TELKOMNIKA, Vol. 11, No. 4, April 2013, pp. 2084~2087
ISSN: 2302-4046

Research on the Pulsed Magnetic Field Device for Sterilization of Fruit and Vegetable Equipment

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Abstract

In view of the requests of the sterilization device of the fruit and vegetable that integrate cleaning and juicing together, and combined with the electromagnetic theory and the cold sterilization technology which is in common use in modern food industry, circuits are designed for the pulsed magnetic field sterilization device of the integrated machine. This circuits chose a linear solenoid in which r= 30mm, l= 200mm. The experiment shows that the pulsed magnetic field produced by the device can achieve a better effect in killing bacillus coli, beer yeast and staphylococcus aurous, etc. Compared with the traditional sterilization device, the bactericidal effect of the pulsed magnetic field sterilization device is more obvious so that it will be the direction of the development of food equipments.

***Keywords**: integrated machine for juicing and sterilization, pulsed magnetic field with high voltage, control circuit, linear solenoid*

1. Introduction

There are two mainly sterilization methods in food industry: One is thermal sterilization, another is non-thermal sterilization. Thermal sterilization is the most commonly used method; it includes high pressure instant stilization, boiling sterilization and so on. Non-thermal sterilization includes physical sterilization and chemical sterilization [1]. The traditional heating sterilization although can achieve the purpose of sterilization, but it can affect the nutrition of food flavor and color, and large energy consumption. But non-heating sterilization can not only ensure the safety of food microbiological aspects, but also can well keep food inherent nutrition, quality, color and luster and freshness [2].

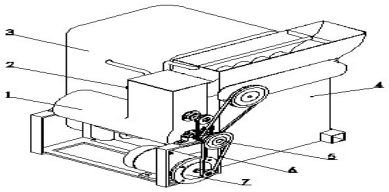

Figure1. Three Dimensional Diagrams for the Multifunction Equipment

1 juicing device, 2 pump, 3 sterilization device, 4 cleaning device, 5 wheel, 6 belt, 7 electric machine

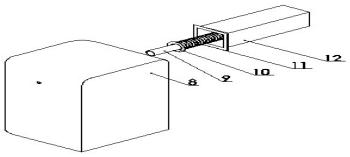

Figure 2, Internal Structure of the Sterilization Device

8 case, 9 tube, 10 solenoid, 11 coil, 12 magnetic cover.

High voltage sterilization with pulse magnetic field is a kind of non-heating sterilization technology, has the characteristics of good sterilization effect, low cost, short time sterilization, low energy consumption, small influence on food quality etc., especially suitable for liquid food. By the aid of linear solenoids, the high strength pulse magnetic field is applied to liquid food for sterilization. This technology has show unique superiority in the fruit and vegetable juice and

Received January 12, 2013; Revised February 23, 2013; Accepted March 5, 2013

other food processing. At present, this sterilization technology is gradually transition to commercialization in Europe, the United States and other developed countries. Also the corresponding research have carried out in china in recent years, but only in the laboratory stage, still some way from commercialization.

This paper aims to research the high voltage sterilization device which used in the multifunction equipment of juicing and sterilization.

2. Introduction for the Multifunction Equipment of Juicing and Sterilization

The multifunction equipment includes cleaning device, juicing device, sterilization device. The fruits and vegetables are washed by the high pressure water which sprays from the hoses located at the top of cleaning device. The brush roller installed above the tank has the function of the scrub when the fruits and vegetables are on the way to transport to the juicing device. Before juicing, the fruits and vegetables are first cut into pieces by the hobbing cutter. And then it was transported to the other side by the roller which diameter increased gradually, and at the same time, the roller press the fruits and vegetables, finally, the juice was delivered to sterilization device by the pump.

Because of unique structure design, this multifunction can easily achieve cleaning, juicing, sterilization for fruit and vegetable, even include sewage treatment.

Sterilization device (as shown in Figure 2) adopt pulse magnetic sterilization. The sterilization mainly includes two aspects: one is the action of the magnetic field, when changing electromagnetic field reaches a certain value, the cell membrane will appear electroporation and shock effect, then fracture. Another is ionization effect, when applied pulse magnetic field with high voltage, the food molecules will break into cation and anion, making the bacterial death. Compared to the normal sterilization equipment, it is greener .It can achieve sterilization effect without all kinds of detergent, but also can keep the original flavor and quality of the drink.

3. Work Principle of Sterilization Device of Pulse Magnetic Field

Sterilization device chiefly consists of pulse magnetic field generation circuit, tube, and coil. Controlled by the high voltage generation circuit, the coil can produce 2~10T pulse magnetic field. When the liquid food pass by the tube, the microscopic animals or bacteria would die because of strong pulse magnetic field.

Firstly, the pulse-generating circuit produces a certain amount of DC voltage, then supply for storage capacitor. When the capacitor is fully charged, the post solenoid would discharge by the control of control circuit, and then form a certain pulse magnetic field for food sterilization.

The pulse-generating circuit mainly consists of four parts: pulse power supply, charging circuit, discharge circuit and control circuit. The control circuit is mainly achieved on the charge and discharge control of the capacitor. The high voltage pulse magnetic field generating circuit is typical of the RLC circuit.

3.1. The Generating Circuit of Pulse Magnetic Field

A step-down transformer (T1) can reduced 220 V voltages to whatever value is desired. Then a step-up transformer (T2) can boost to high voltage even to 5000V.Then Three-phase Full-controlled Bridge Rectification Circuit rectify alternating current to direct current with high voltage. After pass current-limiting resistance and some protective components, the high voltage capacitors which have large value was charged. Energy in the form of the electric field was stored in the capacitors. Charge and discharge of capacitors was controlled by high voltage SCR switches SW1 and SW2. When SW1 is closed, SW2 is turned off. Capacitors enter the charging state. When the capacitors are full charged, SW1 is turned off, SW2 is closed. The capacitors discharge rapidly to solenoid coil. A large number of the electrical energy stored in the capacitors are quickly released through the coil. Thus a high strength of pulse current is generated in the coil. Then high-intensity pulsed magnetic field inside the solenoid is inducted. The closed or turned off state of SCR switch SW1, SW2 is controlled by trigger signal which produced by control circuit. The principle is shown as Figure 3.

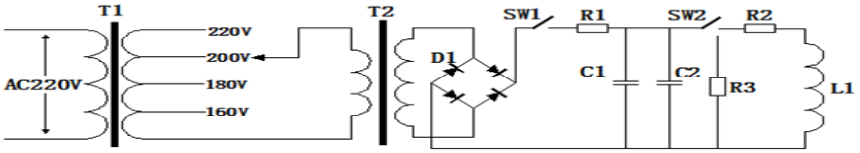

Figure 3. Circuit Principle of Generated
Pulsed Magnetic Field with High Voltage

3.2. Control Circuit

Control circuit has the function of capacitors charging and discharging controlling, and as well as pulse magnetic field frequency parameter settings. Firstly, through two monolithic integrated voltage sampling-hold circuit [4, 5]. Real-time sampling is achieved from capacitor's voltage and DC power supply with high voltage. Then the sampling is connected with the voltage comparator, can output a digital signal (output low-level signal when the voltage of capacitor is less than that of the DC power supply with high voltage, otherwise output high-level signal).This signal is connected with one input terminal of an AND gate. Another terminal is connected with a square wave controlling signal which is produced by Multivibrator composed of 555 timer and peripheral circuit. After passing the amplifying and driving circuit, the output signal of AND gate triggered SCR.

When charging, the capacitor cannot discharge. When discharging, the capacitor cannot charge. That mean, the switching relation between SW1 and SW2 is opposite. The trigger signal is connected to NOT gate, and then the output of the gate can trigger SW1. Changing the capacitor value of the multivibrator can change trigger frequency, thus change the frequency of pulse magnetic field. The design of control circuit is shown as Figure 4.

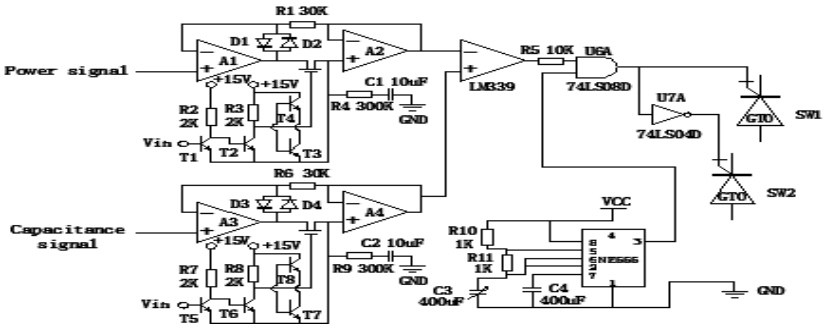

Figure 4. Principle of Control Circuit

4. Design of Solenoid

A strong pulsed magnetic field was formed when each discharge. After about 10 times treatment by the magnetic field, the sterilization for the fruit and vegetable basically reached the requirements [7, 8].

Parameters of discharging circuit and size of solenoid coil should meet:

$$\begin{cases} R_2 > 2\sqrt{\dfrac{L_1}{C_1 + C_2}} \\ L_1 = \mu_0 \dfrac{\pi R_2^2 N^2}{l} \\ N = \sqrt{\dfrac{L_1(3D + 9B + 10C)}{8 \times 10^{-6} D^2}} \end{cases}$$

Where R2 is the load resistance.L1 is the inductance value of solenoid coil. N is number of windings for solenoid. The meaning of D, B, C is shown as Figure 5:

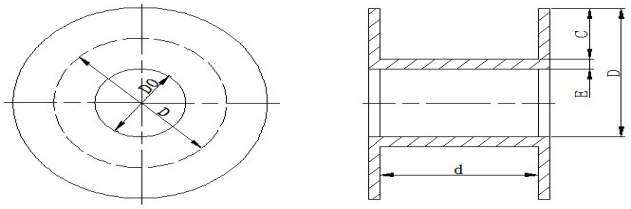

Figure 5. Structural Diagram of Solenoid coil

5. Conclusion

The characteristics of the pulse magnetic field sterilization technology is: Sterilization materials is generally not more than 5. The structure of materials, nutrients and color are no longer destroyed, thus, will not affect its original flavor. The intensity of magnetic field attenuated to the intensity of geomagnetic about 2m near the coil, and therefore it's safe because of no magnetic leakage problem. It's easy control for the generation and abort of the magnetic field.

Compact design, firm, multiple functions and good sterilization effect suit the device to use widely in the future.

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