Work system analysis on puncher bar repair process in the production division of Akademi Teknik Soroako (Soroako Technical Academy)

Burhanuddin1,2 and R S Dewi1,3

1Department of Industrial Engineering, Sepuluh Nopember Institute of Technology, Surabaya, Indonesia
Email: 2burhanats007@gmail.com, 3ratna.sari.dewi80@gmail.com

Abstract. One of the regular services in the Production Division of Akademi Teknik Soroako (Soroako Technical Academy) is repairing puncher bars of PT Vale Indonesia, One of the stages of his work is to straighten each punch bar. For straightening up each puncher bar, the worker needs to hammer each puncher bar with a 5 kg iron hammer manually. This operation requires enormous physical energy and high cognitive effort for controlling body movement, causing fatigue and cumulative musculoskeletal trauma. The research focuses on assessing the risk of musculoskeletal disorders on the straightening employing Ovako Work Posture Analysis System (OWAS) and Rapid Upper limb Assessment (RULA). The result of the study shows that the work postures while straightening the puncher bar has OWAS score = 2 which means it needs corrective action in the near term, and RULA score = 7 which means the work posture improvement should be made right now. Based on the OWAS and RULA score, several improvement programs and techniques are suggested in this study.

1. Introduction
Akademi Teknik Soroako, which was initially named the Inco Sumitomo Memorial Technical Training Center (ISTC) was established as a form of commitment from PT. INCO, now called PT. VALE INDONESIA Tbk, in collaboration with Sumitomo Metal Mining on community empowerment for the people around the company. The Soroako Technical Academy became a tertiary institution in 1993 which organized a Mechanical Maintenance Study Program diploma level 3. Akademi Teknik Soroako has a production unit which is engaged in production services which only acts as a manufacturing unit because the customer has prepared raw materials. Some product design orders are carried out through the Soroako Academy Production Engineering, so that the added value obtained varies. One of the regular services in the Production Division of Akademi Teknik Soroako (Soroako Technical Academy) is repairing puncher bars of PT Vale Indonesia, TBK. Figure 1 shows the shape of the puncher bars before they are repaired. There are several stages in repairing the puncher bars, i.e., measuring a puncher bar dimensions, cutting the puncher bar with an oxy-acetylene cutting machine, straightening up each puncher bar, grinding the tip of each puncher bar and lastly, adding a new puncher bar plate using a welding machine. There are a lot of Musculo Skeletal Disorder (MSD) related complaints from the workers [1] in the straightening up the puncher bar workstation. In this operation, the workers need to straighten the puncher bars by using a 5 kg iron hammer repeatedly. The operation needs large energy and requires worker’s concentration in the movement of the body. Therefore, it is important to do the analysis of the work system related to straightening process. The analytical methods used in this study were the Ovako Work Posture Analysis System (OWAS) [2] and Rapid Upper Limb Assessment (RULA) [3] to measure the risk of musculoskeletal disorders due to improper work postures [4]. OWAS and RULA methods are selected because the puncher bar repair is done manually. Since the dominant work postures are standing, bending, and lifting the load, the assessment of the entire body is needed. The analysis conducted by both methods can show the risk level of work postures and indicate the potential of musculoskeletal disorders resulting from the unergonomic work postures.
2. Research methodology

This study mainly applied OWAS and RULA methods [5] to evaluate the repair puncher bar workstation in the ATS production unit by observing the postures of 3 operators. The three operators were selected since they have been working for quite long period, experienced, and doing the process of puncher bar repairs more than other workers. The repair processes performed by three sampled workers were captured using a camera in video format. The recordings were then analysed and highlighted on the postures that requires large work energy and unsafe body positions. Preliminary data collection is also conducted by distributing Nordic Body Map questionnaires [6] to 20 operators to measure the significance of their complaints regarding muscle fatigue during the repair process of the puncher bar. This study also collected the repairing time of each puncher bar in each workstation.

3. Result and analysis

3.1. Repair time of the puncher bar

Table 1 shows time spent, and tools used for each activity in the repairing process. The time to straighten up the puncher bars is the longest compared to the other activities. As presented at Figure 1, the straightness of each puncher bar may vary. If they are bent significantly, it will take longer time to straighten up the puncher bars.

```
Table 1. Puncher bar repairing time.

| Activity       | Time       | Tool Used                      |
|----------------|------------|--------------------------------|
| Measure        | 0.2 seconds| Roll meter                     |
| Cut            | 0.5 seconds| Oxygen / Acetylene             |
| Straighten up  | 2.65 minutes| *Paron* (base) and iron hammer (5 kg) |
| Grinding up    | 1.5 minutes| Pedestal Burrs                 |
| Weld plate bar | 2 minutes  | Welding machine                |
| Total          | 6.85 minutes|                               |
```

3.2. Nordic Body Map questionnaire data

Table 2 presents the recapitulation of data collected by the Nordic Body Map questionnaire among the 20 workers of the puncher bar workstation. For each type of pain, the distributions among the pain degree (i.e., “painless”, “pretty sick”, “sick”, and “very ill”) are presented as the percentage of the participant number. As can be seen in Table 2, the waist is the body part which has pain degree "sick" for 75% of the workers surveyed. Around 25% to 30% of the workers also reported having pain on their backs, shoulders (either right or left), and left upper arms.
Table 2. Percentage of types of complaints of workers.

| No | Type of pain                  | Grade of complaints |
|----|------------------------------|---------------------|
|    |                              | Painless % | Pretty sick % | Sick % | Very ill % |
| 0  | Paint/stiff in the upper neck| 8          | 40          | 10     | 50        | 2          | 10         | -          | -          |
| 1  | Pain in the lower neck       | 8          | 40          | 10     | 50        | 2          | 10         | -          | -          |
| 2  | Pain in the left shoulder    | 3          | 15          | 12     | 60        | 5          | 25         | -          | -          |
| 3  | Pain in the right shoulder   | 2          | 10          | 13     | 65        | 5          | 25         | -          | -          |
| 4  | Pain in the left upper arm   | 2          | 10          | 13     | 65        | 5          | 25         | -          | -          |
| 5  | Pain in the back             | 1          | 5           | 13     | 65        | 6          | 30         | -          | -          |
| 6  | Pain in the right upper arm  | 1          | 5           | 15     | 75        | 4          | 20         | -          | -          |
| 7  | Pain in the waist            | 3          | 15          | 2      | 10        | 15         | 75         | -          | -          |
| 8  | Pain in the buttock          | 17         | 85          | 2      | 10        | 1          | 5          | -          | -          |
| 9  | Pain in the bottom           | 18         | 90          | 1      | 5         | 1          | 5          | -          | -          |
| 10 | Pain in the left elbow       | 12         | 60          | 5      | 25        | 3          | 15         | -          | -          |
| 11 | Pain in the right elbow      | 5          | 25          | 12     | 60        | 3          | 15         | -          | -          |
| 12 | Pain in the left lower arm   | 5          | 25          | 12     | 60        | 3          | 15         | -          | -          |
| 13 | Pain in the right lower arm  | 4          | 20          | 15     | 75        | 1          | 5          | -          | -          |
| 14 | Pain in the left wrist       | 8          | 40          | 11     | 55        | 1          | 5          | -          | -          |
| 15 | Pain in the right wrist      | 2          | 10          | 17     | 85        | 1          | 5          | -          | -          |
| 16 | Pain in the left hand        | 9          | 45          | 10     | 50        | 1          | 5          | -          | -          |
| 17 | Pain in the right hand       | 3          | 15          | 16     | 80        | 1          | 5          | -          | -          |
| 18 | Pain in the left thigh       | 18         | 90          | 0      | 2         | 10         | -          | -          | -          |
| 19 | Pain in the right thigh      | 17         | 85          | 1      | 5         | 2          | 10         | -          | -          |
| 20 | Pain in the left knee        | 18         | 90          | 1      | 5         | 1          | 5          | -          | -          |
| 21 | Pain in the right knee       | 19         | 95          | 0      | 1         | 5          | -          | -          | -          |
| 22 | Pain in the left calf        | 19         | 95          | 0      | 1         | 5          | -          | -          | -          |
| 23 | Pain in the right calf       | 19         | 95          | 0      | 1         | 5          | -          | -          | -          |
| 24 | Pain in the left ankle       | 19         | 95          | 1      | 5         | 0          | -          | -          | -          |
| 25 | Pain in the right ankle      | 18         | 90          | 2      | 10        | 0          | -          | -          | -          |
| 26 | Pain in the left foot        | 19         | 95          | 0      | 1         | 5          | -          | -          | -          |
| 27 | Pain in the right foot       | 18         | 90          | 1      | 5         | 1          | 5          | -          | -          |

3.3. OWAS and RULA assessment

Based on the observation to 3 sampled workers, in general, the worker's posture in conducting the straightening puncher bar operation is uniform. Therefore, it can be concluded that by evaluating the working posture of one worker will represent the working postures of the other workers. The whole operation of straightening the puncher bar could be divided into two sub-activities, i.e., lifting the 5kg iron hammers to the air and hammering the puncher bars. Figure 2 and 3 show the worker's posture for each of these two sub-activities, respectively.
Figure 2. Worker is lifting the 5kg iron hammers to the air.

Figure 3. Worker is hammering the puncher bars.

The OWAS and RULA scores for each sub-activity are presented in Table 3 and 4, respectively. The OWAS score [7] for lifting 5 kg iron hammer and hammering puncher bar is 2. This result suggests that both postures are slightly dangerous for the musculoskeletal system, and corrective action is needed. While for the RULA [8], both sub-activities’ scores are 7, meaning that the workers are working in the worst posture with an immediate risk of injury from their work posture. Investigation on the reasons is needed and changing the postures the near future is required to prevent an injury.

Table 3. OWAS and RULA scores for lifting 5 kg iron hammer.

| Method | Score | Description |
|--------|-------|-------------|
| OWAS   | 2     | This posture is dangerous for the musculoskeletal system; work posture produces tension; and needs improvement in the future. |
| RULA   | 7     | The risk is in high-level category; and the current changes are required. |

Table 4. OWAS and RULA scores for hammering puncher bar.

| Method | Score | Description |
|--------|-------|-------------|
| OWAS   | 2     | This posture is dangerous for the musculoskeletal system; work posture produces tension; and needs improvement in the future. |
| RULA   | 7     | The risk is in high-level category; and the current changes are required. |

3.4 Work intervention and improvement

OWAS and RULA analyses suggest that work intervention should be conducted to prevent potential injury. Therefore, this study suggests replacing the manual straightening process with a hydraulic press machine. While being straightening with the press machine, the puncher bar is supported by block V as the base. Figure 4 shows the straightening process with the recommended procedure. Since the press
machine replaces the manual operation, the high-risk postures of lifting 5 kg iron hammer and hammering the puncher bar are eliminated. Figure 5 shows how to set up the puncher bar on a hydraulic press machine, while Figure 6 shows the working posture when applying pressure to the machine for straightening the puncher bar.

![Figure 5. Setting up a puncher bar in a hydraulic machine.](image)

![Figure 6. Work posture when straightening puncher bars on a hydraulic press machine.](image)

The OWAS and RULA scores for each of the sub activities of the straightening process with a hydraulic press machine presented on Table 5 and 6, respectively. OWAS score for positioning iron hydraulic press machine is 2. These results indicate that both postures are slightly harmful to the musculoskeletal system, and corrective action is required. As for the RULA, the second score of the sub activity is 6, meaning that workers work at moderate risk, need for further handling, and a change from their working posture.
Table 5. OWAS and RULA scores for setting the puncher bar in a hydraulic machine.

| Method | Score | Description |
|--------|-------|-------------|
| OWAS   | 2     | This posture is dangerous for the musculoskeletal system; work posture produces tension; and needs improvement in the future. |
| RULA   | 6     | Medium risk, advanced handling and need changes. |

Table 6. OWAS and RULA scores for when straightening puncher bars on a hydraulic press machine.

| Method | Score | Description |
|--------|-------|-------------|
| OWAS   | 2     | This posture is dangerous for the musculoskeletal system; work posture produces tension; and needs improvement in the future. |
| RULA   | 6     | Medium risk, advanced handling and need changes. |

Since the process of alignment with the recommended procedure is replacing the manual operation, the high-risk posture of lifting the iron hammer 5 kg and hammering process were eliminated. In addition, this new recommended procedure eliminates the potential of MSD for workers, it also requires shorter operating time. Table 7 shows the time required for each step in the new method. By using the new procedure, the total operating time for each punch bar is 6.18 minutes or approximately 0.6 minutes faster than the original method. That means with a press machine, there are 9.7 puncher bars that can be straightened every hour. Table 8 shows comparison of capacity improvements for both methods.

Table 7. Process time repair puncher bar with hydraulic press machine.

| Activity           | Time  | Tool Used         |
|--------------------|-------|-------------------|
| Measure            | 0.2 seconds | Roll meter          |
| Cut                | 0.5 seconds | Oxygen / Acetylene |
| Straighten up      | 1.98 minutes | Hydraulic press machine |
| Grinding up        | 1.5 minutes | Pedestal Burrs     |
| Weld plate bar     | 2 minutes  | Welding machine    |
| **Total**          | **6.18 minutes** |

Table 8. Comparison of repairing capacity on the existing and recommended procedure.

| Description            | Time (minute) | Puncher bar per hour |
|------------------------|---------------|----------------------|
| Iron hammer 5 kg       | 6.85          | 8.3                  |
| Hydraulic press machine| 6.18          | 9.7                  |
4. Conclusion
Among all operation for repairing puncher bars, straightening up the puncher bar is the riskiest process due to its high potential causing MSD injuries. Analysis using the OWAS and RULA methods result in score 2 and 7, respectively, suggesting that corrective action is needed soon. Proposed improvement to the unergonomic work posture is conducted by replacing the manual puncher bar straightening process with a hydraulic press machine. Besides that, the new procedure will eliminate the potential of MSD injuries, it also saves the operation time for about 0.6 minute for each puncher bar. This improvement will surely be beneficial for the Production Division of Akademi Teknik Soroako for both its occupational health and safety and financial aspects.

References
[1] Stack T, Ostrom LT, Wilhelmsen CA. Occupational Ergonomics. John Wiley & Sons, Inc; 2016 May 9;8-9. doi.org/10.1002/9781118814239
[2] Pramestari D. Analisis Postur Tubuh Pekerja Menggunakan Metode Ovako Work Analysis. Iktiaht-Teknologi. 2017;1;19-22.
[3] Sie KMS, Valentino F, Dearosa EY, Rahardjo B. Analisis Risiko Postural Stress pada Pekerja Di UD.XYZ Dengan Metode Rapid Upper Limb Assessment. Jurnal Rekayasa Sistem Industri. 2017 Oct 31;6(2):149. doi.org/10.26593/jrsi.v6i2.2498.149-154
[4] Colombini D. Working Posture Assessment: The TACOs (Time-Based Assessment Computerized Strategy) Method. 2018 Sep 3;17. doi.org/10.1201/b22442
[5] Indan R, Pratiwi NK, Z MM. Analisis Postur Kerja Karyawan Dibagian Pengangkatan Bahan Baku Dengan Menggunakan Metode OWAS (Ovako Working Posture Analysis) Dan RULA (Rafid Upper Limb Assessment). Majalah Ilmiah UPI YPTK. 2019;26;36-44.
[6] Rahdiana N. Identifikasi Risiko Ergonomi Operator Mesin Potong Guillotine Dengan Metode Nordic Body Map. Industry Xplore. 2017;2;1-12.
[7] Zetli S. Analisis Postur Tubuh Pekerja Manual Material Handling dengan Pendekatan OWAS (Ovako Working Posture Analysis). Rekayasa Sistem Industri. 2017;3;16-25.
[8] Dzikrillah N, Yuliani ENS. ANALISIS POSTUR KERJA MENGGUNAKAN METODE RAPID UPPER LIMB ASSESSMENT (RULA) STUDI KASUS PT TJ FORGE INDONESIA. Jurnal Ilmiah Teknik Industri. 2017 May 22;3(3). doi.org/10.24912/jitiuntar.v3i3.466