CLEAN AIR SYSTEM FOR ENCLOSED WORKING SPACE

SHAMSHUL NAZRI BIN ANUAR

Universiti Malaysia Sarawak
2001

BORANG PENYERAHAN TESIS

Judul: CLEAN AIR SYSTEM FOR ENCLOSED WORKING SPACE

SESI PENGAJIAN: 2001

Saya SHAMSHUL NAZRI B. ANUAR

mengaku membenarkan tesis ini disimpan di Pusat Khidmat Maklumat Akademik, Universiti Malaysia Sarawak dengan syarat-syarat kegunaan seperti berikut.

1. Hakmilik kertas projek adalah di bawah nama penulis melainkan penulisan sebagai projek bersama dan dibiayai oleh UNIMAS, hakmiliknya adalah kepunyaan UNIMAS
2. Naskhah salinan di dalam bentuk kertas atau mikro hanya boleh dibuat dengan kebenaran bertulis daripada penulis
3. Pusat Khidmat Maklumat Akademik, UNIMAS dibenarkan membuat salinan untuk pengajian mereka
4. Kertas projek hanya boleh diterbitkan dengan kebenaran penulis. Bayaran royalti adalah mengikut kadar yang dipersetujui kelak
5. * Saya membenarkan/tidak membenarkan Perpustakaan membuat salinan kertas projek ini sebagai bahan pertukaran di antara institusi pengajian tinggi
6. ** Sila tandakan (3)

☐ SULIT (Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972).

☐ TERHAD (Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/ badan di mana penyelidikan dijalankan)

☑ TIDAK TERHAD

Disahkan oleh

(TANDATANGAN PENULIS)

(TANDATANGAN PENYELIA)

Alamat tetap: 1253, TAMAN MARIDA,SENAWANG, 70450, SEREMBAN, N SEMBILAN

ENCIK A RAHIM MD. AMIN
Nama Penyelia

Tarikh: 26 MEI 2001

Tarikh: 26 MEI 2001

CATATAN * Potong yang tidak berkenaan.
** Jika Kertas Projek ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/ organisasi berkenaan dengan menyertakan sekali tempoh kertas projek. Ini perlu dikelaskan sebagai SULIT atau TERHAD.

CLEAN AIR SYSTEM FOR ENCLOSED WORKING SPACE

SHAMSHUL NAZRI B. ANUAR

Tesis Dikemukakan Kepada
Fakulti Kejuruteraan, Universiti Malaysia Sarawak
Sebagai Memenuhi Sebahagian Daripada Syarat
Penganugerahan Sarjana Muda Kejuruteraan
Dengan Kepujian (Kejuruteraan Mekanikal dan Sistem Pembuatan)
2001

CONTENTS

PENGHARGAAN		v
ACKNOWLEDGEMENT		vi
ABSTRAK		vii
ABSTRACT		viii
LIST OF FIGURES		ix
CHAPTER 1 – INTRODUCTION		
1.1	Introduction To Filtration	1
1.2	Filter and Quality of Air	1
1.3	Sources of Indoor Air Pollution	2
	1.3.1 The Gradually Effects of Polluted Indoor Air	2
1.4	Allergenic Contaminants	4
1.5	Symptoms	5
1.6	The cure	5
1.7	Control Measures	
	1.7.1 Keep the house clean	6
	1.7.2 Use a Good Vacuum Cleaner	6
	1.7.3 Keep Humidity Levels Below 60 Percent	6
	1.7.4 Use a Good Air Filter	7
1.8	**Objective of Research**	7
1.9	**Scope and Limitation**	7
CHAPTER 2- LITERATURE REVIEW		
2.1	Types of filters	8

	2.1.1 Gas Filter	8
	2.1.2 Liquid Filter	9
2.2	Gas filtration theory	9
2.3	Fabric Filters And Bag Houses	10
2.4	Types of Fabric Filters	10
	2.4.1 Mechanical Shaking and Reverse Flow Designs	10
	2.4.2 Pulse Jet Type	10
	2.4.3 Reverse Jet Types	11
	2.4.4 Modified Reverse Flow Cleaning	11
2.5	Types of Fibrous Filters	11
	2.5.1 Panel Types	11
	2.5.2 Continuous or "Roll" Filters	11
	2.5.3 Paper Filters	11
2.6	Deposition	12
2.7	Respirable Particulates	13
2.8	Potential of Water as Particulate Collector	15

CHAPTER 3 – METHODOLOGY

3.1	Background	16
3.2	Setting Up The Filtration Device	16
	3.2.1 Flow of The Air	16
	3.2.2 Preparing the Tank	18
	3.2.3 Calculation of the Forces	19
3.3	Efficiency of The Filter	19
3.4	A Conceptual Design of Implementation In A Shop-floor	20

CHAPTER 4 – DESIGN AND ANALYSIS

4.1	Objective of The Experiment	21
4.2	Selection of Apparatus	21
4.3	Selection of Sample	23
4.4	Conducting The Experiment	24
4.5	Safety Precautions	28

CHAPTER 5 – RESULT AND DISCUSSION

5.1	Result On Water	30
5.2	Result On Sponge	32
	5.2.1 Sponge Used Without Water-based Filter	32
	5.2.2 Sponge Used With Water-based Filter	33
5.3	Discussion	33
5.4	A Proposed Implementation of Water-based Air Filter System On A Shop-floor of A Factory	35
	5.4.1 A Shopfloor	35
	5.4.2 Design of a Shopfloor	36
5.5	Considerations To Be Made	36
	5.5.1 The Location of The Filter	37
	5.5.2 Degree of Freedom of The Filter	37
	5.5.3 Ease of Maintenance	38
	5.5.4 Flexibility of The Filter	39
5.6	The Conceptual Operation	39

CHAPTER 6 – CONCLUSION AND RECOMMENDATION

6.1 Conclusion 41

6.2 Recommendations 43

BIBLIOGRAPHY 45

APPENDIX A 48

APPENDIX B 55

PENGHARGAAN

Alhamdulillah, bersyukur ke hadrat Allah s.w.t. kerana dengan rahmat dan izin-Nya penulis telah berjaya menyiapkan Projek Tahun Akhir ini dengan lancarnya. Ucapan terimakasih yang tidak terhingga kepada Encik A.Rahim Md. Amin kerana dengan kebijaksanaan dan kesabaran beliau, telah banyak membimbing penulis dalam menjayakan projek ini, kepada ibunda tercinta atas doa dan kasih yang sentiasa mengiringi dan para pensyarah serta teman yang sering membantu. Jasamu akan tetap dikenang.

ACKNOWLEDGEMENT

The author would like to thank Allah the Almighty for His bless and consent, has given the author the opportunity to accomplish his Final Year Project. Special thanks to Encik A. Rahim Md. Amin, for his wisdom and guidance has led the author to the right track from the beginning of the project till the end, to his beloved mother who is always there with her prayers and ample love, and to all his lecturers and colleagues who have been very helpful for all these years. You are always in my heart.

ABSTRAK

Penapisan bukanlah suatu perkara yang baru, malah ianya telah dicatatkan bermula sejak zaman Hebrew purba dan permulaan kerajaan China lagi. Walaupun terdapat banyak kaedah baru di dalam teknologi ini. namun masih banyak kekurangan yang ada khususnya teknologi penapisan yang dapat menapis udara, untuk mendapatkan udara yang selamat untuk digunakan. Projek ini dijalankan untuk mengenalpasti potensi air untuk digunakan sebagai media penapisan udara dan seterusnya mengemukakan cadangan untuk digunakan di dalam kawasan industri. Eksperimen dijalankan untuk membuktikan bahawa air mempunyai keupayaan untuk membersihkan udara dan seterusnya berpotensi untuk dimajukan kegunaannya. Seterusnya, satu bentuk sistem baru akan dikenalpasti dan direka khas untuk membolehkan penapis udara berasaskan air menggantikan system pembersih udara yang lama untuk digunakan di dalam kilang pengeluaran. Berdasarkan konsep yang baru ini, para pekerja akan dapat menikmati udara yang lebih bersih dan persekitaran kerja yang lebih sihat.

ABSTRACT

There is nothing new about filtration, as a matter of fact, this technology has been traced as early as the ancient Hebrew and Chinese dynasty. Although there have been various kind of technology concerning filtration, there are still lack of device that can clean the air we breath in, from hazardous particulates. This project is intended to identify the potential of water as filtration medium and furthermore will be proposed, to be used in the working field such as industries. Experiment is carried out to prove that water has the capability to clean air and additional to that, will be developed for the benefit of human race. In addition, a conceptual design will be introduced to apply the new air-filtration system to a shop-floor or production line of a factory. From the results, the occupants of the work place are believed to enjoy a higher quality of air and a better working condition.

LIST OF FIGURES

Figure 1.1:	A Closer Look On The Bacteria	3
Figure 1.2:	Mold	4
Figure 1.3:	Dust Mites	5
Figure 2.1:	Indoor Sources of Respirable Particles	14
Figure 3.1:	The Water-based Air Filter	16
Figure 4.1:	Tank Attached To The Pump	24
Figure 4.2:	The Outlet Where The Sponge Is Placed	25
Figure 4.3:	The Feeding Of The Cement Dust	26
Figure 4.4.	The Physical Appearance of Water Before Dust Being Fed	27
Figure 4.5:	Experimentation While The Cement Dust Being Fed	28
Figure 5.1:	Water Condition Before Experimentation	31
Figure 5.2:	Water Condition After Experimentation	31
Figure 5.3:	The Different Color Of Sponge	32
Figure 5.4:	Characteristic of Direct Reading Particle Monitors	34
Figure 5.5:	A Model Of A Shopfloor	37
Figure 5.6:	Side View of Mechanism	38
Figure 5.7:	Front View of Mechanism	38
Figure 5.8:	Plan View of The Design Location	39
Figure 6.1:	Conceptual Basis For Impact Occupational Stress	43

Chapter 1

Introduction

Filtration can be defined as the process of separating dispersed particles from a dispersing fluid by means of porous media. The dispersing media can be a gas (or gas mixture, most frequently air) or a liquid. Nowadays, various types of filters, which are design to meet certain functions that are desired, have accomplished filtration tasks.

1.1 Introduction to Filtration

There are many kinds of filters that can be found in the market, which are used according to their special functions, including filters that are used to clean contaminated air so that we can maintain a healthy life without having to worry about getting the sickness due to low quality air.

1.2 Filter and Quality of Air

Many people do not notice that the air that we inhale into our lung contains many particles that are hazardous to our health. History has proven that filter has been a big contributor to help maintain the best quality of air that we consume everyday. Although with the help of various types of air filer to trap various kinds of particles, there are still some limitations, which are faced during filtering process, for instance the size of particles, which is very small, and the high cost of maintaining the quality of the device.

Many researches have been conducted to identify the major contributor to the increasing health problems, including asthma, lung problems and skin diseases. One of the identified causes of these phenomena is the air, which is supplied to a closed area (indoor) and the existing air in the area itself.

1.3 Sources of Indoor Air Pollution

Studies have been made to recognize the main sources of indoor air pollution. Researchers have listed them as follow: -

1. The building itself and the furnishings in the building emit hazardous chemicals such as formaldehyde and styrene.

2. Sources range from particleboard to ceiling tile to carpets and furniture to paints and finishes.

3. Chemicals inadvertently brought into the home such as the residue in dry cleaned clothing, the hydrocarbons collected

4. On our clothing while driving home, the small amount of chemical residue on the food from the grocer.

5. Cleaning products of all types, smoke and the 3600 chemicals resulting from it.

7. Organic residue from insects, rodents, roaches, pets, etc.

8. Mold, mildew, and fungus

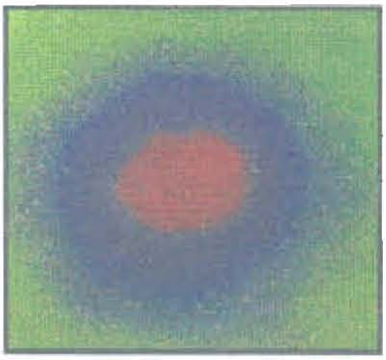

Figure 1.1: A closer look on the bacteria

1.3.1 The Gradually Effects of Polluted Indoor Air

It is interesting to note that most of the pollutants are organic in nature and that the chemicals, which we consider to be problems, exist all around us in nature, where they are not considered to be problems. To become a problem, as noted earlier, the dosage must be such that adverse affects result. Dosage is, of course, a function of both concentration and time of exposure. Even small amounts of pollutants will cause adverse effects if the time of exposure is long enough.

These adverse effects occur so gradually that they are not associated with their true cause:

1. The gradually increasing frequency of headaches may never be associated with the move to a new home or the acquisition of new furniture

2. A child's allergy problem may not be associated with an exposure to pollutants in the bedroom that began at birth

3. The hyperactivity of a child may not be connected to the fact that it began with a subtle change in the environment.

Figure 1.2: Mold

1.4 Allergenic Contaminants

These changes have accelerated since the date of the first oil embargoes when the cost of energy for heating and cooling our environments soared. From that date we have attempted to eliminate all outdoor air from our indoor environment. One of the most highly allergenic contaminants found indoors is house dust, often heavily contaminated with the fecal pellets and skins of House Dust Mites (Air Sponge Filter Company, 1999). Estimates are that dust mites may be a factor in 50 to 80 % of asthmatics, as well as in countless cases of eczema, hay fever, and other allergic ailments. Common causes of allergy include house dust mites (**Figure 1.3**), cat dander, cock droppings and grass pollen.

Figure 1.3: Dust mites

1.5 Symptoms

Some symptoms from cases, which have been reported, includes respiratory in nature, usually not a rash. However, there are reports of a red rash around the neck. The wheeze-inducing proteins are digestive juices from the mite gut and are potent. An exposure to the mites in the first year of an infants life can trigger a lifelong allergy.

1.6 The Cure

So far, there is no cure for these problems apart of prevention (Essential Zone, 1999). One must control the levels of dust mites. Beds are a prime habitat, a typical mattress may have anywhere from 100,000 to 10 million mites inside. Mites prefer warm, moist surroundings such as the inside of a mattress when someone is on it. Their favorite food is dander (human skin flakes), also, bedroom carpeting and household upholstery support high mite populations.

Dust mites, due to their very small size (250 to 300 microns in length) and translucent bodies, are not visible to the unaided eye. For accurate identification, one needs at least 10X magnification. Through a microscope, one will see many oval-shaped mites scuttling around and over one another. There are eight hairy legs, no eyes, no antennae, a mouthpart group in front of body (resembles a head) and a tough, translucent shell, giving a "fearsome appearance".

1.7 Control Measures

Recommendations focus on "dust control". One must reduce the concentrations of dust borne allergens in the living environment by controlling both allergen production and the dust, which serves to transport it.

1.7.1 Keep the house clean

Dust mites, pollens, animal dander, and the allergy causing agents can be reduced, although not eliminated through regular cleaning

1.7.2 Use a Good Vacuum Cleaner

Most vacuums actually cause the problem to worsen because the filter bags in most models are not efficient and cause allergen levels to rise.

1.7.3 Keep Humidity Levels Below 60 Percent.

Dust mites as well as other allergens thrive on high humidity. Homes with air conditioning constantly have lower mite counts than non-air conditioned homes.

1.7.4 Use a Good Air Filter

Most store bought air filters, which are not capable of trapping mites and their by-products. One should also look for a filter that has anti-microbial properties, to prevent the filter from becoming a breeding ground for allergens. Filters that call themselves "washable" should be avoided because it just is not possible to wash 100% of the biological contaminants out of them and they will also become a breeding ground.

1.8 Objective of Research

The main objective of this research is to identify, determine, and develop a new device that can reach 100 percent efficiency in gas filtration technique by using water as a filtering media. Apart of that, the study will emphasize on recognizing the potential of water as and attraction element to particles in gas filtration.

1.9 Scope and Limitations

This research is limited to improving the air quality of a working space or a larger scale indoor condition. The scope of the study will be covering the ways to improve the air quality in shop-floor or production line of a factory by using the technology of water-based air filter.

Chapter 2

Literature Review

In this chapter, we will make a review of the recent technology, which has been developed and created concerning the filtering system. This is to determine the potential area that can be improved or later developed.

2.1 Types of Filters

Basically, filters can be divided into two types, according to the main fluid that they are filtering, which is gas filter and fluid filter.

2.1.1 Gas Filter

This technique is the oldest and usually the most reliable method for removing dust, fumes and mists from gases. Filters afford high collection efficiencies with moderate power consumption except for very fine particles or hygroscopic materials. R.Dennis (1987) wrote that filters are generally operated dry, i.e., without water washoff. He has categorized it into three basic types of gas filters: woven or felted fabrics in the form of bags, envelopes or sleeves; panel filters consisting of semirigid fibrous mats supported within frames; and bulk granular material packed in a column.

2.1.2 Liquid Filter

According to A.S.Ward (1987), the term solid liquid filtration covers all processes in which a liquid containing suspended solid is freed of some or the entire solid when the suspension is drawn through a porous medium.

2.2 Gas filtration theory

According to J. Pich (1964) the filtration process can be characterized by several parameters. The pressure drop of a filter Δp is defined by

$$\Delta p = p_1 - p_2$$

where p_1 is the gas pressure below the filter and p_2 that behind the filter.

There are three basic types of industrial gas filter: woven or felted fabrics in the form of bags, envelope, or sleeves, panel filters consisting of semi rigid fibrous mats supported within frames; and bulk granular material packed in a column. The performance of a filter is characterized by its pressure loss, collection efficiency and service life both the fabric and ancillary components (J.D. McKenna and G.P. Greiner, 1981) .

2.3 Fabric Filters And Bag Houses

The basic filter element consists of a woven or felted textile material in the shape of a tube or envelope structure. Many filter elements are contained in a single chamber or compartment, each having its individual gas inlet and outlet connections, damper or valves, dust collection hopper, and cleaning system. Fabric filters may be used for controlling dust concentration ranging from 0.1 to 100 g/m^3 and particle sizes down to sub micrometer fumes. Special fabrics permit operation at high temperatures ($\approx 250^0$ C) while resisting corrosion from the chemical constituent of a gas stream (H.C. Gutler and R. DeBruyne, 1977).

2.4 Types of Fabric Filters

2.4.1 Mechanical Shaking and Reverse Flow Designs

This type uses the principle of removing collected dust from a fabric filter by shaking and/or a backflow of clean gas in the filtration system.

2.4.2 Pulse Jet Type

Gas flows from the outside to the inside of the bags or tubes, requiring that they be supported with wire cages to prevent collapse. As dust accumulates on the filter, periodic cleaning is accomplished with brief pulses of compressed air that are directed into the normal exit end of the bag (E. Bakke, 1974, K.Linoya and Y. Mori, 1979, M.J. Ellenbecker and D.H. Leith, 1979, R.Dennis, J.E. Wilder and D.L. Harmon, 1981)

2.4.3 Reverse Jet Types

This type represented the first successful attempt to use high-energy reverse flow cleaning. Rather than pulsing individual bags or groups of bags, this type reverse jet approach consisted of traversing each bag with slotted, concentric tube (blow ring) through which a high velocity air jet was directed at the clean (exterior) side of the filter bag.

2.4.4 Modified Reverse Flow Cleaning

A de-dusting system that combines the reverse and pulsating flow concepts.

2.5 Types of Fibrous Filters

2.5.1 Panel Types

Described as fibrous media supported with in a rigid frame Steam cleaning followed by re-oiling is used to recycle heavy metal screen or fiber units used (K. Makkono and K. Linoya, 1968, D.Rimberg, !969)J. Claes and R DeBruyne, 1976).

2.5.2 Continuous or "Roll" Filters

Applied for pre-cleaning of ambient atmospheres where the object is to remove the coarser particles at relatively low-pressure losses.

2.5.3 Paper Filters

Commonly designed to provide two level of performance: high --efficiency pre-cleaning where 90 to 95% of the approaching particulate material (atmospheric dust size) is captured, and ultrahigh-efficiency collection where 99.95% capture of 0.25μm is attained. The filter medium usually consists of glass or other mineral fibers to enable high-temperature operation and to reduce combustion problem.

2.6 Deposition

It has been established that in the deposition of particles from a flowing fluid several mechanisms are acting, the most important of which are described below.

a. Diffusion deposition

The trajectories of individual small particles do not coincide with the streamlines of the fluid because of Brownian motion. With decreasing particle size the intensity of Brownian motion increases and, as a consequence, so does the intensity of diffusion deposition.

b. Direct interception

This mechanism involves the finite size of particles. A particle is intercepted as it approaches the collecting surface to a distance equal to its radius. A special case of the mechanism is the so-called sieve effect, or sieve mechanism, which occurs if the distance between fibers is smaller than the particle diameter d_p.

c. Inertial deposition

The presence of a body in the flowing fluid results in a curvature of the streamlines in the neighborhood of the body. Because of their inertia, the individual particles do not follow the curved streamlines but are projected