DESIGE AND MANUFACTURE ELECTROSTATIC PRECIPITATOR SYSTEM COMBINING OZONE DEODORIZATION AND ACTIVATED CARBON FILTER

Hai Ninh Nguyen Thi[1], Anh Dang Thi Ngoc[1]

[1]*Thai Nguyen University of Technology, Thai Nguyen city, Viet Nam*

ABSTRACT

This article presents the results of a research project to design and manufacture an electrostatic precipitation system combining ozone deodorization and activated carbon filter. The project proceeded to solve a practical problem - the treatment of smog arising from a heat treatment furnace of a mechanical workshop. By theoretical and experimental methods, as a result, a modern smog treatment system has been successfully designed and manufactured with air quality after treatment guaranteed to meet the standards of the Ministry of Natural Resources and Environment. The above results are the scientific basis for perfection and widespread deployment in production.

Keyword: *Electrostatic precipitation system, Ozone deodorization, Activated carbon filter*

1. INTRODUCTION

As known, dust is a collection of different compounds of large and small size, some of which are too small to be seen with the naked eye and are always suspended in the air. Dust is divided into two main types: flying dust and settled dust [1]. For smog arising from factories and production facilities today, without emission control technology solutions, the content of pollutants such as dust, SO2 and NOx (causing acid rain) will exceed the permissible limit. Over the past century, electrostatic precipitators have been widely used in industries to filter smog because of their high efficiency and low cost [2,3]. Research problems are raised from production practice. Specifically, it is necessary to treat dust and smoke arising from the heat furnace of the mechanical workshop of Thai Ha Precision Engineering Private Enterprise. Because the capacity of the heat treatment furnace system is small (less than 7.5 kW) and for good processing quality, the research team chose the solution to research, design and manufacture an electrostatic precipitation system combining ozone deodorization and activated carbon filter.

The article is divided into 5 parts: (1) Introduction; (2) design and manufacture; (3) Results; (4) Conclusion; (5) Reference;

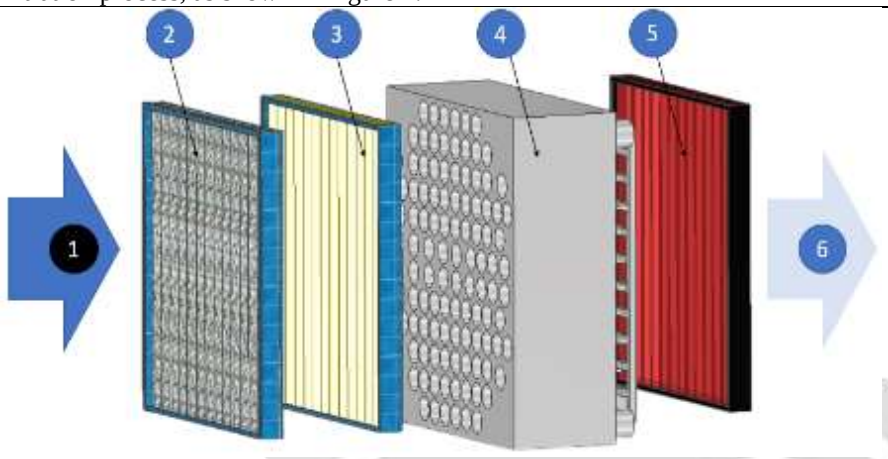
2. DESIGE AND MANUFACTURE

2.1 Method

This study uses a combination of theoretical and experimental methods. Theoretical research is the process of researching and analyzing solutions that have been available in the world, in particular, the publication on electrostatic precipitation [2], design and manufacture of electrostatic precipitators [3], research on fine dust arising from factories in Germany [5]. Experimental research is the design and manufacture of dust filter systems, then use this system to research and analyze the results of smoke and dust treatment to determine the optimal parameters of the system such as voltage, dust filter field current, concentration of harmful gases, etc.

2.2 Processing

Through the theoretical research process, the research team applied a combination of 5 treatment steps in the dust filtration process, as shown in Figure 2.



1: Dust

2: Coarse filter plate

3: 7-layer oil separator dust collector filter

4: Eectrostatic filters using high voltage fields

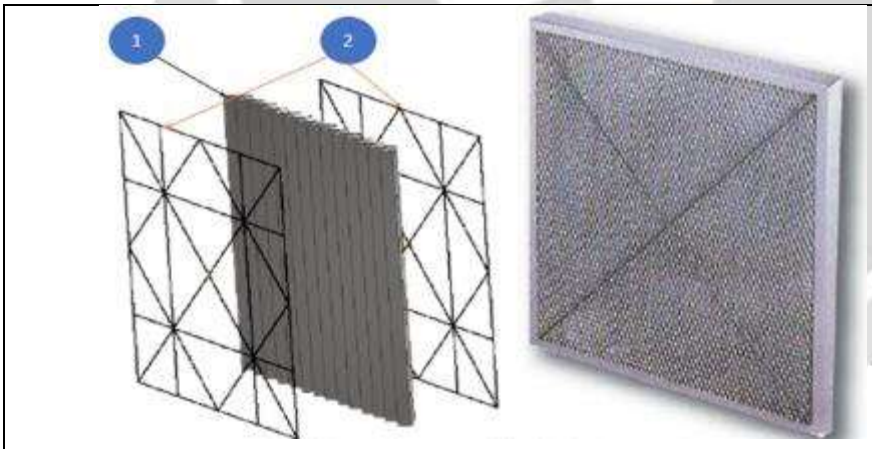
5: Carbon filter plates

6: Stream of treated clean air combined with ozone

Fig -1: 5 treatment steps in the dust filtration process

Step 1: Coarse filter plate

Right at the top of the cone capture, a Coarse Filter is installed (**Fig -3**) to trap dust particles, soot, and evaporating oil particles of large size. Workers easily observe the level of fouling, selling grease and soot into the filter mesh, periodically remove the filter mesh for cleaning, spray with high-pressure water to rinse the filter.



1: Coarse filter

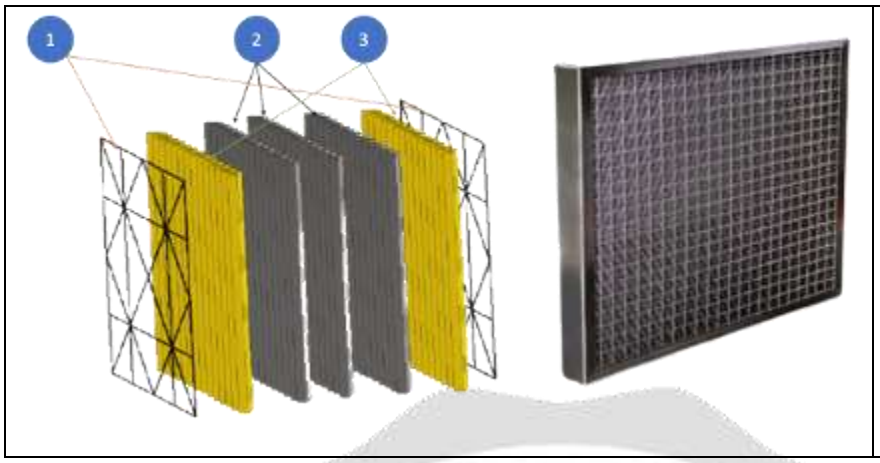
2: 0.5mm stainless steel mesh panel

Fig -2: Coarse filter plate

Colored and odorless exhaust smoke consisting of small dust particles and combustible organic compounds will follow the pipe to the inlet of the built-in electrostatic smoke filter.

Step 2: 7-layer oil separator dust collector filter

This filter will retain medium-sized dust particles, retaining moisture carrying oil and other organic compounds. (Fig-3)



1: Stainless steel mesh

2: Coarse filter;

3: Aluminum mesh separating oil and stainless steel foil

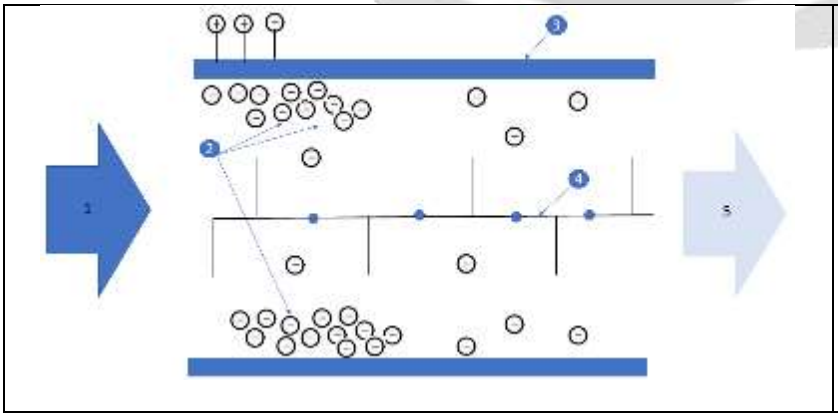
Fig - 3: 7-layer oil separator dust collector filter

Step 3: Electrostatic precipitation by high voltage electric field

This is the most advanced filtration technology available today. This filter uses a 25kV DC high-voltage electric field (**Fig** - 4). The electrostatic filter is in the form of a circular tube inside with a barbed electrode.

Fig - 4: Structure of Electrostatic precipitation

Efficacy of electrostatic filter technology Treatment of exhaust gas is up to 90% effective, exhaust smoke is no longer black, greatly reducing odors. Color and odor-bearing organic substances are also broken down (oxidized) into molecules of smaller size and less odor. After a period of use, the filter needs to be cleaned, removed layers of dust and put into use.



1: Dust

2: Discharged dust molecules with a negative charge (-)

3: Positively charged tube walls (+);

4: Barbed electrode

5: Treated air

Fig - 5: Operating principle of electrostatic filter

Step 4: Deodorize with activated carbon filter

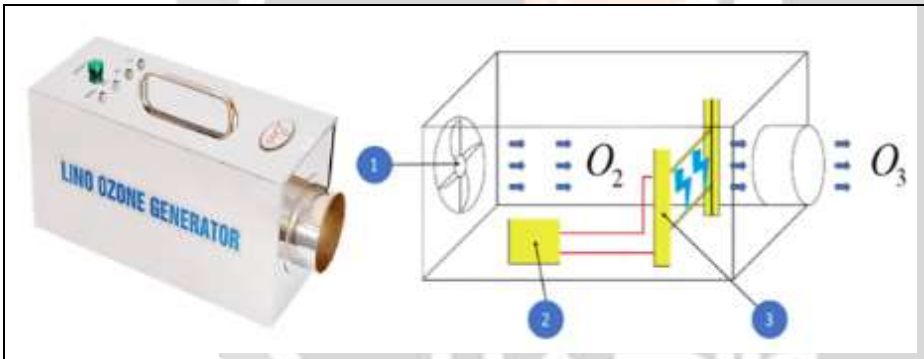
The air stream with a small amount of dust and odor will be filtered and deodorized again when it passes through the activated carbon filter (**Fig** - 6).

1: Stainless steel mesh plate

2: Carbon filter plate.

Fig - 6: Deodorize with activated carbon filter

To optimize the deodorizing effect of the firing and tempering steel system with oil smoke and unpleasant odors, the smoke purifier is also equipped with an ozone generator (**Fig** - 7) 40g/h providing oxygenated O3 gas. high chemistry at the end of the filter.



1: Air blower fan

2: High voltage circuit;

3: Ozone generating electrode

Fig - 7: Ozone generator with capacity of 40g/h

2.3 Design of electrical control part

The key technical problem put into use in electrostatic precipitation and deodorization systems is to create a DC high-voltage electric field.

Solution to improve the booster circuit by using the principle of SMPS - Switching Mode Power Supply with a fly-back transformer instead of the previous step-up circuit using a ferromagnetic core transformer. The schematic diagram of the electrostatic precipitator and deodorizing system is shown in **Fig -8** .

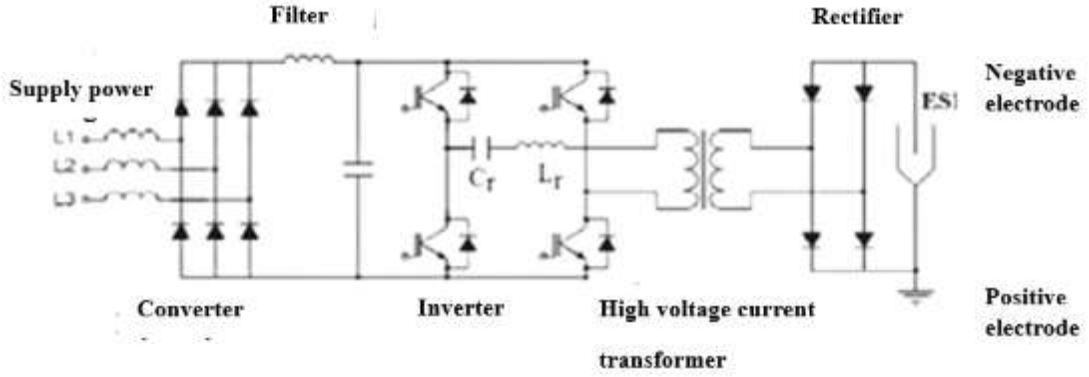


Fig - 8: The booster circuit uses the principle of SMPS

The use of an improved booster circuit solution using the SMPS principle has helped to raise and stabilize the voltage and current of the dust filter field, thereby helping to retain many harmful dust molecules.

Fig - 9: Fly-back transformer

3. RESULTS

After applying a combination of 5 processing stages with 4 modern dust-filtering and deodorizing technologies and is considered the most effective today, the exhaust gas from the kiln area and mechanical detailing at the company's workshop Thai Ha Precision Engineering Company can achieve the environmental protection criteria and be eligible to discharge into the environment.

Advantages: Very high dust filtration efficiency from 90-98%; very little power consumption, less than 1kWh; human-friendly and safe, environmental protection; do not use chemicals to process and leave no residue; handle a large amount of exhaust gas with high efficiency; easy cleaning, installation and replacement; High quality material, long life.

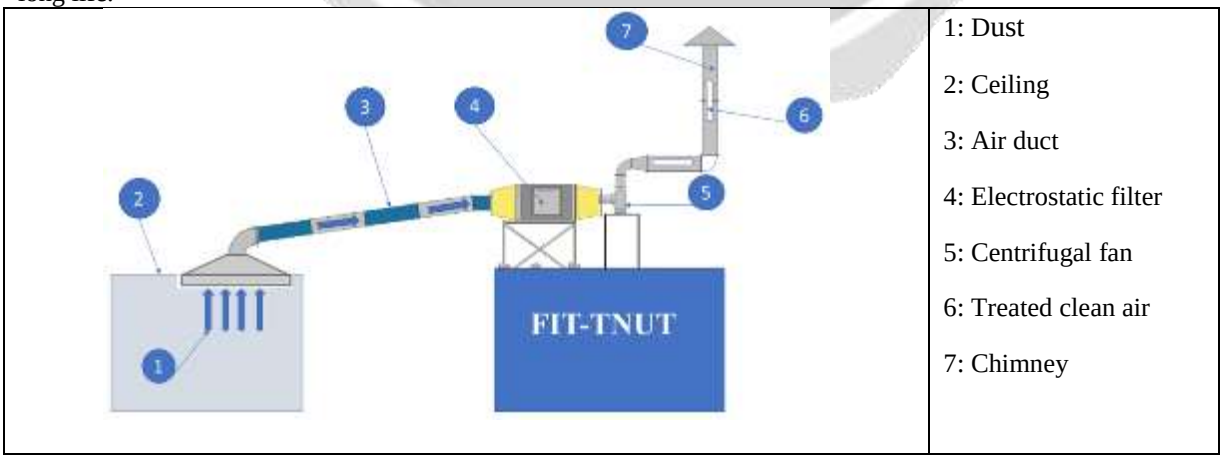


Fig - 10: Electrostatic precipitator system with ozone deodorization and activated carbon filter

To assess the quality and efficiency of the system, the Center for Natural Resources and Environment Monitoring conducted measurements and analyzed the air quality as it passed through the system.
The results of the air treatment quality assessment of the system are shown in Table 1.

Number	Target	Method	Unit	R esult			Average	QCVN 19-2009/BTNMT	
				1st	2nd	3rd		A	B
1	Temperature	US EPA method 5	^oC	35,1	33,1	34	34,1	-	-
2	Flow	US EPA method 2	m^3/phút	1	1	1	1	-	-
3	NO_x	US EPA method 7	mg/Nm^3	76,47	74,16	78,61	76,41	1000	850
4	SO_x	US EPA method 8	mg/Nm^3	23,6	14,9	29,7	29,7	1500	500
5	CO	TCVN 7242-2003	mg/Nm^3	<63	<63	<63	<63	1000	1000
6	n-heptane	PD CEN/TS 13649 - 2014	m^3/phút	2,6	3,2	1,8	3	2000	
7	n-hexan	PD CEN/TS 13649 - 2014	mg/Nm^3	4,1	5,4	2,9	4	450	

Table -1: Air treatment quality assessment results

4. CONCLUSIONS

The article has introduced the results of research, design and manufacture of an electrostatic precipitator system combining ozone deodorization and activated carbon filter in order to maximize the quality of treatment of smoke and dust generated from the system. heat treatment system of a mechanical factory. By combining theoretical and experimental methods, a smoke and dust treatment system applying modern treatment technology has been successfully designed and manufactured. The results of measuring and evaluating the quality of the system show that the air quality after treatment has very well ensured the regulations on emission quality of the Ministry of Natural Resources and Environment.

ACKNOWLEDGEMENT

The authors thanks for the financial support of Thai Nguyen University of Technology for the research team to design, implement and complete the product.

5. REFERENCES

[1] http://trungtamytemtldct.com/bui-trong-moi-truong-san-xuat-lao-dong/
[2] Series publications of Electrostatic Precipitation, http://www.isesp.org/
[3] S. Oglesby, G.B. Nichols, Electrostatic Precipitation, Marcel Dekker Inc., New York, 1978.
[4] Electrostatic precipitation, in: K. Yan (Ed.), 11th International Conference on Electrostatic Precipitation, Springer-Verlag GmbH, Berlin Heidelberg, Hangzhou, 2008.
[5] C. Ehrlich, G. Noll, W.D. Kalkoff, G. Baumbach, A. Dreiseidler, PM 10, PM 2.5 and PM 1.0-emissions from industrial plants-results from measurement programmes in Germany, Atmos. Environ. 4 (2007) 6236e6254.
[6] Y. Zhao, S. Wang, C.P. Nielsen, X. Li, J. Hao, Establishment of a database of emission factors for atmospheric pollutants from Chinese coal-fired power plants, Atmos. Environ. 44 (2010) 1515e1523.
[7] M.F. Khan, Y. Shirasuna, K. Hirano, S. Masunaga, Characterization of PM2.5, PM2.5-10 and PM>10 in ambient air, Yokohama, Japan, Atmos. Res. 96 (2010) 159e172.
[8] J. Sun, Q. Zhang, M.R. Canagaratna, Y. Zhang, N.L. Ng, Y. Sun, J.T. Jayne, X. Zhang, X. Zhang, D.R. Worsnop, Highly time- and size resolved characterization of submicron aerosol particles in Beijing using an Aer.
[9] Q. Yao, S.Q. Li, H.W. Xu, J.K. Zhuo, Q. Song, Studies on formation and control of combustion particulate matter in China: a review, Energy 34 (2009) 1296e1309.
[10] F.J. Gutiérrez Ortiz, B. Navarretea, L. Cañadasa, L. Salvadora, A technical assessment of a particle hybrid collector in a pilot plant, Chem. Eng. J. 127 (2007) 131e142.