

**STUDY OF KITCHEN HOOD WATER MIST SYSTEM FOR
COOKING EMISSION (UL1046) FILTRATION WITH LOW
PRESSURE DEFLECTED NOZZLE**

AHMAD SYAKIR BIN MOHAMAD JAMIL

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SPECIAL GRATITUDE TO;

THE MOST BELOVED PARENTS.

Mohamad Jamil Bin Yeop Majlis and Zaniah Binti Omar

For their support in whole of my life

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ABSTRACT

Most kitchen hoods in restaurants and hotels use standard water mist filtration. There are two types of filtration used in the kitchen hood, namely the washing water and water mist. Water mist spray works continuously to filter the system and facilitate cleaning purposes by collecting oil and disposing it. In a study undertaken previously, for heavy work activity on kitchen hood water mist system, water only is not effective in dissolving oil to clean the filter in kitchen hood system. In fact, water generates a high level of reading on the emission of the kitchen hood plenum system. Flat fan spray nozzle is used only for liquid spray to produce to spray water mist on kitchen hood filtration and require a low pressure water spray. In this study, mixtures of organic citric acid (lemon water) with ratio (1:10) and (3:10) were used. Citric acid was selected because it has the same characteristics as detergent for cleaning processes. The AL 75 nozzle was used on kitchen hood system to replace the flat fan spray nozzles for determining the water and air reduction. Kitchen hood system was built to carry out research and Grease Machine (UL1046) was used to produce a vapor as heavy work cooking activities. Results of the study showed that flat fan spray nozzle with a mixture of citric acid on Lemon 30 % and Water 70% (L30W70) is more effective as it is able to decrease 26.4 % of CO₂ emission in comparison to no water mist test. Results of studies using AL 75 (1:1) with L30W70 condition is effective in reducing the amount of CO₂ on average, from 5678 ppm to 4187 ppm. Mixtures of organic with experiment instruments showed that the vapor released can be controlled and nozzle AL 75 (1:1) is effective as a filtration system. The mixed water with citric acid can reduce the emission for heavy work cooking activity on kitchen hood water mist.

ABSTRAK

Jenis hud dapur yang lebih efektif dalam penapisan adalah jenis basuhan air atau pun semburan kabus air. Jenis hud dapur ini menggunakan semburan kabus air secara berterusan kepada sistem penapis dan sistem saluran untuk membersihkan dan memudahkan minyak untuk dilupuskan. Namun seperti yang diketahui, air tidak boleh melarutkan minyak secara berkesan terutama semasa proses pembersihan alat penapis. Air akan menghasilkan tahap bacaan pelepasan wap yang tinggi pada sistem hud dapur dan bahagian dapur. Nozel kipas rata yang digunakan hanya menggunakan cecair untuk menghasilkan semburan dan memerlukan tekanan air yang tertentu bagi menghasilkan semburan yang lebih baik. Dalam kajian ini, campuran organic citric acid (Air Lemon) dan air dengan nisbah (1:10) dan (3:10) digunakan sebagai memenuhi syarat yang ditetapkan. Citric Acid dipilih kerana mempunyai ciri-ciri yang sama seperti bahan pencuci untuk proses pembersihan. Nozel AL 75 telah digunakan untuk menggantikan nozel kipas rata bagi melihat kecekapan campuran air dan udara dengan tekanan nisbah (1:1) dan (1:2). Hud dapur telah dibina untuk menjalankan kajian dan *Grease Machine* (UL1046) yang digunakan untuk menghasilkan pelepasan wap pembakaran sebagai aktiviti masakan berat. Keputusan kajian menunjukkan, nozel kipas rata adalah lebih efektif dengan campuran acid citric Lemon 30 % Air 70% (L30W70) dapat mengurangkan 26.4 % bacaan pelepasan karbon dioksida antara ujian yang tidak menggunakan nozel. Keputusan kajian menggunakan AL 75 (1:1) dengan proses L30W70 adalah sangat berkesan dengan menurunkan jumlah CO₂ pada 5678 ppm hingga 4187 ppm dalam lingkungan purata. Campuran air dan lemon yang telah ditetapkan menunjukkan bahawa pelepasan wap pembakaran boleh dikawal dan nozzle AL 75 adalah lebih berkesan sebagai sistem penapisan. Campuran acid citric dengan air mentah akan memberikan kadar penurunan bacaan wap pembakaran pada hud dapur jenis semburan kabus.

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SYMBOLS / ABBREVIATION

ppm	-	Parts per millions
ρ	-	Density
ρ_A	-	Air Density
ρ_L	-	Water Dencity
GM	-	Grease Machine
μ_L	-	Viscosity
mm	-	Millimeter
Δp	-	Different pressure
%	-	Percent
KHV	-	Kitchen Hood Ventilation
CKV	-	Commercial Kitchen Ventilation
IAQ	-	Indoor Air Quality
sec	-	Second
psi	-	Pound per square inch
CO	-	Carbon Monoxide
SO ₂	-	Sulfur Dioxide
CO ₂	-	Carbon Dioxide
TVOC	-	Total Volatile Organic Compound

CHAPTER 1

INTRODUCTION

1.1 Background of Research

Kitchen hood ventilation functions as a system to reduce heat, moisture, smoke and vaporized grease from the kitchen area to the outdoor. Commercial Kitchen Ventilation (CKV) systems have a major impact on the energy consumption of food service facilities. CKV has a high fire risk because the grease discharged will accumulate in kitchen hood surface and can easily burn even with a small fire. Therefore, kitchen hoods must be clean from contaminant that sticks at the filter and a large amount of water is needed in the cleaning process. The main task for this project is to remove grease from the filter and reduce the amount of water used for cleaning.

In a kitchen hood ventilation system (KHV), the type of nozzle used for water mist system is the flat fan nozzle. These nozzles produce tapered edge, flat-fan spray patterns. The standard flat-fan nozzle normally operates between 30 and 60 pounds per square inch (psi), with an ideal range between 30 and 40 psi (Kabir, 2011). These nozzles are used to clean up the filter by using water. However, the filtration capacity is not satisfactory because water cannot dissolve oil and grease on the filter. Therefore, a new nozzle of mist spray using organic citric acid and water mixture for the kitchen hood ventilation system will be tested in order to analyses the characteristic of the mist spray. The apparatus of the flow control system will be used to test the nozzle. Direct imaging analysis, can examine the formation of spray pattern, spray angle, and spray penetration (Bachus, 2008).

1.2 Significance of Study

In kitchen hood ventilation water mist system filters systems available is the baffle. This study is expected to provide further information on the new design of the deflected flat spray internal mix nozzle using chemical and air mixture for the kitchen hood ventilation system. Additionally, this study will expose the emission characteristic of the grease loading machine after passing through water mist spray. The results obtained through the experiments will be a reference in order to improve the efficiency of the filtration system of the kitchen hood.

The result may be helpful to others to gain insights on the filtration system using a nozzle. A good nozzle design will provide the perfect effect of a spray formation and high efficiency in reducing emission. In addition, this study also provide new information on the benefit of organic citric acid and water mixture for filtration system as well the cleaning process. Therefore, this study will be crucial in finding good filtration for grease emission and cleaning processes.

1.3 Problem Statement

Currently water mist is used for kitchen hood ventilation system, efforts are being made to effectively reduce the emission. In the kitchen hood ventilation system cleaning process the use of nozzles can reduce the grease emission and reduce the temperature on the wall surface kitchen plenum. Water alone cannot dissolve oil and grease effectively to clean up the filter unit and decrease the amount of emission (heavy work cooking activity). For study concentrations on the ventilation requirement for heavy work is through grease machine process. The filtration of nozzle AL 75 and flat fan spray nozzle is done to maintain an effective kitchen ventilation capacity level. The heavy work cooking activity on kitchen hood can create a non-healthy environment for workers. In

this study, the kitchen hood ventilation water mists system uses the AL 75 nozzle. The kitchen hood ventilation system is low level cleanliness of standard filter (Baffle filter).

1.3 Objective

The purpose of this research is to study the effect of cooking using low-pressure spray mist atomizer deflector on the hood ventilation system used for cleaning the kitchen. In particular, this study aims to:

- i. Study the emission characteristic through grease loading test (UL1046) with the filtration system using AL 75 nozzle and flat fan spray nozzle.
- ii. Determine the optimum mixture ratio between organic citric acid and water.

1.4 Scope of study

To achieve the objectives above, the following scopes were outlined:

- i. Type of kitchen hood is commercial kitchen hood ventilation water mist island canopy.
- ii. 2 types of low pressure deflected nozzle, flat fan spray and AL 75 with 3 different conditions water 100 %, lemon 10% water 90% and lemon 30% water 70%.
- iii. Cooking activity through grease machine (UL1046) with water and vegetable oil at $385^{\circ}\text{C} \pm 14^{\circ}\text{C}$ in vapor box. Flow rate standard UL1046 in the ducting of kitchen hood provides air delivery of $65 \text{ m}^3/\text{min}$.
- iv. Measurement of temperature, CO, CO₂, SO₂, and TVOC.
- v. Experiment parameters carry out 47 minutes testing.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In kitchen room area can be found moisture, grease, odors, and heat from the stove-top food preparation. Commercial kitchen hood ventilation from a range hood or vent was invented to remove stale, odorous steamy air through ducts which in turn will eliminate or lessen these problems. Steam from cooking condenses on windows and walls, and carbon monoxide from gas-range combustion can build up.

Type of hood offers a continuous water mist that is sprayed into the filters and ducts area, which will emulsify or harden the grease. One of the more effective types of commercial kitchen hoods, in terms of grease collection and removal, is the water wash or water mist type of exhaust hood.

Instead of the grease vapors floating around until they settle, it will immediately cool and can be collected in a trough area which is far easier to clean. In kitchen ventilation exhaust with water wash or water mist, the type of nozzle that is being used is the flat fan spray nozzle (Accurex, 2009).

2.2 Types of Kitchen Hood Ventilation System

Every commercial kitchen requires ventilation, and in the past, the importance of a proper ventilating system has been overlooked. At present, commercial kitchen hood ventilation is a significant component of energy consumption in restaurants and fast-food kitchens. Kitchen ventilation function is to reduce fire hazards and exhaust cooking effluent to comply with air quality standards within a commercial kitchen. Thus, an adequate ventilation system is required to efficiently remove smoke, volatile organic compounds, grease particles and vapor from a kitchen space (Abanto, 2006).

Table 2.1 : Hood compilation table - Specification (Rivera, 2009)

Type of kitchen hood	Kitchen Ventilation	Kitchen Double	Kitchen indoor	Kitchen Back shelf
Baffle Filtration	/	/		
Lighting IP 6S			/	/
Grease Filter	/		/	/
Capture Jet system			/	/
Make-up air supply		/		/
Capture Ray UV system				
Water Wash system	/			
Low Proximity	/			
ANSUL fire suppression		/		
LED lighting			/	
Halogen Spot light			/	
MARVEL DCV system			/	

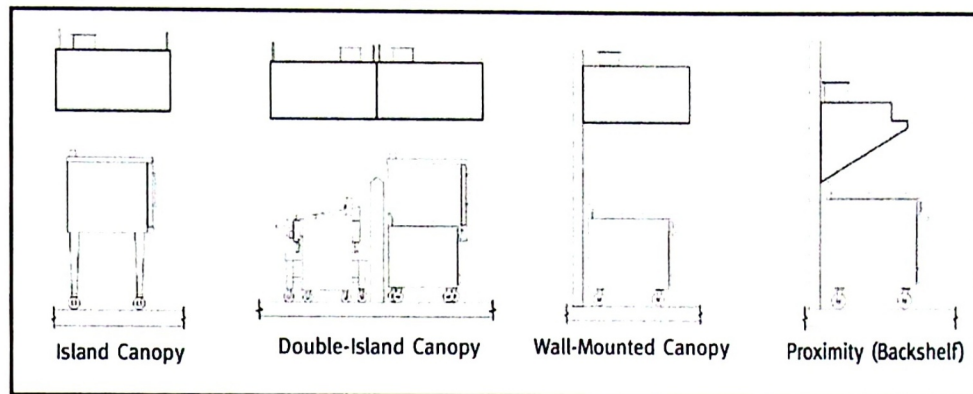


Figure 2.1: Common exhaust hood styles (Rivera, 2009)

Commercial kitchen exhaust hoods are available in many different configurations and specifications as shown in Table 2.1. These varying configurations can impact the hoods ability to capture and contain effluent, including odors, gases, heat, and oil. The commercial kitchen hood style as shown in Figure 2.1, construction features, and proximity of hood installation, give different capture area of hood (Rivera, 2009).

The hood styles, in order from the highest exhaust requirement to least, generally include:

- i. Single-island canopy hood.
- ii. Double-island canopy hood.
- iii. Wall mounted canopy hood.
- iv. Back-shelf hood.

2.3 Design of Kitchen Hood

The purpose of kitchen hood system is to remove the heat, smoke, effluent, and other contaminants. The thermal plume from appliances absorbs the contaminants that are released during the cooking process. Room air replaces the void created by the plume. If convective heat is not removed directly above the cooking equipment, impurities will spread throughout the kitchen, leaving discolored ceiling tiles and greasy countertops

and floors. Therefore, contaminants from stationary local sources within the space should be controlled by collection and removal as close to the source as it is practical (Z, (Accurex, 2009).

Table 2.2: Process for development of industrial Kitchen (Accurex, 2009)

1. Kitchen Layout Design	2. Kitchen equipment definition	3. Kitchen Hood Design
a) Kitchen type b) Kitchen menu c) Cooking process Cooking equipment d) Setting the Indoor Air Quality criteria e) Loads f) Room properties g) Preliminary room system selection	a) Cooking equipment b) External Loads c) Equipment Loads d) Light e) Workers	a) Hood type b) Air flow rate c) Capture efficiency

2.3.1 Type of Kitchen Hood

Cooking appliances are categorized as light, medium, heavy, and extra heavy duty, depending on the strength of the thermal plume and the quantity of grease, smoke, heat, water vapor, and combustion products produced. The strength of the thermal plume is a major factor in determining the exhaust rate. By nature, these thermal plumes rise by natural convection. However, they are turbulent and different cooking processes have different “surge” characteristics. For example, the plume from hamburger cooking is strongest when flipping the burgers. Ovens and pressure fryers may have very little plume until they are opened to remove food products. Open flame, non-thermostatically controlled appliances, such as under fire broilers and open top ranges, exhibit strong, steady plumes. Thermostatically controlled appliances, such as griddles and fryers have weaker plumes that fluctuate in sequence with thermostat cycling (particularly gas-fired

equipment). As the plume rises, it should be captured by the hood and removed by the suction of the exhaust fan. Air in the proximity of the appliances and hood moves in to replace it. This replacement air, which must ultimately originate as outside air, is referred to as makeup air (Nickel, 2004).

The design exhaust rate also depends on the hood style and construction features. Wall-mounted canopy hoods, island (single or double) canopy hoods, and proximity (back shelf, pass over, or eyebrow) hoods all have different capture areas and are mounted at different heights and horizontal positions relative to the cooking equipment (see Figure 2.2). Generally, for the identical (thermal plume) challenge, a single-island canopy hood requires more exhaust than a wall-mounted canopy hood, and a wall-mounted canopy hood requires more exhaust than a proximity (back shelf) hood. The performance of a double-island canopy tends to emulate the performance of two back-to-back wall-canopy hoods, although the lack of a physical barrier between the two hood sections makes the configuration more susceptible to cross drafts (Nickel, 2004)



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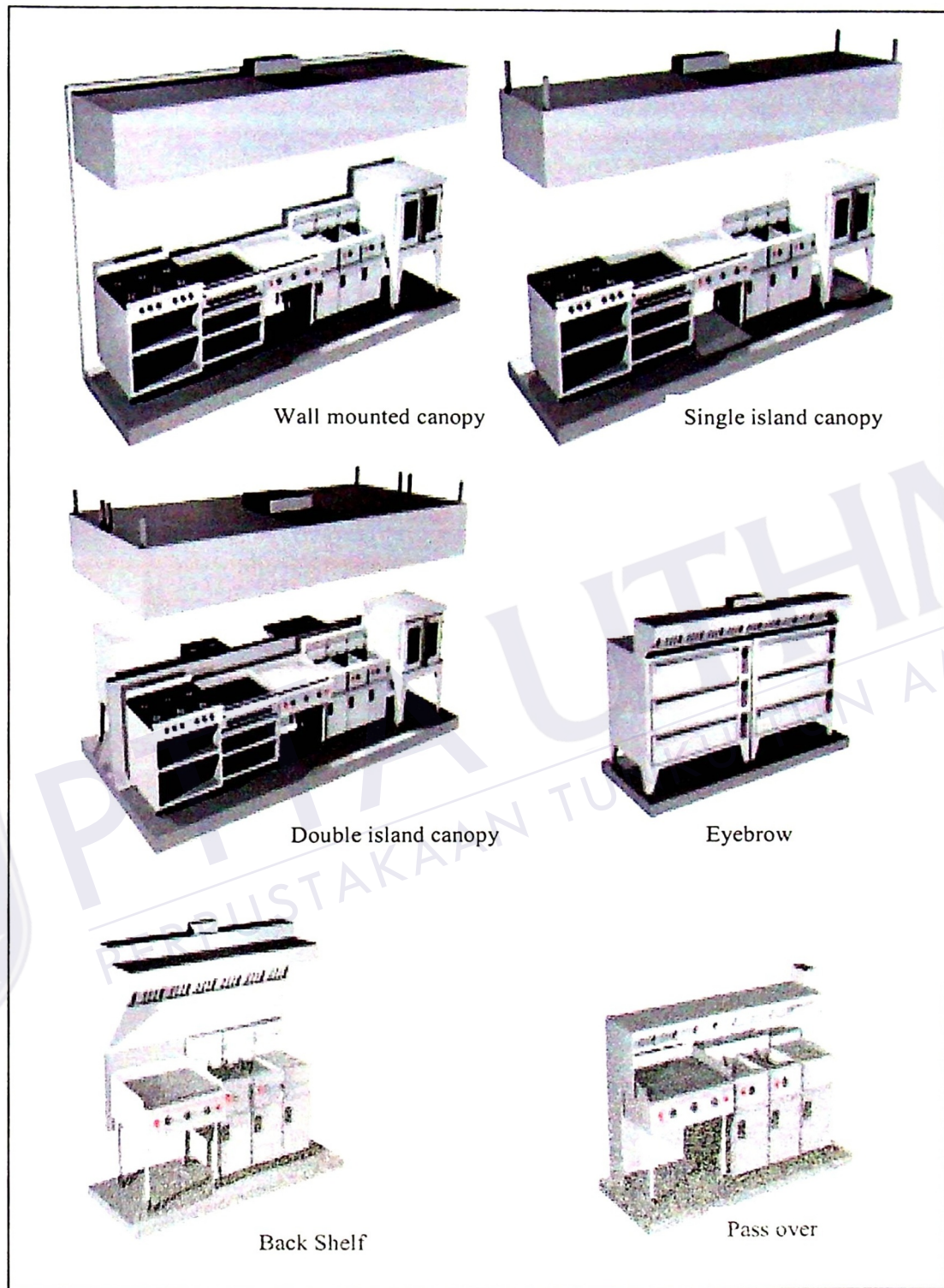


Figure 2.2: Style of kitchen hood system exhaust hood (Nickel, 2004)

2.4 Types of Filtration

Most commercial cooking equipment such as ranges, griddles, and fryers requires the use of an exhaust hood. These hoods are designed to remove smoke, heat, steam, and fumes, as well as dirty kitchen air. However, the air in commercial kitchens is filled with bits of grease and food residues that can quickly clog up the ductwork in a hood system if not properly filtered out. By selecting the appropriate hood filter for your establishment, you can keep your exhaust hood working at peak performance and ensure clean kitchen air (Greenheck's, 2011).

Table 2.3 : Filtration options (Greenheck's, 2011)

Filter	Application	Appliances	Static Pressure	Grease removal (9x4 foot hood)	Grease removal (at 8 microns)
Grease Grabber Multistage Filtration System	Heavy to extra heavy duty grease	Solid fuel cooking appliances upright broiler gas, electric and lava.	1.1 to 1.3 in.wg	100 %	99%
Grease x factor Centrifugal Filtration	Medium to heavy duty grease	Combination ovens gas and electric fryers griddles grill up-right broiler Electric char-broiler	0.7 to 0.8 in. wg	69%	51%
High-Velocity Cartridge	Light Duty Grease	Gas and electric ovens / Steamers / Rangers food warmers and Pizza ovens	0.7 to 0.8 in.wg	42%	21%
Baffle	Light duty grease	Gas and electric Ovens / Steamers / Rangers / Food warmers and Pizza ovens	0.5 to 0.6 in.wg	28%	16%

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PT. AKAN TUNGU TOPI AMINAH
PERPUSTAKAAN TUNGU TOPI AMINAH