Improvement the Pressing Workstation Arrangement of the Slide Manufacturing Plant

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1. INTRODUCTION

Many industries employ considerable amounts of assembly work, which by its nature requires many manual workers and is very difficult to automate. Many tasks involve extensive arm and hand movements, which are associated with an increased prevalence of musculoskeletal disorders in the neck, shoulder, arms and hands (Hansson et al., 1996). Highly repetitive movements of the wrist, hand and forearm in office and industry jobs play an important role in the development of cumulative trauma disorders (CTDs) (Fagarasanu et al., 2004; Kuorinka and Forcier, 1995). Clinical and epidemiological studies have identified four main causative factors, i.e. joint angles away from neutral, rate of repetitiveness, force level, and insufficient recovery time (Sullivan and Gallwey, 2002). To estimate the risk level of actual workplace tasks, accurate actual joint angle data is required. Hence, it is necessary to collect data on the source of variation in shoulder and wrist angles for a particular workplace, and to examine the relation between the aided tool used and the risk of injury.

2. METHOD

The study may is divided into two stages. In the first stage of survey and observation, researchers go to the slide manufacturing plant to determine the pressing workstation layout and its workload for each operator. In addition, questionnaires are collected from operators to assess the musculoskeletal disorders problem. In the second stage, researchers, based on the result of the first stage, design work field operation experiment and assess the operation of pressing workstation.

2.1 Survey and questionnaires

Samples are drawn from the slide manufacturing plant of a ball bearing drawer slides. A total of 25 operators at the plant undertake the survey and answer the questionnaire whether they have musculoskeletal disorders. According to the result of questionnaire, the study finds the possible risk factors caused by workpiece placing position and aided tool operators apply.

2.2 Participants

Six male operators participate in the experiments after providing informed consent to the survey procedures. The mean age is 28.6 years, mean stature 168.2 cm, and mean body mass 67.1 kg. All participants are healthy and report no musculoskeletal problems or cardiovascular diseases which might influence performance detrimentally. In addition, all participants are instructed to avoid vigorous physical activity and wine drinking 12 hours prior to the experiment.

2.3 Apparatus and materials

The study applies the eight channels posture measurement system (Biometric DataLINK, UK) to real-time monitor the postures during pressing operation. The twin-axis goniometry, type SG65, type SG110 and type SG150/B is placed on right/left wrist, shoulder and neck, respectively. Therefore, the radial/ulnar deviation and palmar flexion/dorsiflexion on wrist, flexion/extension on shoulder, and flexion/extension on neck can be recorded.
2.4 Experimental procedure

In the actual work site of pressing workstation in the slide manufacturing plant, the study chooses a pressing workstation as experiment object (Figure 1). First, we comprehend the complete operation procedures of this workstation, and then design the experimental procedure. A two-way randomization complete block design is used. The independent variables include the aided tool (no aided tool, right hand using aided tool, and both hands using aided tool) and workpiece positions (in front and right side).

Before commencement of the actual experiment, participants are given time to warm up and practice each trial, and asked to perform the known experimental tasks until they are capable to provide steady manipulation. Six operations are performed at three levels of aided tool and two levels of workpiece position. Each participant undergoes 20 times for each operation and executes a total of 120 trials in this experiment. The orders of these operations are randomly assigned for each participant.

2.5 Data analysis

A randomized complete block design (blocks as individual subjects) with two within-subject factors (aided tool and workpiece position) is used for this study. All trial data files are exported in Microsoft Excel format; with the peak values for each motion axis on dependent variables are calculated over trials. Further, two-way analysis of variance (ANOVA) is used to identify significant differences between conditions for dependent variables. Statistical significance is set at a probability level of 0.05.

3. RESULTS

3.1 Field survey

This questionnaire takes 25 operators of pressing workstation as sample. They have 36.08 month experience in pressing work (SD=38.54), and female takes up 28%, and the remaining 72% male. The mean age of all subjects is 29.92 years old (SD=8.74); mean ststure 167.9cm (SD=9.00); and mean body mass 64.64kg (SD=14.07). Results of 25 questionnaires show that operators have musculoskeletal disorders on shoulder (48%), neck (32%), wrist (24%), lower back or waist (24%), elbow (20%), upper arm (12%), ankle or feet (8%), and knee (8%).

3.2 No aided tool

In the pressing workstation, the operator, without using aided tool, has larger radial deviation and palmar flexion when putting workpiece in the front than by the right side of the right wrist. At the same time, his left wrist has larger ulnar deviation, palmar flexion and dorsiflexion. Further, when putting workpiece in the front his shoulder has larger flexion and his neck nas large flexion and extension (Table 1).
### Table 1 Deviation angle when putting workpiece in the front and right side

<table>
<thead>
<tr>
<th>Joint</th>
<th>Movement</th>
<th>No aided tool</th>
<th>Aided tool at right hand</th>
<th>Aided tools at both hands</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Front</td>
<td>Right</td>
<td>Front</td>
</tr>
<tr>
<td>Right wrist</td>
<td>Ulnar deviation</td>
<td>7.12</td>
<td>17.04</td>
<td>15.32</td>
</tr>
<tr>
<td></td>
<td>Radial deviation</td>
<td>26.75</td>
<td>21.98</td>
<td>21.09</td>
</tr>
<tr>
<td></td>
<td>Palmar Flexion</td>
<td>*9.17</td>
<td>7.24</td>
<td>*20.88</td>
</tr>
<tr>
<td></td>
<td>Dorsiflexion</td>
<td>33.70</td>
<td>*33.7/9</td>
<td>*18.07</td>
</tr>
<tr>
<td>Left wrist</td>
<td>Ulnar deviation</td>
<td>*27.8/2</td>
<td>13.47</td>
<td>13.73</td>
</tr>
<tr>
<td></td>
<td>Radial deviation</td>
<td>7.92</td>
<td>14.06</td>
<td>7.66</td>
</tr>
<tr>
<td></td>
<td>Palmar Flexion</td>
<td>*14.5/4</td>
<td>10.66</td>
<td>*10.63</td>
</tr>
<tr>
<td></td>
<td>Dorsiflexion</td>
<td>12.66</td>
<td>1.53</td>
<td>6.34</td>
</tr>
<tr>
<td>Shoulder</td>
<td>Flexion</td>
<td>*2.16</td>
<td>1.82</td>
<td>*0.78</td>
</tr>
<tr>
<td></td>
<td>Extension</td>
<td>24.62</td>
<td>29.94</td>
<td>19.99</td>
</tr>
<tr>
<td>Neck</td>
<td>Flexion</td>
<td>*13.0/5</td>
<td>12.62</td>
<td>*9.17</td>
</tr>
</tbody>
</table>

* P<0.05

#### 3.3 Aided tool at right hand

In the pressing workstation, the operator, with aided tool at right hand but not left hand, has larger ulnar deviation and palmar flexion when putting workpiece in the front of his right wrist than by the right side. At the same time, his left wrist has larger ulnar deviation and radial deviation. Further, when putting workpiece in the front his shoulder has larger flexion and his neck has large flexion and extension.

![Figure 2. Interaction between workpiece position and aided tool on right wrist dorsiflexion angle](image-url)
3.4 Aided tools at both hands

In the pressing workstation, the operator, using aided tools with both hands, has larger radial deviation, palmar flexion and dorsiflexion when putting workpiece by the right side of right wrist than in the front. At the same time, his left wrist has larger ulnar deviation and radial deviation than putting workpiece in the front. Further, when putting workpiece by the right side his shoulder has larger flexion and extension and his neck has large flexion.

3.5 Discussions

The interesting result from the viewpoint of the right hand dorsiflexion angle is the significant interaction between workpiece position and aided tool. Figure 2 shows the interaction plot of right hand dorsiflexion angle between workpiece position and using aided tool. For pressing operation without aided tool, the same dorsiflexion angle is found at both workpiece positions. When only right hand using aided tool and putting workpiece by the right side, right hand dorsiflexion angle is smaller than putting workpiece in the front. By contrast, the dorsiflexion angle is dramatically greater while both hands using aided tools with workpiece placing in right side.

Figure 3 shows the interaction plot of neck flexion angle between workpiece position and using aided tool. The neck flexion angle is small while putting workpiece by the right side and no or one aided tool using than putting workpiece in front. By contrast, the neck flexion angle is greater while both hands using aided tools with workpiece placing in right side.

4. CONCLUSIONS

From the analysis result of questionnaire survey and workstation experiment, it is known that the pressing operators’ shoulders, neck, lower back and waist would aggravate existing discomfort problems as cumulative trauma disorders significantly. The application of aided tool and workpiece position would ease the operator’s movement significantly. The combination of empty-handed (no aided tool) and putting workpiece on the right side is the worst; the combination of using aided tool with both hands and putting workpiece in the front is the best. Thus it is known that the cause of cumulative trauma disorders is closely related to working posture in the work environment.

Since the factors caused by cumulative trauma disorders are closely related to pressing frequency, this study suggests that besides adopting the best combination of pressing workstation, the plant owners give operators adequate rest and use auto offloading or auto pressing equipment to reduce the operators’ repetition frequency and the possibility of the occurrence of cumulative trauma disorders. The study also shows that, for the safety consideration, the application of aided tool can reduce work injuries and increase the work efficiency. Therefore, the future study can aim at optimizing the work efficiency and ergonomic requirements.

REFERENCES


