Pulmonary Function Status among Welders in Malaysian’s Automotive Industries

Azian Hariri, N. Azreen Paiman, A. M. Leman, and M. Z. M. Yusof

Abstract—Welding process has potential physical and chemical health hazards. Welding fumes, toxic gases and metal particles are the chemical hazard that leads to long-term and chronic lung function effects. This study investigates the effects of duration of exposure and smoking status on pulmonary function status among welders of two automotive assembly plants in Malaysia (Plant 1 and Plant 2). This study assesses 61 male welders by pulmonary function test (PFT) using spirometer. These welders worked with spot, metal inert gas (MIG) and robotic welding without the benefit of fume control ventilation or respiratory protective devices. Welding workers in both plants showed significant reduction in lung function parameters relative to controls. The results of the study also showed that in Plant 1, smoking status influence significantly on pulmonary function status. However, in Plant 2, duration of work and smoking status both influence significantly on welders pulmonary function status. This study provides information to welders on chemical hazard effects among Malaysia’s automotive industries.

Index Terms—Pulmonary function test, spirometry, welding process.

I. INTRODUCTION

Welding is the common process in manufacturing industries. Welding involved inhalable exposures that may lead to chronic respiratory disease. In welding, the intense heat of the arc or flame vaporizes the base metal and/or electrode coating. This vaporized metal condenses into tiny particles called fumes that can be inhaled. The thermal effects can cause agglomeration of the particles into particle chains and clusters that can be deposited in the human respiratory tract [1]-[3]. Toxic gases also produce from welding processes which include nitric oxide, nitrogen dioxide, carbon monoxide and ozone. These toxic gases can cause pulmonary oedema, headache and drowsiness [4].

Researchers have done various works in evaluating the effects of welding chemical hazards to the pulmonary function of welders. However, there are disagreements among these studies mainly due to bias from inclusion and exclusion criteria (smoking status, type of welding process, duration of exposure, ventilation control) [5], [6].

In Malaysia, only limited study had been done. The aim of the present study is to evaluate the pulmonary function status of welders by taking into account the smoking status and duration of exposure. This study provides information for welders and the company’s management about the hazards of welding fumes.

II. RELATED RESEARCHES

Previous studies had been conducted in evaluating the effect of chemical exposure to the pulmonary function of welders. Some of the studies have shown a reduction of pulmonary function value in welders’ population compared to control group [5]-[7].

Reference [8], concludes that smoking and occupational exposure to welding fumes are both associated with increased risk of chronic bronchitis. Reference [9] showed that symptoms of expiratory flow obstruction were more than double in welders compared to non welders. Reference [10] studied on shipyard welders and caulker-burners and concluded that FEV1 of smoking welder decrease three times greater than non smoking control. Reference [8], [9], [11] suggest that there is a synergistic relation between the effects of smoking and welding causing lung disease and increased respiratory symptom.

On the other hand, differences exist in welder populations, such as industrial setting, types of ventilation, type of welding processes and materials used [12], hence this study was conducted to obtained data on welders working in Malaysian automotive industries. It is expected that a better understanding of welding exposure in Malaysia automotive industry will be obtained in order to promote the protection through legislation, health communications strategies or behavioral intervention where such data are needed.

III. METHODOLOGY

Pulmonary function test (PFT) was conducted in two automotive plants in Malaysia. Plant 1 was an automobile assembly plant with 32 welders working on spot welding. Plant 1 operated 8 hours per day with 2 hours overtime work if applicable. All the welders were locals people with 21 welders had been working less than 10 years and 11 welders had been working for more than 10 years. Plant 1 has adequate workstation spacing and plenty of non-barrier free space.

Plant 2 was an automotive parts manufacturer with 29 welders working with spot welding, metal inert gas (MIG) welding and robotic welding. Plant 2 operated 12 hours daily. 90% of the welders were from Nepal, Bangladesh and Indonesia. These welders worked on contract for 2 to 3 years and renew their contract if applicable. Thus, out of 29 welders, only 3 welders worked more than 10 years. The

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workstation spaces in Plant 2 were cramped and welding area was situated in the middle of the plant surrounded by metal pressing machine.

Welders on both plants worked without the benefit of fume ventilation or proper respiratory protective devices. Fans were located at each work station by means of controlling exposure. From the observation of the condition of workplace area and type of welding process conducted, it is expected that pulmonary function values for welders in Plant 2 is much more decreased compared to Plant 1.

Before conducting PFT, welders were first interviewed on their background information (age, education, working duration, work history, smoking status etc.). PFT were performed on handheld spirometer (Micro Medical DL, UK) connected to spirometer software (Care Fusion, San Diego) on computer. Spirometer was calibrated daily with a 3L calibration syringe. The manoeuvre was explained with the help of short video clip demonstration. Manoeuvre were performed in standing positions without nose clips. Tests were conducted according to forced vital capacity procedure of the American Thoracic Society recommends [13]. Measured parameters were forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1) and peak expiratory flow (PEF) were all expressed as a percentage of the predicted value and FEV1/FVC ratio. The predicted set used in this study was taken from Pneumobile Project, Indonesia [14].

For controls subjects’ purpose, healthy male workers (normal spirometry results) were selected from similar plants that did not have exposure to welding. They were primarily of technicians, engineers and administrators.

Statistical analysis was conducted by SPSS software (SPSS Inc., Chicago version 18). An independent sample t-test was used to compare pulmonary function parameters in welders and control. Linear regression analysis was done to get association between working duration and smoking status with pulmonary function parameters. The level of significance was taken as p<0.05.

### Table I: Descriptive Statistic for Plant 1

<table>
<thead>
<tr>
<th>Plant 1</th>
<th>PFT status</th>
<th>n=32</th>
<th>Mean ± SD</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>normal</td>
<td>21 (64%)</td>
<td>28.9±9.2</td>
<td>0.061</td>
</tr>
<tr>
<td></td>
<td>abnormal</td>
<td>11 (36%)</td>
<td>29.8±10.3</td>
<td>0.072</td>
</tr>
</tbody>
</table>

- **Less than 10 years**
  - normal: 14 (67%)
  - abnormal: 7 (33%)

- **More than 10 years**
  - normal: 7 (33%)
  - abnormal: 4 (19%)

### Table II: Descriptive Statistic for Plant 2

<table>
<thead>
<tr>
<th>Plant 2</th>
<th>PFT status</th>
<th>n=29</th>
<th>Mean ± SD</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>normal</td>
<td>14 (48%)</td>
<td>29.8±9.2</td>
<td>0.061</td>
</tr>
<tr>
<td></td>
<td>abnormal</td>
<td>15 (52%)</td>
<td>30.8±10.3</td>
<td>0.072</td>
</tr>
</tbody>
</table>

- **Less than 10 years**
  - normal: 14 (54%)
  - abnormal: 12 (46%)

- **More than 10 years**
  - normal: 5 (19%)
  - abnormal: 2 (18%)

### Table III: PFT status distribution for Plant 1 and Plant 2

<table>
<thead>
<tr>
<th>Plant 1</th>
<th>PFT status</th>
<th>n=32</th>
<th>Mean ± SD</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>normal</td>
<td>21 (64%)</td>
<td>91.8±9.3</td>
<td>0.169</td>
</tr>
<tr>
<td></td>
<td>abnormal</td>
<td>11 (36%)</td>
<td>90.0±9.0</td>
<td>0.014</td>
</tr>
</tbody>
</table>

- **FEV1 (% pred)**
  - normal: 99.7±10.0
  - abnormal: 90.5±11.6

- **FEV1/FVC**
  - normal: 108.3±8.1
  - abnormal: 105.8±10.1

- **PEF (% pred)**
  - normal: 82.3±8.4
  - abnormal: 79.5±15.6

### Table IV: PFT status distribution for Controls, Case study 1 and Case study 2

- **Controls n=15**
  - mean ± SD: 72.3±11.6
  - P-value: 0.022

- **Case study 1 n=32**
  - mean ± SD: 87.1±14.9
  - P-value: <0.001

- **Case study 2 n=29**
  - mean ± SD: 88.5±11.7
  - P-value: <0.001

Pulmonary function data (mean ± standard deviation (SD)) of welders for both plants and control groups was analyzed by using independent sample t-test as shown in Table III. Pulmonary function results showed that the mean of all pulmonary function parameters of welders were lower than control. However, the difference of means was significant for FEV1 (p<0.014) for Plant1 and FVC (p<0.022), FEV1 (p<0.001) and PEF (p<0.002) parameters for Plant 2. Results for Plant 2 were consistent with finding by [10]. Reduction of FEV1, FEV1/FVC and PEF relative to control indicates an obstructive ventilator defect. Reduction of FEV1 and PEF can be a sign of airway narrowing or obstruction [5]. Apparently, pulmonary function parameters in Plant 2 are lower than Plant 1 except for FEV1/FVC indicating welders in Plant 2 was at higher risk of pulmonary function problems.

Table IV and Table V show the pulmonary function data (mean ± SD) of welders according to less and more than 10 years of working duration for Plant1 and Plant 2 respectively. The mean value of pulmonary function parameter for both Plant 1 and Plant 2 showed the same trends of decrease mean value of FVC and FEV1 parameters in more than 10 years working welders. Comparison of means based on working duration was significant for FEV1/FVC ratio (p<0.027) in Plant 1. However in Plant 2, parameters FVC (p<0.001), FEV1 (p<0.001) and FEV1/FVC (p<0.014) show significant mean comparison. Normally the increase value of FEV1/FVC was associated with a restrictive ventilator effect, however the number of subjects investigated for more than 10 years
working experience was rather small and influence the mean value of FEV$_1$/FVC parameters. It can only be confirmed by increasing the study size.

### Table VI: Linear Regression Analysis of Pulmonary Function at Plant 1

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Working duration</th>
<th>Smoking status</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC (% pred)</td>
<td>0.023</td>
<td>0.002</td>
<td></td>
</tr>
<tr>
<td>FEV$_1$ (% pred)</td>
<td>0.003</td>
<td>0.003</td>
<td></td>
</tr>
<tr>
<td>FEV$_1$/FVC</td>
<td>0.012</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>PEF (% pred)</td>
<td>0.301</td>
<td>0.058</td>
<td></td>
</tr>
</tbody>
</table>

### Table VII: Linear Regression Analysis of Pulmonary Function at Plant 2

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Working duration</th>
<th>Smoking status</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC (% pred)</td>
<td>0.003</td>
<td>0.002</td>
<td></td>
</tr>
<tr>
<td>FEV$_1$ (% pred)</td>
<td>0.003</td>
<td>0.003</td>
<td></td>
</tr>
<tr>
<td>FEV$_1$/FVC</td>
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<td></td>
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<td>PEF (% pred)</td>
<td>0.301</td>
<td>0.058</td>
<td></td>
</tr>
</tbody>
</table>

V. CONCLUSION AND FUTURE WORKS

In this study, a comparison was made between pulmonary function parameters of welders and control groups. Results of PFT reveal that welders in both plants suffered from decrease pulmonary function compared to control group. However, obstructive ventilator defect of welders were statistically significant only in Plant 2.

Decreased of mean value of FVC and FEV$_1$ in more than 10 years welders compare to less than 10 years working welders in both plants were obtained. Conversely the FEV$_1$/FVC value of both plants increased due to the small size samples of welders for more than 10 years working duration. It is suggested in future works that selection of case study with balance number of samples for low and high exposure welders should be considered for accurate results.

Linear regression analysis of pulmonary function parameters reveals that the decreased pulmonary function was only proportional to smoking in Plant 1 but proportional to duration of exposure and smoking in Plant 2.

It can be concluded that welders in Plant2 were at risk for pulmonary disease due to welding exposure comparing to welders in Plant 1. Thus it is advisable that welders and company management work together to adopt technical preventive and control measures to reduce exposure of welding (using a less hazardous welding agent, installation of local exhaust ventilation, wearing suitable respiratory protective equipment). It is also suggested for the welder to undergo medical surveillance tests periodically.

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REFERENCES


Azian Hariri was born in Perak, Malaysia on 27 August 1978. Holds a B. Eng (Mechanical) from University of Fukui, Japan in 2002 and M.Eng (Mechanical) from Universiti Tun Hussein Onn Malaysia, Batu Pahat, Johor in 2009.

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