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Measuring the Amount of Nickel and Iron Oxide in the Breathing Zone of Welders

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Abstract

***Background*:** Diagnosis and measurement of air pollution in workplace is one of the most important aspects of controlling chemical agent and purpose of this study is to measure inhalation exposure welding fumes.
***Materials and Methods*:** In this study, with the help of a personal pump and ester cellulose filters, welding fumes in total working hours was measured. The samples prepared and analyzed by atomic absorption.
***Results*:** The findings suggest that the inhalation of iron oxide is higher than threshold limit value but the amount of nickel is less than the limits.
***Conclusion*:** Results confirms the need for some corrective actions.

Introduction

Today in industrial processes are to be highly variable pollution sources that depending on the type of process, a variety of contaminants air being distributed in workplace and create air pollution problem. There are different ways to enter Pollutants in people body that who are most important to them is breathing. Thus, the sampling and determination of pollutants concentration in air are very important factors in assessing occupational exposure to hazardous chemicals [1].

One of the jobs in the field of airborne contaminants is welding, applicable in many manufacturing processes and welders are exposed to various diseases. The most important respiratory problems are due to inhalation of welding fumes. Since welding fume components are different according to the type of product, electrode and condition of welding, variety of complications and diseases in welders breathing zone are observed [2]. For example, the studies have found that many welders have experienced of bronchitis, fever, mill fever and increasing of diffuse pulmonary infections. Studies also showed that welders typically suffer from limitations in their lung volume [3]. Thus, the aim of present study is measuring the welding fume of nickel and iron oxide to estimate the risk of welder's exposure and applying control strategies.

Materials and Methods

The study was a historical cohort study that aimed to measure personal exposure of nickel and iron oxide welding fume in city gas projects. For this purpose, all welders engaged for this activity, were studied after obtaining informed consent.

In this study, sampling of welding fumes was based on ASTM standard method. Membrane filters with 25 mm diameter and 0.45 microns pore size were used [4]. Also, SKC sampling pump with adjustable flow rate range 0.5-5 liters per minute was applied to supply 2 liters per minute after calibration with electronic calibrator and Tygon tubes were used for all connections. Moisture removed from filters by putting them in desiccators for 24 hours and they were weighted by 0.0001 gravimetric balances carefully. Atomic absorption spectrophotometer with acetylene-nitrous oxide flame and Ni and Fe hollow cathode lamp was used to analyze the samples. Additionally climatic factors were measured by using WBGT and fan Anemometers.

Hydrochloric acid, nitric acid and nitrate nickel 6 water were applied with high purity and were obtained from Germany Merck manufacture. For preparation of iron standard solutions, iron stock solution with 1000 ppm concentration were used that supplied by Chem. Tech British companies.

Before and after sampling, sampling pump was calibrated using an electronic calibrator in circuit and achieved the actual flow rates required for sampling. The apparent rate was 2.7 that were equal to the real rate of 2 liters per minute. To delete the effect of environmental moisture, sampling filters were put in to the desiccators for 48 hours. Also, at the time of sampling, the filter was placed in a filter holder. The set of sampling containing sampling pump, filter holder installed and attached in workers back by a clamp located in snood and the back of shield near the mouth for all working day.

It should be noted that for three samples during a sampling day, one blank sample was collected in worker's breathing zone. After sampling, the filter holder was removed and the two ends of them was closed by putting the lid and transferred to the laboratory. In laboratory, filters were put within desiccators again to remove moisture. Finally, based on the method recommended in

ASTM standard method, the filters were weighed and prepared for analysis.

In analysis process, atomic absorption was set in 248.3 and 232 wavelengths for iron and nickel respectively. Six standard application solutions of iron and nickel in concentrations of 0.5, 0.75, 1.5, 2.5, 5 and 10 mg/ml were prepared to draw calibration curve to estimate pollutant concentrations in samples. The calibration curve regression coefficient equal to 0.998 was achieved. Eventually the amount of absorbing fume was recorded for each sample and control. The absorbing fume was compared with ACGIH standards threshold limit value for each element and samples with higher threshold limit concentrations in the breathing zone were determined.

In order to achieve the objectives of the study, the effective indices of the amount of pollutant was measured in table 1 and pollutant concentration in mg/m^3 was calculated according to the following formula.

$$C = \frac{10^3(w_2 - w_1)}{V_{meas}}$$

Where C, concentration of pollutant (mg/m^3), w_1 and w_2, respectively, the primary and secondary weight of filter (mg) and corrected V_{meas} is volume of air sampled (m).

Table 1. The amounts of factors affect sampling results

Factor / Sample	Time (min)	Rh* (%)	P** (mmHg)	Temperature (K°)	Volume (Lit)	Size of pipe (inch)
1	330	48	785.325	286.8	643.83	8
2	290	43	785.325	586.7	565.5	6
3	240	45.2	785.325	295.1	481.8	2

Rh: Relative humidity, **P: Atmospheric pressure

Table 2. Result of sampling in welder breathing zone

Size of pipe (inch) / Average concentration (mg/m^3)	Pipe 8 inch	Pipe 6 inch	Pipe 2 inch	TLV (mg/m^3)
Iron oxide	61	63	176	5
Nickel	0	0.9	0.56	1.5
Blank sample	0	0	0	0

Results

The result of this study showed that the amount of iron oxide in welding fume in breathing zones of all subjects and for all sizes of pipe welding are higher than the ACGIH recommended threshold limit. Although the amount of nickel in the samples are lower than recommended threshold limit and this could mean that only a very small percentage of nickel is dedicated to compound pipe and welding electrodes. In addition, the results showed that by reducing the cross section of the welded pipes, nickel and iron oxide in the welder's breathing zone was increased (Table 2).

Discussion

The result of this study appointed that iron fume levels in the breathing zone of welders are higher than threshold limit. This can be one of the causes wheezing, coughing and shortness of breath. Although the periodic examinations were not showed the risk of pulmonary complications, but the symptoms were observed frequently during the sampling. This can result from outside activities, having seasonal allergies or beginning of winter effects. In addition, the results indicated that the amount of nickel in obtained samples from different section of pipes welders were always less than the threshold limit. The results also showed that the iron oxide concentrations in the breathing zone of welders increased by reduction of pipes size. It caused the increased workload of welders as a result of less needed time for transportation and more mobility in the channel, brushing and grinding and the frequency of welding would be higher than pipes with a more diameter so, in the long term it can cause various diseases in welders.

The report form Health and Safety Executive (HSE) in 2010 showed that amount of nickel in welder's breathing zone with different kind of welding were lower than the threshold limit value [5]. The assessment of spirometry results of a group of nonsmoking welders with 9 years exposure indicated a significant decrease in aerobic capacity [6].

Studies conducted by other researchers showed that smoking is an influencing factor for lung restriction in welders [7, 8]. Research of Scharrer et al. on 20 people with no heart or lung disease, but with exposure to welding fume showed that endothelin blood levels greatly reduced [9]. National Institute of Occupational Safety and Health (NIOSH) also acquired limited evidence in order to confirm carcinogenic effects of gases and welding fumes in human [10]. Hamill, Levy and Llinas in their study found that long term exposure to iron oxide fume can cause siderosis, brain damage and eye injuries [11-13]. What was said to find out welding fume are not lead to significant short-term effects but long-term exposure to it can cause lung disease and functional changes in the heart. So it seems that the use of protective strategies such as engineering methods and personal protection equipment can prevent serious pulmonary injury in the future.

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Authors' Contributions

All authors had equal role in design, work, statistical analysis and manuscript writing.

Conflict of Interest

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