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Exploring the risk of welders' exposure to the gases and metal fumes in a shipbuilding industry: a case study

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Abstract

Introduction: Risk identification and investigation is an appropriate and practical approach for the occupational health professionals. This paper aims to determine exposure to the gases and metal fumes and to perform risk analysis in three common types of welding activities in a shipbuilding industry.

Material and method: This analytical cross-sectional study was conducted in a shipbuilding industry and three types of welding were considered including SMAW, MIG and MAG welding. Sampling of Mn and Cr fumes was carried out using NIOSH 7300 standard method, and NIOSH 6014 method NO2 sampling, and also direct reading devices for CO and O3 gases. Moreover, SQCRA risk assessment method was adopted to specify the level of exposure risk.

Results: The results of risk analysis showed that among gas pollutants, O3 and NO2 in all welding processes had a very high-risk level, while among the metal pollutants; Mn metal showed a high and very high risk level in MIG and SMAW welding.

Conclusion: According to the both sampling results and risk analysis, MIG process welders are more dangerous position than other types of welding.

Keywords: Risk Assessment, Fume, Gas, Job Exposure, Welding.

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1. Introduction

Nowadays, welding operation has increased and utilized in all small and large workshops to repair various metal parts [1]. Welding is a "bonding process of two metal pieces to each other by melting a metal called an electrode." In the process of shielded metal arc welding (SMAW), the protection of the molten pool is provided by electrode coating [2]. GMAW is a metal bonding process in which the arc between the continuous and consumable electrode wire and the weld metal is welded. Welding arc is protected from atmospheric pollution by gases such as carbon dioxide, argon, helium, and so on. The main variables in the GMAW process include welding current, arc voltage, and welding speed [3].

During welding operations, toxic gases such as carbon monoxide (CO), ozone (O3) and nitrogen oxides (NOX) are generated and released [4]. The IARC and the European Union have classified several metals existing in the welding fume (such as Mn, Cadmium, Lead, and Nickel and Cobalt Oxides) as "human carcinogens" [5]. Manganese is an essential element for the body; however, excessive exposure and inhalation of them can cause nerve toxicity [6]. Therefore, this paper aimed to determine the level of risk of welders' exposure with metal fumes and gas pollutants in the shipbuilding industry.

2. Material and Methods

This cross-sectional analytical study was conducted in a shipbuilding industry in Iran. As, 55 male welders were randomly selected in this study. The considered welding process included the most common types of welding operations available in the shipbuilding industry, including Shielded Metal Arc Welding (SMAW), Gas Metal Arc Welding with Metal Inert Gas (GMAW-MIG) and Gas Metal Arc Welding with Metal Active Gas (GMAW-MAG).

After identifying the emission pollution stations, sampling of gases and welding fumes was performed. O3 gas sampling was carried out through a glass fiber filters (GFF) with a diameter of 37 mm with a flow rate of 0.2 liters per minute by SKC sampling pump and in accordance with the OSHA (American Occupational Safety and Health Administration) No. 214 method. Then, UV-VIS spectrophotometer was applied to analyze ozone samples. Besides, the NIOSH(National Institute of Occupational Safety and Health) -6014 method was utilized for NO2 sampling, and the UV-VIS spectrophotometer was used to analyze the samples. Furthermore, direct reading devices were used for sampling of CO and CO2 gases. These devices included 1372 CO meter and 1370 NDIR CO2 made by TES company.

In each workstation, the welding fumes sampling was implemented by mixed cellulose esters (MCE) membrane filter via a diameter of 37 mm and a porosity of 0.8 μm, and with a flow rate of 2 liters per minute from the respiratory area. Method No. 7300 NIOSH was used to determine the amount of metal fumes. After the preparation steps, the analysis of welding fumes including two metals, Mn and Cr, was performed by the inductively coupled plasma (ICP) (model RL-Liberty, Varian Italian company).

In this way, to specify the exposure risk level to the metal fumes and gas pollutants, a developed method so called "Semi-quantitative risk assessment" (SQCRA) method developed by Malaysian Department of Occupational Safety and Health. Regarding the diversity and extent of welders' exposure to the metals and metal fumes emitted during welding operations, it was essential to perform a health risk assessment. After identifying the welding stations, the degree of risk and exposure and the risk level of each welds and contaminants were determined:

Data collected from measuring the amount of pollutants were collected and classified using SPSS software, 21. The data were analyzed using descriptive statistics, one-way analysis of variance (ANOVA), with a $P < 0.05$ was significance level.

3. Results and Discussion

According to the type of welding process, exposure levels of the welders to gases are reported in Table 1. The average range of welders' exposure to carbon monoxide (CO), nitrogen dioxide (NO2) and ozone (O3) were 41.50-54.30, 3.75-7.44, and 0.31-0.55 ppm, respectively. Moreover, the exposure levels were at 2.12-3.39 and 2.44-6.11 mg / m3 for Mn and Cr fumes. Meanwhile, results showed that the mean values of Mn and Cr metals are significantly higher than the TLV-TWA (P value <0.05). In this regard, the maximum concentration of exposure to all metals studied was observed in metal arc welding processes with coated electrode (SMAW). Among

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Table 1. Average and standard deviation of welders' exposure to gas and metal contaminants by welding types

Contaminant type \ Welding type	Total fume or gas	MIG	MAG	SMAW
CO	45.09±9.98	54.30±13.16	41.33±9.74	41.50±10.18
NO2	4.24±1.14	7.44±1.33	4.50±0.83	3.75±1.04
O3	0.31±0.1	0.55±0.21	0.4±0.11	0.32±0.08
Cr	3.66±1.45	2.44±0.67	3.75±1.55	6.11±2.33
Mn	2.40±0.67	2.12±0.36	2.33±0.74	3.39±0.72

samples, ozone and nitrogen dioxide gases had the highest risk ratios in all three types of high-risk welding (VH). While, regarding the metals, Mn had the highest risk rating among two types of welding with high and very high risk (VH). SMAW welding had the highest risk rating among the welding followed by MIG welding.

As can be seen in the results, the welders in the industry are mainly exposed to three pollutants inlcuding, NO2, CO and O3, during welding operation. Welders' exposure to average total gas revealed that MIG welders were exposed to higher levels of pollutant gases than other welding operators, which may have been interpreted due to the process of people's activity at the welding station, use of shielding gas, and lack of an air conditioning system, appropriate location at the welding station, and the location of the relevant welding site. This conclusion is in accordance with the Popovice study, which found that the concentrations of carbon monoxide and carbon dioxide in MIG welding are higher than MMAW and SMAW welding [7]. The results confirmed that the density of CO, NO2 and O3 gases is higher than the permissible level of occupational exposure (TLV-TWA). The reasons may be described due to the duration of continuous welding, the high electrical voltage of the welding operation, the indoor space of the welding site, and the lack of local ventilation in the welding site.

It should be mentioned that all metals in SMAW welding were at their highest concentration levels. In a study conducted by Pacheo et al. [8] on a variety of welding processes, they found that the amount of fume in iron, Mn, cadmium and Cr metals in celestial welding was higher than in other types of welding , which is in line with the findings of current study. Perhaps, the reason for the high amount of metals in this type of welding can be attributed to the formation of fumes and welding gases by factors such as current, the voltage used, period, and nature.

In the Semi-quantitative Risk Assessment (SQCRA), the results showed that the highest risk of exposure to fumes in a variety of welds belonged to the SMAW welding operator. It can be concluded that the output of risk assessment concepts with the output of numerical findings obtained from sampling and actual measurement of pollutants in the workplace was often complementary. On the other hand, regarding the metallic nature of pollutants, the highest and lowest risks were related to Cr and nickel metals, respectively. The results of gas pollutant risk assessment indicated that the highest risk is related to SMAW welding and NO2 and O3 gases with very high risk levels (Table 2 and 3). The results of a study by Golbabai et al. confirmed that the risk rating of GMAW welders was high, while resistance spot welding had a low risk rating [9].

4. Conclusions

The results showed that welders working in SMAW process had higher levels of exposure to metal fumes and gases produced during welding than other welding processes. On the other hand, the results of semi-quantitative risk assessment also showed that some gases, especially CO, NO2 O3, and Cr and Mn metal fumes in all types of welding, had high risk (H) and very high (VH) ratings. It is critical to periodically monitor the air pollutants of the welders' work environment and evaluate the risk of these welders regularly. It is also recommended that further studies be performed with a larger number of fume and gas samples and welds that are more varied to enhance the accuracy of the study results.

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Table 2. Risk, exposure and risk of exposure to gas pollutants in the welding

Welding type	Pollutant name	Risk rate	Exposure rate (ER)	Risk rating	Investigation
SMAW	CO	4	4	4	H
	NO2	4	5	4.45	VH
	O3	5	5	5	VH
GMAW- MIG	CO	4	4	4	H
	NO2	4	5	4.45	VH
	O3	4	5	5	VH
GMAW-MAG	CO	4	5	4	H
	NO2	4	5	4.47	VH
	O3	5	5	5	VH

N: negligible H: high VH: very high

Table 3. Risk level, degree of exposure and risk rating of exposure to metal fumes in welded joints

Welding type	Pollutant name	Risk rate	Exposure rate	Risk rating	Investigation
SMAW	Mn	5	4	4.47	VH
	Cr	2	5	3.16	H
GMAW – MIG	Mn	5	5	5	VH
	Cr	2	5	3.16	H
	Mn	5	3	3.87	H
GMAW-MAG	Cr	2	3	2.44	M

M: moderate H: high VH: very high

and the welders of the shipbuilding industry in completing this research.

6. References

[1] Alkahla I, Pervaiz S, editors. Sustainability assessment of shielded metal arc welding (SMAW) process. IOP Conference Series: Materials Science and Engineering; 2017: IOP Publishing.

[2] Lenin N, Sivakumar M, Vigneshkumar D. Process parameter optimization in ARC welding of dissimilar metals. Science & Technology Asia. 2010;15(3):1-7.

[3] Teker T, Kursun T. Effect of the manual (GMAW) and pulsed (P-GMAW) welding processes on impact strength and fracture behavior of AISI 304-AISI 1040 dissimilar steel joints fabricated by ASP316L austenitic stainless steel filler metal. KOVOVE MATERIALY-METALLIC MATERIALS. 2017;55(2):141-8.

[4] Sriram K, Lin GX, Jefferson AM, Roberts JR, Chapman RS, Chen BT, et al. Dopaminergic neurotoxicity following pulmonary exposure to manganese-containing welding fumes. Archives of toxicology. 2010;84(7):521-40.

[5] Persoons R, Arnoux D, Monssu T, Culié O, Roche G, Duffaud B, et al. Determinants of occupational exposure to metals by gas metal arc welding and risk management measures: A biomonitoring study. Toxicology letters. 2014;231(2):135-41.

[6] Hassani H, Golbabaei F, Shirkhanloo H, Rahimi Foroushani A. A survey of neurobehavioral symptoms of welders exposed to manganese. Journal of Health and Safety at Work. 2013; 3 (1) :39-46

[7] Popović O, Prokić-Cvetković R, Burzić M, Lukić U, Beljić B. Fume and gas emission during arc welding: Hazards and recommendation. Renewable and Sustainable Energy Reviews. 2014;37:509-16.

[8] Pacheco R, Gomes J, Miranda R, Quintino M. Evaluation of the amount of nanoparticles emitted in welding fume from stainless steel using different shielding gases. Inhalation toxicology. 2017;29(6):282-9.

[9] Golbabaei F, Ghahri A, mehdizadeh M, Ghiasodin M, Mohajer K, Skandari D. Risk assessment of welders` exposure to total fume in an automobile industry. Journal of Health and Safety at Work. 2012; 1 (1) :9-18

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