P-ISSN 2586-9000
E-ISSN 2586-9027
Homepage : https://tci-thaijo.org/index.php/SciTechAsia
Science & Technology Asia
Vol.26 No.2 April - June 2021
Page: [46-60]
Original research article

A Systematic Approach to the Implementation of Ergonomics Culture in the Large-Sized Manufacturing Industry

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Received 9 December 2019; Received in revised form 5 August 2020
Accepted 5 November 2020; Available online 25 June 2021

ABSTRACT

Building an ergonomics culture helps the company reduce work-related musculoskeletal disorder problems. This study identifies five key factors, namely, Leadership, Policy and Strategy, People, Resources, and Processes, and their 29 attributes to enhance the ergonomics culture in the large-sized manufacturing industry. Five key factors are assigned and adjusted with the criterion weights in this study, with a total score of 1000 points. An ergonomics culture maturity level is established with a total of six maturity levels so that an organization can assess its current maturity level, and plan for the improvement to progress through to higher levels of maturity. A case study is presented to illustrate an action plan used to enhance the ergonomics culture maturity level in a large-sized manufacturing company. It is expected that other large-sized manufacturing companies can use the study results to better understand key factors and maturity levels, and effectively plan for the ergonomics culture enhancement.

Keywords: EFQM excellence model; Ergonomics culture; Maturity level; Large-sized manufacturing company

1. Introduction

The large-sized manufacturing industry is considered one of the building blocks at every level of the production and consumption in agriculture, construction, manufacturing, and services industries [1]. It plays a significant role in Thailand's economic growth, and accounts for about 80% of the country's annual expansion of GDP [2]. Most manufactured products are export items, bringing a tremendous amount of income to the country each year. Major industries include textile and garment, agricultural processing, beverage, cement, electric appliances, computer and parts, plastics, and automotive parts. The GDP of the industry is expected to grow by around 9% this year and 13% by the end of 2022 [3].

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The industry, however, has experienced an increasing number of accidents and injuries, including the ergonomic-related problems. The number of workers in manufacturing making claims for severe occupational injuries was the largest among all industrial categories [4]. Around 17 out of 1000 workers are reported with incident cases. Moreover, a maximum of one-half of the total industry cost comes from the compensation and medical and service-related expenses [2]. WorksafeBC [5] claimed that most of the serious injuries and the longest short-term disability duration claims in large-sized manufacturing companies come from the poor ergonomics culture. Despite provisions made in various legislation about compliance with the health and safety of the workforce, many employers still do not comply, and are not changing the way the activities are carried out. It was argued that some of the unfavorable ergonomic challenges, such as repetitive and awkward work routines, might lead to strains, sprains, musculoskeletal disorders and carpal tunnel syndrome. These problems could contribute to absenteeism and reduced work productivity [6]. A better understanding of ergonomics culture will help companies control and reduce their costs, and improve their overall occupational health and safety performance.

Ergonomics is applied in many industries. Helander [7] studied the ergonomic improvement at the IBM plant in Austin, Texas, and listed several improvements, such as, installation of special lighting for inspection, job rotation to avoid monotony, improved communication, material handling guidelines, housekeeping, and noise reduction. Krajewski et al. [8] investigated the implementation of an ergonomics process designed to identify and reduce exposures to ergonomics risk factors found in a US coal mine. The company applied ergonomics knowledge and awareness to other functions, such as, purchasing equipment, implementing new procedures, and developing new training. Klangsin [9] studied the effect of ergonomics intervention on physical symptoms and work performance in Thai workers at the production department of a cardboard box factory. The results showed that ergonomics intervention significantly reduced symptoms even when the workload remained the same.

This research aims at developing a systematic approach to the implementation of ergonomics culture in the large-sized manufacturing industry by adopting the European Foundation for Quality Management (EFQM) Excellence model as a basic model. Criterion weight of each key factor is assigned and adjusted to be used to measure the ergonomics culture score. Six ergonomics culture maturity levels are used to assess the current level of maturity of a case study company, so that it can plan for the ergonomics culture improvement to achieve higher maturity levels.

2. Materials and Methods

2.1 Conceptual model of ergonomics culture

There are many ways to apply ergonomics in the manufacturing environment. One approach that addresses ergonomics at all levels of an organization is to grow an "ergonomics culture" [10]. To create an ergonomics culture, the organization must look into four major elements, including human, equipment, environment, and task, and recognize that all of these elements interact and affect the system output (i.e. productivity and performance efficiency). Lardner [11], for example, mentioned that the goal of the science of ergonomics is to find the best fit between workers and job conditions. To maintain a good ergonomics condition, it is suggested that the companies supply appropriate equipment for specific tasks [12].

Leadership is also a key factor to build the ergonomics culture by, for example, encouraging more two-way communication on how to build the ergonomics culture,

involving in any ergonomics- related activities, and setting up financial policies to support the ergonomics-related activities and resources [11-13].

2.2 Five factors of the conceptual model of ergonomics culture

To create a positive ergonomics culture, this research utilizes the EFQM Excellence model as a basic model since it has a positive effect on the organizational performance [14]. In this study, an ergonomics culture model is developed based on an assumption that by improving how the organization operates, there will be an improvement in the results. Therefore, the focus of the study is mainly on the improvement of the five factors, in expectation of achieving better results, as shown in Fig. 1. Each factor is assigned with a criterion weight (as shown in the number of points). Details of the criterion weight are explained in the next section.

The model assumes that leadership drives people management, policy and strategy, as well as resources, and that these three factors collectively influence an ability to achieve the results through the implementation and improvement of suitable processes [14]. Each factor comprises a number of attributes extracted from a number of safety-and-ergonomics-related literatures to explain its construct.

- Leadership: Leadership commitment is crucial in developing a positive ergonomics culture. It is associated with eight attributes: (1) management commitment, (2) two-way communication, (3) accountability, (4) role model, (5) supportive environment, (6) quick response, (7) perceptions of ergonomics, and (8) ergonomics initiatives.
- Policy and Strategy: Clear ergonomics policies, plans, objectives, targets, and processes are required to support the implementation of the ergonomics program. This factor consists of three attributes: (1) reward and recognition, (2) alignment of ergonomics, and (3) clear ergonomics rules.
- People: Nine attributes are associated with this factor: (1) empowerment, (2) adequate supervision, (3) workers' involvement, (4) workers' relationships, (5) ergonomics-related training, (6) compliance to ergonomics rules, (7) workload, (8) work pressure, and (9) feedback.
- Resources: An organization needs to manage its resources to support its policies and strategies of its ergonomics-related processes. Three attributes associated with this factor are: (1) financial resources, (2) ergonomically designed equipment, and (3) ergonomics-related information.
- Processes: An organization should design, manage, and improve its processes to support its ergonomics-related policies and strategies. This factor consists of six attributes: (1) training processes, (2) risk assessment, (3) injury/illness investigation, (4) no-blame culture, (5) audit, and (6) documentation.

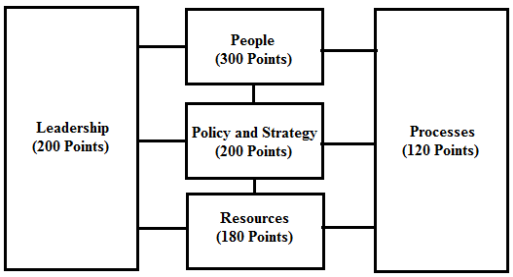

Fig. 1. The proposed ergonomics culture model.

2.3 Criterion weight of the five key factors

Criterion weight is an important part of the model. Many researchers report different distributions to the factors and results. EFQM [15], for example, allocating 500 points to the factors as follows: 100 points to Leadership, 90 points to People, 80 points to Policy and Strategy, 90 points to Resources, and 140 points to Processes. Eskildsen et al. [16], on the other hand, allocated 700 points to the factors, i.e., 144, 135, 144, 136, and 164 points to Leadership, People, Policy and Strategy, Resources, and Processes, respectively. Tavana et al. [17] divided 1,000 points into 213, 197, 208, 193, and 189 points for Leadership, People, Policy and Strategy, Resources, and Processes, respectively.

In view of the score diversity, this study allocates 1,000 points to the five factors as shown in Fig. 1.

2.4 Ergonomics culture maturity levels

To be able to assess the level of ergonomics culture maturity and advance to higher levels, an ergonomics culture maturity level is needed. There are two important parts of the maturity level, i.e., number of levels and score range in each level. Many researchers report different guidelines for scoring each level. Ahmed et al. [18], for example, proposed seven maturity levels with a total score of 1,000 points. The score range of each level is 150, 150, 200, 150, 200, 149, and 1 points, respectively. Tervonen et al. [19], in contrast, allocated 1,000 points to six maturity levels with the score ranges of 150, 100, 200, 200, 150, and 200 points, respectively. Mohamed and Chinda [20] divided 1,000 points into five levels, with equal scores of 200 points in each level.

Based on the above diversity, the organization, together with its management team, should discuss and adjust the number of maturity levels and score ranges in individual levels so that they reflect the real practices of the organization. In this study, a total of six levels of ergonomics culture maturity are adopted and adjusted based on the comments from management team in the case study (see Fig. 2).

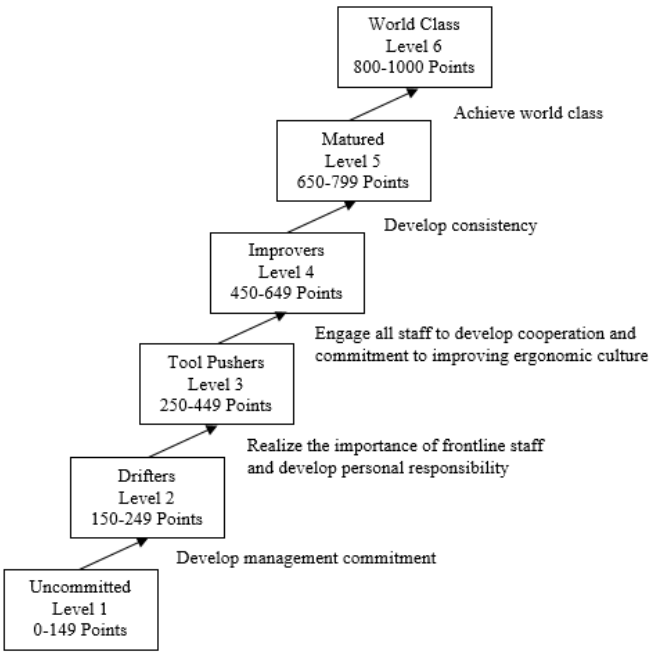

Fig. 2. Six levels of ergonomics culture maturity used in the case study.

2.5 Systematic approach to the ergonomics culture implementation

The ergonomics culture implementation approach consists of three steps as follows:

1) Assessment of the current maturity level - This step is intended to evaluate the aforementioned five factors of the ergonomics culture model for the organization. The evaluation method can be accomplished using a questionnaire survey. As a result, the maturity level of the five key factors can be determined.
2) Development of an action plan to enhance the ergonomics culture - This second step helps the organization to develop an appropriate action plan to improve the five factors of the ergonomics culture model. Typically, the action plan can be divided into two consecutive periods (with the period length of 3 to 6 months) that focus on the weak factors of the model. Firstly, important attributes of the weak factors (based on the maturity scores) are improved. Next, the remaining weak factors are subsequently improved.
3) Post-implementation assessment - The third step is a follow-up assessment of the factors of the ergonomics culture model, which can be performed at a regular interval, such as, every 3 or 6 months. As a result, the post-implementation assessment can overlap with the action plan. The same questionnaire used in the first step is normally used in this step.

The following sub-sections describe the above three steps in detail.

2.5.1 Step 1: Assessment of the current ergonomics culture maturity level

To measure the current ergonomics culture maturity level and plan for improvement, each attribute of the five factors is assessed using a 5-point Likert scale, from 1 = strongly disagree to 5 = strongly agree. The 5-point Likert scale is commonly used in research studies, such as those in manufacturing, safety, and ergonomics [21-23]. Target respondents should be in both lower and higher levels to gain mixed perceptions of current ergonomics practices in the organization. Respondents give their opinions on each attribute. The mean score of each attribute is then calculated. Subsequently, the total score of each factor is determined by summing the mean scores of its associated attributes.

The total score of each factor is adjusted to match with its criterion weight (see Fig. 2). The final total score by weight is determined by summing the total scores by weight of the five factors. This final total score is then evaluated with the ergonomics culture maturity level, adjusted by the company, to determine its current level of maturity. An ergonomics culture assessment form is shown in Table 1.

2.5.2 Step 2: Development of an action plan to enhance the ergonomics culture

The ergonomics culture maturity level evaluated from the ergonomics assessment form (see Table 1) represents the current status of ergonomics practices in the organization. To improve the ergonomics culture and progress through to higher maturity levels, the organization should focus on the factor having the lowest score (as represented by the lowest percentage) among the five factors. The action plan should be built based on the attributes in the weak factor to increase the score of that factor, as well as the ergonomics total score. The action plan could be divided into two periods, 3 to 6 months each, to prioritize the activities to be implemented to enhance the total score. The proposed action plan for the improvement of the five factors is as below.

2.5.2.1 Leadership factor

The action plan to improve the Leadership score should focus on the following six attributes:

- Management commitment: Top management sets up an executive

meeting, focused on creating a positive ergonomics culture, and emphasizes the benefits of having a positive ergonomics culture in the organization.

- Two-way communication: To create a positive ergonomics culture, it is important that the opinions from top and bottom level employees be heard. Employees must be provided with a number of channels to communicate with top management, such as email and suggestion boxes.
- Accountability: Management assigns appropriate ergonomics responsibility to employees, and proactively monitors the performance.

Table 1. An ergonomics culture assessment form.

Factor and attribute	Score	Max score	Max weight score	Adjusted score	% achieved
Leadership					
Management commitment		5			
Two-way communication		5			
Accountability		5			
Role model		5			
Supportive environment		5			
Quick response		5			
Perceptions of ergonomics		5			
Ergonomics initiatives		5			
Total Leadership score		**40**	**200**		
Policy and Strategy					
Reward and recognition		5			
Alignment of ergonomics		5			
Clear ergonomics rules		5			
Total Policy and Strategy score		**15**	**200**		
People					
Empowerment		5			
Adequate supervision		5			
Workers' involvement		5			
Workers' relationships		5			
Ergonomics-related training		5			
Compliance to ergonomics rules		5			
Workload		5			
Work pressure		5			
Feedback		5			
Total People score		**45**	**300**		
Resources					
Financial resources		5			
Ergonomically designed equipment		5			
Ergonomics-related information		5			
Total Resources score		**15**	**180**		
Processes					
Risk assessment		5			
Accident investigation		5			
Training processes		5			
No-blame culture		5			
Audit		5			
Documentation		5			
Total Processes score		**30**	**120**		
Adjusted total score			**1000**		
Ergonomics culture maturity level		☐ Level 1 (0-149 points) ☐ Level 2 (150-249 points) ☐ Level 3 (250-449 points) ☐ Level 4 (450-649 points) ☐ Level 5 (650-799 points) ☐ Level 6 (800-1000 points)			

- Role model: For employees to have a positive perception of ergonomics, it is important that their managers be a role model on the ergonomics implementation.
- Supportive environment: Management sets up a team to work on the ergonomics culture project and support the implementation of ergonomics throughout the entire company.
- Quick response: Managers have quick responses and actions to the suggestions for ergonomics improvement, and communicate these actions throughout the organization.

2.5.2.2 Policy and strategy factor

The action plan to improve the Policy and Strategy score should focus on the following four attributes:

- Reward and recognition: Employees with good ergonomics awareness and behaviour receive tokens at the end of the year. They are also recognized by having their names posted on the information boards and the company's web board.
- Alignment of ergonomics: Efforts and support given to implementing the ergonomics program should be the same as those for other projects.
- Clear ergonomics rules: An ergonomics expert is requested to approve the ergonomics rules prior to their enforcement. Rules must be clear and detail the punishments for those who do not follow.
- Ergonomics initiatives: An ergonomics contest is initiated to encourage employees to participate in the ergonomics implementation.

2.5.2.3 People factor

To improve the People score, the organization should focus on the following nine action plans:

- Empowerment: Employees are empowered according to their ergonomics responsibility, so that they can make decisions on ergonomics-related matters.
- Perceptions of ergonomics: Benefits of having a positive ergonomics culture, in terms of individuals and organization, must be communicated to all employees through, for example, emails and circulated mails.
- Workers' involvement: Workers are given the opportunity to provide input into the design and implementation of ergonomics programs, such as being a member of the ergonomics committee, reporting incidents to supervisors, and identifying training needs.
- Workers' relationships: Ergonomics day is created, with a number of ergonomics related activities, to improve the relationships among employees, both within and between departments.
- Ergonomics related training: Employees in each department receive precise ergonomics related training specific to their jobs.
- Compliance to ergonomics rules: A representative from each department is selected to monitor the ergonomics implementation and report to the supervisor.
- Adequate supervision: Supervisors work closely with the representatives from each department to support and control all activities to ensure the successful implementation of ergonomics culture.
- Work pressure: Workload must be reasonably balanced to avoid high work pressure. Recreation corners are also provided for employees during the shift break.
- Workload: High workload is likely to increase fatigue and unsafe acts. Adequate staff must be assigned to perform work safely.

2.5.2.4 Resources factor

To improve the Resources score, the organization should focus on the following three action plans:

- Financial resources: Financial support is given to acquire the ergonomically designed equipment and distribute ergonomics related information.
- Ergonomically designed equipment: Specific equipment, such as ergonomic chairs, hand supporters, and back supporters, are provided to needy employees to encourage the ergonomics implementation.
- Ergonomics related information: Useful information about the ergonomics implementation is posted on the web board. Comments and suggestions are also posted to enhance the communication. Video clips are shown at lunch and break times to enhance a positive contribution of ergonomics.

2.5.2.5 Processes factor

The action plan to improve the Processes score should focus on the following seven attributes:

- Training processes: Daily exercise and specific training of ergonomics are planned for each department in the organization. Every employee is involved in the daily training, and each of them must, at least once, lead the ergonomics exercising.
- Risk assessment: Ergonomics risk assessment is performed regularly.
- Injury/ illness investigation: Causes of injuries and illnesses are investigated, and preventive methods are proposed.
- Feedback: Employees are encouraged to give feedback on ergonomics matters through a number of channels, such as, opinion boxes and web mails.
- No-blame culture: An organization adopts a no-blame culture in which workers feel that they are fairly treated and are not blamed when they report ergonomics issues.
- Audit: A benchmark system is utilized in the auditing process to plan for the ergonomics improvement.
- Documentation: Risk plans, site accident logbooks, and minutes of the ergonomics meetings are documented and used for the ergonomics improvement plan.

2.5.3 Step 3: Post-implementation assessment

The action plan, emphasizing specifically in the areas listed in the weak factors, is implemented to improve the ergonomics culture maturity level. Post-implementation assessment is then performed on a regular basis, for example, every 3 months, every 6 months, or annually. The ergonomics culture maturity level is also re-evaluated using the ergonomics assessment form (see Table 1) to progress to higher maturity levels.

3. Results and Discussion

3.1 Data collection

A case study is conducted with a large-sized manufacturing company, with almost 1500 staff, located in Rayong Province, Thailand. It is a global enterprise with core competencies in the life science fields of health care and agriculture. Major businesses in Thailand are under its divisions of pharmaceuticals, consumer health, and crop science.

The company has a total of nine departments, which involve activities that can cause ergonomic-related problems, such as lifting, bending, pushing, and repetitive work. This results in a high amount of compensation cost, leaves, and turnover rate in the company. The laboratory department, for example, has the highest claims of muscle pain from repetitive work, while workers in the Film Processing department experience spinal problems from bending and lifting.

Managers, supervisors, and workers participated in the project. The company, together with its management team, discussed the ergonomics culture maturity levels, and adjusted the number of maturity levels and the score-range in each level to

reflect real practices of the company, as illustrated in Fig. 2.

3.2 Step 1: Results of an assessment of the current ergonomics eulture maturity level

A total of 1,200 questionnaires were sent to staff, supervisors, and managers through email, with 418 responses, representing a 34.8% response rate. The analysis was performed, and the assessment results are as shown in Table 2. The results showed that the attributes with the highest mean score were "management commitment" and "no-blame culture" attributes, while "work pressure" was the attribute with the lowest mean. The company was currently in the fourth level of the ergonomics culture maturity. The People factor and the Resources factor were found to have the lowest total scores among the five factors, respectively. To plan for the ergonomics culture improvement, the action plans that focus on the above two factors were initiated.

3.3 Step 2: Action plans to enhance the ergonomics culture maturity

The company divided the action plans to improve the ergonomics culture into two 3-month periods.

3.3.1 The first period plan

The first period plan focused mainly on the improvement of the weak attributes of the two factors, including the People and Resources factors. The action plan for the first period is listed below:

- To improve the "work pressure" score: The sport corner, book corner, and internet corner were provided for employees.
- To improve the "ergonomics-related training" score: The Film Processing department, representing a pilot department, defined specific ergonomics training needed for the department. Employees in the department were also requested to attend the training to improve their understanding of ergonomics.
- To improve the "compliance to ergonomics rules" score: The Community of Practice (CoP) representative from each department was selected to monitor and assist in the ergonomics implementation.
- To improve the "adequate supervision" score: Supervisors must work closely with their CoP representatives to ensure the ergonomics implementation.
- To improve the "workers' involvement" score: Employees participated in ergonomics activities on the Safety Day. They were also asked to participate in the Exercise Video Clip Contest.
- To improve the "ergonomically designed equipment" score: Appropriate mouse pads with palm rest were purchased and provided to office employees. Back supports were purchased and provided to employees working in the Film Processing department, as employees were often required to bend and lift the film products. The correct use of such back supports was also explained. Ergonomic chairs with adjustable seat height and backrest angle were purchased and provided to employees working in the control room.
- To improve the " ergonomics- related information" score: An ergonomics web board was set up to share the ergonomics-related information. The CoP team was also set up to communicate ergonomics activities to every department.

3.3.2 The second period plan

The second period plan continued the implementation of the first period plan, and improved the weak attributes of the other three factors, including the Policy and Strategy, Processes, and Leadership factors.

Table 2. Ergonomics culture assessment results.

Factor and attribute	First assessment			Second assessment		
	Score	Adjusted score	% achieved	Score	Adjusted score	% achieved
Leadership						
Management commitment	3.6			3.7		
Two-way communication	3.5			3.6		
Accountability	3.5			3.6		
Role model	3.3			3.5		
Supportive environment	3.3			3.4		
Quick response	3.3			3.5		
Perceptions of ergonomics	3.5			3.6		
Ergonomics initiatives	3.5			3.5		
Total Leadership score	**27.5**	**(200x27.5)/40=137.50**	**68.75**	**28.2**	**(200x28.2)/40=141.20**	**70.60**
Policy and Strategy						
Reward and recognition	3.2			3.3		
Alignment of ergonomics	3.3			3.4		
Clear ergonomics rules	3.2			3.3		
Total Policy and Strategy score	**9.7**	**(200x9.7)/15=129.30**	**64.70**	**10.0**	**(200x10.0)/15=133.20**	**66.60**
People						
Empowerment	3.4			3.5		
Adequate supervision	3.2			3.3		
Workers' involvement	3.3			3.4		
Workers' relationships	3.1			3.3		
Ergonomics-related training	3.0			3.2		
Compliance to ergonomics rules	2.9			3.1		
Workload	3.0			3.1		
Work pressure	3.1			3.2		
Feedback	3.0			3.4		
Total People score	**28.0**	**(300x28)/45=186.67**	**62.22**	**29.4**	**(300x29.4)/45=195.70**	**65.20**
Resources						
Financial resources	3.2			3.3		
Ergonomically designed equipment	3.0			3.3		
Ergonomics-related information	3.0			3.2		
Total Resources score	**9.2**	**(180x9.2)/15=110.10**	**61.30**	**9.8**	**(180x9.8)/15=117.40**	**65.20**
Processes						
Risk assessment	3.4			3.5		
Accident investigation	3.3			3.4		
Training processes	3.4			3.4		
No-blame culture	3.4			3.6		
Audit	3.5			3.4		
Documentation	3.2			3.3		
Total Processes score	**20.2**	**(120x20.2)/30=80.80**	**67.30**	**20.6**	**(120x20.6)/30=82.40**	**68.70**
Adjusted total score		**644.70**	**64.47**		**669.90**	**66.99**
Ergonomics culture maturity level		Level 1 (0-149 points) Level 2 (150-249 points) Level 3 (250-449 points) Level 4 (450-649 points) Level 5 (650-799 points) Level 6 (800-1000 points)			Level 1 (0-149 points) Level 2 (150-249 points) Level 3 (250-449 points) Level 4 (450-649 points) Level 5 (650-799 points) Level 6 (800-1000 points)	

- To improve the "clear ergonomics rules" score: An ergonomics expert was asked to comment and clarify ergonomics rules to be used at the Film Processing department (pilot department) to ensure practical implementation. The approved rules were documented to be used as a guideline for the implementation.
- To improve the "reward and recognition" score: Employees with good ergonomics awareness and behaviour were recognized and awarded tokens by the company.

- To improve the "documentation" score: Updated ergonomics-related information (e.g., upcoming ergonomics-related training) was posted on the information boards and the web board.
- To improve the "supportive environment" score: Management participated in the meeting and approved the requested equipment and specific training.

The aforementioned action plans are summarized in Tables 3 and 4.

3.4 Step 3: Post-implementation assessment results

After 6 months of the ergonomics culture implementation, following the action plans listed in the two periods, a post-implementation assessment was performed to assess the ergonomics culture maturity level. A total of 418 questionnaires were launched to staff, supervisors, and managers who participated in the first period plan. A total of 369 responses were received, representing 88.3% of the total survey. The results (see Table 2) showed that the company progressed from level 4 to 5 of the culture maturity, thus confirming the effectiveness of the action plans.

However, some employees commented on the action plans on the following issues.

- Employees in the Film Processing department commented that the nature of work in their department was not quite related to the ergonomics implementation. An investment in labour-saving machines was instead needed.
- Not many employees visited the ergonomics web-board as there were many web boards in the company.
- Only office employees participated in ergonomics activities. Most of the shift workers focused only on getting their job done.
- The CoP team found that some ergonomics-related problems were specific, and that it took time to find the answers.
- The ergonomics knowledge of the representatives from each department was still limited.
- Continuous improvement of the ergonomics implementation was not mentioned after the end of the project.

Based on the above comments, it is recommended that the company continue the implementation program. Moral support is also needed from management to progress through to higher maturity levels.

4. Conclusion

An ergonomics culture is important in the large-sized manufacturing industry to reduce the number of ergonomics-related problems. This study utilizes the EFQM Excellence model, an international quality management model, to assess the maturity level of an ergonomics culture. Five key factors are used to assess ergonomics culture in this study, including Leadership, Policy and Strategy, People, Resources, and Processes factors. Each factor is assigned with its criterion weight, adopted in this study, with a total score of 1000 points. Six ergonomics culture maturity levels are applied to be used to assess current maturity level of the company, and plan for the improvement to progress through to higher levels of maturity.

A case study is then performed in a large-sized manufacturing company in Thailand. The results show that the People and Resources factors had the lowest total scores among the five factors. As a result, the action plan was set mainly based on these two factors. It is found that, after 6 months of the implementation, the case study company progressed from level 4 to level 5 of maturity. In addition, there was useful feedback from the implementation that the company could use in order to help to improve its ergonomics culture.

Generally, this research contributes to the large-sized manufacturing industry as a whole in the following ways. The five key factors, namely the Leadership, Policy and

Table 3. Action plan for the first period.

Factor	Attribute	Action plan	Result	Success
People	Work pressure	• Sport corner, book corner, and internet corner were provided for employees.	• Workers were satisfied with the provided recreational areas.	Y
	Ergonomics-related training	• Film Processing department, acting as a pilot department, defined specific ergonomics-related training required for the department. • A number of training agencies were contacted for quotation and price comparison. • Employees in the department were required to attend the training to improve their understanding of ergonomics.	• Training for the Film Processing department was not quite successful due to a specific nature of work. • Workers instead required specific ergonomically designed equipment to reduce chances of having ergonomics-related problems. • Common ergonomics- related training could be considered for workers.	N
	Compliance to ergonomics rule	• The CoP representative from each department was selected to monitor and assist in the ergonomics implementation.	• Workers enjoyed the CoP visit, and found that it was more effective than going through websites to get information about the ergonomics culture.	Y
	Adequate supervision	• Supervisors worked closely with their CoP representatives to ensure the successful implementation.	• Workers and supervisors worked together to enhance the ergonomics culture.	Y
	Feedback	• Opinion boxes were placed in every department. • The CoP team visited each department to listen to ergonomics- related problems and suggestions from workers. • Ergonomics- related problems were shared on the web board, and answers to those problems were sought.	• Common ergonomics-related problems were solved by the CoP team. Complicated problems were forwarded to an ergonomics expert for the best solution.	Y
	Workers' involvement	• Employees participated in ergonomics acrivities on the Safety Day. • Employees were asked to participate in the Exercise Video Clip Contest, and the best video clip was shown on the company's buses. Employees got involved in the morning exercise and morning talk to discuss about various ergonomics issues.	• Workers participated in the contest. Management team was also encouraged to get involved in the contest. • Morning exercise was posted on the website so that everyone could follow.	Y
Resources	Financial resources	• Supervisors listed ergonomically designed equipment and specific trainings needed for their departments, and summarized the total costs. • Supervisors also listed the importance and benefits of those equipment and trainings to improve the ergonomics implementation in their departments. • Management approved appropriate budget to implement the plan.	• Common ergonomics-related training was approved for all workers to attend. • Some ergonomically designed equipment (e. g. , ergonomics chairs used in the control room) were approved and purchased.	Y
	Ergonomically designed equipment	• Mouse pads with palm rest were purchased and provided to office employees. • Back supports were purchased and provided to employees working in the Film Processing department.	• Management approved the purchasing of requested equipment.	Y

		• Ergonomics chairs with adjustable seat height and backrest angle were purchased and provided to employees working in the control room.		
	Ergonomics-related information	• Ergonomics web board was set up to share the ergonomics-related information. • The CoP team was set up to communicate ergonomics activities to every department.	• Ergonomics- related news was updated on the website every month. Workers suffering from ergonomics-related injuries/illnesses were interviewed and posted on the website to share information to other workers.	Y

Table 4. Action plan for the second period.

Factor	Attribute	Action plan	Result	Success
Policy and Strategy	Clear ergonomics rules	• An ergonomics expert was asked to comment and clarify ergonomics rules to be enforced at the Film Processing department (pilot department) to ensure practical implementation. • The approved rules were documented to be used as a guideline of the implementation.	• Guideline for the ergonomics implementation was available for workers.	Y
	Reward and recognition	• Employees with good ergonomics awareness and behaviour were recognized and awarded with tokens by the company.	• Information of employees with good ergonomics awareness and behaviour was posted on the inofmration boards and web board.	Y
Processes	Documentation	• Ergonomics-related information were regulatrly updated.	• Upcoming ergonomics- training was posted on the information board and web board.	Y
Leadership	Supportive environment	• Management participated in the meeting to discuss about ergonomics-related issues.	• Management participated in the meeting, and approved the requested equipment and specific training.	Y

Strategy, People, Resources, and Processes factors provide an understanding of the ergonomics culture implementation to large-sized manufacturing companies. The ergonomics culture maturity level can assist the companies in assessing their current maturity level, and identify areas for improvement to progress through to higher maturity levels. A case study presented in this paper also showed the action plans that the large-sized manufacturing companies can follow to improve their ergonomics culture.

It is noted here that the scores of the five factors and five levels of maturity in this research were from the opinions of the respondents in a case study company. Those scores may be adjusted to suit each company's conditions.

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