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Respiratory Health Effects of Metalworking Fluid among Metal Machining Workers: Review Article

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ABSTRACT

Background: Metalworking fluids are the most common coolants and lubricants used in metal machining industry in order to protect the machine and the products. The most common form of MWF is water based MWF. During the machining process the MWF can be splashed into workers' environment and suspended as aerosols that can be inhaled by the workers into their respiratory system. Exposure to MWF can lead to serious respiratory diseases as cough, phlegm, asthma, chronic obstructive lung disease, or hypersensitivity pneumonitis. **Objective:** To review and summarize the principle of respiratory exposure to MWF among metal machining workers and the adverse health effects on respiratory system. **Method:** A survey of the literatures concern on MWF respiratory exposure, respiratory health effects of MWF, microbial contamination of water based MWF, effectiveness of permissible exposure limits of MWF and assessment of respiratory health of workers exposed to MWF were reviewed and summarized in this review paper. **Result:** Review shows, the workers in metal machining industries and handling MWF in their daily activities are at high risk of respiratory diseases due to respiratory exposure to MWF. **Conclusion:** There is a shortage in number of related studies on exposure to metalworking fluids in Malaysia.

Keywords: *Metalworking fluid, respiratory exposure, respiratory health, metal machining workers.*

1. Introduction

Metalworking fluids (MWFs) are variety of substances can be used during machining of metals such as cutting, turning, grinding, milling and drilling. MWFs provide lubrication, cooling to the metal pieces during the machining and help to carry away the small debris such as swarf and fine metal particles that were generated by the machining of the metal. According to Health and Safety Executive (HSE) MWFs can help to increase the machining performance and extend the life of the cutting tools in addition to providing corrosion protection for the work pieces (HSE, 2011).

MWF is available in different forms such as straight oil (neat oil), soluble oil (emulsifiable oil), semisynthetic MWFs, and synthetic MWFs. During machining processes worker can be exposed to MWFs through skin contact and inhalation. Respiratory exposure can occur when the fluid splash from the machine leaving MWF aerosols suspended in the workers' environment and inhaled by the workers especially if the workers were not wearing the proper personal protective equipment and the lacking of local exhaust ventilation to remove the MWF aerosols. The levels of the exposures were directly related to the close proximity of the workers from the machine or the speed and pressure of the machine (Fishwick et al. 2015, NIOSH, 2012, NIOSH, 1998).

Malaysian Investment and Development Authority (MIDA, 2014) had reported that more than 1,700 companies with around 540,000 employees are active in machinery and equipment sectors in Malaysia and it's continuously growing in the future. Exposure to MWFs aerosols or mists through inhalation can lead to adverse respiratory health effects such as cough, phlegm, wheeze, cough with phlegm, rhinitis, acute impairment of lung function, and hypersensitivity pneumonitis (Lillienberg, et al. 2010).

Hypersensitivity pneumonitis (HP) is one of the conse-quences to MWFs respiratory exposure and it occurred among workers who work with water-based MWF and it was found that the microbial contamination of the MWF had been suspected to be the underlying agents for the HP (Burge, 2016, Rayan, et al. 2016, Barber, et al., 2014, Lewis, et al. 2001).

2. Materials and Method

This paper is a review of the available literatures and serves as a reference for future research on occupational exposure to metalworking fluids (MWFs) and the consequences on the respiratory health of the workers. The online sites of PubMed (http://www.pubmed.gov), Medline (http://medline.gov) and other electronic databases were used to identify relevant studies in the published literature from 1998 to 2016. Additional references were selected from the reference lists of reviewed articles. From the identified papers, studies meeting the following eligibility criteria were selected: Metal-working fluids, studies on occupational exposure to MWFs and the adverse health effects on respiratory health of workers in metal machining industry. A case study, cross-sectional, and review papers were selected.

3. Results and Discussion

3.1. What is Metalworking Fluid?

MWF is coolant that splashed at the friction point during the machining process such as drilling, grinding, turning and honing of metals to provide lubrication and cooling that carry away debris and fine metal particles and help to improve machining performance and prolong the life of tools as well as provide protection against corrosion for better products (NIOSH, 2011). There were numerous formulations, ranging from straight oils as petroleum oils to water based fluids which include soluble oils and semisynthetic/synthetic fluids. It can be a complex compound of oils, emulsifiers, anti-weld agents, corrosion inhibitors, pressure additives, buffers (alkaline), biocides, and others. The compound can be contaminated with substances from the manufacturing process as tramp oils, particulate matter from metal machining operations. The water-based metalworking fluids support microbial growth and introduce biological contaminants as bacteria and fungi or their biological byproducts as endotoxin, exotoxins and mycotoxins (NIOSH, 2012).

3.2 Occupational Exposure to MWF

MWFs can enter the body through variant routes as through inhalation of mist, aerosol or vapors generated during machining, through skin by direct skin contact particularly hand and forearm, through cuts and abrasions or through mouth if the worker eats or drinks in the work areas or he doesn't wash his hands before eating (NIOSH, 2012, Fishwick, et al.2015).

Studies have concluded that exposure to MWF may compromises the health of the workers and it may leads to different adverse effects on health such as exposure to respiratory system leads to hypersensitiv-

ity Pneumonitis in the lungs of the workers in metal machining and autoworkers (Barber, et al. 2014, Rayan, et al. 2016).

A study has reported significant rise the prevalence of respiratory disease as asthma, alveolitis diseases, impaired lung function, bronchitis or others among exposed workers in addition to increment the prevalence of skin symptoms as dermatitis among exposed workers (Burton, et al. 2012).

A researcher has reported that cases of work-related Asthma and hypersensitivity pneumonitis due to exposure to MWF were decreased in the last 10 years. However, that decrease was not true, but, it was a consequence of lack of recognition and deficiencies in surveillance system (Rosenman, 2015). Therefore, it is crucial to continue studying occupational exposure to MWF and the health consequences of that exposure.

Other researchers have found that workers in metal machining factory and handling MWF were at high risk for exposure to heavy metals such as Chromium (Cr) (Zailina, et al. 2015, Walter, et al. 2012). A study in Taiwan was conducted to evaluate the level of Cr exposure among workers dealing with MWF and the findings showed the level of Cr and Ni exposure were higher than the permissible level among workers in metal processing unit. However, the exposure to sump MWF did not contribute to the high exposure to Cr and Ni. These findings provided clue that the source of Cr was the metal processing (grinding, turning, and others) and the MWF was the carrier (Liu, et al. 2012).

3.3 Respiratory adverse health effects of MWF exposure

Different studies have stated that exposure to MWF lead to different health effects on respiratory system. However, the respiratory system can be protected and the respiratory diseases can be prevented by application of intervention programs (Surronen, et al. 2008, Hodgson, 2004).

Oudyk, et al. (2003) have reported the odd ratios (OR) of respiratory symptoms among exposed group were cough with phlegm (OR 1.58), wheeze (OR 2.15), chest tightness (OR 2.22). On other hand, researchers have found the prevalence of work related respiratory symptoms among workers exposed to MWF was 75% and considered a high prevalence compared to other studies (Fishwick, et al. 2005). Also, it was reported that metal workers were in high risk of developing occupational chronic obstructive pulmonary diseases due to using the MWF (Fishwick, et al. 2015).

A study was conducted in Sweden to assess the exposure-response relations in workers exposed to MWF aerosols have reported that exposure to concentration below 1mg/m3 can make varieties of upper and lower respiratory symptoms as cough, cough and phlegm, wheeze, impairment of pulmonary function and hypersensitivity pneumonitis. While, in USA, researchers have stated that with exposure below the National Institute of Occupational Safety and Health (NIOSH) recommendation which is 0.4 mg/m3 as permissible exposure limit (PEL) for respiratory exposure to MWF also showed direct associations with health impairment of lower and upper respiratory system of the workers (Oudyk, 2003).

In systematic review paper, the exposure to MWFs may lead to Asthma, bronchitis, hypersensitivity pneumonitis, extrinsic allergic alveolitis, and others (Burton, et al. 2012).

Other studies have stated that presence of microbial substances in MWFs contribute to occupational respiratory diseases as occupational asthma and hypersensitivity pneumonitis (Passman, 2008, Lewis, et al. 2001). Beckman et al (2014) have presented in Sweden that the direct exposure to water based metal-working fluid can cause chronic obstructive lung diseases among workers in metal machining industry and also reported the level of exposure to MWF was 0.1 mg/m3 which was less than the PEL in Sweden, nevertheless, the prevalence of airways symptoms were high, therefore, the PEL of 0.4 mg/m3 need to be reviewed.

In order to assess the functionality of the respiratory system of workers, Spirometry test can be conducted regularly to identify early the impairment in respiratory system as stated by American Thoracic Society and European Respiratory Society (Miller, et al. 2005, Miller, 2005, Pellegrino, et al. 2005). A study was described despite the prevalence of respiratory symptoms was higher among workers exposed to MWF but the range of FEV1 was within normal range. These results reveal that the exposure to MWF is most probably targeting the upper respiratory system (Fishwick, et al. 2005). By this, we can conclude that the prevention of respiratory diseases among metal machining workers is possible by preventing or decreasing significantly the exposure to MWF.

4. Discussion

In comparing the Pb and Cu distributions with a previous study performed in Italy among seventy-five welders, this study reported extremely high Pb exposure (0.66 versus 68.00 µg/g) and Cu levels (13.27 versus 34.91 µg/g) (D'Ilio et al., 2000). The difference

between the study in Italy and this study was the focus on the production of batteries in which the complete working cycle from melting to casting was carried out by a single craftsman (D'Ilio et al., 2000).

5. Conclusion

MWFs have been proven to be very effective materials in improving various machining processes widely used as lubricants in the machining industries. The most commonly used MWF in Malaysian industry is water-based MWF. Metal machining workers are the most exposed to MWF and very susceptible to respiratory health diseases. On same time, there is a shortage in number of related studies on exposure to metalworking fluids in Malaysia. Therefore, this review contributes knowledge concerning the respiratory exposure to MWF and the adverse health effects on respiratory system. The interventions can be applied to inhibit the exposure and then prevent the related health complications can be taken in the future. It is recommended that further research is needed to address the health effects of MWF on respiratory system of workers and how to protect the workers in metal machining industries.

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