Toxic Gas Eliminator from Print Ink by Applied High Frequency High Ripple Pulse Corona

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Abstract. This paper presents the design and development of toxic gas eliminator from print ink using high frequency high ripple pulse corona technique for decrease VOCs gas in the suction gas of printing ink using high voltage AC switched mode power supply. Using mini inverter principle and control of the switching by IC No.MB3579. The inverter is designed to operate at 10 kHz to 20 kHz through a high voltage switching transformer at output voltage of 1.5 kV, and at the input voltage of 18 VAC 50 Hz. By adapting the non-uniform electric field to the electrode design 3 tubes, one - hour operating yields the ozone gas (O₃) generating capacity of 6.3 ppm enables decrease VOCs gas as well.

1. Introduction

Nowadays, ozone gas is utilized, for example, using ozone gas to wash fruits instead of pomegranate. To eliminate germs and reduce the amount of chlorine in the water-pool. But ozone has disadvantages as well. If used in too much doses, it can cause irritation to the body. But if we use the right amount and suitable for the work that uses ozone gas in the application above, it will bring good health benefits. In this article, we will create an ozone generator with high-frequency switching high-voltage circuits by using IC No. MB3579 as the PWM generator. By sending the high frequency square wave waveform to the signal amplifier IC in order to drive the Power MOSFET high-voltage switching transformers work to send a voltage of 1.5 kV to the electrode in which ozone is produced by the principle of oxygen molecules breaking down which will produce ozone from the equation \( O_2 + O = O_3 \), which ozone has the ability to withstand a certain voltage. And heat affects the amount of ozone produced. Therefore, it has to be controlled amount of high voltage and the appropriate high frequency for ozone production. The chemical energy needed is 493 kJ/mol to 762 kJ/mol. To convert the unit, the required energy area is 5.583 kWh/m³ to 8.631 kWh/m³. There is approximately 21% oxygen. Therefore, the required energy range is 1.172 kWh/m³ to 1.812 kWh/m³ is enough to produce ozone in the air gap of the electrode rods.

2. Materials and methods

Therefore, this research requires experimentation by spraying ozone gas into VOCs in the gas suction pipe from the printing ink. To see the amount of VOCs that has decreased or not.

The principles of ozone production are as follows.

a) Materials used to generate ozone gas are 2 types which are
   - Use dry air that is everywhere.
   - Use pure oxygen
Figure 1. Block diagram of the VOCs reduction system in the gas suction pipe from the printing platform by using a toxic gas remover from the created ink.

Figure 2. Reaction to destroy pollution (VOCs) of ozone.

b) Ozone generator can be separated according to the following principles
   - use electrical principles which we call corona discharge process which is divided into 2 types according to frequency which are low frequency type and high frequency type. For hot weather and moisture, high frequency type is more suitable because it can produce ozone concentration is higher.
   - using UV lamps (Ultraviolet: UV), this type will generate ozone. Low concentration will be used in air treatment for water treatment is not suitable because the solubility is very low and therefore not effective.

3. Research objectives
a) To study the design and construction of high-ripple high-frequency pulse power supplies and co-axial cylindrical electrode cells In order to produce ozone gas
   b) To study ozone production methods with the use of highly uneven electric fields
   c) To study the use of ozone gas to eliminate toxic gas from printing ink.

4. Method of research
The research design is divided into 2 main parts as follows
a) Design of an electrode for ozone production
   b) The high ripple pulsed power supply design
5. The design of toxic gases eliminator.

5.1 Electrode stick design (Ozone production rods)

In the design of a 2-layer coaxial cylindrical rod, the design principle is quantity. Ozone gas is formed very well in the electric field stress which is very uneven. Therefore, the design of the electrode is used in double layers insulation because the use of different values of insulation is suitable for uneven electrical fields. Which will cause the electric field stress in each valuable layer having different values are similar. Therefore, the design of the 2-axis co-ordinated cylindrical rod design, in which the 2-axis co-ordinated cylindrical rod consists of:

a) Insulation class 1 uses glass as an insulator because glass has an effect on the formation of ozone gas with a coefficient (1) of 8 with a diameter of 2.6 centimeters and a length of 30 centimeters;

b) Insulation layer 2 will use air as insulation with a coefficient (2) equal to 1;

c) Cathode terminals are used as copper coils. Is inside of insulating glass;

d) Anode terminal is used as a cylindrical stainless steel rod. With a diameter of 2.9 centimeters and a length of 30 centimeters.

![Figure 3. A set of double-layered cylindrical rod electrode structure.](image)

At electrical energy area of 5.58 kWh/m³ to 7.73 kWh/m³, in the air there is 21% (O₂) oxygen using at electrical energy range 1.172 kWh/m³ to 1.620 kWh/m³.

Therefore, the electric power equation is equal to equation 1.

\[
W = \frac{1}{2} \int E^2 dv
\]

(1)

Therefore, the electric field intensity is equation 2:

\[
E = \sqrt{\frac{2W}{\varepsilon \text{vol}}}
\]

(2)

When the glass is valued and precious weather is Therefore the voltage when fed to the electrode unit is then done creating ozone gas equal to equation 3:

\[
V = E \cdot r_2 \cdot \varepsilon_2 \left( \varepsilon_1 \ln \left( \frac{r_1}{r_2} \right) + \varepsilon_2 \ln \left( \frac{r_2}{r_1} \right) \right)
\]

(3)

5.2 High voltage pulse switched mode power supply design

Switched mode power supply, high voltage, high frequency, switching type using IC No.MB3579 as a (PWM) pulse width modulation generator Which is the control circuit of the Power MOSFET with a
switching frequency of about 10 kHz to 20 kHz and then send the driving signal to the IC No.TLP250 to separate the ground and amplify the signal between the control unit and the converter set. After that, drive it to power final Power MOSFET going through the high voltage switching transformer to get the high voltage, high frequency as required by creating a high voltage of 1.5 kV to supply the 3 tubes electrode as in the Figure 4.

![Figure 4. High voltage pulse switched mode power supply.](image)

6. Research results

6.1. The measurement results of the Power MOSFET driver and high-voltage high-frequency (HVHF) signal on the output side.

![Figure 5. a) Power MOSFET driver signal using the probe x 10; b) high frequency high voltage signal](image)
output using the probe x 1000.

6.2. Electrical effects and the amount of ozone gas produced in Table 1.

| $f_{SW}$ (kHz) | $V_{in}$ (V) | $I_{in}$ (A) | $P_{in}$ (W) | PF | $V_{out}$ (kV) | Ozone Gas Quantity (ppm), (3 tubes) |
|---------------|--------------|--------------|--------------|----|---------------|-------------------------------------|
| 14.37         | 220          | 1.5          | 346.94       | 0.83 | 1.5           | 6.3                                 |

$f_{SW}$ (kHz) is the switching frequency of the mini converter.
$V_{in}$ (V) is the input voltage of the mini converter.
$I_{in}$ (A) is the input current of the mini converter.
$P_{in}$ (W) is the input power of the mini converter.
PF is the input power factor of the mini converter.
$V_{out}$ (kV) is the output voltage of the high voltage switching transformer.
Ozone Gas Quantity (ppm) is the amount of ozone gas.

6.3. Effect of VOCs (before and after ozone spraying) in accordance with Table 2.

| Before spraying the ozone gas into the suction pipe | After spraying the ozone gas into the suction pipe |
|----------------------------------------------------|---------------------------------------------------|
| 119.35 ppm                                        | 12.78 ppm                                         |

7. Conclusion and discussion of research findings
This research has designed and built a toxic gas elimination machine from printing ink. By the application of high frequency pulse spark plasma in the test, which is divided into 3 main parts: Part 1 tested the high voltage pulse spark power supply that was created of which the power supply can be adjusted to 1.5 kV at 14.37 kHz frequency. In the second part, the co-axial cylindrical rod test is performed or the ozone generator that is created. The electrode can produce ozone by 6.3 ppm and in the third part, the test by using the produced ozone gas to reduce the amount of VOCs in the gas suction tube from the printing ink. The result is a gas remover. Poisoning from this created ink can decrease the amount of VOCs gas to only 12.78 ppm (with the amount of VOCs beginning at 119.35 ppm) according to Table 2, in the future; the researcher will apply ozone gas to eliminate other air pollution which is one part that helps reduce global warming.

8. Suggestions
In this research there should be a test to reduce and increase the number of electrodes (ozone rods) to see the change in the amount of VOCs at the gas suction tube. In the 45 minute testing period in order to use the information to develop a toxic gas scrubber from the ink.

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