterized in that a throttle stem (4) in the form of a truncated cone with an external surface arranged parallel to the internal surface of the hopper sleeve (1) is slidably mounted in the hopper (1), and the throttle stem (4) is connected to a linear drive system (5) operating in a vertical axis, which is connected to a controller (6) of its position mounted in the housing (7), while filling level sensors (8.1, 8.2, 8.3) are mounted in the hopper sleeve (2), connected by means of signal cables to the controller (6) of the position of the throttle stem (4).

### Short description

A bulk material feeder having a hopper (1) connected at its end to a hopper sleeve (2), which is connected to the mixer chamber (3), is characterized in that a throttle stem (4) in the form of a truncated cone with an outer surface parallel to the inner surface of the hopper sleeve (1) is slidably mounted in the hopper (1). The throttle stem (4) is connected to a linear drive system (5) operating in a vertical axis, which is connected to a controller (6) of its position mounted in the housing (7). Fill level sensors (8.1, 8.2, 8.3) are mounted in the hopper sleeve (2), connected via signal cables to the controller (6) of the throttle stem (4) position.

Fig.

(1 patent claim)

