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A STUDY OF RECIRCULATION SYSTEM FROM WATER LOSS IN KITCHEN HOOD: GREASE EMISSION FILTRATION EFFICIENCY USING STRAINER

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***Abstract*— This study focus on the grease emission filtration from cooking process using fresh cold water & recirculation cold water with cooking load will obtain from 4 pieces of chicken and using the scale kitchen hood from Halton Food service. In this study, water mist operation are applied to reduce the temperature inside the ductwork and to control the emission produce from cooking smoke. The parameter conducted in this study is carbon monoxide, carbon oxide, volatile organic compound, and temperature. This parameter compared with fresh water and wastewater. From the data available we could identify parameter that used exceeded value of the allowable measurement points. The more money user can saving for 25% of water reduction, the user already saving RM 399.per year. While for 50% of water reduction, the user can save RM798. The more wastewater recycle back to water mist process, the more money user can saving.**

Keywords: Water Mist, Kitchen Hood, Grease Emission, Filtration, CO, CO_2 Temperature, TVOC

I. INTRODUCTION

The fundamental of kitchen hood system is, it could remove much of the heat produced by cooking but mix in smoke, volatile organic compounds, grease, odours, particles and vapour. Few modern kitchen hood have automatic water mist and water wash with filter that maintain grease extractor performance and keep the entire system running at peak performance. With advanced design nowadays, it will require less maintenance from the kitchen hood which can reduce the labour costs [2].

The process started when grease emission drawn into kitchen hood by fan while being sprayed by water mist and gradually filtered before being relinquished into the air. Grease emission emitted from typical cooking process and enters the kitchen ventilation system consist the combination of particulate and vapour [8]. The first filtering result will produce very dirty waste contain of FOG, then it will be channelled to strainer unit. The FOG in the waste water floats on the surface and trapped meanwhile the clean water will go through to the strainer. The process proceeds to water filter unit for final treatment before it can be reused for water mist process again [1][2].

II. METHODHOLOGY

Concept of water mist spray in commercial kitchen hood system is to trap the smoke and grease from the air stream while cooking. Grease and dirt can easily build up in the kitchen hood. This can lead to breeding ground for bacteria and other undesirable fungus, so it’s important to apply the cleaning process in the kitchen hood. With this cleaning system, it also can reduced the temperature inside the exhaust plenum and mist curtain from water mist spray will work as spark arrester from entering the exhaust plenum which can reduce the fire risk.

As a theory, water mist spray curtains will trap the airborne particles and reduce the smoke temperature inside the exhaust plenum of kitchen hood as shown in Fig1. The smoke produces from cooking which contains the combination of high temperature, particulates and vapour is forced to pass through the mist curtain at specified exhaust air flow rate. There are several of previous research study on the effectiveness of water mist spray for smoke control, suppress fire and cooling system [10]. It can conclude that when several of parameter are controlled with adequate water mist flow rate, nozzle type and spray height and distance between nozzles it would give better results in emission control, cooling effect and fire suppression.

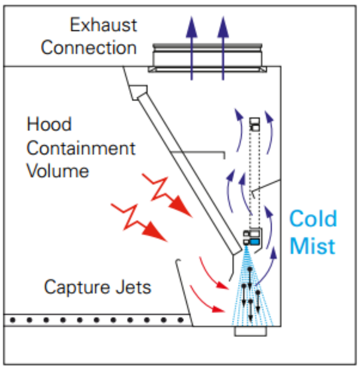

Fig. 1. Water Mist process on Kitchen Hood system.

A. *Grease Emission*

Various study of indoor air have identified cooking as one of the most significant particle generating activities indoors [5][6]. Certain cooking processes such as typical Asian, Mediterranean and western cuisine are identified to release undesirable pollutant into the atmosphere in the form of particulate and vapour [5].

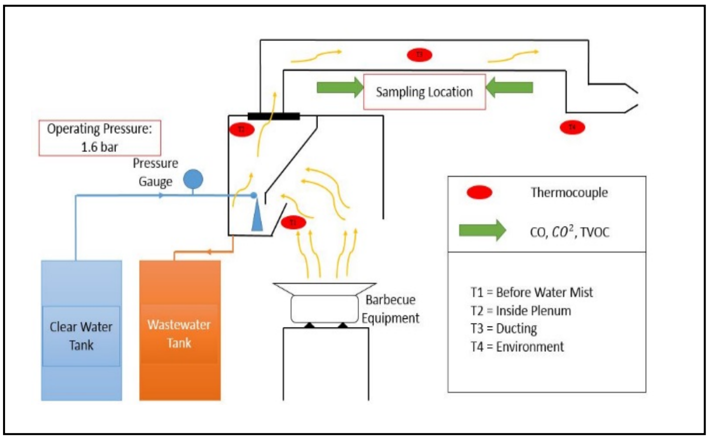

Fig. 1. Sketch of the test setup kitchen facilities.

As been known cooking activities create high concentration of aerosol indoors. Emission generated lead to one major indoor particulate pollutant that significantly affect air quality and increase risk to human health. The main pollutants release such as carbon monoxide, carbon dioxide, nitrogen dioxide and many more. Carbon monoxide is one the deadly toxin gas. In one study [7][12], 51% of kitchen ranges tested increase CO concentrations in the room above the EPA standard 9 part per million. The emission of CO not only was related to the cooking period, it also exist a result of the burning of the gas. If the CO concentration too high, it can cause headache, vomiting and nausea. In fact, in worst case scenario it can lead to death situation. Furthermore, when someone expose to moderate and high levels of CO over long period of time, it can increased the risk of heart disease.

However, the formation of TVOC was vice versa from CO and CO^2. The formation of TVOC attributed in large part to using the seasoning, ingredients and the behaviour of marinating. At the low level exposure of TVOC, little is known about the effects. Several studies indicated that exposure to TVOC may make symptoms worse in people who have asthma or are particularly sensitive to chemicals [11].

B. *Strainer*

A strainer removes a solid or foreign object from a fluid stream by physical obstruction. The mechanism of a strainer to remove the foreign object from a fluid stream is by using screen which has pore, mesh or whole diameter [4]. If a strainer screen had an orifice diameter of 10 microns, a particle larger than 10 microns in diameter would not pass through[9][10].

C. *Experiment Setup*

The scale test kitchen hood with water mist exhaust plenum was carried out and the dimension of the hood and ducting system is similar with the kitchen hood Halton Company. A schematic diagram of the test setup is shown in Fig 1. The type of water mist nozzles was used during this test is 1/8 KJSB 0.5 and was manufactured by John Brooks Company. There are 3 numbers of nozzles was installed horizontally along kitchen hood length with of 200 mm distance between nozzle as shown in Fig 3.

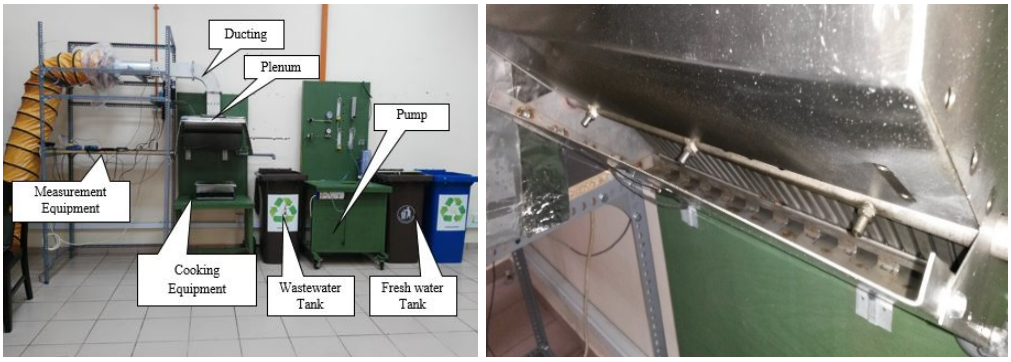

Fig 3. Water Mist spray setup.

The pressure of the working fluid was set to 1.6 bar at water mist spray flow rate 0.29 l/min for each nozzle. The K-type thermocouples, CO, CO^2 and TVOC sensors were installed and labelled as in Fig 1 for temperature measurements and gas sampling for 25 minutes. Barbecue is choose as cooking method and charcoal as a fuel. The exhaust velocity was set at 2 m/s.

TABLE I. List of equipment

Type	Measure	
TSI Indoor Air Quality	Carbon monoxide, Carbon dioxide	
Toxic Gas, TG-502	Total Volatile Organic Compound	
Thermocouple Data Logger , (K-Type)	Temperature	

Continues measurement of temperature, CO, CO^2 and TVOC were recorded using equipment shown in Table I. The quality of wastewater controlled by the use of chemical and physical parameters. Various parameters are used to qualify the effluent wastewater and evaluate the potential of a further treatment strategy. The main parameters that have been identified important on this research are the carbon monoxide (CO), carbon monoxide (CO2), volatile organic compound (TVOC), oxygen O2,temperature and pattern of spray before and after.

III. RESULT

A. Temperature

In Fig 4, show the graph for comparison of before water mist temperature for 3 condition of cooking. According to the graph, all show an upward and downward trend. For test condition without water mist activation, the temperature moderate increase 36.2 % and achieved the highest values at range 66.6°C after 9 minutes of sampling. At the 9 minutes also, temperature decreased 39.9% compare to other 2 test condition. For the lowest temperature recorded at the condition of cooking with water mist using wastewater (strained water) which is 32.86 °C. The fluctuation reading at 9 minute for condition without water mist cause by spark from charcoal during cooking.

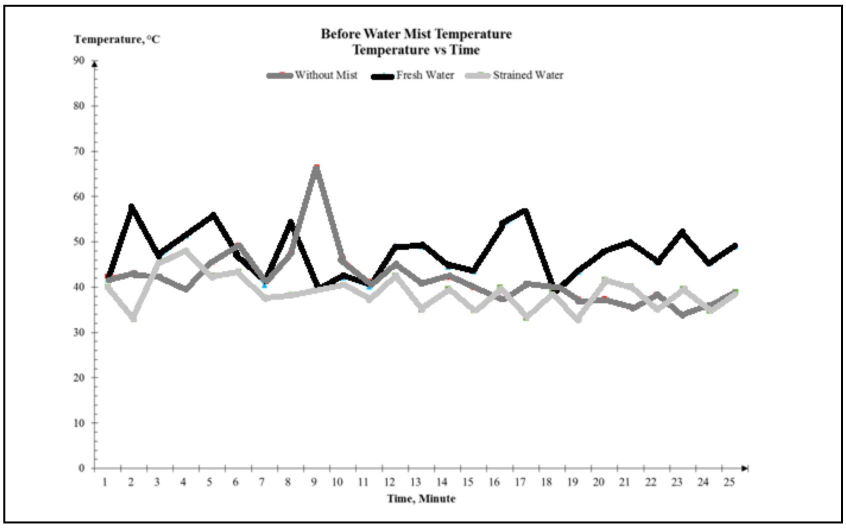

Fig 4. Comparison of Before Water Mist for 3 Condition Cooking.

The temperature of ducting sample was collected inside the exhaust ducts for 3 test conditions (without water mist, with water mist using fresh water and with water mist using wastewater) at 25 minutes sampling time as shown in Fig 5.

This graph also shows a comparison between average temperatures before water mist with 3 test condition. From the graph, the temperature before water mist at 4 minutes is higher 30.9% than temperature inside the exhaust ducts for 3 test conditions. In fact, it still shows highest reading than 3 condition test temperature until 25 minutes. There is not much different temperature reading for 3 test condition. The temperature for strained water is slightly lower than without water mist and with water mist using fresh water. As results, is shows the water mist activation has lower down the temperature inside the exhaust duct.

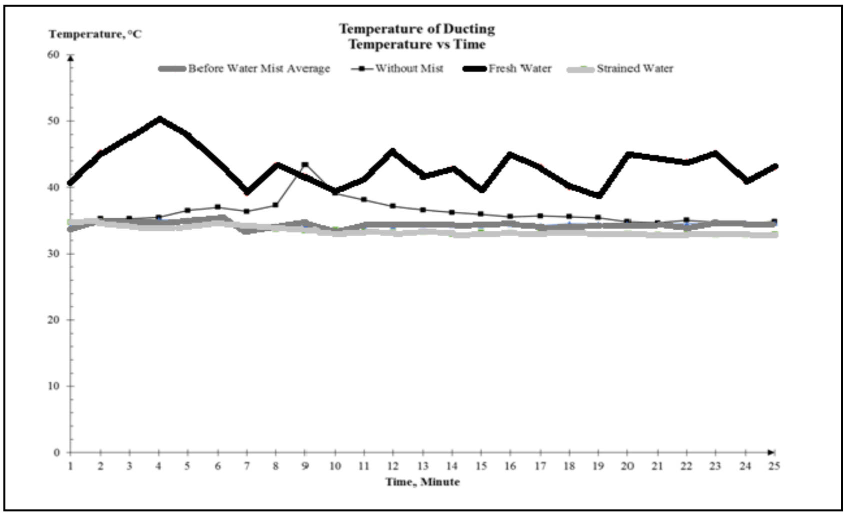

Fig 5. Comparison of Ducting for 3 Condition Cooking.

In fig 6, shows the graph comparison of kitchen plenum for 3 test condition (without water mist, with water mist using fresh water and with water mist using wastewater) at 25 minutes sampling time. The water mist activation along durations of 25 minutes shows us that the grease emissions temperature at location before water mist decreased compared to others test conditions. The temperature drop occurs when the water mist spray curtains capture the airborne particles and reduce the smoke temperature inside the kitchen plenum. From the graph, the temperature before water mist at 4 minutes achieved 50.1°C and higher 30.5% than temperature inside the kitchen plenum for 3 test conditions. In fact, it still shows highest reading compare to 3 condition test temperature until 25 minutes. The lowest temperature recorded 31.6 °C at the location water mist using fresh water.

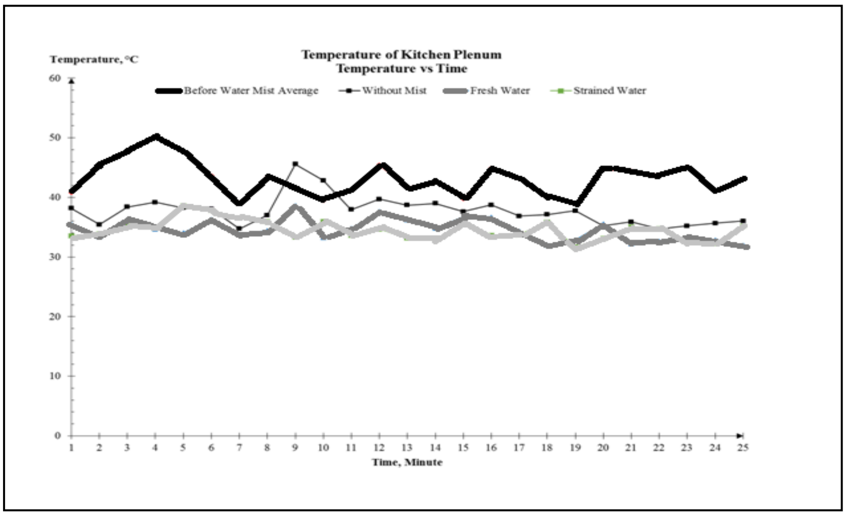

Fig 6. Comparison of Kitchen Plenum for 3 Condition Cooking.

B. *Carbon Dioxide*

In comparison of carbon dioxide, we measured the background value for 25 minute. There are 3 condition of cooking involve which is cooking without water mist, cooking with water mist using fresh water and cooking with water mist using wastewater. Fig 7 showed the result of carbon dioxide recorded during cooking. As soon as the charcoal burning, the concentration of carbon dioxide increased. Among them, the carbon dioxide concentration for condition cooking without water mist achieved the peak value 4246 ppm after 9 minutes of sampling. Meanwhile, the lowest reading for carbon dioxide value recorded 1390 ppm at 6 minutes of sampling. When the cooking starts, the reading rose sharply 35.5% and achieved the peak value at 4246 ppm. Previous study discovered that the generation of carbon dioxide produced largely as a result of burning of the gas and has a little to do with the cooking behavior. So, it is reasonable that the reading of carbon dioxide during cooking don't change too much. For test condition with water mist using fresh water, the highest value achieved 2038 ppm at 3 minutes of sampling and the lowest reading 1390 ppm at 6 minutes of sampling. While the test condition with water mist using wastewater, the highest value achieved 1796 ppm at 2 minutes of sampling and the lowest reading 1409 ppm at 25 minutes of sampling. The concentration value without activation water mist dropped drastically compared to test condition with water mist using fresh water 55.3% and with water mist using wastewater 61.5%. As results, is shows the water mist activation has significant effects on CO_2 contamination. From these data, we could find that the emissions of CO and CO_2 not only were related to the cooking period, but also exist largely as a result of the burning of the gas. The higher of the heat was used in cooking, the larger of CO_2 was produced. In fact, when we start the fire at the beginning, graph the increase dramatically.

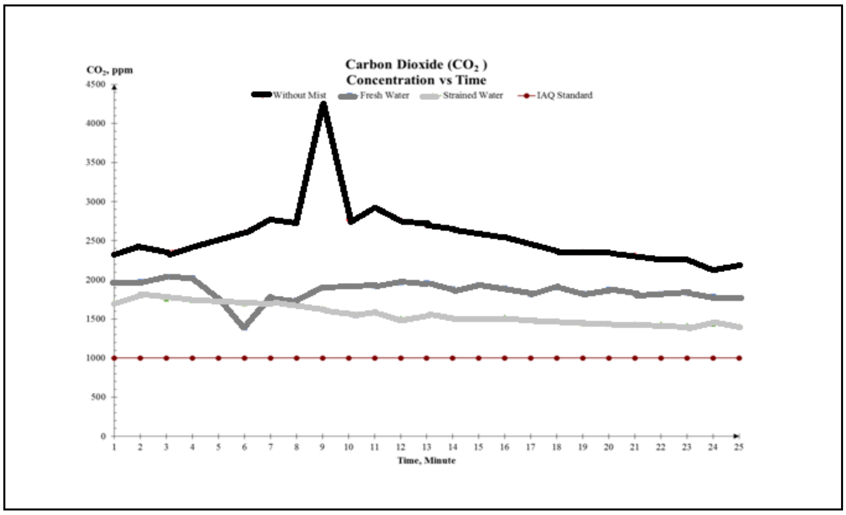

Fig 7. : Comparison of Carbon Dioxide for 3 Condition Cooking

C. Carbon Monoxide

Fig 8 show the graph for comparison of carbon monoxide involved 3 cooking condition which is cooking without water mist, cooking with water mist using fresh water and cooking with water mist using wastewater measured for 25 minutes. Among them, the condition for cooking without water mist shows the highest concentration which is 380.8 ppm at 10 minutes of sampling. Meanwhile, the lowest temperature achieved 95 ppm at 23 minutes of sampling at test condition using water mist with wastewater.

For test condition without water mist, the CO contamination steady increase 8.4% at 10 minutes of sampling and moderate fall until 25 minutes of sampling. During water mist activation using fresh water, at 6 minutes of sampling show a downward pattern graph but slightly increase until 25 minutes of sampling. While the test condition for with water mist using wastewater decrease slightly but the reading not difference to much until the end of the sampling. The concentration value without activation water mist decrease slightly compared to test condition with water mist using fresh water 41.4 % and with water mist using wastewater 56.1 %. As results, is shows the water mist activation has significant effects on CO contamination. The reading for 3 test condition still under the level of indoor air quality standard.

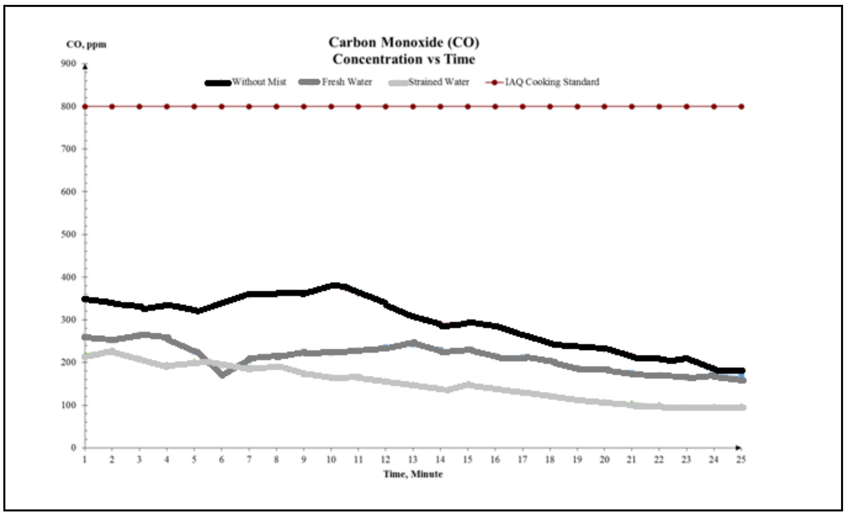

Fig 8. Comparison of Carbon Monoxide for 3 Condition Cooking

D. Total Volatile Organic Compound

The TVOC sample was collected inside the exhaust duct for 3 test conditions (without water mist, with water mist using fresh water and with water mist using wastewater) at 25 minutes sampling time. The result as in Fig 9 shows the TVOC contamination for test at location at the exhaust ducts. For test condition without water mist, the TVOC contamination rose steadily 77.5 % and achieved the peak values at average 0.49 mg/m^3 after 14 minutes of sampling time.

During water mist activation using wastewater (strained water), the TVOC contamination rose slightly 42.4% and achieved the peak values at average 0.33 mg/m^3 after 9 minutes of sampling time. While water mist activation using fresh water, the TVOC contamination rarely dropped gently 57.1% and only achieved the peak values at average 0.17 mg/m^3 at 23 minutes. The fluctuation of the test was predicted at the beginning of the cooking because the previous study state that the generation of TVOC attributed in large part using the seasoning, ingredients and marinating. As result, it shows the water mist activation has significant effects on TVOC contamination.

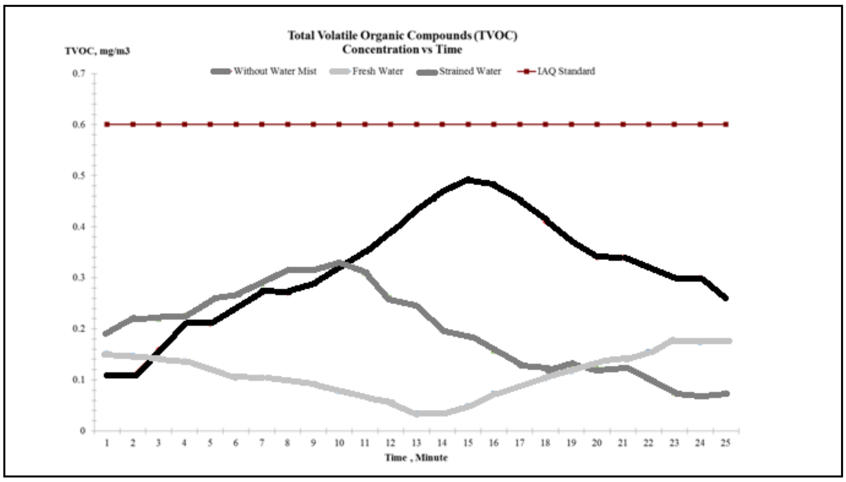

Fig 9. Comparison of TVOC for 3 Condition Cooking

E. Water Consumption Cost

We clearly see from Table II that under these conditions the water mist hood represent an important operating cost for the user. For user that operating 14 hours per day, they will use 2660 m^3 per year of fresh water. The user will suffer to pay their water bill when high consumption of water use in water mist process which worth RM 1596 per year. But in a kitchen where the water mist process is really important all the day a recirculating system of water can saving the cost by reducing the usage of the water.

We can see in the table 4.2 that for 25% of water reduction, the user already saving RM 399.per year. While for 50% of water reduction, the user can save RM798. The more wastewater recycle back to water mist process, the more money user can saving.

TABLE II. Water consumption cost

No of nozzle (water mist)	3
Operating pressure, Bar	1.6
Water flow nozzle, l/min	0.29
Water flow all nozzle, l/min	0.87
Operating time, h/day	14
Operating time, day/week	7
Fresh water, l/day	730.8
Fresh water, l/week	5115.6
Fresh water, m^3/year	2660
Tariffs, RM/m^3	0.60
Total water cost, RM/year	1596
Saving/year @ 25% water reduction	RM 399
Saving/year @ 50% water reduction	RM 798
Saving/year @ 75% water reduction	RM 1197
Saving/year @ 80% water reduction	RM 1276.8

IV. CONCLUSIONS

As stated previously, the objectives of the present project are to determine the grease emission filtration efficiency by water mist spray of kitchen hood using strainer. With this intention, the expecting outcome of the research is to able solving those issues, which is the cost of water use in water mist spray and filtration of grease emission was achieved. The research has proceeded based on three condition of cooking which is cooking without water mist, cooking with water mist using fresh water and cooking with water mist using wastewater. From this, we can get the wastewater and prove that the water we get from kitchen hood filtration can be recycle back for water mist process without any problem hence obtain information how much water we use and cost for each cooking. As a result, its shows that water mist has significant effect on CO, CO_2 and TVOC contamination. The temperature inside the kitchen plenum and ducting also reduce by water mist activation. The wastewater also has been proving effective to use in water mist process which can saving the cost.

V. FUTURE SCOPE

This study is for the future scope to expecting outcome of the research is to able solving those issues, which is the cost of water use in water mist spray and filtration of grease emission. Using strainer for grease emission filtration efficiency on kitchen hood system industry.

VI. ACKNOWLEDGEMENTS

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