



CHAPTER II

LITERATURE REVIEW

Drury (1984) described a seven-step inspection task as follows :

1. Orient the item to be inspected.
2. Search the item.
3. Detect a flaw or usual phenomenon.
4. Recognize and classify the phenomenon.
5. Decide on status of item.
6. Dispatch item to a appropriate destination.
7. Record information pertaining to the item.

Based on his description, sub-tasks 2 to 5 and sub-task 7 had the specification of cognition, and the rest of 1 and 6 requires only manual skill.

Cognition or cognitive process is the brain process that refers to all the process by which sensory input is transformed, reduced, elaborated, stored, recovered and used. The characteristics of cognition are using acquired knowledge from theory and from experience and being able to develop a strategy in which the individual knows exactly what he is doing. Though it is accepted that permanent input of the same phenomenon signals or data may skip the cognitivity through evolving towards a stereotype, in quality control there still is a basic vigilant level needed to fulfill the task. Whenever the brain is taxed by any cognitive task, it is accepted that mental workload exists. There are several methods mentioned to measure this mental workload, such as

1. Psycho physiological indices.

Heart rate variability (HRV) has been proposed by Kalsbeek (1973) as an indicator of mental work load. Heart rate normally varies up and down around a mean. This variability reduces whenever mental load exists. In addition, electroencephalogram (EEG) has been proposed to measure the functional state of mind. It is the measurement of brain waves. This method give fairly result with respect to the amount of mental load. It is only a picture of a momentary workload but which give no idea about the work strategy of the worker. This is in case of monotonous work not very relevant. Technique to measure EEG in the field is extremely technically difference. Another

technique is critical flicker fusion (CFF) of the eye. A flickering light will be seen as continuous light at a sufficiently high rate of flicker. At resting stage, fusion occurs around 35 to 40 Hz. After working under cognitive load CFF could drop 0.5 to 7 Hz.

2. Behavior time-sharing method.

This method requires the simultaneous performance of two mental tasks, the primary task of interest and the secondary task of side. With attention to the primary task, the differences in workload will be reflected in the performance of the secondary task. The decrement in degree of performance is considered as an index of mental load. The examples of the secondary task are rhythmic tapping, reaction time, memory search, time estimation, and etc.

3. Subjective ratings.

This method is the easiest techniques used to measure mental load. The subjects are asked to estimate the state of their mental conditions before, during and after a mental task by marking a number on a scale that is placed the state at the end of it. Differences in markings indicate the degree of mental load.

A sustained fixed working position with repetitive movements may cause muscular as well as mental fatigue resulting in increased muscular tension and mental symptoms. To evaluate of this tensions of muscles, electromyography (EMG) is used. EMG is a technique for metering and testing muscular action and exertion on individual muscle groups. Its function is based on measurement of electrical signals in the muscles. Contraction in an individual muscular cell produces an electrical potential. As degree of contraction increases, more functional muscular cell units (motor units) become involved and the electrical potential increases. The potential measured at the surface of the skin above the muscle is the total produced by several motor units and describes the activity of the muscle. The signal produced by the muscle can vary in intensity about 1 μv to about 5,000 μv .

Schüldt et al (1986) studied the effects of changing the sitting posture on the level of neck and shoulder muscular activity, by using surface electrodes of EMG, the level of muscular activity of neck and shoulder was recorded as normalized, full-wave rectified low-pass filtered EMG.

Weber, Jermini and Grandjean (1975) studied the relationship between objective and subjective assessment of experimentally induced fatigue. They reported that flicker fusion frequency threshold was especially correlated with the self-scaling questionnaire of fatigue. The scale was stretched between eight opposite designations as : refreshed-tired with $r = 0.809$, strong-weak with $r = 0.833$, awake-sleepy with $r = 0.976$, and vigorous- exhausted with $r = 0.833$.

Grandjean (1971) studied the air-traffic controllers at Zurich airport. The tests took place nine times every 24 hours at an average interval of 2.5 hours. Sixty-eight controllers participated in the study. During the first 6 hours of work, CFF showed drop of 0.5 Hz and fell more quickly until 10 hours of work, when the total drop was 2.3 Hz.

Srirak Srithongchai (1992) studied the degree of mental fatigue caused by the continuous working of the two repetitive works, pipe cutting and pipe machining, based on the theory of fuzzy set (FCFF). Eight workers were investigated three times, before and after four and eight hours of work. She found that threshold level set length, obtained from FCFF, was highly correlated with the self-scaling questionnaire only for refreshed-tired, strong-weak, and vigorous-exhausted with 95 % significance.

Chaiyos Kuananusonhi et al (1989) studied the reaction time of morning and night shift workers. The report showed that shift work affected to workers' health, the disruption of eating and sleeping habits, and the family and social inconvenience. These led to stress accumulation, work evasion, and etc. Working in night shift, especially, lowered working efficiency and health due to the need of regular cycles of sleep contrasting with the unnatural working time. These induced the absence, dissatisfaction, decreased output, and increased accident occurrence.

Chartchai Usadornsak (1993) carried out the investigation of task and shift work relationship on fatigue level by using fuzzy set theory. Twelve male workers, four from each department, were participated as subjects in this study. Fatigue was determined from heart rate, hand grip strength, flicker fusion frequency, reaction time, and questionnaire. He found that there was less relationship between subjective and objective method of measurement due to the negative attitude of workers to their work and beings. Tasks and shift work had highly effects on physical and mental fatigue level of the workers. Spray

workers, had higher physical fatigue while inspection workers, had higher mental fatigue. Night shift work had lower fatigue level than morning shift for all type of tasks because of the flexibility of work control and work speed.

Haider (1963, quoted in Grandjean, 1979) studied fatigue of 337 female workers in textile factories, 207 of the workers working on a moving production line, as machine-paced, and the others working on their own, as self-paced. The workers' subjective feelings were assessed by using a self-assessment card of 12 pairs of contrasting states. The results showed that the workers who worked in the moving production line were much more tense, bored and sleepy than the other who work with their own speed. And the dissatisfaction and the tension of the production line workers were as high as 20 - 25 %.

Saito and his colleagues (1972) investigated the inspection task in the food industry. The workers inspected the bottle on the conveyer line that moved so quickly that the job was rated to be difficult, monotonous and repetitive. After working a short period the rejected bottle quantity became distinctly decrease. This phenomenon showed the diminution of workers alertness. Moreover a distinct fall in the flicker fusion frequency would be recorded. The fall in flicker fusion frequency depended on the time-scale. As in the first hour there was a little change. During the second to fourth hour it was strongly affected. And the hour before lunch break it became better.

McFarling and Heimstra (1975) carried out an investigation in simulated inspection. The investigation examined potential performance between self-paced and machine-paced inspection task, and measured subject perceptions of inspection tasks. Twenty women were used as volunteer subjects, ten for each of the two task conditions. Subjects in both self-paced and machine-paced conditions inspected 225 simulated printed circuits varying in circuit complexity. Performance measures of defect detection rate, false alarm rate and time required for decision were recorded. They found that self-paced subjects performed better, but the performance of both groups decreased on the more complex circuits. Subjects in both pacing conditions showed general agreement to the tasks as being relatively unpleasant but the machine-paced subjects tend to have more negative perceptions of the tasks.

Mahathevan (1982) reported the effects of shift work in industrial developing countries. Workers were disrupted their social and family life, the biological alteration of metabolic, glandular and sleep rhythm, and gastric function. Workers who worked two shifts had frequently suffered from fatigue and indigestion. Irregular work-rest cycles also disrupted them. These caused high absenteeism rates of workers.

Janaro and Bechtold (1985) developed the work-rest model to determine optimal rest break policies that aimed to maximize work output over specific time. The policy consisted of the number, duration, and placement of rest break. Ten subjects participated in this study. Workers firstly used a self-determined rest break policy. Then the proposed model was used. The result indicated that output increased nearly 13 % when subjects used the model's policy.

Yager (1975) presented the basic elements of fuzzy set theory based on Zadeh's concept of fuzzy subset that fuzzy subset is the generalization of the ideas of an ordinary set. The basic definition of fuzzy subsets is shown as follows :

Assume X is a set of corresponding to the universe

$$X = \{ X_1, X_2, \dots, X_n \}$$

A fuzzy subset A of X is characterized by a membership function $U_A(X)$ which associates with every member of X . A number of $U_A(X)$ is in the interval $[0,1]$ which indicates the grade of membership of X_j in A . A can be written as

$$A = \{ U_A(X_1)/X_1, U_A(X_2)/X_2, \dots, U_A(X_n)/X_n \}$$

The larger $U_A(X_1)$, the stronger the degree of membership of X_1 in A . The only requirement is that the actual value for the function $U_A(X)$ is a subjective evaluation of the decision-maker.

For example ;

$$X = \{ 1, 2, 3, 4, 5 \}$$

$$A = \text{the set greater than 3}$$

$$A = \{ 0/1, 0/2, 0/3, 1/4, 1/5 \}$$

In the above sample, $\{ 1, 2, 3 \}$ is less than 3 so the degree of membership is 0 in the fuzzy subset A . This means they are not the member of A .

The other sample is ;

$$X = \{ \text{Chonburi, Trung, Phuket, Krabi} \}$$

$$A = \text{the province near Bangkok}$$

$$A = \{0.8/\text{Chonburi}, 0.1/\text{Yala}, 0.5/\text{Phuket}, 0.7/\text{Rayong}\}$$

The degree of membership of Chonburi is larger than Rayong, Phuket, Yala, respectively. This indicates the distance from Bangkok to those province. The larger the degree, the nearer the province.

Many researchers have used the fuzzy set theory to analyze the data in ergonomics (Wang, Sharit and Drury, 1986; Marek and Noworol, 1986; Mital and Kawowski, 1986; Chignell and Hancock, 1986). More recent ones are Srirak Srithongchai (1992), Chartchai Usadornsak (1993), and Kitti Intaranont and Vanwongerghem (1993) which utilize the Fuzzy Theory to prioritize contributing factors on inspection performance. This study also utilizes the above idea to classify the contributing factors to inspection performance.