

## Total Ergonomic Approach in Decreasing Quality of Fatigue of Metal Crafters

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Overtime work condition can create work related fatigue caused by stress. Work condition improvement could decrease quality of fatigue of the employees. A total ergonomic approach (TEA) was conducted to decrease the quality of fatigue of metal crafters at Kediri Tabanan. Samples ( $N = 23$ ) were chosen randomly from the population. Fatigue was measured through a modification of 30 items questionnaire from the Industrial Fatigue Research Committee. Results show a 9.22% ( $p < 0.05$ ) decrease in fatigue, revealing that decrease of motivational fatigue is higher than decrease in fatigue due to physical activity, due to the type of work: manual, repetitive, and continuous. It was suggested to use TEA continuously to decrease the fatigue and maintain motivation.

*Keywords:* work condition, total ergonomi approach, quality of fatigue

Kondisi kerja lembur dapat menimbulkan kelelahan sebagai salah satu akibat stres. Perbaikan kondisi kerja diharapkan menurunkan kualitas kelelahan karyawan. Sebuah pendekatan ergonomi total telah dilaksanakan untuk mengetahui perubahan kualitas kelelahan perajin logam di Kediri Tabanan. Sampel sejumlah 23 orang dipilih secara acak dari populasi. Kelelahan diukur dengan modifikasi 30 butir kuesioner model Industrial Fatigue Research Committee. Hasil-hasil menunjukkan penurunan kelelahan sebanyak 9.22% ( $p < 0.05$ ) dan menunjukkan bahwa penurunan kelelahan motivasi lebih banyak daripada kelelahan aktivitas fisik, mengingat jenis pekerjaan yang manual, repetitif, dan berkelanjutan. Disarankan pendekatan ergonomi total diteruskan untuk menurunkan kelelahan dan mempertahankan motivasi kerja karyawan.

*Kata kunci:* kondisi kerja, pendekatan ergonomi total, kualitas kelelahan

Global economic development requires the ability of everyone capable of dealing with change, competition and complexity, including in the small scale industries. Small scale industrial competition should have the ability to meet consumer desires for customer satisfaction. Among the expected form of satisfaction is the ability to maintain the productivity of employees, in order to execute the production process just in time.

Various efforts can be implemented to meet customer desires such as addition of employees and work for 24 hours. But those efforts could not be implemented due to differences of ability of employees based on work experiences and their respective skills. Therefore, an effort that could be

done is just encourage the employee to add their working hours. Normally, employees work from 8 am to 5 pm every day including lunch time and break. Addition of working hours is performed every time before the deadline in the form of work overtime. Length of work overtime varies from 1 - 4 hours per day, starting from 5 pm until 10 pm, even occasionally until dawn.

Work overtime should be avoided because it will provide a variety of psychological and physiological effects (Anonymous, 2003; Spurgeon, 2003). One of the effects of working overtime is emergence of stress on the employees. The accumulated stress will be manifested in the form of complaints and behaviors that affect productivity. There are various forms of complaints and physiological changes due to the accumulated stress. One form of complaint is the perceived physical and mental fatigue of employees such as drowsiness and headache (Manuaba, 2003; Grandjean & Kroemer, 2000).

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Fatigue is one of the complaints that was submitted by the employees, that could be primary fatigue as a result of the production process activity, additional complaints due to work overtime and can also result in household work. In this case the employees are women. Dual role of women in households and as an employee can also aggravate existing fatigue. Meanwhile, work at home is not only household, but still added by the obligations as members of society (Nala, 2002). In the painting workshop, the activities are monotonous and repetitive that could enhance fatigue qualitatively as well as quantitatively. Therefore, working overtime is an additional burden that should be avoided (Spurgeon, 2003).

Fatigue can be interpreted as a loss of efficiency and reluctance to do various activities. Physiologically, fatigue can be differentiated as central fatigue and local fatigue, and can be divided into general fatigue and muscle fatigue too. Fatigue is a physiological event, as a form of body defense to avoid the occurrence of cellular, organ, or system injury within the body (Grandjean & Kroemer, 2000; Guyton & Hall, 2000).

General fatigue is a condition when the body is unable to perform optimal activity (Grandjean & Kroemer, 2000). This condition occurred as a result of the action potential disturbances in the brain caused by stress. General fatigue is more frequently caused by: (1) external stress such as working conditions, work environment, tasks that must be done and socio-cultural factors; (2) the internal stress such as physical condition, mental status and nutritional intake.

There are various methods of indirect measurement of fatigue, such as: (1) the quality and quantity of work, (2) subjective complaints of fatigue, (3) eye blink test, (4) reaction time, (5) speed, accuracy and concentration test. Based on quantitative and qualitative quality, fatigue can be categorized into three groups with each containing 10 questions. Quantities of fatigue just record the number of complaints. Quality of fatigue was revealed by the level of feelings on each question in each group in the form of Likert scale, such as: A = not at all, B = mild, C = moderate and D = severe. Scores were given: 1 for A, score 2 for B, score 3 for C, and score 4 for D. The higher the score selected show the higher levels of fatigue.

Quality of fatigue is one indicator of workload particularly mental stress faced by the employees.

According to the Industrial Fatigue Research Committee (IFRC) Japan, fatigue assessment of employees are grouped into: (a) fatigue associated with the activity, (b) fatigue associated with motivation and (c) fatigue associated with physical complaints (Yoshitake, 1971). Fatigue as measured by Yoshitake only recorded the number of complaints without judging the quality of perceived fatigue. Respondents just give a check to the statement that is felt in accordance with the conditions themselves. Therefore, each item of fatigue questionnaire is modified into several levels according to Likert scale ranging from not at all to strongly felt/severe (Sutjana & Sutajaya, 2000). By using modifications of the questionnaire from the IFRC, the quality of worker fatigue can be measured. So the quality of fatigue shows the level of feelings of fatigue experienced by the workers ranging from not feeling tired at all to feeling very tired.

Fatigue measurement tools are made in the form of 30 questions fatigue questionnaire modified from the IFRC with the four-scale fatigue level (Sutjana & Sutajaya, 2000). Fatigue items were measured through (a) ten questions about the weakening of activity, such as: heavy feeling in head, whole body fatigue, heavy legs, yawning, confused thoughts, drowsiness, strain in the eye, awkward and stiff movements, unstable standing, desire to lie, (b) ten questions about the weakening of motivation, such as: difficulty in thinking, tired to talk, nervous, lost of concentration, hard to concentrate, forgetful, self-confidence decreases, feel anxious, attitude control difficulty, not diligent at work, (c) ten questions about the description of physical exhaustion such as: headache, shoulders stiffness, back pain, shortness of breath, thirst, hoarseness, feeling dizzy, eyelid spasm, tremors of limbs, feeling unwell.

Fatigue experienced by employees as the accumulation of external and internal stress may arise as a result of improper working conditions. Working conditions that may have impact can be grouped into eight ergonomic aspects such as: work posture, musculoskeletal condition, nutrition, environmental conditions, information conditions, socio-cultural conditions, time conditions, and

man-machine interaction. The working conditions should fit to the capacity of employees such as: advantages, disadvantages, and limitations of employees. Employee productivity could be obtained through several efforts to adjust the existing working conditions with the capacity of employees to create the working conditions healthy, safe, comfortable, effective, and efficient (Manuaba, 2000; 2001; 2005).

Total ergonomic approach is one model of ergonomics approach that is used in working conditions improvement by considering a systemic, holistic, and interdisciplinary and participation approach (SHIP) in combination with appropriate technology (AP) criteria such as: technically sound, economically sound, ergonomically sound, socio-culture aspects, efficient energy use, and preserving the environment. So, combination of both SHIP approach and AP in implementation of working conditions improvement is known as total ergonomic approach (Manuaba, 2004, 2006a, 2006b).

Application of total ergonomic approach on small scale industries can be implemented through various stages, during the planning, the implementation, as well as the evaluation stages. The implementation of total ergonomic approach in small scale industries begin with an introduction speech, workshops, dissemination and adaptation, and evaluation (Manuaba, 2006b). The steps should be implemented as follows. (a) Preparation, which is done to communicate with employees, employers and other stakeholders to make a schedule and list of participants in the program; (b) Introduction speech on site about ergonomic working conditions; (c) Workshops of working condition improvements, then following these stages: (1) identify the problem, (2) make a priority, (3) make a positive sentence, (4) analysis of strength, weakness, benefits, risk (SWBR), (5) make a strategic plan, (6) make an action plan. (d) Dissemination and adaptation of improvement plan; (e) Evaluation after improvement.

## Methods

The experiment was conducted with metal crafters at Kediri Tabanan on February - March 2007.

This experimental research was designed as treatment by subject. Samples were selected from metal crafters, especially in the painting department at Kediri Tabanan, Bali who meet the criteria. There were 23 people, who were chosen by random sampling using random numbers.

Measurement of research subjects was done to get data base, scores of fatigue before and after working condition improvement. The improvement process according the total ergonomic approach follows these steps: (1) participants selection who should participate in the introduction speech and workshops other than the subjects themselves; (2) introduction speech was given to provide information about ergonomic working conditions; (3) workshop was held to find the best solutions in working condition improvement. Stages of workshop was conducted through identifying problems, prioritize issues, create positive sentences, internal and external analysis, making work plans and action plans, and (4) implement an action plan after the process of dissemination and adaptation.

Impact of improved working conditions in the form of fatigue was assessed qualitatively and quantitatively. The assessment were done before and after improvement of working condition using modified 30 item questionnaire of fatigue (Sutjana & Sutajaya, 2000). Respondents were asked to fill in all the questions by putting a check on the scale of perceived fatigue. The higher the score of the selected items shows the higher level of fatigue. Fatigue scores of employees who were assessed using the modified questionnaire showed levels of fatigue at the end of work. Analysis of fatigue's quality is calculated by accumulating the scores of each question from the 30 items perceived fatigue and compared the before and after improvement using Statistical Package for the Social Sciences (SPSS) 13.0.

## Results and Discussion

### Basic Data

Metal craft paint industry at Kediri Tabanan has 46 employees who work daily or according to contracted work agreement. Research subjects were selected from the population who has charac-

Table 1  
*Characteristics of Metal Crafters of Painting Industry at Kediri Tabanan*

| No | Parameter                  | Mean  | Standard deviation |
|----|----------------------------|-------|--------------------|
| 1. | Age (years)                | 28.2  | 9.2                |
| 2. | Systolic (mmHg)            | 115.2 | 8.5                |
| 3. | Diastolic (mmHg)           | 76.5  | 8.3                |
| 4. | Rest pulse (beats/minutes) | 77.7  | 8.5                |
| 5. | Body weight (kg)           | 51.70 | 7.0                |
| 6. | Body height (cm)           | 154.6 | 4.1                |
| 7. | Body mass index            | 21.4  | 2.7                |

Table 2  
*Working Environment of Metal Craft Painting Industry at Kediri Tabanan*

| Parameter            | Min   | Max   | Mean  | SD    |
|----------------------|-------|-------|-------|-------|
| Wet temperature (°C) | 24.50 | 26.00 | 25.08 | 0.49  |
| Dry temperature (°C) | 28.50 | 30.00 | 28.92 | 0.66  |
| Humidity (%)         | 70 %  | 80 %  |       |       |
| Desk lighthing (lx)  | 8.00  | 49.00 | 29.83 | 14.33 |
| Noise (db)           | 73.60 | 91.30 | 81.27 | 6.28  |

teristics as shown in Table 1. All of the subjects were healthy based on physical examination and body mass index. These conditions enable employees to work optimally according to their ordered tasks to paint various models of metal craft.

Environmental conditions of employee reveals a workshop partially open and located in rural environment. Characteristic of environmental conditions of employee was described in Table 2. The existing environmental condition was comfortable, so the employee can work optimally. Environmental conditions before and after treatment was controlled in the same condition, so it does not affect the

#### **Results of total ergonomic approach implementation at metal craft paint industry.**

Results of working conditions improvement can be evaluated through the attendance of participants. The introduction speech before workshops was fully appreciated by the employers, employees and other stake holders. This was recorded in the list of attendance of participants in accordance with the invitation that was submitted. During the workshop all participants were attending the workshop until finished. This showed the commitment

of all participants in the workshop. Through the participation approach, all participants were encouraged to produce the following things:

- a. identification of problems faced in metal craft painting industry, which were noted as 49 negative sentences. The problems posed are grouped into (i) 18 urgent problems; (ii) 12 important problems; and (iii) 11 essential problems;
- b. changes from negative to positive sentences;
- c. analysis of internal and external factor could indentify strengths, weaknesses, benefits and potential risks;
- d. ten work plans for work condition improvement;
- e. five action plans made in the form of the matrix by (1) what has been done, (2) why was it done, (3) who should do, (4) when would it be done, (5) where should it be performed: (6) how much cost is required, (7) how to implement, and (8) should have legal clearance;
- f. dissemination and adaptation of action plans; and
- g. evaluation of the implementation of action plans.

The usage of total ergonomic approach has become a new model in improving working conditions. This approach has already been applied in

several industries in other countries (Kogi, 2006). The approach that has been implemented usually integrate the various aspects and ask for participation, thus supporting the concept of social engineering in the design of working conditions especially using appropriate technology. Total ergonomic approach was similar to the approach that had been taken in small and large industries in other countries (Carayon, 2006; Vink, 2006). In the same way, total ergonomic approach has been applied in other fields of human activity such as education (Sutajaya, 2005). This condition is caused by flexibility of the total ergonomic approach when applied in small industries and households, as well as in large industries.

#### **Impact of Improved Working Conditions for Employee's Fatigue**

Implementation of action plans through dissemination and adaptation will affect the working conditions of metal craft painting industry. Impact of improvement on fatigue was decreasing fatigue quality of employees as indicated by scores of fatigue, before and after improvement. Before the improvement was implemented, scores of fatigue was greater than the score of fatigue after improvement (see Table 3).

#### **Fatigue Test Differences Before and After Improvement of Work Conditions**

To determine the effect of improved working conditions using total ergonomic approach towards the quality of fatigue, the mean different test of

paired samples was done on the mean of fatigue scores, with the t-test. Test results of mean difference scores of fatigue between before and after improvement are shown at Table 4. General fatigue, physical fatigue and activity fatigue decreased significantly after improvement ( $p < 0.005$ ), whereas motivation fatigue decreased not significantly ( $p > 0.005$ ).

Effect of improved working conditions on metal crafters at painting industry is the reduction of (1) general fatigue  $(37.9 - 34.7) / 34.7 = 9.22\%$  ( $p < 0.05$ ), (2) activity fatigue  $(13.5 - 11.9) / 11.9 = 13.45\%$  ( $p < 0.05$ ), motivation fatigue  $(11.7 - 11.1) / 11.1 = 5.41\%$  ( $p > 0.05$ ) and physical fatigue  $(13.4 - 11.7) / 11.7 = 14.53\%$  ( $p < 0.05$ ). Qualitatively the decrease was reflected in physical and activity fatigue, while motivation fatigue did not show any significant decrease. Weakening of the perceived decrease in physical and activity qualitatively were of the feeling of heaviness in the head, tired of the whole body, weight on the legs, yawning, confused thoughts, drowsiness, strain in the eye, awkward and clumsy movements, unstable standing, desire to lie, headache, shoulder stiffness, back pain, shortness of breath, thirsty, hoarseness, feeling dizzy, eyelid spasm, limbs tremors, unwell feelings. Perceived quality score of 3 and 4 (moderate and severe) were decreased to score of 1 and 2 (not at all and mild). While the motivation fatigue was not significantly decreased ( $p > 0.05$ ) such as concentration, perseverance, confidence and a sense of anxiety, because the perceived quality is only somewhat mild and none.

**Table 3**  
*Scores of Fatigue of Metal Crafters at Painting Industry at Kediri, Tabanan*

| No | Parameter          | Improvement | Mean | Standard Deviation |
|----|--------------------|-------------|------|--------------------|
| 1. | General fatigue    | Before      | 37.9 | 5.7                |
|    |                    | After       | 34.7 | 5.3                |
| 2. | Activity fatigue   | Before      | 13.5 | 1.9                |
|    |                    | After       | 11.9 | 1.9                |
| 3. | Motivation fatigue | Before      | 11.7 | 1.9                |
|    |                    | After       | 11.1 | 2.1                |
| 4. | Physical fatigue   | Before      | 13.4 | 1.6                |
|    |                    | After       | 11.7 | 1.7                |

Table 4  
*Mean Difference Test Before and After Working Conditions Improvement Through Total Ergonomic Approach on Metal Crafters Painting Industry at Kediri Tabanan*

| No | Variable           | Mean   |       | Mean differences | t     | p     |
|----|--------------------|--------|-------|------------------|-------|-------|
|    |                    | Before | After |                  |       |       |
| 1. | General fatigue    | 37.9   | 34.7  | 3.2478           | 2.906 | 0.008 |
| 2. | Activity fatigue   | 13.5   | 11.9  | 1.5261           | 3.573 | 0.002 |
| 3. | Moviation fatigue  | 11.7   | 11.1  | 0.6478           | 1.910 | 0.069 |
| 4. | Physysical fatigue | 13.4   | 11.7  | 1.7435           | 3.544 | 0.002 |

In terms of quantity, activity fatigue of employees between before and after treatment showed a decrease. Severe complaints in the head decreased from 26.8% to 23.7%. Fatigue feeling of the whole body decreased from 48.7% before treatment to 43% after treatment. The urge to yawn was recorded 35.7% before treatment and decreased to 21.3% after treatment. Feeling sleepy decreased from 38.4% to 36.3% and desire to lying down decreased from 37.3% to 28.1%.

Physical fatigue showed a decrease in quantity. Thirst feeling before improvement was 49.4% slightly thirsty, 15.7% thirsty and 5.7% very thirsty. Feelings of thirst was due to high humidity in the workplace thus speeding up the rate of evaporation through the skin. After improvement, the complaint of thirst decreases to 35.5% slightly thirsty and 3.7% no thirsty. So the thirst decreased from 70.7% to 39.3%.

Feelings of headache decreased from 39% to 23.7%, as well as fatigue in the shoulder and back pain decreased from 54.2% to 33.7% in the shoulder and decreased backpain from 36.2% to 33.7%.. Feeling dizzy and unwell complained by employees decreased from 27% to 17.8%.

By using total ergonomic approach, the working conditions changed into optimal, thus decreasing the quality of employee fatigue, although only on physical and activity fatigue, while motivation fatigue was not significantly changed. This shows that the painting job causes more physical fatigue as a whole compared to employee motivation. Motivation was not fatigue so much because their wages are calculated based on the amount of product produced.

### Conclusion

It was concluded that total ergonomic approach can reduce quality of fatigue, especially reducing the level of activity and physical fatigue significantly ( $p < 0.05$ ), while motivation fatigue did not decrease significantly ( $p > 0.05$ ). This is because the task performed cause more physically fatigue, while employee motivation did not show so much fatigue decline because their wages are calculated based on the amount of product produced. It was suggested that total ergonomic approach should be continued because it can reduce the quality of physical and activity fatigue and capable of maintaining employee motivation during implementation of the task.

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(Appendix follow)

## Appendix

### Fatigue Questionnaire (modified)

Checklist of fatigue of industrial workers comprising 30 items, designed by the Industrial Fatigue Research Committee of Japanese Association of Industrial Health in 1977, by checking as follows: **A** (not at all), **B** (mild), **C** (moderate), **D** (severe). (Yoshitake, 1971).

#### A : (1-10)

1. Do you feel heavy in the head?
2. Does your whole body feel tired?
3. Do you feel your legs are heavy?
4. Do you yawn frequently?
5. Do you feel confused?"?
6. Do you feel drowsy?
7. Do you feel your eyes strained?
8. Do you feel rigid or clumsy in motion?
9. Do you feel unsteady while standing?
10. Do you feel a desire to lie down?

#### B: (11-20)

11. Do you have difficulty in thinking?
12. Do you feel tired to talk?
13. Are you becoming nervous?
14. Are you unable to concentrate?
15. Are you unable to focus your attention?
16. Do you have a tendency to forget easily?
17. Do you have a lack of self-confidence?
18. Are you anxious about something?
19. Are you unable to control your attitude?
20. Are you unable to be diligent in work?

#### C: (21-30)

21. Do you feel a headache?
22. Do you still feel stiffness in the shoulders?
23. Do you feel pain in the waist?
24. Do you feel constrained in breathing
25. Do you feel thirsty?
26. Do you feel husky in your voice?
27. Do you feel dizzy?
28. Do you feel a spasm of the eyelids?
29. Do you feel a tremor in your limbs?
30. Do you feel unhealthy?