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Study on mold sterilization using High Electric field generation system

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ABSTRACT

There are several electricity applied sterilizers such as sterilizer with high frequency, sterilizer with ozone, sterilizer with high voltage, and so on. Those sterilizers feature "because there is no chemical process, there is no secondly environmental pollution". At the power conversion part, ZVS and ZCS methods have been used that it results in reduced switching loss, miniaturized size, and lightened weight. Besides, the current in the device is smaller than that of existing method. Thus, it is expected that the cost of sterilization process, when quality of the device is measured by power consumption, will be reduced.

1. Introduction

There are several electricity applied sterilizers such as sterilizer with high frequency, sterilizer with ozone, sterilizer with high voltage, and so on. Those sterilizers feature "because there is no chemical process, there is no secondly environmental pollution". Among them, the sterilizer with high voltage uses only corona discharge, so it has been reported that bacteria are eliminated by accumulated electro charge or residual current on cell wall. Such way of bacteria elimination has been numerously reported about liquid state. However, there was almost no report on solid or powder state sterilizing.

In order to eliminate bacteria in manufacturing of chinese medicines, high temperature sterilization is traditionally used but this method brings reduced effect of the medicines due to some destroyed elements in the medicines. Besides, chemical method is not suitable because there are poisonous remainders in the medicines. Nowadays, radioactive rays are used to eliminate bacteria, but there are some defects such as protection of radioactive source, inconvenience in usage, pollution during transporting, high cost, and so on. Therefore, the goals of this study are to solve the problem of the existing medicines sterilization, investigate economical and effective method, and introduce improved sterilizer by the sterilizer with high field.

<Table 1> The specification of High Electric Field Generation unit

item	experimental unit contents
Input	380V 60Hz
Output	5kVDC ~ 20kVDC
efficiency	90%upper
High frequency High voltage transformer	N1:N2 = 14:510
Control method	ZVS, ZCS switching

Generally, condenser input rectifier circuits are mainly used for DC-link part in power transformation devices.

Input current of this circuit becomes pulse type at peak part of input voltage, so it makes low input power factor. Also,

the current has lots of harmonic elements which have a bad effect on power system. Thus, by applying partial resonant switching whose input power factor is controlled almost by unit power factor, it is expected that switching loss will be decreased, harmonic will be reduced, and power factor will be improved. Then, stable AC power supplies high field with the sterilizer through high frequency high field transformer.

2. Principles of the sterilizer with high field

Fatal effect on bacteria depends upon electric field intensity, processing time, number of pulse, and attenuation time constant, and there are studies which have been investigating that

sterilizing effect is affected by applied voltage, corona electricity, processing time, and so on. This study is based on existing research data that inactive ratios are 60% at a minute processing time and 99.99% at over 5 minutes processing time when microorganisms are exposed under 20kV electric field peak. From the data, the device for applying high electric field is composed, then sterilizing ratio is examined. The power transformation device for this experiment is an inverter circuit, that uses ZCS, ZVS switching loss less mode, and AC 20kV is applied to the device through high frequency and high voltage transformer from rectified input 3 phase 380V(AC).

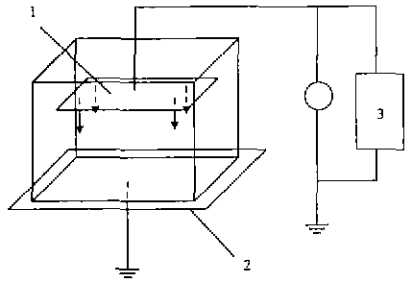


Fig.1 The sterilizer for powders with High Electric Field (1) The plate electrode, which has needle (2) The ground line (3) The high frequency high voltage power converter

Fig. 1 shows the experimental sterilizer that consists of 46×31cm aluminum sheet electrode and 45×30×30cm acryl box which covers the electrode. Once discharge electrode is star type wire, corona current appears bigger. On the contrary, when plate electrode, which has needle is used, the current disperses well. Thus, for this experiment, the electrode, which has needle, is used and AC high voltage(60Hz) is applied, that gives highest sterilizing power, and under those condition, sterilization effect is examined.

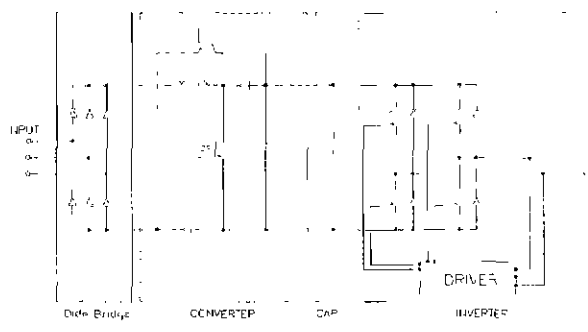


Fig.2 The configuration of main power converter system

3. Design of the high voltage generating device

Composition of the power transformation system is shown Fig.2 Input 3phase 380V(AC) is rectified through diode bridge and is supplied to the inverter through DC-link part which uses boost up chopper of the partial resonant switching control. Again, output AC voltage from the inverter generates high voltage high electric field at the sterilizer through the high frequency high voltage transistor.

4. Simulation and result

4.1 Mould used in this experiment

A variety type of dry things which human beings take in, according to drying method, can be mingled with various microorganisms from nature. Depending on situation, these bacteria can cause diseases. In order to eliminate the bacteria, it is commonly used to boil or heat the dry things, but in case of polluted microorganisms, it is difficult to be perfectly sterilized with that method. Especially, non-sporiferous microorganisms can be eliminated by relatively short time heat treatment, sporiferous microorganisms (generally mould), however, have strong tolerance of simple dry heat sterilization. If those bacteria are sterilized over 170℃ with long time, the product bthat includes dry things will be degraded. Besides, the mould used in this experiment is aspergillus niger that appears everywhere and is used at fermentation industries on a big scale with starch or albumen resolvent enzyme. That mould is the worst microorganism to be eliminated in normal sterilizers. Therefore, when artificially added spores of the aspergillus niger to the experimental product are sterilized and simultaneously, elements of the product are preserved in this experiment, it is assumed that each and every microorganism is sterilized which is poisonous to human beings.

4.2 Simulation waveforms

Fig.4-1 shows current and voltage of switches

at the partial resonant boost up and down switching. When the switches are turned on there is ZCS operation, and on the contrary, ZVS operation is occurred at turning off.

Fig.4-2 shows unipolar gate control signal, and output voltage and current wave forms. Fig.4-3 shows

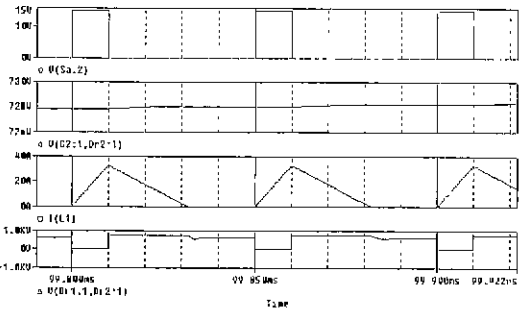


Fig.4-1 The partial resonant switching waveform of DC-link

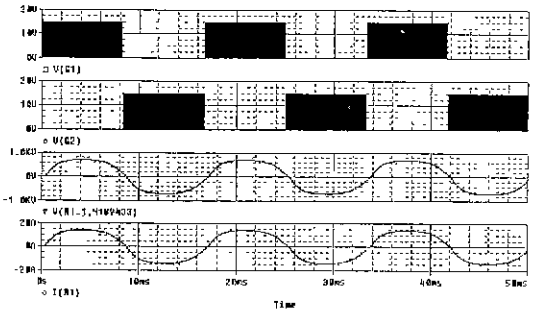


Fig. 4-2 The Uni-polar Gate control signal and output V,I waveform

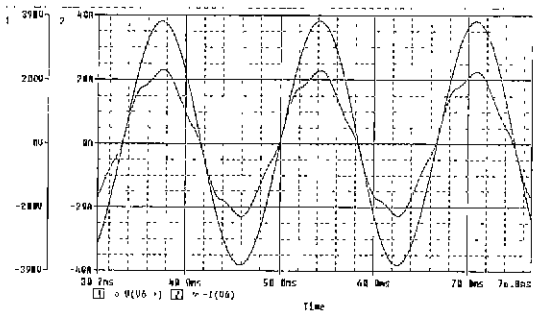


Fig. 4-3 The input V,I of power-converter

input voltage and current waveforms of the power transformation device, and it is understandable that the power factor is almost unit power factor according to the figure.

4.3 Photo of the sterilizer

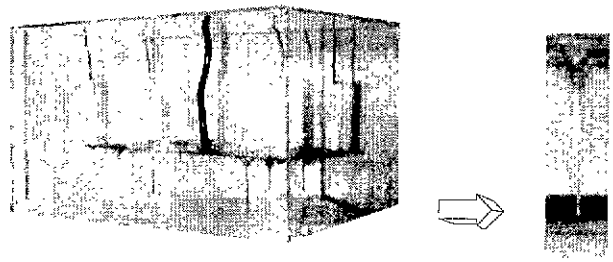


Fig. 4-5 the sterilizer experiment unit (Left) The overall model (Right) The pole of needle and the pole of plate

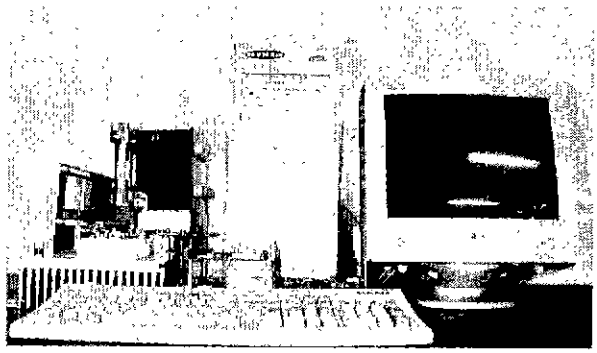


Fig. 4-6 The configuration of total system

4.4 Result

- The using a culture ground : YM agar
- The time of cultivation : 20 ~ 24hour at constant temperature
- dilution method : The each sample 10^4times diluting on 1g
- The spacing of a sample and the needle pole : 2.5(cm)
- During the Electric field time : 5minute
- Experimental results
  - before sterilization : $1,800\times10^3$numbers

<Table 2> The input voltage and sterilizing ration

Input voltage	12[kV]	15[kV]	18[kV]	20[kV]
detected mould numbers (random sampling)	$1,010\times10^3$	695×10^3	595×10^3	500×10^3
sterilizing ratio percent(%)	43.9	61.4	66.9	72.2

Owing to the imperfect design of needle electrode arrangement for composing uniform electric field, the bacteria weren't sterilized equally. Therefore, sterilizing ratio was getting lower when the experimental product located further from needle electrode than other products

which were closer to the pole. According to applied voltages, Fig. 4-8 shows cultivated moulds after sterilization. Those photos indicate that the higher voltage the sterilizer has, the better the bacteria are eliminated.

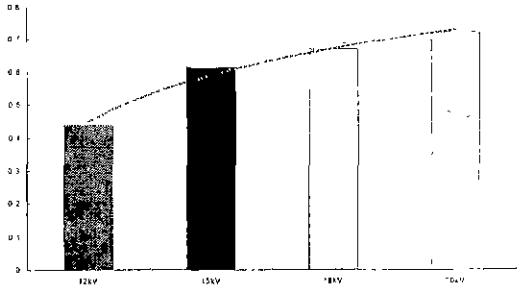
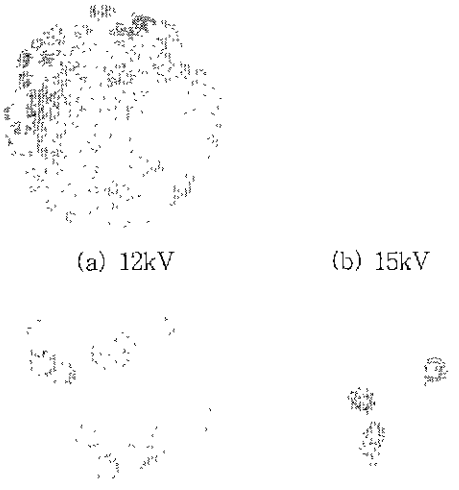


Fig. 4-7 The graph of sterilizing ration and input voltage



(a) 12kV (b) 15kV

(c) 18kV (d) 20kV

Fig. 4-8 The picture of mould cultivated which is after sterilization for input voltage

5. Conclusion

By the low power consumption high voltage power transformation device for sterilizer, sterilizing ratio has been measured through the process that powder, which had diluted moulds, was put into the experimental device then AC voltage was varied. And results are summarized below.

(1) Diluted moulds in powder can be effectively eliminated by 60Hz AC corona discharge.

(2) The operation that eliminates or destroys moulds is caused mainly by corona current.

(3) By means of using the partial resonant boost up DC-link part, reduced switching loss and high power factor(power factor 1) can be obtained.

(4) The high frequency and high voltage transistor can be miniaturized and corona current is extremely small, thus, it is possible to design low cost and low power consumption sterilizers.

Problems on the device design were losses by unsatisfactory insulation what was supposed to prevent consecutive discharge which occurred on surface of the sterilizer and local discharge that occurred on corners of the sterilizer. Next goal of this study is treating perfect insulation to prevent those losses and obtaining optimized values with the sterilizer but other electrode and *experimental product.*

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