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Building a Knowledge Base in Patented Technology and Equipment for Dispensing Various Types of Substances

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Abstract

Dispensing of bulk and liquid substances is widely applied in various industries. In this regard, developing new and elaborating existing technologies and equipment for dispensing various types of substances is actively taking place around the world. In recent years, there have been increasingly patented new intellectual property objects on technologies and devices for dispensing in food-manufacturing, construction, chemical, cement, medical, cosmetic and other industries, as well as in agricultural sector. The above indicates that the problems of improving the quality and effectiveness of dispensing technologies and dispenser design are still to be solved. All this necessitates the synthesis and patenting of new technologies and equipment for dispensing that will be competitive in the market. To this end, the authors of this work conducted the study aimed at building the knowledge base in the field of patenting the technologies and equipment for dispensing various types of substances. This study helped to reveal the current state and trends in the patenting in the field of dispensing technologies, to identify the major patenting goals (effects) of patented intellectual property objects. The article presents the features of the most noteworthy patents found in the process of knowledge base building.

Keywords: dispenser, dispensing, bulk and liquid substance, industries, patent search, intellectual property.

1. INTRODUCTION

Currently, the dispensing of bulk, liquid and other substances is one of the most important operations that determine the effectiveness and quality of many technologies in the food, construction, chemical, metallurgical, cement, medical, cosmetic, agricultural and other industries. When selecting dispensing technologies and, accordingly, designs, parameters and operating modes of dispensers, developers consider the specifics of numerous parameters and characteristics of the working environment around the dispensing process. Among the main parameters and modes are: the type of dispensed substance (liquid, powder, viscous mass, large or small pieces, etc.), density, dispersibility, humidity, etc. In this regard, research and development in the field of creating new and improving existing technologies and equipment for dispensing various types of bulk and liquid substances for various industries are actively conducted in various countries. Various dispensing technologies and designs of dispensers are characterized not only by their own specific benefits, but also by their drawbacks, and to effectively eliminate them, abrupt technological and technical solutions are required. One of the crucial factors that confirms the level of such solutions is the patenting by researchers and developers of the results of their intellectual property. It is no accident that in recent years, new intellectual property objects have been actively patented for technologies and devices intended for dispensing operations in number of industries. This fact indicates that the problems of improving the quality and effectiveness of dispensing technologies and dispenser designs have not been completely solved.

All the above necessitates synthesizing and patenting new market-competitive technologies and equipment for dispensing applied in various industries, with regard to specifics of these industries, the features and characteristics of the substances being dispensed, and the requirements for the results of dispensing process. In this regard, the authors based on an extended patent search performed research aimed at building a knowledge base in the field of patenting technologies and equipment for dispensing various types of substances. This work develops the authors' research [41] in the field of building

the knowledge base for analyzing the current state and developmental trends of technology and equipment for the synthesis of patentable solutions.

2. LITERATURE REVIEW

Numerous research results [4; 5; 16; 17; 30; 46] demonstrate that dispensing various types of substances is one of the most important operations that determine the effectiveness and quality of many technologies in food, construction, chemical, cement, medical, cosmetic and other industries, as well as in metallurgy [9], in the glass production [45], in the production of concrete and asphalt [8; 38], in the production of detergents [49], in agriculture [18; 59; 28], in forestry [22].

The analysis of these works shows that method of volumetric dispensing is applied for measuring a given volume of continuous media (bulk and liquid). The advantages of volumetric dispensing equipment include simplicity of design and maintenance, and high reliability. Among the disadvantages are the complexity of ensuring high accuracy of dispensing when working with fine bulk substances that are prone to self-compaction. Weight-based (mass) dispensing is used for measuring the mass of continuous media (bulk and liquid). These dispensers provide more accurate dispensing than volumetric dispensers, but are characterized by a more complex design. According to the operating time, the dispensing can be periodic (discrete) and continuous. Periodic (discrete) dispensing involves the supply of material in specified portions at certain intervals. Continuous dispensing involves a constant uniform flow of material with a specified weight or volume flow rate.

For the process of dispensing, special equipment is used – dispensers (metering devices). The main components of the dispensers are: a hopper (receiving chamber) – a unit for receiving, accumulating the working medium; a dispensing system – a unit that measures and discharges the desired amount of working medium; a control system. The main technical characteristics of dispensers are the performance determined by the measurement time and the accuracy of dispensing, determined by the deviation of the measured batch from the set value. There are various designs of dispensing devices and technological processes for dispensing. All of them have certain advantages and disadvantages.

The analysis of information collected based on the study of patents, scientific and technical literature helped to identify methods of dispensing and dispenser design intended for the use in the food industry. The selected technical solutions were categorized according to the type of working environment:

- bulk material dispensers;

- dispensers for hard-running, clumping, sticking materials;

- dispensers for puree-like and viscous products;

- dispensers for water and free-running materials;

- dispensers for micro-doses.

Bulk material is a mechanical mixture of solid particles of various shapes and sizes that are in contact. Bulk materials can flow, but their flow significantly differs from the flow of continuous media (liquids, elasto-plastic masses). The peculiarity of the bulk solids movement is that they do not have a solid contact area with a hard surface. When filling a hopper, particles of bulk material form voids due to the lack of density of fitting to each other. A hopper for bulk material must meet the requirements for maximum utilization of their volume and uniform distribution of bulk material over their volume.

In the course of studying the scientific and technical literature, the following difficulties of dispensing the bulk materials were identified:

- the dependence of the material flowability on the degree of its compaction. In this regard, special devices are used in loading hoppers – agitators – units that mix bulk material at a low speed, at which it does not compact;

- periodic shaking of bulk material in order to prevent its clumping and the formation of voids and bulk near the hopper walls.

3. MATERIALS AND METHODS

This study aims at building a knowledge base in the field of patenting technologies and equipment for dispensing various types of substances. The objectives of this study include: to identify the current state and trends of patenting in the field of dispensing; to determine the main effects that patentable objects of intellectual property are aimed to achieve; to describe the features of the most noteworthy patents for technologies and equipment for dispensing various types of substances.

The dispensing technology is considered as a process that provides measuring of the required amount of working medium by mass or volume. When selecting a method of dispensing and, accordingly, equipment for its implementation, it is necessary to consider the specifics of the working environment, such as the type of the substance to be dispensed (liquid, powder, viscous mass, large or small pieces, etc.), density, dispersibility, humidity, etc.

The methodology of work involved patent and information research with a time frame of the patent search of 30 years. The patent search among legal documents of the Russian Federation was conducted using the databases of the Federal Institute of Industrial Property (FIPS), which forms the state patent fund and is the central repository of the state patent fund. The patent search among legal documents of foreign countries was conducted using the databases of the European Patent Office's patent information network (esp@cenet) and the World Intellectual Property Organization WIPO (panentscope). The article presents a review of the most noteworthy patents found in the process of knowledge base building.

4. RESULTS AND DISCUSSION

Screw dispensers allow for dispensing by volume and weight. A screw is the working body of the dispenser of this type. The amount or volume of the bulk is determined by the number screw revolutions. In front of the screw, agitators are installed

in the loading hopper, which, by mixing the working medium, prevent its clumping and arching.

The invented screw dispenser (Patent RU181725) is installed on vibration supports, and provides bulk and powdery materials dispensing by weight and volume and is aimed at improving the accuracy of dispensing. Another type of screw dispenser of bulk powder products for beverage preparation (Patent RU182378) prevents the sticking of bulk products on the walls of the device by installing a vibrator on the wall of the dispenser discharge channel. The patented invention (Patent US2013200101) solves the problem of designing a dispensing device capable of controlling and effectively discharging the powdery material. The patent (Patent CN107089356) describes a device designed with a screw dispensing system and an automatic weighing unit.

Vibration dispensers are used for weight and volume dispensing.

In the patented device (Patent RU2444708), activators are installed inside the housing of the vibration dispenser, and inside the housing sections, on the shaft, there are mounted agitators – spiral rods. Weight-based dispenser of discrete action (Patent RU125966) is designed for batch dispensing of bulk materials of various degrees of dispersibility, of small and large particles. Automatic packaging machine (Patent CN202717042) with weight-based dispensing includes a vibrating feed system, weighing system, split packaging system and chain management system, in which the vibrating feed system, weighing system, split packaging system and chain management system are sequentially arranged from top to bottom.

Vacuum-based dispensers ensure that the movement of the product is realized due to the pressure drop. Feeder vacuum dispenser (Patent RU2230010) is connected to the airtight container through a vacuum system. The elastic properties of the housing material allow its walls to self-shake during the dosing process. According to the method (Patent RU2620905), a vacuum is created in the hopper by pumping gas out of it, as a result of which a mixture of bulk material with gas enters the hopper through the pipeline. When a certain amount of pressure drop is reached, on the material layer in the hopper, the material is discharged through the discharge pipeline under the action of gravity.

Dispensers with a fluidized bed of the working medium. The device (Patent RU131365) reduces the amount of ground bulk material by "fluidizing" it. To do this, the dispenser is equipped with a hollow screw with through holes for entering compressed air into the material in order to create a "fluidized" state of the latter over the entire volume of the dispenser. In the invention (Patent RU2542638), the rod of the dispenser is equipped with a piston that periodically feeds fluidized gas to the lower part of the bulk material array loaded into the hopper.

Dispensers with the use of electromagnets. An example of such a design is a dispenser for packing bulk materials in valve bags (Patent RU2270159), equipped with a vibration exciter and an electromagnetic valve.

Gate-based dispenser (Patent RU76823) for dispensing bulk fine products in the food industry includes a housing, a drive, a slide gate plate with an opening for dispensing, located between the upper and lower fixed plates. There are also other designs of gate dispensers (Patent RU63521; Patent RU125564), etc.

The rotary dispenser (Patent RU38726) includes a product loading zone with an accumulating hopper, a product unloading zone, and a drive rotor located between them. The rotor is made with evenly spaced dispensing chambers in the form of telescopic cylinders with movable bottoms, equipped with a mechanism for opening the bottoms. The dispensing device (Patent RU180000) is designed for dispensing powdery, granular or flacculant substances. Feeder-dispenser (Patent RU141559) is designed for dispensing bulk materials that are prone to arching. Another design of the volumetric dispenser for the food industry (Patent CN1970409) provides stable feed, high accuracy of dispensing, and increased service life.

The weight-based dispenser (Patent RU94212) can be used for dispensing fine bulk dusty materials for the purpose of their subsequent packaging. In this device, dispensing is performed directly into the packaging container (package) in two stages (rough set, precise set). The bulk product dispenser (Patent RU100237) is made in the form of a container with discharge openings along its side, and the tray is in the form of cascading troughs placed under each other, under the discharge parts of the troughs of the underlying cascade there are units for weighing. The flour weighing dispenser (Patent RU164350) contains a flour feeder, a rack, and a control unit connected to at least two strain gauges that are structurally designed as supports for a weighing hopper with a window at the bottom for discharging flour batches. The control unit is designed as a controller that includes a processor and an analog-to-digital converter connected to strain gauges. The piston dispenser (Patent US5309955) during dispensing compares the weight of the dispensed batch with the weight standard and adjusts the stroke of the dispensing piston.

4.1. Dispenser of hard-running, clumping, sticking materials

The dispenser (Patent RU80100) is designed for dispensing bulk materials that are prone to caking and clumping. Dispensing is performed by giving the capacity of reciprocating movements along the axis of the dispensing channel. The dispenser increases the reliability of dispensing of bulk materials that are prone to clumping and caking. The dispenser (Patent RU2302115) provides volumetric dispensing of viscous masses in the food industry. The dispenser contains at least one measuring volume, a feeder for its filling, and a punch mounted with the possibility of reciprocating movement in the said measuring volume.

4.2. Dispenser of viscous, puree-like media

The dispenser (Patent RU153863) can be used in the food industry for dispensing non-Newtonian food media such as dough, minced meat, puree of fruits and vegetables. Dispenser for food environments (Patent RU172894) contains a hopper, a discharge chamber, a dividing head and a unit for maintaining the constant pressure in the chamber, built just before the

dividing head made in the form of flat slit pocket communicating with the chamber, and bounded by the circular arc and flat surface with a plate spring installed in the pocket.

The dispenser (Patent RU138630) provides weight-based dispensing of high-viscosity and pasty liquids. The proposed design makes it possible to test the weight-based dispenser discharge valve with a high-viscosity liquid with minimal costs in laboratory conditions using a small amount of specially prepared high-viscosity liquid composition.

The dispenser (Patent CN108146709) involves placing a viscous medium in a dispensing hopper; the viscous food is pushed to the holding cylinder by a spiral pushing device. After the desired amount of the viscous mass is derived, the control device stops the operation of the spiral pushing device, and the rotary scraper rotates to cut materials. The device allows effectively measure viscous materials, and performs full-automatic control.

4.3. Dispensers for water and free-running materials

One of the problems of dispensing free-running materials is related to the fact that the closing of the dispensing valve takes some time, which results in entering of some additional amount of substance in the container. Such an effect is explained by the fact that the valve, which is a mechanical component, and the valve control device that activates the valve, are subjected to a reaction and "dead" times. As a result of this phenomenon, as a rule, the amount of substance released in the container exceeds the final value causing a signal for valve closing.

Rotary dispensers. The rotary liquid dispenser (Patent RU78168) provides adjustment of the volume of the liquid dose and the accuracy of the dose without replacing the cylinders. To achieve this task, a dispenser containing a rotating shaft, with a feed tank attached to it, is used. Cylinders for feeding the liquid with floats and top lids are placed under the tank. Taps are located under the cylinders. The upper cylinder lids are equipped with height-adjustable cylinder stops with longitudinal axial openings.

The rotary multi-channel dispenser (Patent RU2474521), with a small number of dispensing shells and even with only one, discharges batches of the product through multiple channels for a single cycle of work. In this device, the number of measuring shells is reduced while the number of channels for dispensing product doses is increased. The nutrient solution dispenser (Patent RU2097995) is aimed at increasing the uniformity of feed flavoring with a nutrient solution and ensuring the dispensing of the nutrient solution per unit of feed mass, which will allow flavoring the feed of different densities. To this end, the dispenser contains a feed mass sensor, a container for a nutrient solution, a material pipe with a discharge opening, and a sprayer. The feed mass sensor is located under the material pipe's opening and is designed as a four-bladed dispensing reel.

4.4. Diaphragm dispensing pump

The diaphragm dispensing pump (Patent RU127415) can be used for pumping and dispensing the toxic, aggressive, sterile, food and other liquids. The technical result of the proposed utility model includes: more accurate dispensing of pumped liquids due to the regulation of the pulse generator signal ratio (multivibrator), as well as increasing the reliability of the dispensing pump due to the introduction of a second electromagnetic drive.

Liquid dispenser (Patent RU2413673) refers to the liquid media dispensing in bottles, containers, cans, flasks, and other types of packaging (glass, plastic, metal). It is additionally equipped with a lid that has a cavity and a channel, a slack diaphragm, locking elements, a disk-catcher, an elastic membrane, and guide rods with springs. The slack diaphragm is located between the upper part of the housing and the lid. An elastic membrane is located between the lower part of the body and the disc-catcher.

4.5. Piston dispenser

The dispensing pump (Patent RU2580892) prevents the interaction of the dispensed liquid with the pump material, reduces the defect ratio when dispensing liquid media, reducing the time of assembly/disassembly of the pump when it is sterilized. The dispensing pump contains a hollow two-part cylindrical housing made of a crystal based on α-$A_{l2}O_3$, one part of the body has a larger diameter and is designed for pressing at least one feeder channel and one discharge channel and a retainer for installing the dispensing pump on the dosage line, made of a crystal based on α-$A_{l2}O_3$. Firstly, the housing is adapted to locate the plunger or piston made of a crystal based on the α-$A_{l2}O_3$ and designed to move inside the housing with a rod made of crystal based on the α-$A_{l2}O_3$ and designed for pressing the plunger or piston. Secondly, the housing is designed for placing a gate made of a crystal based on α-$A_{l2}O_3$ inside it.

The piston dispensing pump (Patent RU2553849) is designed for pumping, dispensing and mixing of food liquids. It consists of a cylinder, two suction valves, a rod, a piston, a discharge cavity, a pressure line, and two by-pass channels with by-pass valves located inside the piston. The rod is made in the form of a plate that divides the suction cavity into two chambers. Each chamber has its own suction valve. One of the bypass channels connects the discharge cavity with one suction cavity chamber. The second bypass channel connects the discharge cavity with second suction cavity chamber, with the intersection of the bypass channels. The technical result is the possibility of precise dispense of the pumped liquids and obtaining a homogeneous mixture.

The piston dispensing pump (Patent RU161692) consists of two electromagnetic drives, two armatures, two springs, two pistons, two suction valves and two discharge valves connected to one discharge line, four bypass valves in each piston and a partition dividing the discharge chamber into two parts for accurate dispensing. Owing to the discharge valves of the pistons being connected in one line, and the pistons having different suction chambers, it is possible to mix two different liquids. By adjusting the ratio of the multivibrator signal, the supplied liquids are dispensed by each section of the dispensing

pump. A similar problem is addressed by a piston dispensing pump from another invention (Patent RU127410).

4.6. Device equipped with a controlled dispensing valve

The invention (Patent RU2309094) presents an example of liquid product dispensers for the packaging industry, in particular, dispensers for filling liquid products in containers that are placed for filling manually or by means of a conveyor in small industries. The purpose of the invention is to improve the accuracy of dispensing.

The dispenser (Patent RU161553) reduces the cost of dispensing liquid components for flour-based products. The dispenser contains a rack, a control panel, and dispensing tanks equipped with pipes with valves for the feed of liquid components and pipes with valves for the discharge of liquid components into the general container. The bottom of the general container is inclined in the direction of increasing of the liquid mass viscosity.

The patent (Patent US2014326360) describes a device for simultaneously feeding at least two products in a viscous or pasty form into a container. Products are fed into the container in a dosed manner through a nozzle. The device is equipped with a controller that controls the operation of rotary dispensing disks mounted in the channels for feeding components into the nozzle.

4.7. Siphon dispenser

The device from the invention (Patent RU2183821) can be used to convert a constant flow of liquid with a small flow rate into a discrete flow with a large flow rate and to feed it in specified portions alternating between several channels. The device consists of a storage tank, a feeding tube with a tap, a working siphon with mechanisms for starting and breaking the vacuum, and mechanisms for automatic liquid switching. They consist of interconnected suction parts by means of a siphon collector with drain parts deepened in cups equipped with discharge pipes. The discharge pipe of each cup of the preceding siphon is connected by a micro-siphon with the lower part of the cavity of the cup of the next siphon. The pipe of the cup of the last siphon is connected to the lower cavity of the cup of the first siphon.

4.8. Micro-dispensing devices

The invention for mixing micro-additives in the preparation of combined feed (Patent RU2332253) provides a high degree of homogeneity of the prepared mixture, introduction of micro-components in the prepared mixture, the gradual mixing and introduction of components, that increase the homogeneity of the mixture. To this end, the micro-mixer contains a frame with a sectional body, inside which there is a central shaft with mounted agitators with blades.

Micro-dispenser for liquids (Patent RU80942) comprises a housing, an electromagnet and a control system. To improve the dispensing accuracy, an electromagnet armature is rigidly connected with the locking needle, on which a position sensor is secured, and the electromagnet winding is electrically connected with the control system, consisting of serially connected analog-to-digital converter, microcontroller and electromagnet driver.

When analyzing the patents for the above inventions, the following key effects (goals) of improving technologies and equipment for dispensing (achievable effects) were identified:

- productivity increase;
- improving the dispensing accuracy;
- improving the uniformity of dispensing;
- increasing the reliability in operation;
- simplifying the design;
- reducing the weight of the device;
- reducing the energy intensity of the process and reducing its cost;
- reducing the dimensions of the device;
- simplifying the device maintenance and operation.

During the study, the following number of patents was considered with grouping by types of dispensers and according to the achieved effect:

Screw dispensers: increasing productivity – 5 RU patents; enhancing dispensing accuracy – 11 RU patents, 3 CN patents, 1 US patent; improving the uniformity of dispensing – 11 RU patents, 3 CN patent, 2 FR patent; enhancing reliability – 8 RU patents; simplified design – 7 RU patents, 1 DE patent; reducing the weight of the device – 1 RU patent; reducing the energy intensity of the process and reducing its costs – 1 RU patent, 1 DE patent. Thus, the main goals of elaboration of the screw volumetric dispenser are to increase the dispensing accuracy, improve the uniformity of dispensing.

Vibration dispensers: productivity increase – 9 RU patent; enhancing dispensing accuracy – 4 RU patent; improving the uniformity of dispensing – 5 RU patents, 1 US patent; enhancing reliability – 4 RU patents, 1 CN patent; reducing the weight of the device – 2 RU patent; simplified design – 1 RU patent; reducing the size – 1 RU patent; reducing the energy intensity of the process and reducing its costs – 1 RU patent. Thus, the main goals of elaboration of the volumetric dispensers of the vibration type are to increase productivity, improve the uniformity of dispensing, and increase reliability.

Vacuum dispensers: enhancing dispensing accuracy – 4 RU patents; reducing the energy intensity of the process and reducing its costs – 1 DE patent; simplifying maintenance and operation – 1 RU patent, 1 DE patent. Thus, the main goal of improving vacuum dispensers is to increase the accuracy of dispensing.

Dispensers with a fluidized bed of the working medium: increased productivity – 5 RU patents; enhanced dispensing accuracy – 13 RU patents, 1 US patent; improved uniformity of dispensing – 2 RU patents, 1 US patent; enhanced reliability in operation – 5 RU patents; simplified design – 2 RU patents.

Therefore, the main goals of improving the dispenser with a fluidized bed of the working medium are to enhance the accuracy of dispensing, increase productivity, and enhance reliability in operation.

Electromagnet-based dispensers: increased productivity – 2 RU patents; improved uniformity of dispensing – 2 RU patents; enhanced reliability in operation – 1 RU patent; simplified design – 2 RU patents.

Gate-based dispensers: enhancing the accuracy of dispensing – 7 RU patents; enhancing the uniformity of dispensing – 1 RU patent; increasing the reliability – 2 RU patents; simplifying the design – 3 RU patents; simplifying maintenance and operation – 1 RU patent.

Hence, the main goals of elaboration of the volumetric gate-based dispensers are to increase the accuracy of dispensing and simplify the design.

Rotary dispensers: productivity increase – 2 RU patent; enhancing dispensing accuracy – 9 RU patents, 1 EP patent, 1 DE patent, 1 CN patent and 1 EA patent; improving the uniformity of dispensing – 3 RU patent; enhancing reliability – 3 RU patent; simplified design – 5 RU patents, 1 EP patent, 1 EA patent, and 1 CN patent; reducing the weight of the device – 1 CN patent; reducing the energy intensity of the process and reducing its cost – 4 RU patent; reducing the size – 3 RU patent, 1 EA patent and 1 CN patent; simplifying maintenance and operation – 2 RU patent. Thus, the main goals of improving rotary dispensers are to increase the accuracy of dispensing, and simplify the design.

Weight-based dispensers: increased productivity – 10 RU patents and 1 WO patent; enhanced dispensing accuracy – 11 RU patents, 1 US patent, 1 DE patent and 1 WO patent; improved uniformity of dispensing – 4 RU patents and 1 US patent; improved reliability - 3 RU patents; simplified design – 3 RU patents; reduced dimensions – 1 RU patent; simplified maintenance and operation – 2 RU patents; reduced energy intensity of the process and reduced its cost – 1 RU patent and 1 DE patent. Thus, the main goals of improving weight-based dispensers are to increase the productivity and accuracy of dispensing.

Dispensers of hard-running, clumping, sticking materials: improving the uniformity of dispensing – 2 RU patents.

Dispensers of viscous, puree-like media: increased productivity – 2 RU patents, 1 CN patent, 1 US patent, 1 PL patent and 1 DE patent; improved accuracy of dispensing – 7 RU patents, 1 EP patent, 1 PL patent, and 1 CN patent; improved uniformity of dispensing – 1 RU patent, 1 GB patent and 1 EP patent; enhanced reliability in operation – 1 RU patent; simplified maintenance and operation – 1 RU patent and 1 CN patent. Hence, the main goals of elaborating the dispensing of viscous and puree-like media are to increase productivity and improve the accuracy of dispensing.

Micro-dispensing devices: improved productivity – 1 RU patent; improved accuracy of dispensing – 3 RU patents; improved uniformity of dispensing – 1 RU patent.

Dispensers for water and free-running materials are divided into five groups:

- Rotary dispenser: increased productivity – 1 RU patent; increased dispensing accuracy – 2 RU patent; improving the uniformity of dispensing – 2 RU patent; enhanced reliability – 1 FR patent; simplified design – 3 RU patent; reduced of energy intensity of the process and reduced costs – 1 RU patent; reduced dimensions of the device – 1 RU patent; simplified maintenance and operation – 1 RU patent.

- Diaphragm dispensing pumps: increased productivity – 2 RU patents; improved dispensing accuracy – 5 RU patents; improved uniformity of dispensing – 1 RU patent; increased reliability in operation – 2 RU patents; simplified design – 3 RU patents. Thus, the main goal of improving a diaphragm dispensing pump is to increase the accuracy of dispensing.

- Piston dispensers: increased productivity – 2 RU patents; improved dispensing accuracy – 5 RU patents, 1 US patent and 1 WO patent; improved uniformity of dispensing – 1 RU patent and 1 EP patent; improved reliability – 2 RU patents; simplified design –2 RU patents; reduced weight of the device – 1 RU patent; reduced dimensions of the device – 1 RU patent and 1 EP patent; simplified maintenance and operation – 3 RU patents. Hence, the main goal of elaboration of a piston pump-dispenser is to increase the accuracy of dispensing.

- Dispensers equipped with a controlled dispensing valve: increased productivity – 1 DE patent and 1 RU patent; improved dispensing accuracy – 3 RU patents, 1 WO patent and 1 US patent; enhanced uniformity of dispensing – 1 RU patent; enhanced reliability – 2 RU patents; simplified design – 3 RU patents; reduced energy intensity of the process and reduced cost – 3 RU patents. Thus, the main goal of improving the dispensing process using a controlled dispensing valve is to increase accuracy of dispensing, as well as reduce operating costs.

- Siphon dispensers: increasing productivity – 1 RU patent; increasing the accuracy of dispensing – 1 RU patent; improving the uniformity of dispensing – 2 RU patents; enhancing reliability in operation – 3 RU patents; simplifying the design – 3 RU patents.

5. CONCLUSION

This work develops the authors' research in the field of building the knowledge base for analyzing the current state and developmental trends of technology and equipment for the synthesis of patentable solutions. Attention to the building of a knowledge base in the field of technologies and equipment for dispensing of bulk, liquid and other types of substances is due to the fact that dispensing process is one of the key operations that determine the effectiveness and quality of many technologies in the food-manufacturing, construction, chemical, metallurgical, cement, medical, cosmetic, agricultural and other industries. However, the problems of improving the quality and efficiency of dispensing technologies and dispenser designs are still to be solved.

Basing on analysis, for the research were selected two hundred and thirty-four patents: one hundred and ninety-seven patents of Russian researchers and thirty-seven foreign patents. It should be noted that patents issued in the People's Republic of

China, the United States of America, and the Federal Republic of Germany predominate among the selected foreign patents.

Each of the three categories was categorized into a number of subcategories depending on the type of dispensing and design features of the equipment.

1. Dispensing of bulk materials: 1.1: Volumetric dispensing – 185 patents: 1.1.1: screw dispensers – 54 patents; 1.1.2: vibration dispensers – 30 patents; 1.1.3: dispensers equipped with vacuum – 10 patents; 1.1.4: dispensers with a fluidized bed of the working medium – 29 patents; 1.1.5: dispensers equipped with electromagnets – 7 patents; 1.1.6: gate-based dispensers – 15 patents; 1.1.7: rotary dispensers – 40 patents; 1.2: weight-based dispensers – 39 patents; 1.3: dispensers for hard-running, clumping, sticking materials – 2 patents (a small number of patents in this group is due to the fact that most dispensers are designed to work not only with sticking, but also with bulk materials, therefore, such patents fell into other categories).

2. Dispensers for viscous, puree-like media – 22 patents;

3. Dispensers for water and free-running materials – 70 patents: 3.1: rotary dispensers – 9 patents; 3.2: diaphragm dispensing pumps – 14 patents; 3.3: piston dispensers – 21 patents; 3.4: dispensers using a controlled dispensing valve – 16 patents; 3.5 – siphon dispensers – 10 patents;

4. Micro-dispensing devices – 5 patents.

The study allowed identifying the main effects of patented intellectual property objects, as well as highlighting the features of the most noteworthy patents.

However, the analysis showed that the main goal of developing the patentable dispensers is to improve the accuracy and uniformity of technologies and equipment for dispensing various substances in a number of industries. It should be noted that increasing the accuracy and uniformity of dispensing often entails a decrease in productivity, especially for continuous dispensing devices.

The analysis demonstrated that patents aimed at improving the energy efficiency of the dispensing process are rarely issued. This indicates that the energy costs of the dispensing process in comparison with the energy costs of other operations in enterprises can be considered acceptable, and a promising area for elaborating the considered objects is to increase the accuracy and uniformity of dispensing.

From the analysis of patents, it follows that the key reason for the complexity of accurate and uniform dispensing of bulk materials is their arching at the entrance to the feeder, the formation of clogged zones and caking, and when dispensing the free-running mediums, the main problem is the difficulty to measure the value of dispensing medium passing through the dispensing device when its working body closes.

The results of the conducted research made it possible to build a knowledge base in the field of patented technological and technical solutions for the research objects. The results obtained can be used as analogues and prototypes in the synthesis and patenting of new technical solutions for improving and creating fundamentally new technologies and equipment for dispensing in food-manufacturing, construction, chemical, cement, medical, cosmetic, agricultural and other industries.

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