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A STUDY OF TEMPERATURE REDUCING OF HIGH VOLTAGE SWITCHING POWER SUPPLY CIRCUIT OF ELECTROSTATIC AIR CLEANER BY APPLIED THERMOELECTRICITY

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Abstract

This research paper presents a study of temperature reducing of high voltage switching power supply circuit of electrostatic air cleaner by the application of thermoelectricity as this air cleaner uses electric field's force technique based on electrostatic precipitator (ESP) and high voltage with direct current to switch power supply. The power supply is based on a fly-back converter. The converter is designed to operate at high frequency with more than 19 kHz while Power MOSFET is switching the device through high voltage high frequency fly-back transformer#TLF14649. The circuit is capable of generating up to 4 kVdc for ionization part and collector part in air filter. The problem incurred is the heat coming up in high voltage switching power supply resulting in high consumption rate of electrical power. Therefore, the researcher tried to find a way to reduce the temperature of high voltage switching power supply by using cool air produced from thermoelectricity to observe its electrical power consumption rate. In testing, we measured temperature at high voltage switching power supply circuit and the electrical power consumption rate of air filter before and after the installation of cool air production system from thermoelectricity. The testing result appears that before installation, cool air production system from thermoelectric temperature is 27 and power consumption is 26.7W, while after the installation of cool air production system from thermoelectricity, the temperature is 23 and power consumption is 22.9W. Therefore, it is concluded that cool air production system from thermoelectricity can reduce the temperature and reduce electric consumption power of air filter resulting in lessening electricity bills. In future, the researcher will develop an application of cool air system from thermoelectricity to reduce temperature in other industrial systems to cut down electrical consumption of the country.

Keywords: *thermoelectricity; cool air; electrical consumption; electrostatic air cleaner*

Introduction

Polluted substances composed in air are the kinds of substances that negatively affect human health and also for other creatures. These hazardous components in air are undesirable aspect of all living life which can either directly or indirectly give disadvantage to life. There are many sorts of toxin or mingled elements such as dust, particles and smokes; for example, carbon monoxide (CO), sulfide's oxide (SO_x), nitrogen's oxide (NO_x), lead (Pb) and radioactivity's dust, etc. These substances can critically harm to people, animals and plants lifecycle if they are of higher quantity over time. Furthermore, such toxin may result in death of living creatures. Some types have chronic effect to terminate lives in a later time. The toxin may

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enter into a living body just by touching, breathing it in, or indirectly accessing them through food poisoning or fibered on clothes which then it can transfer into bodies.

This paper presents a study of economically reducing temperature and power used for high voltage switching power supply circuit on an electrostatic air cleaner using cool air by the application of thermoelectricity.

Materials and Methods

Electric Field.

The breakdown field strength [1], [2], E_b, for the small air cleaner is based on electric field, dielectric properties, pressure, temperature, and so on. The employed electrode used in this germination comprises of dissimilar electric field strength in each point. The uniformity of electric field strength is depended on a figure of electrode. Electric field strength can be calculated by general equation as follows:

$$E_{max} = \frac{V}{d\eta^*} \quad (1)$$

where

η^* = field utilization factor which is defined that

$\eta^* = E_{av}/E_{max}$ The ordinary value of η^* is $\eta^* \leq 1$

E_{av} = average value of electric field (V/m)

d = distance between each plate of electrode (m)

Movement of object.

Force is the pulling or pushing that performs on object. Force is vector which possesses both size and direction. Resultant force makes object movement with acceleration in force direction. Acceleration proportion with resultant force to mass of object as following this [3];

$$F = ma \quad (2)$$

where

F = resultant force (N)

m = mass of object (kg)

a = acceleration (m/s^2)

Force taken place from electric field is the different from its potential between two points. If a tested is placed in electric field, the resultant force and direction of movement of dust is depended on two forces as shown below;

$$\vec{F}_T = \vec{F} + \vec{F}_e \quad (3)$$

if

$\vec{F}_T$ = the resultant force (N)

$\vec{F}_e$ = the electric field force (N)

$\vec{F}$ = the motion force (N)

Structure of electrostatic air cleaner.

Principle of working

Electrostatic air filter by applied electric field with high voltage directed current switching power supply makes the surrounding air to be purified and cleaned by feeding the high voltage to the conductor that causes the high condensed electric field. When atom or molecule of air past through its inner phase, the air will be ionized. The dirty air, for instance, dust smoke and pollution are mixed. When they are in the air cleaner, the air will turn through pre-filter which peculates the dust and the atom's mingling materials. Then this air is given the energy with highly condensed electric field to be ionized and occur electricity while changing from the dust. After that, the electric-charged dust will move to touch with collector plates which have the opposite electric field charged. And there it will get clean and clear out itself of dusts, other particles, and smoke. In general air, it has the quantity of dust smoke and diseases mixed in it, so if we pass the air to be ionized with high voltage electric circuit, the dust will get the electricity charged and moved to perch beside the collector. So the air we breathe is clean with atom and free of diseases to enable our health get better.

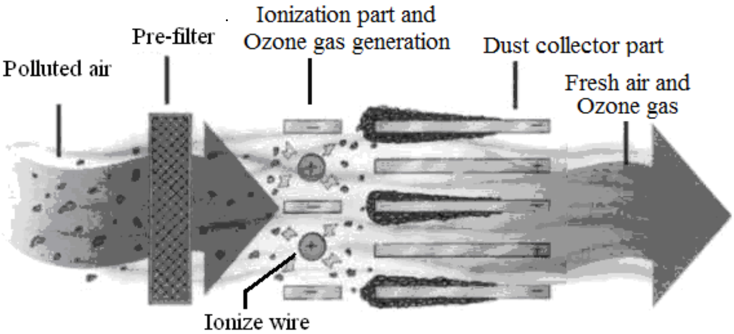

Fig. 1. Diagram of ozone gas air cleaner's work by applied uniform electric field.

Electrostatic air cleaner: For ionization part and collector part

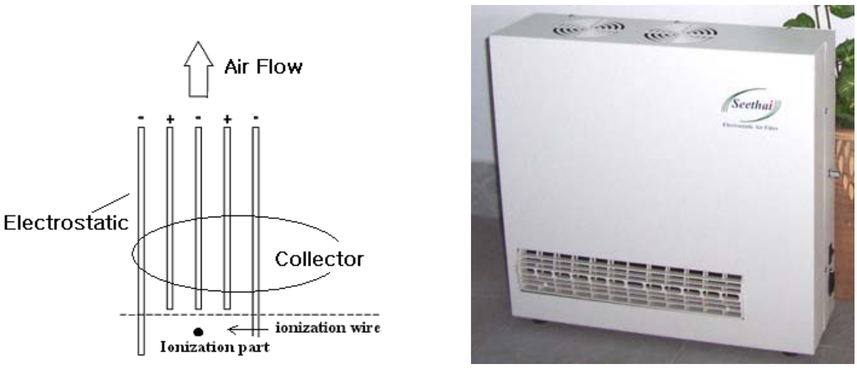

Fig. 2. Ionization part and collector part of electrostatic air cleaner.

High voltage switching power supply using fly-back converter

The erection of switching power supply of high voltage using IC#TL494 [4] to erect pulse's width modulation or PWM to be the circuit of controller - the switching that use Power MOSFET#IRFP460 to be the equipment in conducting which has the speed of switch about 19 kHz. At last, the fly-back transformer is passed to cause directed current voltage as needed by erecting one level of 4 kV_{dc}.

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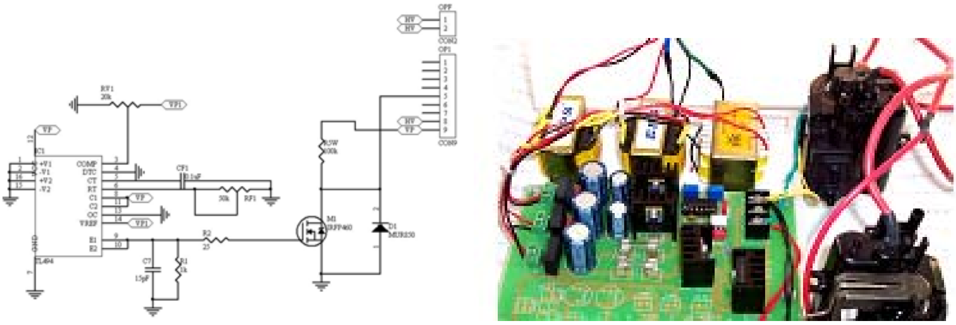


(a) (b)

Fig. 3. (a) Control circuit and fly-back converter and (b) High voltage switching power supply circuit of electrostatic air cleaner.

Part of cool air from thermoelectricity

Thermoelectric cooling.

Thermoelectric cooling uses the Peltier effect to create a heat flux between the junctions of two different types of materials. A Peltier cooler, heater, or thermoelectric heat pump is a solid-state active heat pump which transfers heat from one side of the device to the other, with consumption of electrical energy, depending on the direction of the current. Such instrument is also called a Peltier device, Peltier heat pump, solid state refrigerator, or thermoelectric cooler (TEC). They can be used either for heating or for cooling (refrigeration), although in practice the main application is cooling. It can also be used as a temperature controller that either heats or cools [5] shown in Figure 4.

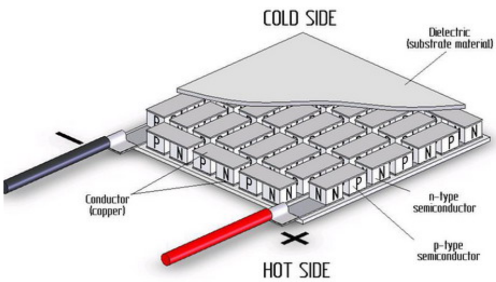


Fig. 4. Thermoelectric - Peltier cooling ($12V_{dc}$ 40W) [6].

Results and discussions

In Figure 5. shows diagram block of the experiment results of the first part are temperature and power measurement and the second part is FFT signal measurement using digital oscilloscope (before and after installation cool air production system).

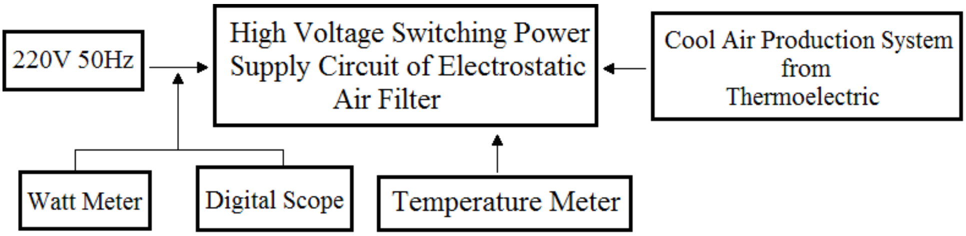


Fig. 5. Block diagram of the experiments.

3.1 Results of the first part

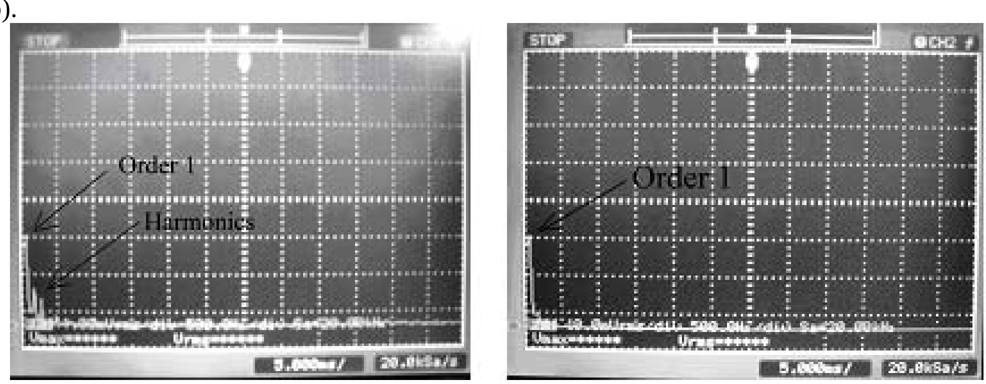
The results of the temperature measurement and power measurement of high voltage switching power supply circuit of electrostatic air cleaner (before and after installation cool air production system shown in Table 1.

Table 1. The result of power and temperature measurement of high voltage switching power supply circuit of electrostatic air cleaner (before and after installation cool air production system

cool air production system	Temperature of high voltage switching power supply circuit of electrostatic air cleaner (°C)	Power of high voltage switching power supply circuit of electrostatic air cleaner (Watt)
before installation	27	26.7
after installation	23	22.9

Results of the second part

The testing of FFT measurement of input current of high voltage switching power supply circuit of electrostatic air cleaner (before installation cool air production system) shown in Figure 6 (a) and (b) FFT signal of input current of high voltage switching power supply circuit of electrostatic air filter (after installation cool air production system) shown in Figure 7 (b).



(a) (b)

Fig. 6. (a) FFT signal of input current (before installation cool air production system) and (b) FFT signal of input current (after installation cool air production system).

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Fig. 7. Cool air production system by applied thermoelectric.

Conclusions

Reducing the temperature of the high voltage direct current switching power supply circuit in electrostatic air cleaner by the application of cold air produced from thermoelectricity, it is found that when using a high voltage circuit in the electrostatic air filter, the temperature will be 27°C, the power used is equal to 26.7W and it produces harmonics quantity to order 3 and order 5 as also shown in Figure 7 (a), but when the cold air produced by thermoelectricity to trigger the high voltage power supply circuit it is found that the temperature will drop to 23°C, power consumption is reduced to 22.9W and it will not appear on the harmonics quantity. Therefore, it is concluded that the cold air produced from thermoelectricity reduces the temperature and power consumption to its minimum. And also the quantity of harmonics reduced as shown in Figure 8 (b) resulting in better system stability and help to reduce global warming and electrical consumption to its minimum as well.

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