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Optimization and Design of Key Technology of New Type Bottled Water Filling Machine

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Abstract

Mainly for the current bottled water filling machine common production efficiency is low, the product type is relatively single and other shortcomings. Combined with the production line method of beer double-row filling machine put forward by Comrade Qingbo of Nanjing University of Technology, the design scheme of the high-efficiency parallel filling machine for bottled water is put forward. Among them, the bucket unit is used adjustable small bezel to separate the barrel, the spacing of the small bezel can be adjusted according to the diameter of different barrel types. For the filling part, the capacity of the filling is controlled by the number of receiver wave pulses from an electronic flow meter. The error is verified to be within the allowable range based on the actual prototype. The side-by-side filling valve is filled with a large conduit, with a large catheter filling at 90% of the preset value, followed by a small catheter filling, which prevents liquid splashing and also guarantees filling accuracy. For the cap system to increase the volume of the cap, reduce the cover cycle, reduce the labor load of workers. The upper cover of the barrel cover method uses the gas pump to absorb to the designated position, which in the process of adding the barrel cover to the cap, there is secondary pollution and can not be timely sterilization, so the design of this topic in the barrel cover rise process using the whole process of ultraviolet sterilization, to solve the problem of secondary pollution after sterilization is not timely. According to the results of the application, the original bottled water filling efficiency is greatly improved, and the new bottled water filling machine is analyzed in theory to improve the production efficiency by 100%, but the actual application results are improved by 83%. The new bottled water filling machine designed by the article also improves the filling speed from the original 19s filling a 5 gallon bottled water, to the current filling of two identical models only 17.4s. The new bottled water filling machine is optimized to increase productivity and reduce production costs.

Keywords

Two-row bottled water filling machine; Separate the small bezel; Secondary sterilization; Efficiency.

1. Introduction

We all know that water is the source of life for people, and with the improvement of people's living standards since the reform and opening up, our demandfor daily access to drinking water is getting higher and higher[1,2,3]. But our environment has been severely damaged with the progress of industry. With the continuous improvement of people's living standards, the demand for bottled water is also increasing[4,5]. It is therefore very important to improve the productivity of the current bottled

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water filling machine. As the bottled water market continues to be hot, the annual growth rate of more than 20%[6], especially during the outbreak, everyone stay at home for the demand for bottled water is a significant increase. And to increase the production efficiency of current bottled water can significantly increase the annual profits of enterprises. Design a high-efficiency bottled water filling machine for the current situation. Combined with the current market existence of bottled water production lines are generally used is the production model is single-line production. However, this paper combines the production line mode of beer double-row filling machine to optimize and design a parallel production line model for a variety of barrel-type bottled water. Theoretically, the productivity is doubled compared to the single-line production model. At the same time, the key components in the filling machine: filling valve, caping mechanism, etc. to optimize the design. The design scheme for the new bottled water filling machine is proposed. Improve the production efficiency of the current market filling machine, and solve the problem of secondary pollution after sterilization is not timely.

2. The overall design of the new filling machine

2.1 Determination of main technical parameters

The filling machine described in this article is a high-efficiency bottled water filling machine, mainly used for 5 gallons of bottled water filling, the main goal is to improve the current bottled water filling efficiency. According to the requirements of design and production, the main technical parameters of the new bottled water filling machine are determined, such as Table 1.

Table 1 Main technical parameters of the new barreled water filling machine

Number of filling heads (pcs)	Filling capacity (L)	Production capacity (barrel/h)	Air source pressure (MPa)
28	18.9/16.8/10/7.5	400	>0.8
Cleanliness level (grain/L)	Air consumption (m^3/min)	Filling accuracy (ml)	Overall dimensions (mm×mm×mm)
⩽120	2.5	<80	24611×2541×4340

2.2 The overall design.

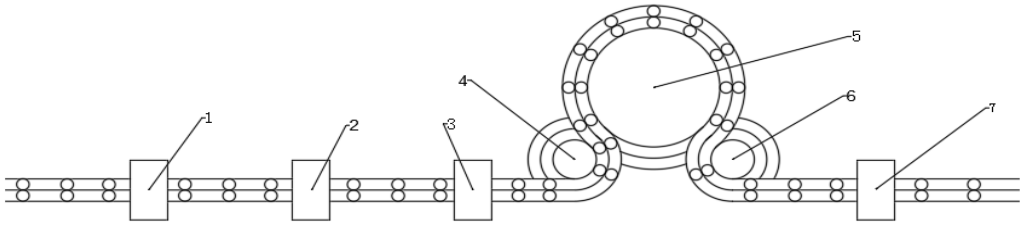

Figure 1 The overall layout of the new high-efficiency filling machine

The filling machine is used for filling barrels of pure water, so it has strict requirements on sanitation. According to the sanitary requirements, the material of the new high-efficiency barreled water filling machine uses stainless steel 316L (the part in contact with the product water), and the rest of the materials are made of stainless steel 304[7]. Because the new high-efficiency filling machine has strict sanitary requirements, the filling process and capping process of the production process are fully

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enclosed, equipped with high-efficiency filters and uninterrupted ventilation equipment, so that the production environment reaches 100 levels Cleanroom level [7]. 1- capping mechanism; 2-outer washing mechanism; 3-inner washing mechanism; 4-barrel entering device; 5-ring filling mechanism; 6-barrel discharging mechanism; 7-capping mechanism.The layout of the whole machine is shown in Figure 1.

The process of the overall filling machine is as follows:

Manual on the barrel →unplugging →External cleaning →Internal cleaning →filling →capping →finished output.

Throughout the process, only the barrel and capped process requires manual operation, and the rest of the work is done automatically with mechanical control, which greatly improves productivity and production speed, thus greatly reducing the intensity of manual labor. The methods available for the barrel method are: screw into the bottle, turntable into the bottle, dial into the bottle, turntable and screw combined into the bottle and manually on the bottle. As this design is for the filling of bottled water, wherein the diameter of the empty barrel is generally around 350mm and the use of double-row synchronous filling, taking into account the actual production, so the use of manual barrels.

During the production process, the speed of the conveyor belt is controlled by servo. When the empty barrel enters the capping mechanism, because the two barrels enter side by side, after reaching the designated station, the barrels are clamped by the pushing cylinders on both sides to complete the capping action. Enter the washing facility. When the photosensitive sensor senses that a bucket has entered, the cylinder and the brush start to move, and the outer space of the bucket starts to be cleaned. After cleaning the external space, the empty bucket enters the inner washing mechanism. Because it is drinking water, the inside of the bucket is relatively clean. The main task of the inner washing mechanism is to disinfect and clean the inside of the empty bucket [7]. After the internal and external washing is completed, the empty barrel enters the filling part through the bottle feeding device. When the empty barrel to be filled is pushed into the designated station, the cylinder pushes the filling valve to complete the filling. After the filling is completed, it enters the gland part through the conveyor belt. Finally, the workpiece to be capped is capped by the capping mechanism, and finally the entire production process is completed.

3. Design of key components of the new barreled water filling machine

3.1 Design of barrel dividing device

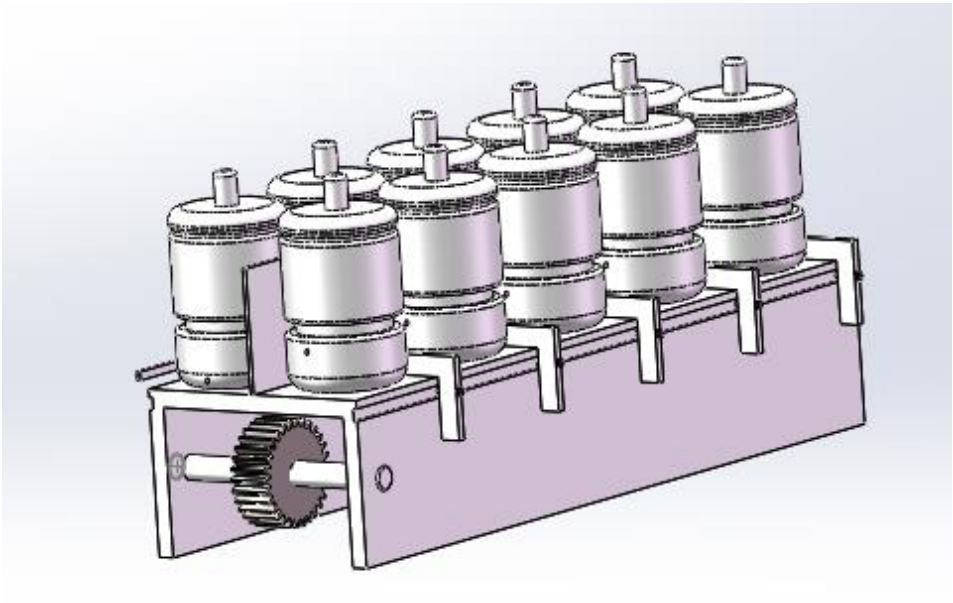

Figure 2 Working state diagram

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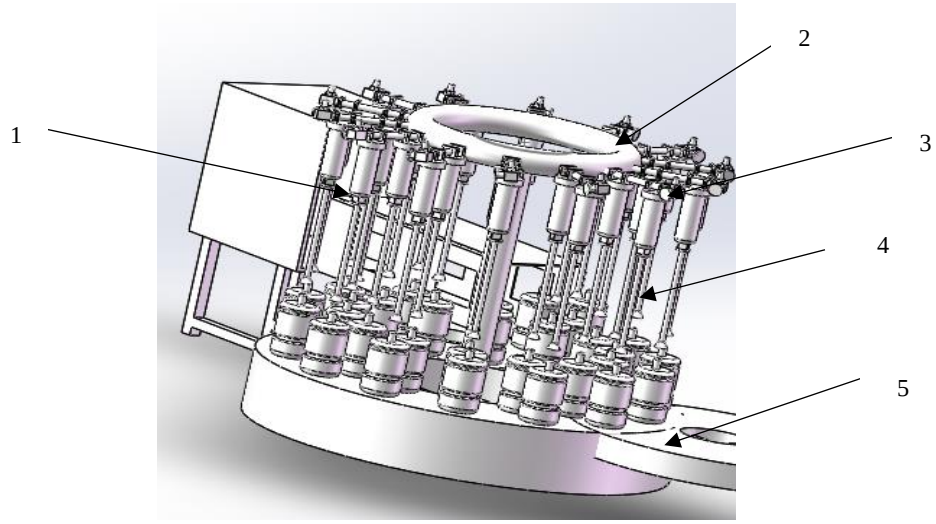
In the traditional method of filling into the barrel, the barrel feeding method generally adopts the method of squeezing the barrel next to the barrel [8][9]. However, the new filling machine abandons the squeezing method and adopts a small baffle isolation method, which is equivalent to separating each barrel into the barrel when entering the barrel, which is conducive to high-efficiency filling during filling. At the same time, it is no longer necessary to use barrels and columns to align the device, simplifying the structure of the filling machine. Its working state is shown in Figure 2.

When a small baffle is used to divide the barrels in parallel, the distance between the small baffles can be adjusted by the side chute. The fixing of the small baffle is clamped by the positioning nut, and the spacing can be adjusted according to the barrels of different diameters to meet the transportation of different types of barrels. It can be adjusted from the original single 18.9L barrel to 16.8L, 10L, 7.5L and other types of filling. Just adjust the spacing between the small baffles to complete a series of actions such as filling and capping of multiple types of barrels.

3.2 Parallel filling valve design

The filling valve is an important part of the filling machine. It directly affects the overall speed of filling and the accuracy of filling, etc. [8]. In this prototype, the filling valve hose is made of food-grade hose, which guarantees the sanitary standard of the part in contact with the product water. For the new high-efficiency filling machine, high-speed filling is inseparable from the corresponding high-efficiency filling valve. In this new type of filling machine, the method of pressure filling is used to fill the empty barrel to be filled by controlling the opening and closing of the filling valve.



1- cylinder; 2- filling liquid storage tank; 3- electronic flow meter; 4- filling hose; 5- bottle feeding turntable

Figure 3 Filling main structure

Its working principle: After the position of the small baffle of the barrel is fixed, the 28 empty barrels to be filled are sequentially placed on the filling station; because each barrel is separated by the barrel baffle, it is not necessary The fixture is fixed, and it can be fixed next to itself by a small baffle; the parallel filling valve is moved down by moving the cylinder, and the filling hose is tightly closed to the barrel mouth, through the electronic flowmeter installed on each parallel filling valve , The filling volume controls the filling capacity of each empty barrel to be filled through the control system tracking the square wave pulse number of the electronic flowmeter, when the empty barrel to be filled reaches the preset value (by calculating the number of square wave pulses) , Automatically close the valves of the parallel filling valves to achieve quantitative installation. When the model of the empty barrel to be filled changes, the number of square wave pulses received by the electronic flowmeter can be changed by adjusting the preset value through the program, and then the filling equivalent can

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be controlled. According to the test of the prototype test platform, in the case of the entire filling time of 17.4s, the level difference of the water in the barrel can be controlled within ±80ml. The main structure of the filling is shown in Figure 3. The parallel filling valve is shown in Figure 4.

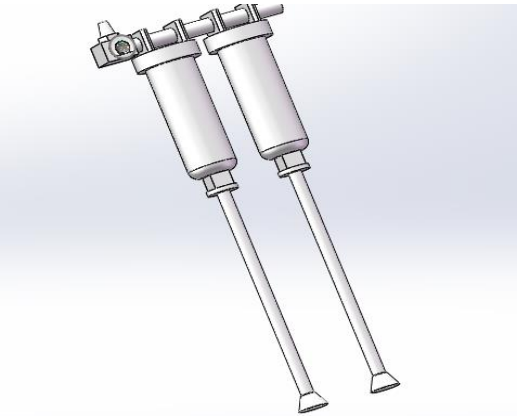

Figure 4 Parallel filling valve orifice

For each double-row filling valve, two water pipes are built in. The large pipe adopts a water pipe with a diameter of 30 mm; the small pipe adopts a water pipe with a diameter of 15 mm. Its function is to use a large tube to infuse at the beginning of filling, and to use a small tube to infuse to 90% of the preset value. This design saves time and improves filling accuracy. The power of the filling system is provided by the water pump. Some parameters of the water pump selected according to the design requirements are shown in Table 2.

Table 2 Some parameters of the pump

Pump flow（m^3/h）	Flow rate（mm/s）
6.3	2000

The calculation formula of the flow q1 of large pipe diameter:

$$q = \frac{1}{4} \times \pi \times d^2 \times v \tag{1}$$

Bring in the data to get:

$$q_1 = 1.41L/s$$

The calculation formula for the flow q2 of the small pipe diameter is:

$$q = \frac{1}{4} \times \pi \times d^2 \times v \tag{2}$$

Bring in the data to get:

$$q_2 = 0.35L/s$$

If filling a 18.9L empty barrel to be filled, the opening time of the large tube valve is about 12s, and the time required for filling with a small tube diameter after filling reaches the preset value is 5.4s. So the total filling time is 17.4s. It is calculated that 206 barrels can be produced per hour, because the new double-row barreled water filling machine is used, so the total production capacity is 412 barrels per hour. 400 barrels per hour to meet the design requirements.

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3.3 Calculation of cylinders for parallel filling valves

For the selection of the bore diameter of the cylinder, the axial load F of the cylinder is mainly determined according to the load state of the cylinder; the load factor η of the cylinder is pre-selected according to the load motion state; the operating pressure P (P should be less than the minus 85% of the inlet pressure of the pressure valve).

According to the filling valve cylinder is the power source for filling, its action is to start the electronic flowmeter after the empty barrel to be filled enters the filling station, and fill the product water in the storage tank into the empty barrel, according to the formula Calculate the cylinder bore:

$$D = 1.23\sqrt{\frac{F}{P}} \tag{3}$$

In the formula:D─ cylinder bore, mm

F─Axial load force, N

p─air source pressure, MPa, take p=0.8MP

Calculated to: D=55.64mm

Select the cylinder diameter as: D=56mm

3.4 Design optimization of the gland mechanism

Because the filling of bottled water is very strict with sanitation requirements, and the traditional sterilization of the lid in the traditional bottled water production line generally uses an independent sterilization device, which is manually supplied to the lid mechanism after killing the bacteria. In the process of the upper cover, secondary infections are prone to occur. However, it cannot be sterilized in time after secondary pollution. The device that uses the cover generally uses a crawler-type cover mechanism, but the crawler-type cover machine has a large working space, high manufacturing cost, and high maintenance cost.

Combining the above problems, the new high-efficiency filling prototype adopts a fully-enclosed top cover mechanism, which solves the problem of timely sterilization after secondary pollution and reduces the cost of manufacturing and maintenance. The overall structure is shown in Figure 5,

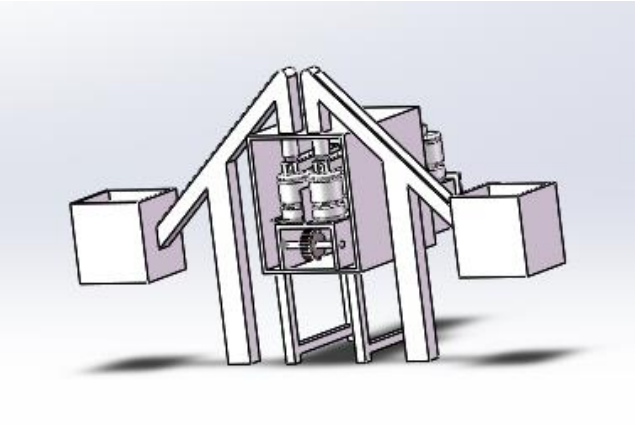

Figure 5 Gland overall mechanism

Its working principle:

1) The upper cover mechanism adopts adsorption lifting, which has a stable operation and is suitable for various types of cover types.

2) The upper cover mechanism is made of steel plate stamping, without welding, ensuring the processing accuracy. And the use of fully enclosed to prevent serious secondary pollution. Combined with missing cover alarm detection function, improve the efficiency of uncovering.

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3) Before lifting the lid, you need to wash the lid with disinfectant and ozone water. After washing the lid, add the lid container. Even if secondary pollution occurs during the period, secondary sterilization is carried out by ultraviolet rays in the bucket cover in the container and during the lifting process, which can ensure complete sterilization. In the process of lifting the lid, the lid relies on the suction force of the air pump to suck the lid, so the squeeze on the lid is small during the suction process, and the slideway for sucking the lid is assembled by stamping and cutting, with little deformation , High strength, easy adjustment, no jamming and other advantages [10][11].

4. Summary

At present, the main problems of the filling machines that are generally present in the market are that the barrel type for filling is relatively simple, the efficiency of filling is not high, and the secondary sterilization is not perfect. This subject mainly proposes the optimized design scheme and ideas of the key components of the new high-efficiency filling machine for bottled water. Creatively designed a small baffle for crawler sub-barrel, which can slide back and forth, with a chute on its side, the distance is preset according to different barrel diameters, so that the new filling machine can adapt to the filling of different barrel diameters produce. The original double-row filling was mainly used for the filling of small-bottle bottles like Xilin bottles, but in this new type of bottled water filling machine, it was creatively applied to the filling of bottled water according to the double-row filling principle of Xilin bottles. Outfit. Among them, the high efficiency of double-row filling theoretically analyzes that the filling efficiency has doubled compared with the original. In the gland pressing mechanism, the cover is sterilized by secondary sterilization, using disinfectant and ozone water for manual sterilization for the first time, and ultraviolet sterilization for disinfection to prevent secondary pollution. In the subsequent design, the automation program can be further optimized and designed according to the working conditions of the filling machine, so as to basically realize automated unmanned production, which is also the focus of future research [12].

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