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Design of Local Exhaust Ventilation for Spray Booths: Proposed Study

[1] Nor Halim Hasan, [2] M.R. Said, [3] A.M. Leman
[1, 2] Department of Structure and Material, Faculty of Mechanical, University Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia.
[3] Department of Plant and Automotive Engineering, Faculty of Mechanical and Manufacturing Engineering, University Tun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat, Johor, Malaysia.
[1] irnorhalim@student.utem.edu.my, [2] radzai@utem.edu.my, [3] mutalib@uthm.edu.my

ABSTRACT

Workers are exposed to contaminant at workplace. Employers in Malaysia shall comply with Factories and Machineries Act 1967 and Occupational Safety and Health 1994 to minimize the exposure that hazardous to workers health. Engineering control such as to provide Local Exhaust Ventilation (LEV) is to control contaminant to the employees. This report is a research proposal to carry out for Local Exhaust Ventilation study at Automobile Assembly Plant in Malaysia focusing in spray paint to look on current design and purpose new design and advanced material to the system. Data collections are based on survey questionnaires, chemical monitoring, LEV inspection, testing and examination. Expected results are comparison from experimental, analytical and finite-element used in automotive industries prediction of advanced material will propose to the systems.

Keywords: *Local Exhaust Ventilation Design, Automobile Assembly Plant in Malaysia, Spray Booth System, Chemical Exposure Monitoring*

1. INTRODUCTION

In Malaysia, Occupational Safety and Health Act, Act 514 has known as an OSHA 1994, which has been enforced for more than 16 years since 1994. In the act, it required the employers to ensure workers' safety, health and welfare. Furthermore, it avoids workers from exposing themselves to any risk of accident. In current work, a mechanism to control hazardous to workers health is proposed to design and implementations a good ventilation system.

Industrial ventilation is a system of controlling airborne toxic chemicals or flammable vapors by exhausting contaminated air away from the work area and replacing it with clean air. It is one alternative to control employee exposure to air contaminants in the workplace. Other alternatives include process changes, work practice changes, substitution with less toxic chemicals, or elimination of the use of toxic chemicals. Industrial ventilation is typically used to remove welding fumes, solvent vapors, oil mists or dusts from a work location and exhaust these contaminants outdoors.

The objective of a local exhaust ventilation system is to remove the contaminant as it is generated at a source. Controlling the air in which they are contained controls gases and vapors and exist. Special procedures are required to control large particles that are generated at the source. These particles are controlled for other than health purposes.

Industrial which involved and used with ventilation systems are required to comply with Malaysian Legislation such as Occupational Safety and Health Act 1994, Use of Standard Exposure Chemical Hazardous to Health Regulation and Factory and Machinery Act 1967 and Regulations under this Act.

1.1 Problem Statement

Study will be focusing on the automotive painting industry in Malaysia which using industrial ventilation system.

1.2 Propose of the Study

This study will be evaluated the efficiency of existing Local Exhaust Ventilation at Spray Booths such as:

a. To measure level of concentration of the air contaminants.
b. To determine efficiency of existing industrial ventilation using in spray booths especially in small medium industry in Malaysia.
c. To recommending new application of advance material use for industrial ventilation system and
d. To evaluate significant effect of health outcome in relation to level concentration of air contaminants.

1.3 Significant of the Study

Result of Local Exhaust Ventilation measured, design and implementation will be compliance to Occupational Safety and Health Legislations to help policy maker / stake holder to plan, implement and control any related matters.

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1.4 Research Question/Hypotheses

What are the existing concentrations of chemical and relationship between level concentration of chemicals and symptom of the health personnel? What the impact to the sprayer and symptoms level of the exposure? What of the prevalence of personnel symptoms? What are the comparison between analytical, experiment and simulations? Study current effective filter for air cleaning device? Propose organic compound for one of the alternative filter device.

2. LITERATURE REVIEW

Change to clean air to the workers who exposed to contaminants such as air borne toxic chemicals or flammable vapor can control the exposure by controlling using ventilation. Hazard control method is to eliminate the toxic contaminant is the best solution. Commonly used the industrial ventilation to remove contaminant from workplace where exposed. 1

A qualified ventilation engineer or firms specializing in this field should handle the design and troubleshooting of industrial ventilation systems. A Guideline recommended by ACGIH provided information in a guideline can be influenced by other factors in an industrial environment (material handling techniques, cross-drafts and replacement air, work practices and housekeeping, etc,)2

In Great Britain, big issue in Occupational Health is a occupational asthma due to exposed to iso cyanate who are working as a vehicle paint sprayers working in motor vehicle repair (MVR) body shops and in the commercial vehicle and trailer manufacturing industry. The risk is over 80 times greater than the industrial average.3

To comply with the local legislation, the Industries need to install the Local Exhaust Ventilation System to remove the contaminants in a workplace will involves a cost. Estimating cost must consider in system design before install. Buy and Mathews (2005) claim that without a detail design and costing model, there are no accurate cost estimation can do. 4

2.1 Legal Requirements

Compliance to the regulation is an approach to reduce and maintain the exposure level of employees to chemicals hazardous to health. The requirements are to the lowest practicable level or below permissible exposure limits.

Engineering Control Equipment (Regulations 2) means any equipment, which is used to control exposure of employees to chemicals hazardous to health and includes local exhaust ventilation equipment, water spray or any other airborne chemical removal and containment equipment? The equipment shall be maintained and operated at all times while any machinery or plant is in operation, and for such time. (Regulation 17) 6

Ventilation in Regulation 25 (1): Where the means of natural ventilation is not adequate further means of natural or mechanical ventilation or both shall be provided.5Dilute the concentration of the airborne contaminant before it reaches the worker ventilation, to cool the air, to create adequate air move.

Adequate ventilation: Regulation 25 (2)5: where the number of air changes every hour is:

- Not less than ten (10) in the case of processes which generate little or no heat, smoke or fume,
- Not less than twenty (20) in the case of processes which generate heat, smoke or fume,
- Not less than thirty (30) if any fume generated is likely to cause bodily injury.

Mechanical Ventilation Design: Regulation 25 (3): The total free area of any ventilation air inlets shall be at least 50% greater than the total free area of the air outlets. Air inlets shall, so far as practicable, be located at floor level, and air outlets shall be located as high as practicable. 5

Air Cleanliness: Regulation 26 (1): where any process given off any offensive fume or dust which is or is likely to be offensive or injurious to any person or being accumulated, measures shall be taken to protect such persons against inhalation and to prevent it accumulating. 5

Removal dust laden air: Regulation 26 (2): Dust laden air shall be removed by a settling chamber, water spray, cyclone, filter or any combination of these or other suitable appliance. 5

Hood and Ducting: Regulation 26 (3): Any hood, enclosure, canopy or shall be constructed so as to envelop, as far as practicable, the point of origin of the fume or dust so that a smooth and uninterrupted flow is maintained. In addition to this requirement the hood, enclosure, canopy, or ducting for the extraction of fume shall be constructed so as to maintain the air velocity at the surface thereof at a rate not less than one hundred and fifty (150) feet per minute.5

Design, construction and commissioning of local exhaust ventilation equipment. Regulation 18: any local exhaust ventilation equipment installed shall be designed according to an approved standard by a registered professional engineer and constructed according to the design specifications; and tested by a registered professional engineer after construction and

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installation to demonstrate that the equipment meets the design specifications. 6

2.2 Principle of Local Exhaust Ventilation

Basic Flow relationship in Industrial Ventilation by Jeff Burton (2009) 14

a. Pressure
   Tp = Sp + Vp
   Where;
   Tp = Total Pressure
   Sp = Static Pressure
   Vp = Velocity Pressure

b. Volume flow rate
   Q = V x A
   Where;
   Q = volume flow rate, cfm (ft^3/m)
   V = Average velocity, fpm
   A = Area, sqf.

c. Velocity and Velocity Pressure
   $V = 4005 \sqrt{Vp}$
   Where;
   V = Average velocity, fpm
   Vp = Velocity Pressure, inches of water

2.3 Natural Ventilation

Buildings should be designed with controllable natural ventilation. A very high range of natural ventilation rates is necessary so that the heat transfer rate between inside and outside can be selected to suit conditions. Ventilation rates are selected to control temperature, pollution, and air movement. Ventilation with heat reclaims and the thermal capacity of the building has to be considered. Buildings need to be designed with natural ventilation in mind to minimize the use of fossil fuel energy.7

2.4 Local Exhaust Ventilation

The objective of a local exhaust ventilation system is to remove the contaminant as it is generated at the source. Controlling the air in which they are contained controls gases and vapors. The initial opening through which contaminated air enters a local exhaust system is called the hood. The term hood is used generically for any opening whether it is specifically designed or consists of simply the open end of a round or rectangular duct section. Many hoods are specifically designed and located to meet the requirements of the operation and the contaminant being generated. After the contaminated air has entered the hood, it flows through a duct system that directs the flow o f contaminated air and prevents mixing of this air with the workroom atmosphere. Branches may exist within the duct to join separate local systems into one single exhaust system. The third component of a local exhaust system is a method for cleaning the air. It is often necessary to remove the contaminant from the air before exhausting the air into the atmosphere to prevent hazardous materials from entering the breathing zone of individuals in the community surrounding. 2

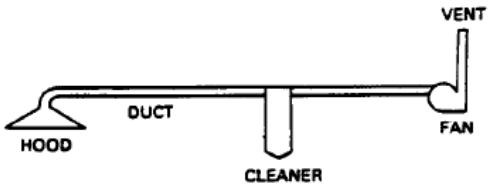

Fig 1: Illustration Local Exhaust Ventilation

2.5 Car Paint Workshop Issues

A study by Chris and Philip (1992), in Australia found that typical contaminants of the chemical products used in this industry were encountered (aromatic hydrocarbons, C5-C7 aliphatic hydrocarbons, ketones, esters). Studies were conducted in 46 spray painting workshops in the Sydney metropolitan area. Solvent exposure was highest when spraying acrylic paint in the open workshop and lowest when spraying two pack paint in a spray booth. They monitored that personal protective equipment was available in all workshops, but wide variation in its use was observed. Material safety data sheets were not observed in any of the workshops. 9

W.H Choi et al (2002) have analyzed Ventilation characteristics of toluene in a room of a small-scale painting process with various exit locations and with different suction velocities at the exits. The result shows that a careful design of workspace is needed to maintain allowable concentration, which may depend on the position of exits and local room mean air age. 10

In 1996, Rhode Island Department of Environmental Management conducted a survey of pollution prevention to identify risk reduction opportunities. They found that one-half of the shops employ three or fewer people their potential exposure to workplace contaminants while nearly all of the shops use spray-painting booths, 38% own booths of the more, and in many cases, spray painters double as body repair technicians thereby increasing effective downdraft design. Better method of risk communication; a professional licensing requirement; and targeted training, compliance, and technical assistance would help to achieve greater levels of risk reduction in the in this mature, high hazardous industry. 12

Studies conducted by EPA with various Department of Defense (DoD) services, however, have demonstrated that the cost associated with typical spray booth control system can be significantly reduced through the use of spray booth recirculation. Reductions

of exhaust flow rates of up to 90 percent may be possible when using recirculation in property design and operated booths without concern for the industrial hygiene or fire safety issues often mentioned when discussing re-circulating booths. [13]

2.6 Contaminant and Filter

A study by Renata et al. (2002), the effect of temperatures of 23, 29, and 50 ^{o}C on formaldehyde and volatile organic compounds (VOCs) emission from laminate flooring Type A (with particle board as substrate) and Type B (with high density fiber (HDF)) was examined. At 23 and 29^{o}C the measurements did not show any emissions of formaldehyde and very low emissions of VOCs. At a temperature of 50^{o}C, Type A showed a high initial emission of formaldehyde and VOCs, which decreased with time. The emission from Type B was much lower. In conclusion, some laminate flooring may affect the chemical contamination of indoor air with the use of floor heating. 8

2.7 Nanotechnology

Recently, huge of consumer nano-based products are already on the market. Besides that, only a few is known of the risks of Engineered Nano materials (ENM) to occupational safety and health (OSH), These materials normally levels of exposure are usually higher at workplaces than in other environments and workers are likely to be at extra risk. Several issues related to ENM in the workplaces require marked attention. The most topical issues include: (1) improved understanding of ENM metrics associated with ENM toxicity; (2) development of monitoring devices for ENM exposure assessment; (3) understanding the changes of ENM structure and state of agglomeration at different concentrations in aerosols; (4) under- standing translocation of ENM in the human body; (5) identifying the key health effects of ENM including pulmonary toxicity, genotoxicity, carcinogenic effects, and effects on circulation; (6) development of tiered approaches for testing of safety of ENM; and (7) utilizing these data for health risk assessment, with a special emphasis on occupational environment. 11

Dr. Halimah (2010) claim that many advanced materials are currently being studied and tested by the engineers like the use of nanotube to create a composite material where can protect against corrosion. 15

3 METHODOLOGY

3.1 Data Collection

Data collections are expected from survey questionnaire and measurement data of the unmodified working place.

3.2 Apparatus

The methods and equipment's are carrying out to measure the efficiency and level of concentration will follow International Standard. Others applications that will be conducted are a) Survey questionnaire, (b) Chemical Exposure Monitoring and (c) LEV Inspection, Testing and Examination.

3.3 Procedure

To perform this study the procedure used will follow and modified standard method from NATIONAL INSTITUTE OF OCCUPATIONAL SAFETY AND HEALTH (NIOSH) Standard Method and American Conference of Government Industrial Hygienist (ACGIH).

3.4 Analysis Plan

The collected experimental data will be further calculated and analyzed to assess the suitability of this technology as an alternative material. In general, data collections are based on survey questionnaires, chemical monitoring, LEV inspection, testing and examination. To analyze, "Statistical Package for Social Sciences (SPSS) Version 16.0. Descriptive Statistics data of the mean, standard deviation will be obtained. ANOVA and t-test will be used for comparison study.

3.5 Scope and Limitation

a. Sampling Size

Purpose for 8 automotive assembly plants in Malaysia including Honda, Toyota, Proton, Perodua, Kia, Hicom, Nissan and Modenas. Also propose for small medium industry such as private car painting or car repair.

b. Inclusion Criteria

- Sample only from automotive assembly plant.
- Only limited to spray booth section (conveyer type)
- Criteria for all filter type

c. Exclusion Criteria

- Not include oven system

4 EXPECTED RESULTS

4.1 Data Description

Expected result are from experimental, analytical and simulation of Local Exhaust Ventilation where used in painting industries.

4.2 Data Analysis

Data analysis expected will be compared to experimental, analytical and simulation for local exhaust ventilation system.

5 CONCLUSION

In Final result, design study and comparison between experimental, analytical and simulation used in local manufacturing in car manufacturing focusing in painting activities are expected. The study will be focusing to small medium industries such as car repair or painting shop and compare to big scale manufacturing.

Second part to study and predict the efficiency of alternative air cleaning device from an advanced materials (e.g. organic compounds). The study will involve in comparison with current market filter to remove volatile organic compound (VOC) in painting activities.

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