ANALYSIS OF RBD PALM OLEIN ABRASIVE BLASTING AS NEW METAL SURFACE CLEANING METHOD

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SPECIAL GRATITUDE TO;

THE MOST BELOVED PARENTS

Zakaria bin Alang Ibrahim and Asma binti Md. Abu

For their support in the whole of my life

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For her advices, support and patience during the completion of this thesis

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ABSTRACT

Abrasive blasting is a process done for surface cleaning which has two methods which are dry or wet process. The dry process which uses abrasive media blasted onto a surface to clean dirt on the surface normally will release fine dust into the environment. Water is used with abrasive media to reduce the dust release into the environment and named as wet abrasive blasting process. However, water causes corrosion to metal surface. In this study, analysis of RBD palm olein as an alternative to the use of water in wet abrasive blasting process was investigated. The analysis in this study covers performance of cleaning process, personal dust exposure reduction, emission rate reduction and corrosion inhibition. In this research, the performance of RBD palm olein abrasive blasting was evaluated using ISO 8501-1 visual assessment method. Abrasive blasting workers' exposure level to the dust release from abrasive blasting activity was determined using NIOSH Method 0500 dan 0600. EPA-42 was used to determine the emission rate in this research. XRD method was also used to determine the dust and material composition as described in the NIOSH Method NMAM 7500. To see the effectiveness of the RBD palm olein as a corrosion inhibitor, samples of tank were soaked using ASTM G31-72 method. In this process, the quality of RBD palm olein shows similar result to dry and wet abrasive blasting in cleaning performance. Exposure monitoring result shows that the workers' exposure to dust release from RBD palm olein abrasive blasting reduced drastically and recorded only 21.11% inhalable dust and 22.82% for respirable dust compared to the result recorded in dry abrasive blasting. The emission rate was also decreased. Result and analysis from XRD show the composition of quartz-silica has exceeded the permission level on material although the silica composition decreased in dust sample during abrasive blasting. Samples soaked in RBD palm olein for 48 hours did not show any corrosion development. In conclusion, RBD palm olein can be a new and sustainable alternative in the metal surface cleaning process in the industries.

ABSTRAK

Abrasive blasting adalah satu proses pencucian permukaan mempunyai dua kaedah sama ada dijalankan secara kering atau basah. Proses secara kering menggunakan media yang keras dan dihentam ke permukaan untuk membuang kotoran di permukaan biasanya akan membebaskan habuk yang sangat halus ke alam sekitar. Air digunakan bersama bahan media *abrasive* untuk mengurangkan pembebasan habuk ke udara dan dinamakan proses *abrasive blasting* basah. Namun air menyebabkan berlakunya pengaratan di permukaan bahan. Dalam kajian ini, analisa *RBD palm olein* sebagai alternatif kepada penggunan air dalam proses abrasive blasting basah dikaji. Analisa dalam kajian ini meliputi prestasi dalam proses pencucian, pengurangan pendedahan habuk, pengurangan kadar pencemaran dan perencatan pengaratan. Dalam kajian ini, prestasi proses *RBD palm olein abrasive blasting* dinilai menggunakan kaedah ISO 8501-1 penaksiran secara visual. Tahap pendedahan pekerja abrasive blasting terhadap habuk dibebaskan daripada aktiviti *abrasive blasting* ditentukan menggunakan NIOSH Method 0500 dan 0600. EPA-42 digunakan untuk menentukan kadar pencemaran udara dalam kajian ini. Kaedah XRD digunakan bagi menentukan kandungan habuk dan kandungan bahan seperti dinyatakan dalam NIOSH Method NMAM 7500. Bagi melihat keberkesanan *RBD palm olein* sebagai perencat pengaratan, rendaman semua sampel tangki menggunakan kaedah ASTM G31-72. Dalam proses, kualiti proses *RBD palm olein abrasive blasting* menunjukkan keputusan yang sama seperti *abrasive blasting* kering dan basah bagi proses pencucian. Pemantauan pendedahan menunjukkan pendedahan pekerja kepada habuk terbebas daripada aktiviti *RBD palm olein abrasive blasting* menurun secara drastik dan mencatatkan hanya 21.11% *inhalable dust* dan 22.82% bagi *respirable dust* berbanding yang dicatatkan oleh *abrasive blasting* kering. Kadar pencemaran juga mencatatkan penurunan. Keputusan dan analisa XRD menunjukan kehadiran silika – quartz yang melebihi had dibenarkan dalam bahan walaupun kandungan silika ini

berkurang dalam sampel habuk diambil ketika proses abrasive blasting dijalankan. Rendaman semua *mild steel* di dalam *RBD palm olein* selama 48 jam juga menunjukkan tiada proses pengaratan berlaku pada permukaan *mild steel*. Kesimpulannya, *RBD palm olein* mampu menjadi alernatif baru dan mampan dalam proses pencucian permukaan logam di industri.

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LIST OF ABBREVIATIONS AND SYMBOLS

ACGIH	American Conference of Governmental Industrial Hygienists
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATS	American Thoracic Society
CHRA	chemical health risk assessment
COPD	chronic obstructive pulmonary disease
COSHH	control of substances hazardous to health
CSDS	chemical safety data sheet
DOSH	Department of Occupational Safety and Health Malaysia
ECCS	European Community for Coal and Steel
FEV_1	forced expiratory volume in 1 second
FVC	forced vital capacity
GHS	Global Harmonized System
ISO	International Organization of Standardization
MSDS	material safety data sheet
NHANES	National Health and Nutrition Examination Survey
NIOSH	National Institute for Occupational Safety and Health USA
PEL	permissible exposure limit
PFT	pulmonary function test
PM_{10}	particulate matter size below than 10 µm
$PM_{2.5}$	particulate matter size below than 2.5 µm
PNOC	particulate not otherwise classified
RBD	refined, bleached and deodorized
RV	relative value
SDS	safety data sheet
SiO_2	silica oxide
SOCSO	Social Security Organisation

TLC	total lung capacity
TWA	time weighted average
UAO	upper airway obstruction
USECHH	Occupational Safety and Health (Use and Standard of Exposure to Chemical Hazardous to Health) Regulations 2000
WHO	World Health Organization
WoE	weight of evidence
XRD	x-ray diffraction

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CHAPTER 1

INTRODUCTION

1.1 Overview

This chapter gives a brief explanation of the research problem. The significance of the study on personal dust exposure, emission rate, safety and health issue, and corrosion process are discussed in detail. Additionally, the problem statements, objective, scope, limitations and significance of the study discuss the major issues to be solved on dust pollution, subjection to blasting dust, and corrosion inhibition process.

1.2 Background of Study

Cleaning is a common process conducted by human everyday. Cleaning process normally uses water as a method and medium. In industry, one of the popular methods for cleaning process is abrasive blasting, whether wet or dry blasting.

The meaning of abrasive blasting is to propel a stream of abrasive materials at high speed by the use of compressed air, liquid stream, centrifugal wheels or paddle on a surface to clean, abrade, etch or modify the initial appearance or condition of the surface (Safe Work Australia, 2012). This is the method most widely used for surface preparation in the industry. Previously, the abrasive media normally and widely used is sand (US Environmental Protection Agency, 1997). Nowadays, there are many abrasive media are being used such as steel grit, aluminium oxide, garnet coal slag and many other abrasive media (Dave Hansel, 2000; Hubbs et al., 2001; Ohriner, Zhang, & Ulrich, 2012; Porter et al., 2002).

The difference between dry and wet abrasive blasting are dry abrasive blasting uses compressed air to accelerate the media into the surface during cleaning process while in wet abrasive process, normally, water is used to accelerate the media. The main advantage for using wet abrasive blasting is to decrease media breakdown and resulting in reduce of the dust release from abrasive blasting process to the environment.

Abrasive blasting or normally known as sand blasting in Malaysia is one of the activities in industries in Malaysia which causes occupational health and safety risk to the workers. In industries, abrasive blasting is normally applied before coating process, cleaning purposes and surface finish process. Marine industries are where abrasive blasting is widely used for cleaning and surface preparations before coating. Abrasive blasting activity will produce very high concentration of dust. There are various substitute materials for abrasive blasting that are used commercially, however the possible pulmonary toxicities have not been determined (Porter et al., 2002).

In Malaysia, safety and health issues for abrasive blasting process are commonly referred under Factory and Machinery (Mineral Dust) Regulations 1989 and Occupational Safety and Health (Use and Standard of Exposure to Chemical Hazardous to Health) Regulations 2000 or known as USECHH Regulations. Regulation 5 under Factory and Machinery (Mineral Dust) Regulations 1989 mentions that the use of sand blasting in any factory should be prohibited without written approval from the Chief Inspector beforehand (P.U. (A) 143/97, 1989). The problem is the regulation only covers abrasive media from mineral dust composition. Under USECHH Regulations, it is not discussed in detail about controlling the abrasive blasting process.

Previously, the most common abrasive blasting media used is sand (Porter et al., 2002). High level of crystalline silica can trigger the progression of pulmonary disease silicosis, if inhaled (Xianglin Shi, Vince Castranova, Barry Halliwell, 1998). One of the approaches that can be used to eradicate this health risk to employees working with abrasive blasting is to substitute to another abrasive media (Porter et al., 2002). Copper slag, steel grit, garnet, and aluminium oxide are another examples of abrasive media used to substitute the use of silica sand in abrasive blasting process. However, their health hazard potential to workers is not really examined. Hubbs et al. and Porter et al. indicated that several abrasives media substitutes are hazardous to the health of exposed employees as there is possible pulmonary toxicity, thus investigation on the substitute for abrasive blasting is necessary (Hubbs et al., 2001; Porter et al., 2002).

Chronic obstructive pulmonary disease (COPD) is lung disease indicated by obstruction of progressive airflow and lung parenchyma destruction including emphysema and persistent bronchitis (Oswald, Neville C, 1955; Salvi & Barnes, 2009). By the year 2020, COPD is predicted to be in the fifth rank for a condition with high burden to society and in third place for being the cause of death worldwide (Ko & Hui, 2012; Murray & Lopez, 1997). The majority of clinical trials previously done have only recruited smokers with a minimum of 20 pack-years of exposure to cigarette smoking (Salvi & Barnes, 2009). However, in the past few decades, particularly in the last 10 years, research found that there is a rising amount of published studies suggesting that the risk factor for COPD besides smoking are strongly related. A study done by Whittemore and co-workers found that the prevalence of COPD in 12,980 participants from the US-based NHANES I, NHANES II, and NHANES who had never smoked was 5.1% (3.7% of men, 5.6% of women) from self-reported diagnosis by physicians, which matched the prevalence of persistent cough, phlegm, or wheezing recorded in Finland of participants who had never smoked (Salvi & Barnes, 2009; Whittemore, Perlin, & DiCiccio, 1995). Bill B Brashier and Rahul Kodgule have listed occupational dust including crystalline silica blasting that attributed to 15% of COPD risk in American population (Brashier & Kodgule, 2012).

In Malaysia, Ministry of Health reported that the age of 80 and above is the peak for the deadliness of chronic obstructive pulmonary disease (COPD) in men (Abajobir et al., 2017). Death through COPD at the lowest rate in men is of age 10–14. The peak rate for mortality in men was 1,326.2 deaths per 100,000 men in 2013, which higher than that of women at 579.9 per 100,000 women. The highest rate of death from chronic obstructive pulmonary disease for women in Malaysia is at age 80 and above. The lowest rate for women is at ages of 20 –24 (Abajobir et al., 2017).

Industrial accidents rate in Malaysia are constantly high every year. The rate of accident reports to the responsible body are around 100 cases for every 10,000 workers every year (Social Security Organisation, 2015). In Malaysia, Social Security Organisation (SOCSO) receives the report for the industrial accident for compensation.

In Malaysia, Factory and Machinery Act 1967 and also Occupational Safety and Health Act 1994 are the main act that should be followed by industries players in Malaysia to protect workers and the public from occupational safety and health accident or incident. Department of Occupational Safety and Health Malaysia (DOSH) is the only government body to enforce and administer all the legislations related to occupational safety and health.

In 2016, the Prime Minister of Malaysia, Dato' Sri Mohd Najib bin Tun Abdul Razak had launched Occupational Safety and Health Master Plan (OSH-MP) 2020 with the theme "OSH Transformation – Preventive Culture". In the plan, the Prime Minister of Malaysia has said that;

> "This OSH-MP 2020 is to contribute to the reduced rate of occupational accidents and diseases and thus assist the Government in raising the quality of life of the people. The quality of working life is one of the elements contributing to the well-being of Malaysians."

1.3 Problem Statements

Malaysia is a developing country and 69.7 percent of Malaysians involve in labour force which equals to almost 14.6 million people in November 2017 (Department of Statistics Malaysia, 2018). Abrasive blasting is one of the common activity in industry that are acutely and chronically dangerous mostly due to its abrasive blasting dust.

The dust release from abrasive blasting activities can be measured according to occupational exposure or as particulate matter (PM) emission into environment. Most studies stated that the dust release from abrasive blasting is high but there are limited data available until now regarding the occupational exposure to the abrasive blasting workers.

For the emission of PM, studies normally discuss the emission according to the environment analysis based on the location of the receiver. In this type of study, the data analysis according to dispersion model indicated the main factor is advection (wind field) (Leelőssy et al., 2014). However, Environment Protection Agency, USA (EPA) has introduced another emission factor analysis for abrasive blasting which analyse the emission rate from the source, not at the receiver (US Environmental Protection Agency, 2007). The advantage of this method is the emission rate is more accurate compared to dispersion model because emission is directly analysed from the source. Although the emission rate method has been introduced for years, there are very limited study using this method.

Many studies of blasting dust effect have been conducted worldwide especially in the United States of America (USA), and the United Kingdom (UK) (Habash et al., 1998; Hubbs et al., 2001; Porter et al., 2002; Querol et al., 2019; S. Tian, Liang, & Li, 2019). These researchers had published the evidence and result which shows the significance of health risk developing inflammatory response, airway irritation symptoms and respiratory problems of workers working in dusty environment, normally during engagement in abrasive blasting activities compared with non-blasters. However, most of the studies only consider the abrasive media itself. There are none of the studies that considered the dust composition developed by abrasive blasting process. Hubs et al. (2001) had found potentially toxic element in abrasive blasting agent. The elements were tested on rats and it showed that there were significant health effect to the rats (Hubbs et al., 2001). The rats showed that the toxicity and inflammation displayed by garnet, staurolite, and treated sand were similar to blasting sand whereas for coal slag, it showed more pulmonary damage and inflammation compared to blasting sand (Hubbs et al., 2001; Porter et al., 2002).

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