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Evaluation of Work Station and Working Posture on Welding Section Review of Ergonomic Factors in Metal SME Road Court Medan

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ABSTRACT

Various risks influencing worker's life must be anticipated by synchronizing the worker, work process, and work environment through ergonomic approach. This study aims at evaluating the synchronization between workstation and work posture and recommending the improvement of workstation and facilities in the attempt to minimize the complaint of pain caused by their working. The evaluation was conducted by means of survey method at the UKM Logam (a small business in metal industrial construction) on jalan Mahkamah Medan with the samples of 10 workers working in the welding section. The taking of worker's anthropometric is an indicator in evaluating the synchronization between workers and workstation which is supported by observing result of study reveals that there is no work facility in the welding section that the workers do not feel comfortable while working. In addition, the work posture including work attitude is not ergonomically formed that it makes several parts of the worker's body tired and painful. In the body map questioners, the pain felt by the workers is dominantly found in the area of neck, shoulder, back, waist and calves. For this purpose, the workstation needs improvement by setting the position of equipment and machine within the worker's reach, 75.6 cm (5-th percentile). The bench work should be adjustable to the height of 92 cm, 95 cm, and 98 cm. The stool (dengklek) should have the height of 14 cm.

INTRODUCTION

Occupational disease is any disease caused by work or work environment. Of the various factors, one of which is the ergonomics factor that arises due to machine/tool construction errors, poor work postures and errors in the work process which will gradually cause physical fatigue and even physical changes in the worker's body (Suma'mur, 1985).).

One of the efforts that can be done to reduce worker complaints is to improve work facilities that are not ergonomic (designs that are not in accordance with the user's anthropometry). Ergonomic work system design in the production process that involves many workers in the division of sorting the production of crisp peanuts. This improvement was carried out by measuring the level of fatigue seen from the heart rate and in relation to energy consumption, and distributing a body map questionnaire which was needed to provide information for designing ergonomic work desks and chairs (Astuti et al, 2003). .

To improve the work system in reducing complaints of pain (tiredness) in the body parts of computer operators by recommending an ergonomic work desk and chair design (Widodo et al, 2003).

Research on seashell craft solder workers, that by using ergonomic work desks and chairs there is an increase in work productivity by 20.75% and due to unnatural work attitudes and being too bent over causes complaints of back pain

(musculoskeletal) highest in the waist and neck (Setiawan, 2003).

Recommendations are also made in the form of improving work facilities in the form of work desks, work chairs and cutting tools (cutting knives) for workers in the peeling section at the processing plant of sweet potato into pasta and sweet potato chips in an effort to reduce complaints of work-related pain (Eka Lestari Mahuni, 2004).).

In the initial survey conducted in the metal construction service industry on Jalan Court Medan, workers in the welding department complained a lot of pain in the back and calves and in general they considered it normal because they were tired after work, they worked in a half-sitting (squatting) position and bending over. for a long time and all work is done physically (manually). With this manual work pattern, there are many situations that are not in accordance with ergonomic principles, namely, the compatibility between the dimensions of the operator's body segments and the dimensions of the facilities used such as work stations so as to form a work posture.

METHOD

Place and time

The research was conducted on metal construction service industry SMEs along Jalan Court Medan. This metal industry produces terraced tents, cafe tents, and others that use iron as basic materials. The research was conducted from April 2006 to July 2006.

Population and Sample

The observations were metal construction service industry SMEs along the Court road, and the population in the study were 10 permanent workers in the welding department. All populations become research samples (total sampling).

Instruments Used

In this study, observations and evaluations of the work station were carried out, with the data collection instruments used were:

1. Body map questionnaire which is used to find out the complaints that arise in the form of pain in the body parts of workers due to physical work done before, during and after work.
2. The human body measuring instrument (Martin Human Body Measuring Instrument Model YM-1).
3. Observation tool in the form of a digital camera (Canon Ixy 5.5 Mega Pixels)

Research design

This research design is a descriptive design using a survey method

Operational definition

a. A work station is an area where the interaction of various facilities used in carrying out activities takes place
b. Work posture is a natural work position formed by the worker's body as a result of interacting with the facilities used or work habits.
c. Pain complaints are complaints of pain or pain in the workers' body parts which are measured using a body map questionnaire.
d. Recommendations are proposals given after an evaluation of the work station and work posture has been carried out.
e. Ergonomics is the compatibility between humans and the tools used.

Data Analysis Techniques

The data analysis technique used in this study is descriptive statistics, namely the data obtained are distributed in tabular form. Anthropometric data from workers will be tested for data uniformity and data normality test using a computer using the Kolmogorv-Smirnov test on the SPSS 13.0 program.

RESULTS AND DISCUSSION

Work Station

The work station in the metal industry does not have a work bench (bench work) so that the work object is placed and worked on on the floor. Work equipment is scattered on the floor and in the corners of the room, because there are no cabinets or boxes for storing equipment, as well as scattered materials that are not organized. Electrical wires and cables from the welding machine were scattered on the floor. None of the workers wear personal protective equipment, only wear sunglasses instead of special eye protection glasses (google), wear flip-flops instead of work shoes.

The results of anthropometric measurements of welding workers as many as 10 workers were taken with the human body measurement instrument (Martin Human Body) and can be seen in table 1.

RESULTS AND DISCUSSION

Table 1
Anthropometric Data of Workers in the Welding Section at the Metal UKM Road Court

Sampel	Tdt (cm)	Tbd (cm)	Tmd (cm)	Lb (cm)	Tsd (cm)	Tp (cm)	Tpo (cm)	Ppo (cm)	Pkl (cm)	Lp (cm)	Tsb (cm)	Rt (cm)	Tmb (cm)	Tbt (cm)	Tbb (cm)	Tb (cm)	Jt (cm)	Td (cm)
Safrianto	76,5	51	67	43,5	18	9	39,5	38,5	49,5	33,5	97	169	148	159	132	17	82	10
Hendri	84,5	58	71,5	40	21,5	10,5	40	38,2	51,3	34	94	160	146	158	132	19	78	10

Tulus	81	56,6	68,5	37	24,5	9,5	40,5	38,7	48,1	35,7	101	161	149	158	134	17,5	75,6	10
Haryono	73,6	50,5	62,5	39	17,5	11	39	39	51	36	99	165	146	155	131	16	83	10
Muchlis	82	51,5	68	155	16,2	12,2	41,5	32	49,5	35	108	167	143	157	128	18,6	117	10
Sumardi	82	51,5	66,8	41	28	13	40	41	53,2	39,6	102	158	146	157	130	22,5	81,5	15
Patmono	75	48	62	39,8	18,5	11	40,3	40	50	37	96	155	140	151	125	20	75,6	15
Supomo	86	67,7	73,5	44,5	23	13	39,3	37,6	53	38	99	171	154	163	137	21	116	15
Tando	82	43,2	69,5	49,5	22	15,5	39	39,2	50,5	42,2	100	172	152	163	134	26,2	86	15
Daniel	83	54,5	70,5	41,3	19,5	10,5	36,8	44	53,5	36	104	176	155	167	139	15,5	81	15
Data Max	86	67,7	73,5	155	28	15,5	41,5	44	53,5	42,2	108	176	155	167	139	26,2	117	15
Data Min	73,6	43,2	62	37	16,2	9	36,8	32	48,1	33,5	94	155	140	151	125	15,5	75,6	10
Std Deviasi (σ)	4,13	6,60	3,65	36,08	3,64	1,94	1,24	3,01	1,81	2,64	3,86	6,70	4,73	4,68	4,15	3,26	15,51	2,64
Rata-rata	80,6	53,3	68	53,1	20,9	11,5	39,6	38,8	51	36,7	99,8	165	148	159	132	19,3	87,5	12,5

tdt = Tinggi duduk tegak
tbd = Tinggi bahu duduk
tmd = Tinggi mata duduk
lb = Lebar bahu
tsd = Tinggi siku duduk
tp = Tebal paha
tpo = Tinggi popliteal
ppo = Pantat popliteal
pkl = Pantat ke lutut
lp = Lebar pinggul
tsb = Tinggi siku berdiri
rt = Rentangan tangan
tmb = Tinggi mata berdiri
tbt = Tinggi badan tegak
tbb = Tinggi bahu berdiri
tb = Tebal badan
jt = Jangkauan tangan
td = Tinggi dengklek yang nyaman

Table 2.
Test Results of Worker Anthropometric Data Uniformity

No.	Antropometri (Dimensi Tubuh)	Rata-rata (cm)	Std Deviasi	Nilai Min (cm)	BKB (cm)	Nilai Max (cm)	BKA (cm)	Keterangan
1	Tinggi duduk tegak (tdt)	80,56	4,13	73,6	68,18	86	92,94	Seragam
2	Tinggi bahu duduk (tbd)	53,25	6,60	43,2	33,46	67,7	73,04	Seragam
3	Tinggi mata duduk (tmd)	67,98	3,65	62	57,03	73,5	78,93	Seragam
4	Lebar bahu (lb)	53,09	36,08	37	-55,15	155,3	161,33	Seragam
5	Tinggi siku duduk (tsd)	20,87	3,64	16,2	9,96	28	31,78	Seragam
6	Tebal paha (tp)	11,52	1,94	9	5,71	15,5	17,33	Seragam
7	Tinggi popliteal (tpo)	39,59	1,24	36,8	35,86	41,5	43,32	Seragam
8	Pantat popliteal (ppo)	38,82	3,01	32	29,78	44	47,86	Seragam
9	Pantat ke lutut (pkl)	50,96	1,81	48,1	45,54	53,5	56,38	Seragam
10	Lebar pinggul (lp)	36,7	2,64	33,5	28,77	42,2	44,63	Seragam
11	Tinggi siku berdiri (tsb)	99,84	3,86	94	88,26	107,5	111,42	Seragam
12	Rentangan tangan (rt)	165,24	6,70	155	145,13	175,5	185,35	Seragam
13	Tinggi mata berdiri (tmb)	147,59	4,73	139,5	133,39	154,6	161,79	Seragam
14	Tinggi badan tegak (tbt)	158,67	4,68	150,5	144,62	167	172,72	Seragam
15	Tinggi bahu berdiri (tbb)	132,07	4,15	124,5	119,61	138,5	144,53	Seragam
16	Tebal badan (tb)	19,33	3,26	15,5	9,55	26,2	29,11	Seragam
17	Jangkauan tangan (jt)	87,53	15,51	75,6	41,01	117	134,05	Seragam
18	Tinggi dengklek yang nyaman (td)	12,5	2,64	10	4,59	15	20,41	Seragam

$$BKA = \overline{X} + 3\sigma_X$$

$$BKB = \overline{X} - 3\sigma_X$$

Jika Xmin > BKB dan Xmax < BKA maka data seragam.

Meanwhile, anthropometric data with normal distribution were obtained using the data normality test (One-Sample Kolmogorov-Smirnov Test) which can be seen in table 3

Table 3
Normality Test Results of Anthropometric Data Workers One-Sample Kolmogorov-Smirnov Test

	N	Normal Parameters[a,b]		Most Extreme Differences			Kolmogorov-Smirnov Z	Asymp. Sig. (2-tailed)
		Mean	Std. Deviation	Absolute	Positive	Negative		
TDT	10	80,5600	4,12747	,242	,137	-,242	,767	,599
TBD	10	53,2500	6,59516	,205	,205	-,138	,647	,797
TMD	10	67,9800	3,65051	,173	,133	-,173	,548	,925
LB	10	53,0900	36,08029	,440	,440	-,328	1,390	,042
TSD	10	20,8700	3,63809	,147	,147	-,100	,464	,982
TP	10	11,5200	1,93609	,206	,206	-,099	,651	,790
TPO	10	39,5900	1,24226	,217	,132	-,217	,688	,732
PPO	10	38,8200	3,01212	,243	,150	-,243	,768	,598
PKL	10	50,9600	1,80505	,171	,125	-,171	,540	,932
LP	10	36,7000	2,64239	,204	,204	-,113	,647	,797
TSB	10	99,8400	3,85896	,134	,134	-,114	,422	,994
RT	10	165,2400	6,70244	,137	,137	-,113	,432	,992
TMB	10	147,5900	4,73438	,129	,124	-,129	,409	,996
TBT	10	158,6700	4,68213	,199	,199	-,161	,628	,825
TBB	10	132,0700	4,15319	,109	,107	-,109	,345	1,000
TB	10	19,3300	3,26021	,140	,140	-,120	,444	,989
JT	10	87,5300	15,50742	,339	,339	-,221	1,073	,200
TD	10	12,5000	2,63523	,329	,329	-,329	1,039	,230

a Test distribution is Normal.
b Calculated from data.

Therefore, all the measured data can be used as needed in designing an ergonomic work station. After determining the average value and standard deviation of each data, the percentile used can be determined. Percentile calculation values from worker anthropometric data are in table 4

Table 4
Percentile Calculation Results From Worker Anthropometric Data

No.	Antropometri (Dimensi Tubuh)	Hasil Perhitungan (cm)		
		P 5th	P 50th	P 95th
1	Tinggi duduk tegak (tdt)	77,61	80,56	83,51
2	Tinggi bahu duduk (tbd)	48,53	53,25	57,97
3	Tinggi mata duduk (tmd)	65,37	67,98	70,59
4	Lebar bahu (lb)	27,28	53,09	78,90
5	Tinggi siku duduk (tsd)	18,27	20,87	23,47
6	Tebal paha (tp)	10,14	11,52	12,90
7	Tinggi popliteal (tpo)	38,70	39,59	40,48
8	Pantat popliteal (ppo)	36,67	38,82	40,97
9	Pantat ke lutut (pkl)	49,67	50,96	52,25
10	Lebar pinggul (lp)	34,81	36,70	38,59
11	Tinggi siku berdiri (tsb)	97,08	99,84	102,60
12	Rentangan tangan (rt)	160,45	165,24	170,03
13	Tinggi mata berdiri (tmb)	144,20	147,59	150,98
14	Tinggi badan tegak (tbt)	155,32	158,67	162,02
15	Tinggi bahu berdiri (tbb)	129,10	132,07	135,04
16	Tebal badan (tb)	17,00	19,33	21,66
17	Jangkauan tangan (jt)	76,44	87,53	98,62
18	Tinggi dengklek yang nyaman (td)	10,61	12,50	14,39

Table Description:
P 5th : 5% of the population whose dimensions are equal to or lower than the 5th percentile
P 50th : 50% of the population whose dimensions are equal to or lower than the 50th percentile
P 95th : 95% of the population whose dimensions are equal to or lower than the 95th percentile

Work Posture

Workers who work in the welding section work in a static half-sitting (squatting) position and the worker's head is lowered when welding.

Body Map Questionnaire

Data on body complaints was obtained by asking the workers directly before working in the morning (8:00 a.m.), before lunch (12:00 p.m.), and before returning home from work (17:00 p.m.). The results of the body map questionnaire for welding workers can be seen in Table 6 and the graph of the percentage of worker complaints in Figures 1, 2, and 3.

Table 6
Results of the Worker Body Map Questionnaire

No	Jenis Keluhan	Pukul 08.00 wib				Pukul 12.00 wib				Pukul 16.00 wib			
		A	B	C	D	A	B	C	D	A	B	C	D
1	Sakit kaku di leher bagian atas	3	7	-	-	2	2	6	-	-	2	-	8
2	Sakit kaku di leher bagian bawah	3	7	-	-	2	2	6	-	-	2	-	8
3	Sakit di bahu kiri	5	5	-	-	3	2	5	-	-	3	-	7
4	Sakit di bahu kanan	5	5	-	-	3	2	5	-	-	3	-	7
5	Sakit pada lengan atas kiri	10	-	-	-	9	-	1	-	9	-	-	1
6	Sakit pada lengan atas kanan	10	-	-	-	9	-	1	-	9	-	-	1
7	Sakit pada punggung	3	7	-	-	-	3	7	-	-	-	-	10
8	Sakit pada pinggang	3	7	-	-	-	2	8	-	-	-	-	10
9	Sakit pada betis kiri	3	7	-	-	-	2	7	1	-	-	-	10
10	Sakit pada betis kanan	3	7	-	-	-	2	7	1	-	-	-	10
	Keterangan:												
	A: tidak sakit B: agak sakit			C: sakit			D: sangat sakit						

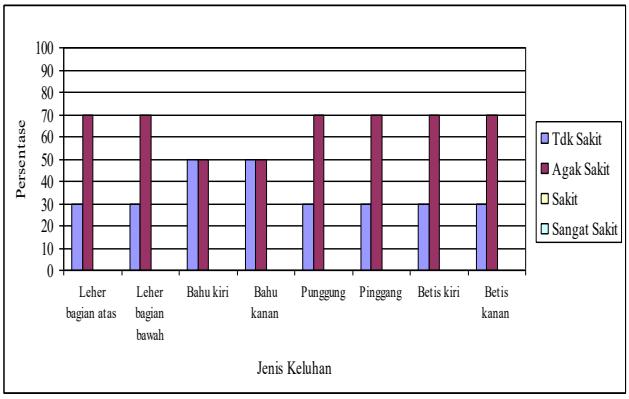

Figure 1. Graph of Percentage of Worker Body Map Questionnaire At 08.00 WIB

In Figure 1 it can be seen at 08.00 WIB before starting work 70% of the workers have felt a little pain in the neck, back, waist and calves, 50% in the shoulders, and only 30% did not feel pain.

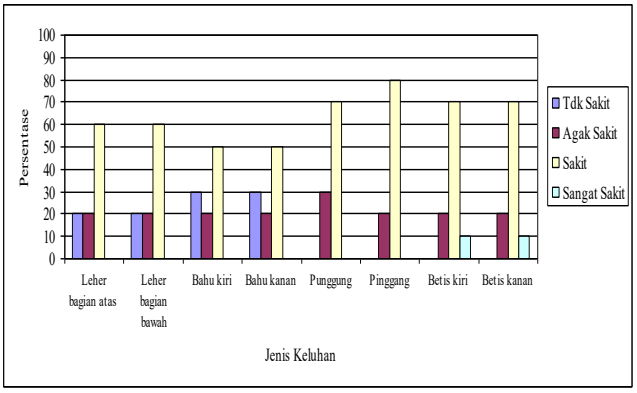

Figure 2: Graph of Percentage of Worker Body Map Questionnaire At 12.00 WIB

In Figure 2 it can be seen at 12.00 WIB during break time 80% of workers feel pain in the waist, 70% of workers have felt pain in the back and calves, 60% in the neck, 50% in the shoulders.

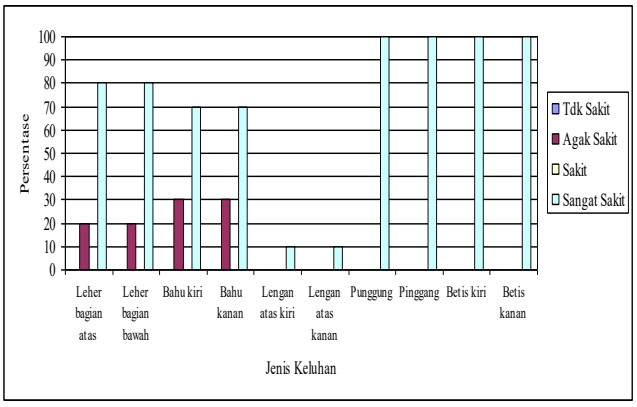

Figure 5. Graph of Percentage of Worker Body Map Questionnaire At 16.00 WIB

In Figure 3 it can be seen at 16.00 wib after finishing work, 100% of workers feel very sick in the back, waist and calves, 80% complains of very pain in the neck, 70% complains of very pain in the shoulders, 10% complains of very pain in the neck. arm part.

DISCUSSION

Work Station

The recommended work station changes and improvements in this study are:

1. Workshop Layout

Setting the layout of the workshop facilities in accordance with the flow of the production process. The trick is to arrange

the location of the machine or work facility that is adapted to the existing process flow, namely: starting from the storage of raw materials, the cutting process, the welding process, then the painting process, and finally the storage place for the production.

In order to minimize the distance of material movement during the production process, work stations are placed close together to reduce shifting time. The work equipment to be used is in the right direction and position within the reach of the worker.

Hand Reach (m):
5% = 75,6 cm
95% = 117 cm

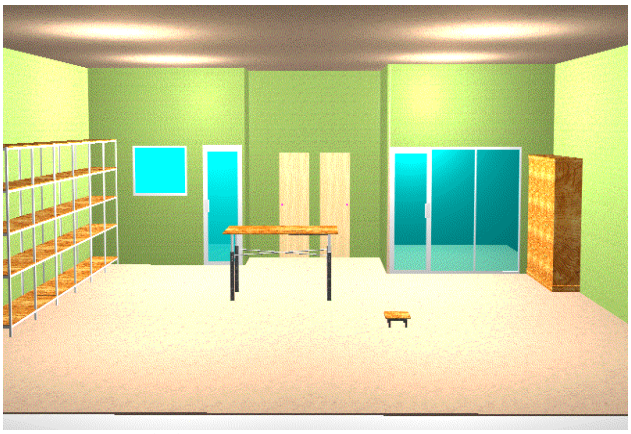

Figure 4. Workshop Layout

2. Work Facilities

The recommended work facilities are:

a. Bench work (bench work);

The operator works in an upright position, with the upper arm relaxed and in a vertical position close to the table, and the forearm slightly tilted from the horizontal, with the work bench height approx. 50 mm below the elbow. (Eko Nurmianto, 1998)

Workers in the welding department have varying heights from 150 cm to 167 cm, if the height of the work bench is made the 95th percentile it will cause problems for smaller operators. So the solution is to design a work bench that uses an adjustment.

Calculation:
Standing elbow height:
5% = 97,08 cm - 5 cm = 92,08 cm
50% = 99,84 cm - 5 cm = 94,84 cm
95% = 102,60 cm - 5 cm = 97,60 cm

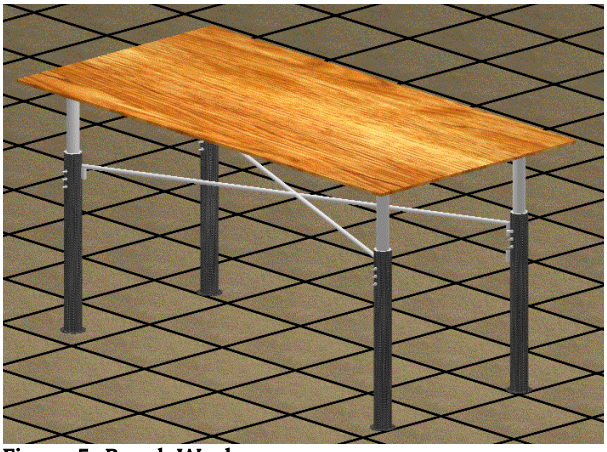

Figure 5: Bench Work

Calculation results are rounded to make it easier to work. So the height of the work bench surface using a regulator that can be adjusted at a height of 92 cm, 95 cm and 98 cm. The material for the work bench for the frame is made of iron pipes and elbows, while for the base surface, wood is used.

b. Low seat (knock);

Anthropometric measurements will form the basis for a low seat height (knock). As a limitation, the adjustment areas are the 5th percentile for women and the 95th percentile for men. (Eko Nurmianto, 1998)

All of the welding workers were male, so the 95th percentile for knee size was taken.

Calculation:
Knee height:
95% = 14,39 cm
Hip Width:
95% = 38,59 cm

Hasil perhitungan dibulatkan untuk mempermudah pengerjaan, sehingga ukuran bangku rendah (dengklek) menjadi 14 cm untuk tinggi dan 38 cm untuk lebarnya. Bahan dari bangku rendah dibuat dari kayu atau untuk rangka menggunakan bahan dari besi siku dan alas permukaan dari kayu

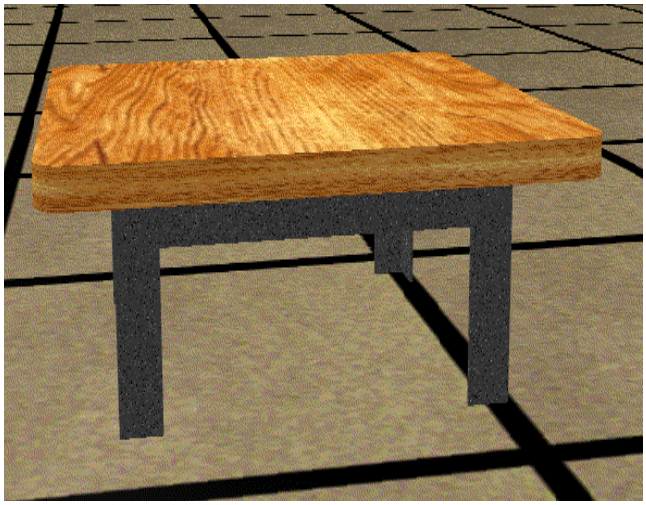

Figure 6: (dengklek)

3. Working system:

Making standard operational procedures for welding to avoid unnecessary retraining and human errors due to habitual patterns that have been adopted. Implementation of standard welding operations, namely:

- Prepare the welding machine
- Wear safety equipment such as gloves, apron, welding helmet (welding helmet), work shoes when doing work.
- Prepare welding tools such as welding brushes, welding hammers, clamping pliers.
- Place the workpiece on the welding workbench and attach the mass clamp as best as possible so that during welding there is a good electrical circuit. Attach the electrodes to the welding pliers and you are ready to start welding.
- After finishing welding, return the tools and machines to the storage area.

4. Maintenance of the Work Environment (house keeping):

It is important to maintain the workplace so that work becomes more effective and efficient and avoids work accidents. The maintenance of the workplace that needs to be done, among others:

- Organize and sort between objects in the work environment, both equipment, machines or materials that are needed and those that are not needed, discarding those that are not needed.
- Storing goods in the right place or in the correct layout so that they can be used in an emergency.
- Cleaning items so that they become clean, checking for cleanliness and creating a workplace that does not have defects and blemishes.

5. Occupational Health and Safety:

a. Work environment;

- Availability of First Aid equipment in Accidents (P3K).
- The work floor is not slippery and has holes.
- Work tools and tools must be inspected and repaired if there are any damaged parts.
- Machine maintenance should be done when the machine is stopped.
- Equipment and machines that use electric current must always be checked and maintained so as not to allow a fire hazard (short circuit) while the machine is operating.
- Electrical wires from and to the machine must not be exposed, must be protected or wrapped.
- Parts of dangerous machine tools must be provided with adequate safety and protective equipment.

b. Welding Aids;

- Welding Cable; Welded wires are usually made of copper twisted and wrapped with insulating rubber. There are three kinds of welding cables, namely: electrode cables, mass cables, and power cables.
- The electrode cable is the cable that connects the welding plane to the electrode. The mass cable connects the welder to the workpiece. Power cable is a cable that connects the power source or power grid with the welding machine.
- Electrode holder; The non-webbed end of the electrode is clamped with the electrode holder. The electrode holder consists of a clamping mouth and a handle wrapped by an insulating material.
- Welding Hammer; used to remove and remove welding slag on the weld line by hitting or or scratching the weld area.
- Wire Brush; used to clean the workpiece to be welded, clean the welding slag that has been separated from the welding path by a welding hammer.
- Clamps Time; is a tool for connecting the mass cable to the workpiece, made of a material with a good electrical conductivity such as copper. The surface of the workpiece to be clamped with mass clamps must first be cleaned of impurities such as rust, paint, and oil.
- Clamps; tongs (pliers) are used to hold or move hot workpieces.

c. Personal Protective Equipment (PPE);

- Welding helmet; as well as welding screens are used to protect the skin of the face and eyes from welding rays (ultra violet and ultra red rays) which can damage the skin and face.
- Gloves; When welding, a pair of leather gloves should always be worn to make it easier to hold the electrode holder.
- Welding suit (Apron); A complete welding suit can protect the body and part of the legs made of leather.
- Welding Shoes; Welding shoes are useful for protecting feet from bursts of sparks.

Figure 7: Welding Personal Protective Equipment

Work Posture

The recommended working postures are:

1. To work on products such as cafe tents with a size smaller or equal to 3 x 4 meters, garden umbrellas with a diameter of 2 meters, and other products with smaller or the same dimensions can be done on a bench work in a standing position with adjustable heights of 92 cm, 95 cm and 98 cm.
2. For products with larger dimensions than cafe tents, such as terraced tents, fences, lamp posts and others, they are done on the work floor with a sitting posture. The work facilities are in the form of a low chair with a height of 14 cm.

Figure 8: Standing Work Posture

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. At the work station for the welding section of the metal industry on Jalan Court Medan, there is no ergonomics, which is indicated by the absence of work facilities in the form of a work bench (bench work) so that the work object is placed and worked on the floor.
2. Work postures of workers in the welding department are not ergonomic, which is indicated by a half-sitting (squatting) working posture and a bowed head.
3. There were complaints in several parts of the workers' bodies in the afternoon after finishing work, namely, 100% of workers who complained of very pain in the back, waist, and calves, 80% complained of very pain in the neck, 70% complained of very pain in the shoulders, and 10% complained of severe pain in the upper arm.

Suggestions

1. Equipment and machinery at the welding work station must be within the reach of workers, namely 75.6 cm (5-th percentile).
2. Make a work bench using an adjustment that can be adjusted at a height of 92 cm, 94.84 cm and 97.6 cm.
3. Make a low chair (bench) with a height of 14.39 cm (95-th percentile).

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