Characteristics of Ozonizers Manufactured in Energy & Environment Electromagnetic Lab. of Yeungnam University

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Abstract

Discharge characteristics research for high voltage and large current electric machinery design, the development of ozonizer with high yield and efficiency for environment improvement, generation of plasma & laser and EMI·EMC are research fields of Enersy & Environment Electromagnetic Laboratory(EEEL) in the school of electrical & electronic engineering of Yeungnam University. On this paper, we would like to introduce the discharge and ozone generation characteristics of ozonizers designed and manufactured by EEEL. After starting research for fluid gas discharge characteristics early in the 1980's, high voltage nozzle(HVN) type ozonizer, neon lamp(Nelamp) type ozonizer, ozone lamp(Olamp) type ozonizer and multi-discharge type ozonizer(MDO) have been investigated since 1990.

1. Introduction

Nowadays, air pollution and water pollution are internationally becoming serious problems, and research as for utilizing ozone(O_3) generated by gas discharge is being carried out to remove these environmentally contaminating materials. Ozone is well known as the second strongest material except fluorine.[1] Therefore, ozone is widely applied to various regions such as sterilization, decolorization, deodorization, organic oxidization reaction and removal of Nox or Sox, and this is eventually deoxidized to oxygen, so it does not cause second pollution.[2] With a method of ozone generation, silent discharge, photochemical reaction, radial ray, and electrolysis etc. have been used in the industry.[3]

Especially, silent discharge type ozonizer using gaseous discharge by Werner Von Siemens in 1857 is applied widely, the continuous researches on its development and utilization have been carried out. But, the problems of dielectric loss by applying A.C. high voltage, of a duct resistance by passing of constant flowing gas and low efficiency of ozone have been rised in the silent discharge type ozonizer. Therefore, theoretical ozone yield of silent discharge ozonizer, which has been investigated so far, is known as about 1,200[g/kwh], but in real experiment, when oxygen is supplied into an ozonizer, it is estimated about to 220[g/kwh]. Moreover, when air is supplied, it is estimated about to 90[g/kwh].[4]

In this respect, energy & environment electromagnetic laboratory(EEEL) of Yeungnam University, high voltage nozzle(HVN) type ozonizer, neon lamp(Nelamp) type ozonizer, ozone lamp(Olamp) type ozonizer and Multi-discharge type ozonizer(MDO) have been designed and manufactured since 1990. Therefore, on this paper, I would like to introduce the discharge and ozone generation characteristics of each ozonizer.[5,6,7,8]

2. Theoretical Analysis

When, oxygen or air are supplied, ozone formation and dissociation mechanisms are briefly shown in equation (1)~(4). The ozone molecules formed by combination between an oxygen molecule and an oxygen atom are dissociated by electron collision. These ozone molecules are dissociated by collision reaction with oxygen atoms or electron.[2,3]

$O_2 + e \rightarrow 2O + e$ (1), $O + O_2 + O_2 \rightarrow O_3 + O_2$ (2), $O + O_3 \rightarrow 2O_2$ (3), $O_3 + e \rightarrow O_2 + O + e$ (4)

3. Characteristics of Ozonizers

3.1 High Voltage Nozzle(HVN) Type Ozonizer

3.1.1 Apparatus

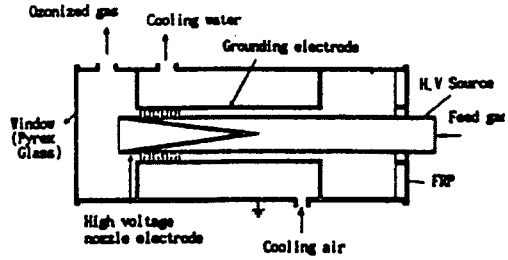


Fig. 1. Schematic diagram of the HVN type ozonizer

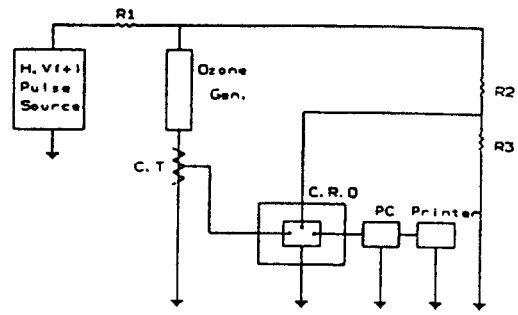
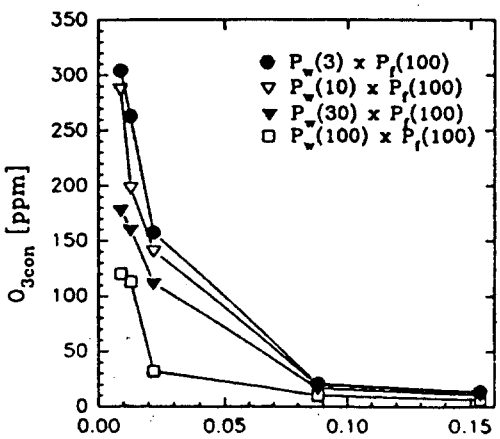
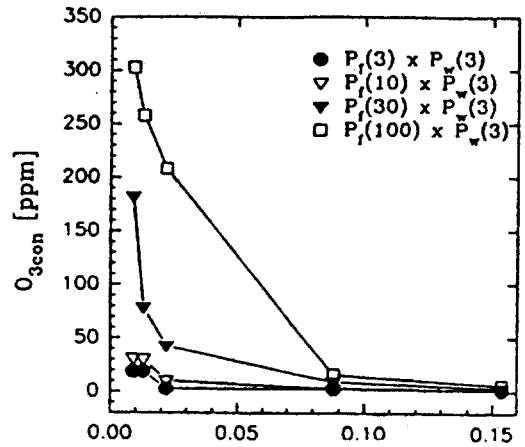


Fig. 2. Experimental circuit

3.1.2 Results



(a) variation of pulse width

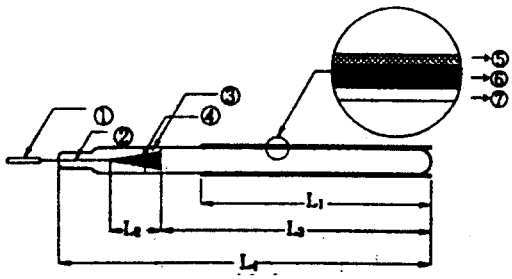


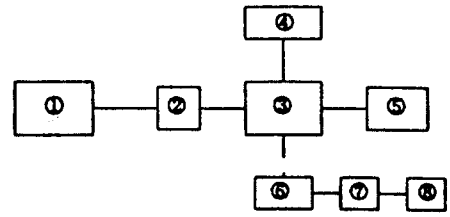
(b) variation of pulse frequency

Fig. 3. Characteristics of Reynold number–ozone concentration

3.2 Neon Lamp(Nelamp) Type ozonizer

3.2.1 Apparatus





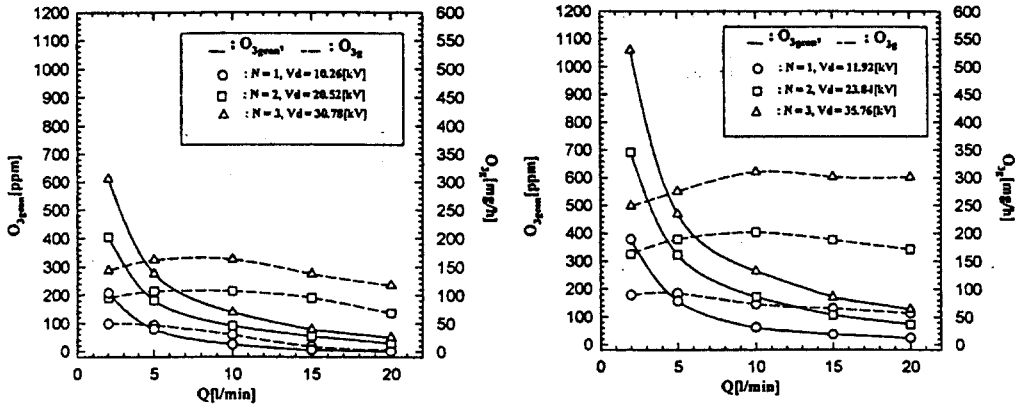
①dumet wire ② leading wire ③mica ④conical internal electrode ⑤mesh external electrode ⑥lead glass ⑦coating area

Fig. 4. Schematic diagram of the Nelamp type ozonizer

①oxygen supplied unit ②flowmeter ③Nelamp ④power supply ⑤ozone monitor ⑥OSC ⑦PC ⑧printer

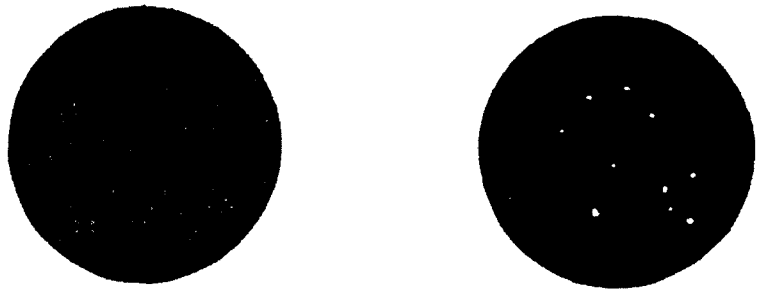
Fig. 5. Arrangement of experiment apparatus

3.2.2 Results



(a) (b)

Fig. 6. Characteristics of oxygen quantity–ozone concentration, generation with variation of discharge voltage and ozonizer number

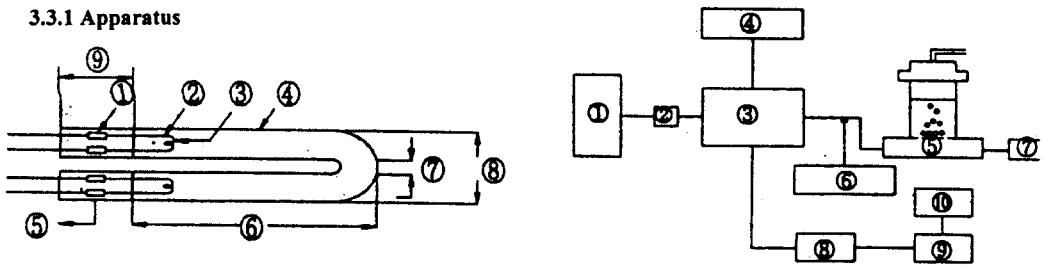


(a) Before reaction(2.75×10^5[cells/ml]) (b) After reaction(2.75×10^5[cells/ml])

Fig. 7. Characteristics of sterilization for Escherichia coli(ozone concentration : 663[ppm])

3.3 Ozone Lamp(Olamp) Type Ozonizer

3.3.1 Apparatus



①dumet wire ②leading wire ③filament ④quartz glass
⑤pinching ⑥L=135[mm] ⑦L=6[mm] ⑧L=32[mm] ⑨L=25[mm]

Fig. 8. Schematic diagram of the Olamp type ozonizer

①oxygen supplied unit ②flowmeter ③Olamp
④power supply ⑤reactor chamber ⑥gas ozone monitor
⑦liquid ozone monitor ⑧OSC ⑨PC ⑩printer

Fig. 9. Arrangement of experiment apparatus

3.3.2 Results

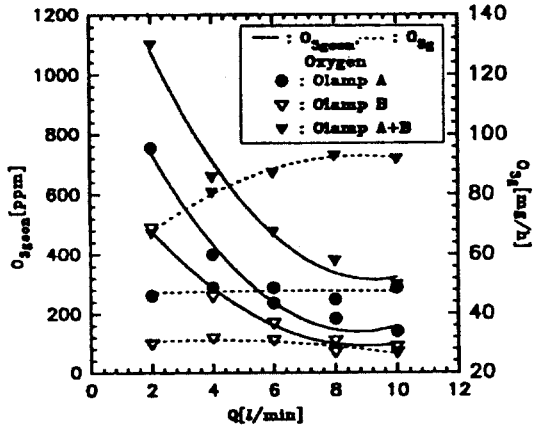


Fig. 10. Characteristics of oxygen quantity–ozone concentration, generation with variation of Olamp kinds

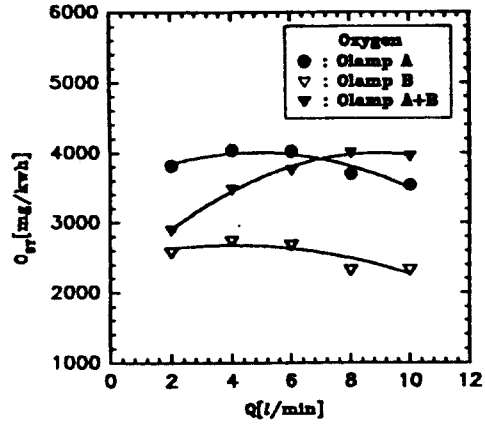


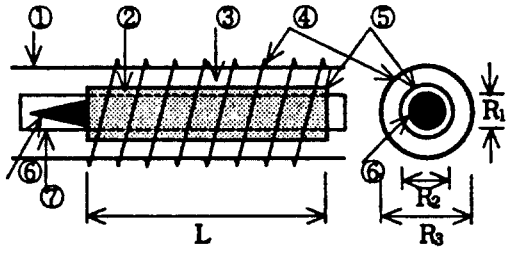
Fig. 11. Characteristics of oxygen quantity–ozone yield with variation of Olamp kinds

Olamp	E[lx]
Olamp A	5.2
Olamp B	5.5
Olamp A+B	10.1

Table 1. The intensity of illumination with variation of Olamp kinds

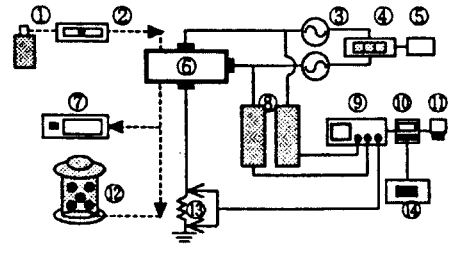
3.4 Multi-discharge Type Ozonizer(MDO)

3.4.1 Apparatus



①pyrex glass ②discharge gap d_1 ③discharge gap d_2
④external electrode ⑤internal electrode ⑥central electrode
⑦lead glass R_1:12[mm] R_2:12.8[mm] R_3:19[mm] L:130[mm]

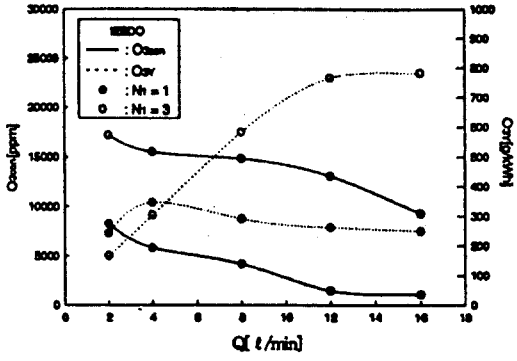
Fig. 12. Schematic diagram of the Olamp type ozonizer



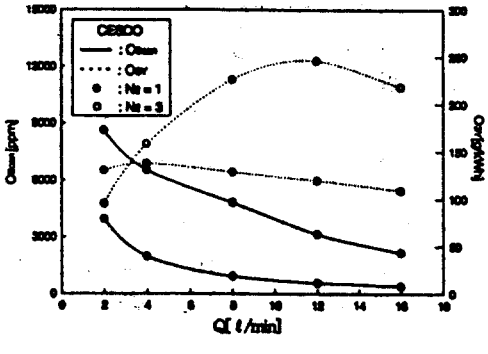
①oxygen supplied unit ②flowmeter ③AC H.V. source
④powermeter ⑤AC 220[V] ⑥MDO ⑦ ozone monitor
⑧H.V. probe ⑨OSC ⑩PC ⑪printer ⑫reaction chamber
⑬50[Ω] ⑭U.V. visible spectrophotometer

Fig. 13. Arrangement of experiment apparatus

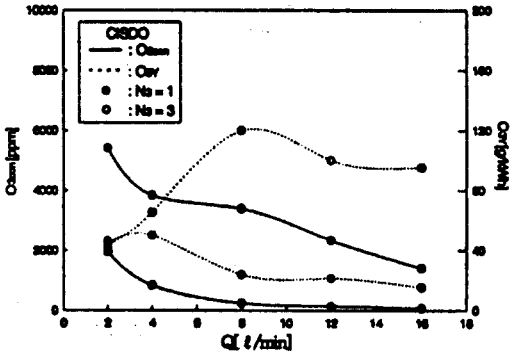
3.4.2 Results



(a)Internal and external electrodes(H.V.)-Central electrode(ground)

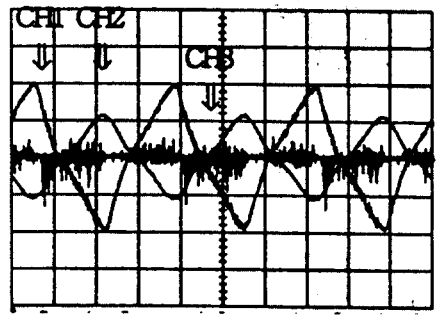


(b)Central and external electrodes(H.V.)-Internal electrode(ground)



(c)Central and Internal electrodes(H.V.)-External electrode(ground)

Fig. 14. Characteristics of oxygen quantity–ozone concentration, yield(O_{3Y}) with variation of MDO number



CH1:4[kV/div], CH2:10[kV/div], CH3:10[mA/div], 5[ms/div]

Fig. 15. Waveform of discharge voltage, current for MDO

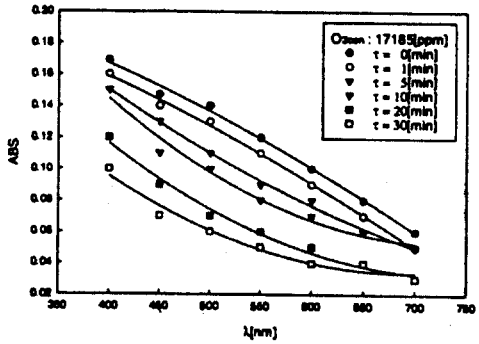
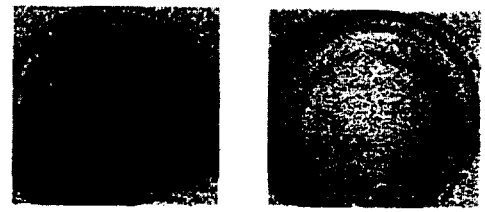


Fig. 16. The decolorant characteristics of dyeing water with variation of ozone reaction time



(a) reaction time:1[min] (b) reaction time 30[min]

Photo. 1. The photographs of dyeing water

4. Conclusions

Energy & environment electromagnetic laboratory(EEEL) of Yeungnam University, high voltage nozzle(HVN) type ozonizer, neon lamp(Nelamp) type ozonizer, ozone lamp(Olamp) type ozonizer and multi-discharge type ozonizer(MDO) have been designed and manufactured. As a results, ozone generation characteristics of each ozonizers are summarized as follows.

Types of Ozonizers	Concentration[ppm]	Generation[g/h]	Yield[g/kwh]
HVN	310	0.1	40
Nelamp	1080	0.5	60
Olamp	1150	1.8	90
MDO	26680	34.7	783

References

[1] A Vosmer, "Ozone", D.Van Nostrand Company, 1916

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[3] Netzer, "Handbook of ozone technology and applications volume Ⅱ", An Ann Arbor Science Book, 1984.

[4] JIEE, "Ozonizer Discharge", Discharge Handbook, pp263-280, 1981

[5] Hyun-Jig Song, Kwang-Sik Lee, Dong-In Lee, "A study on the high voltage nozzle type ozonizer", proceedings of the 11th International Conference on Gas Discharges and Their Applications, Vol.2, pp.320-323, 1995

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