Portable Ozone Generator

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***Abstract*—Ozone gas is now-a-days used for treatment of drinking water, disinfection, and air-purification. What one requires is a small and handy unit to be plugged into mains to get ozonated air at suitable pressure flowing out from a tube. It can then be let into environment or bubbled through water or any other polluted liquid. But the gadget must be completely safe to work with. Ozone generators invariably make use of a discharge tube to which a high electric field is applied so as to break down the oxygen present in the air. This phenomenon occurs at or near a field strength of 25 kV/cm, and the resulting discharge that takes place is known as Corona. The corona has a light bluish glow. It is in this corona field that oxygen becomes ozone (O_3). Ozone generator presented here has a capacity of producing 10 mg/minute of ozone Combined with atmospheric air. This unit can treat five liters of impure water in just two minutes. Complete disinfection of water, in any impure form, is realized with an ozone Content of 4 mg/liter. The discharge tube is supplied air from an air-group, which is built into the unit. The unit produces ozonated air at a pressure head of 15-20 cm of water via its outlet. So, the exit tube can be let into water containers with water up to a level of $10 - 15$ cm.**

***Index Terms*—Air-purification, Ozonated air, Corona**

I. Introduction

Ozone is a colourless to slightly bluish gas which is formed when oxygen is exposed to UV radiation or an electrical charge. The oxygen molecules (O_2) split to form ozone molecules (O_3). This is a very unstable arrangement and the third oxygen molecule will split off to oxidise the first pollutant with which it comes in contact. The pollutant is destroyed, and oxygen remains. Because of its powerful oxidising ability, ozone has been recognised since the early 1900's as an effective disinfectant, deodorizer and anti-pollutant. It will disinfect air, destroy bad odours, toxic fumes, bacteria, algae, fungi, mould and mildew. It is more widely used commercially in the water and waste-water industries for purification and disinfection purposes than as a disinfectant in the food industry.

A Dutch chemist called Van Marum was probably the first person to detect ozone gas sensorially. However, the discovery of ozone was only just mentioned by name decennia later, in a writing of Schonbein that dates to 1840 in the University of Munchen [1]. After 1840, many studies on the disinfection mechanism of ozone followed. The first ozone generator was manufactured in Berlin by Von Siemens. The first technical-scale application of ozone took place in oudshoorn, Netherlands, in 1893. This ozone installation was thoroughly studies by French scientists [2]. Ozone production did not reach its prior level until after WorldWar II. In 1950, the number of ozone installations that were in use worldwide had only grown to 119. In 1977 this number, had increased to 1043 ozone installations. More than half of the installations were in France. Around 1985, the number of applied ozone installations was estimated > 2000 [1].

Boglarski and Telikicherla (1995) stated that ozone was used as early as 1893 in Europe for drinking water treatment, and today is the most commonly used disinfection process in Europe [3].The major ozone installations in drinking water plants using ozone for disinfection were built in Paris (1897) and Nice (1904), France, and in St. Petersburg, Russia (1910).

Today, chlorine is still preferred over ozone for water disinfection. However, the last decennia the application of ozone applications did start to increase again. This was caused by the discovery of trihalomethanes (THM) as a harmful disinfection byproduct of chlorine disinfection, in 1973. Chlorine is highly carcinogenic because when it comes into Contact with remnants of pesticides in our foodstuff (vegetables), it generates halomethanes, which are carcinogenic [8]. Consequentially, scientists started looking for alternative disinfectants. Another problem was an increase in disturbing, difficultly removable organic micropollutants in surface waters. These compounds appeared to be oxidized by ozone faster than by chlorine and chlorine compounds. Furthermore, ozone turned out to deactivate even those microorganisms that develop resistance to disinfectants, such as Cryptosporidium.

This project reviews electrically methods of generation of low-concentration ozone for various applications including water treatment. Various membrane and discharge tube suitable for electrically ozone generation are discussed in terms of the efficiency of ozone yield, material stability against aggressive oxidative environment during ozone generation, as well as costs and power consumption. Ozone is a very powerful oxidant (E=+2.07 V) that can react with numerous organics present in water [4]. Corona discharge is the condition created when a high voltage passes through an air gap. In the case of ozone production, this high voltage transfers energy for the breaking of the O_2 molecule, allowing the formation of a 3-atom oxygen molecule ozone [5]. Ozone has tendency to revert to its original form in about $10 - 20$ minutes, in the atmosphere. Therefore, it is necessary in any ozone application to generate ozone as and when required for use since it cannot

be kept stored the way chlorine is stored (in cylinders).

The unit is that it is light in weight (less than a kilogram) and carries a microcontroller based control with automatic and manual mode, where LCD showing the ozone concentration. It employs a high voltage of over 5 kV at a high frequency of 15 kHz to 20 kHz, which would not cause a lethal shock. Shock Voltages are not cause a lethal shock. Shock voltages are not dangerous at these high frequencies, while at 50 Hz these high voltages are quite dangerous. Commercial ozone generators make use of mains 50Hz frequency and are thus very dangerous while assembling. Extreme care is required to be exercised by the user while diagnosing any problem with such apparatus. Ozone generator at the higher frequencies used here is more efficient and silent in its discharge, one can easily assemble this portable ozone generator in a plastic breadbox (used for storing one full bread), which is all insulated (with no exposed metal parts. The cost of making a simple unit is much less than Rs. 2,000.

Different types of ozone generator are available in the market nowadays which are expensive and portability of those devices are quite difficult and are dangerous might cause a lethal shock if not careful. Finally, in the context of Nepal water purification and waste-water treatment in industries are done through the use chlorine. Also, Nepal is among the least developed countries in the world, with about one-quarter of its population living below the poverty line. Nepal is facing quite a number of issues, some of these significant challenges are related to water pollution, air pollution, sanitation. Regarding these issue, Portable Ozone Generator is developed for the purpose of water purification, waste-water treatment, air-purification, bleaching, vegetable cleaning, mosquito repulsion and many more with the features of portability, lethal shock proof and that falls under affordable price.

II. Methodology

Ozone generators invariably make use of a discharge tube to which a high electric field is applied to break down the oxygen present in the air. This phenomenon occurs at or near a field strength of 25 kV/cm, and the resulting discharge that takes place is known as Corona. The corona has a light bluish glow. It is in this corona field that oxygen becomes ozone (O_3).

The discharge tube is supplied air from an air-group, which is built into the unit. The unit produces ozonated air at a pressure head of 15-20 cm of water via its outlet. So, the exit tube can be let into water containers with water up to a level of 10-15 cm. Pump works on mains and has a 50Hz vibrator attached to a rubber bellows that provides a pulsating airflow that provides a pulsating airflow. This air flows through the cylindrical space of discharge tube and discharge tube outlet gives ozonated air. The overall mechanism are controlled with the help of micro-controller (AT mega 32) embedded in it.

The operational framework of portable ozone generator is shown in figure 1. It contains various sub system including mechanical, electrical and computer. The whole system is divided into two main parts i.e. mechanical and electronical.

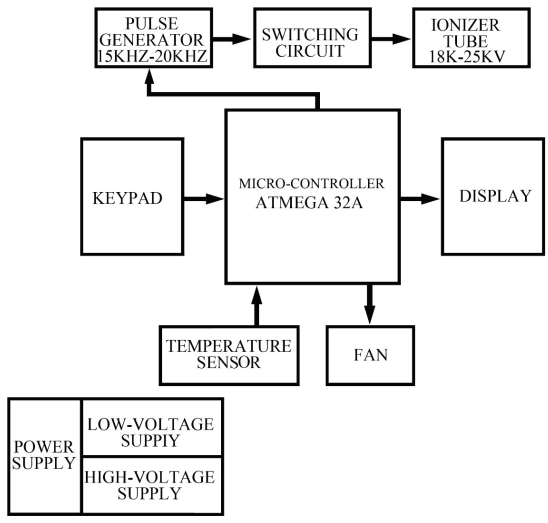

Fig 1: Block Diagram of the System

Electronical System: This section further divided into various sub system. I.e. pulse generator, micro-controller unit, switching unit etc.

Pulse generator section: A simple pulse generator circuit utilized various active and passive component and is designed to generate 1520 KHz pulses. It selects duty cycle of 33%.

Control Unit: As its name implies it is the control unit of the circuit and is comprise of micro-controller ATmega32, keypad, and temperature sensor unit. This unit control the production of ozone.

Switching Unit: This unit consist of switching circuit which is used to switch FBT to generate ozone

Figure 2 describe the flowchart of the system where 't' represent the temperature and t_1, t_2 represents the lower and upper threshold temperature for the device.

Discharge tube is constructed using the 20cm long Aluminium tube of 1cm diameter and Glass tube of 17cm length and 1.2cm in diameter. This aluminium tube is blocked on the inside with a small amount of M-seal compound, so that no air can pass directly through its middle hole. Then, holes of 2mm diameter are made on the tube at the two ends about 3 cm from each end. To provide the discharge gap, a thin walled glass tube, commonly used as chemistry test tube, is used having an inner diameter about 1.2-1.5 mm greater than that of the aluminium tube. Then, the glass tube is cut such that it covers the length of the aluminium tube, except for about 1.5 cm at each end such that the metal tube should be able to go freely in it. Now, the glass tube is rotated over a gas burner to soften the ends of the tube and made chamfered on to the metal tube, such that at the edges, the glass tube fits the metal tube with no gap and still the glass tube is able to slide over the aluminium tube. After the glass tube is so positioned over the metal tube, the ends of the glass tube are taped using Teflon tape.

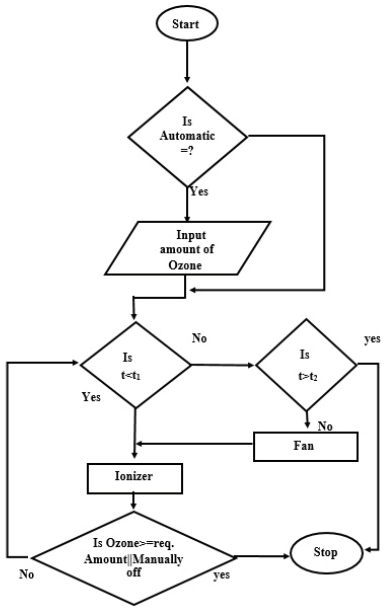

Fig 2: Data Flow Diagram

Preparation of the hot electrode: The hot electrode, to which a voltage greater than 6,000 volts is applied at high frequency, is made by closely wrapping plain aluminium foil around the outer side of the glass tube. The foil is wrapped leaving 1 cm uncovered area on either ends of the tube. The foil is taped for tightness on the outer glass, using cellulose tape, and a piece of Teflon insulated wire connected to the aluminium foil brought out. This wire is connected to the EHT lead from the LOT on the circuit board.

III. Results

Complete disinfection of water, in any impure form, is realized with an ozone content of 4 mg/litre. Ozone generator presented here has a capacity of producing 10 mg/minute of ozone combined with atmospheric air and can treat five litres of impure water in just two minutes.Figure 3 shows the constructed discharge tube for corona discharge.

Fig 3: Discharge Tube

Figure 4 shows frequency(15KHz-20KHz)generation circuit and switching circuit for Flyback Transformer(FBT). Calibration of Ozone is done by quantitative analysis. Potassium iodide (KI) solution is converted to iodine gas by ozone. Taking a known quantity of KI solution and bubbling the ozonated air from ozone generator through it, for a definite time (one minute). The free liberated iodine can be estimated by titration experiment with thiosulphate. Thus, by knowing how much iodine has been liberated. One can find how much ozone has been absorbed in the solution by quantitative analysis. Thus gives us the gas output form the tube in mg/liter. The gas output is determined by finding the time taken to replace the 1 liter of water by the bubbling gas.

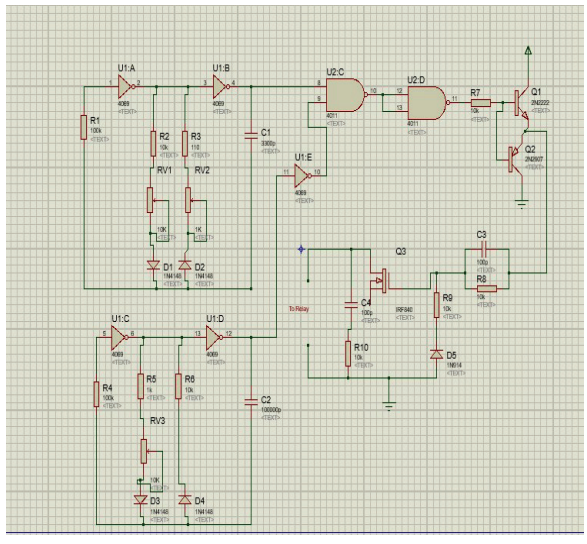

Fig 4: Frequency Generator and Switching Circuit

IV. Conclusion

The idea to construct a device that could be used not just as an alternative way to purify water instead of using chlorine but for also as air-purification, bleaching, vegetable cleaning, mosquito repulsion and many more is presented here. The device is capable of generating 10mg/min and can treat five litres of impure water in two minutes with the features of shock proof, portable, easy to use and it can be set to produce the desired amount of ozone i.e device is automatic and produces required amount of ozone.

Acknowledgment

We would like to express our sincere thanks to Kantipur Engineering College, for providing us the environment in the research of project PORTABLE OZONE GENERATOR .

Our thanks are appreciations goes to our colleagues in the development of the projects and people who have willingly helped us out with their abilities.

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