



## Fatigue in Shift Work on Stamping Division Workers of PT. Toyota Motor Manufacturing Indonesia

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### Abstract

Various health problems are known from shift works. PT. Toyota Motor Manufacturing Indonesia (TMMIN) as a car manufacturing in Indonesia is a large industry that applies a shift work system for the workers. This study aims to see the relationship between shift work system in the Stamping Division of PT. TMMIN. The measurement works by using the reaction time method on the worker the shift (shift I/morning and shift II/night) and non-shift during the workday flash. Based on the average measurement of reaction time for the shift workers I was 284.79 milliseconds and shift worker II was 307.76 milliseconds. The risk of reaction time increase was 3.222 times due to shift works compared to non-shift workers. Based on the value of reaction time, shift workers in PT. TMMIN recommends a repair per shift after work on the eighth day for shift I and twelfth day for shift II.

### Introduction

Occupational health and safety was an essential element in protecting the workforce in order to increase productivity. One aspect that needs attention was the protection of workers through the Occupational Safety and Health (OSH) program. The OSH program ensured that all workers and people in the workplace were safe from the risk of workplace accidents that may occur. Every worker must obtain self-protection from various problems around his workplace and things that could befall him or interfere in carrying out his daily duties. The protection of the workforce aimed to ensure that workers could carry out their daily duties with a sense of security so that the workload received was adjusted accordingly.

Based on data from the Indonesian Social Security Administering Agency (BPJS),

the number of work accidents in Indonesia tends to increase. 2017 recorded as many as 123 thousand cases of work accidents which is almost 27.8% due to the lack of concentration of workers due to work fatigue (Detik Finance, 2018). Tarwaka et al., said that 63% of workers who were suffering from fatigue can result in work accidents.

Work fatigue is a symptom associated with decreased work efficiency skills, boredom and anxiety increase. The word "tired" has its own meaning for each individual and is subjective. Factors triggering the emergence of work fatigue comes from individual workers, jobs and work environment (Loh et al., 2019). This fatigue caused by various factors including work environment, history of illness, workload, nature of work, work shifts, individual factors, and psychological factors (Adrianto &

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Ningrum, 2010; Ihsan & Salami, 2015). Tarwaka et al (Tarwaka, Bakri and Sudiajeng, 2004) also added that 63% of workers suffer from work fatigue due to the influence of shift work in their work environment. Often shift work can usually be done until night. Nowadays, almost a fifth of the worldwide workforce was engaged in shift work, with ~20% of European and American workers engaged in night shifts (Boivin & Boudreau, 2014).

Shift work, and night shift, in particular, was one of the most frequent reasons for the disruption of circadian rhythms, causing significant alterations of sleep and biological functions, which, in turn, can affect the physical and psychological well-being and negatively condition work performance (Hirshkowitz et al., 2015; Taylor, Merat, & Jamson, 2018). Humans have a circadian rhythm that was the fluctuation of various bodily functions for 24 hours. At night humans were in the trophotropic phase, which was the phase where the body was renewing energy reserves or strengthening again. Otherwise, at noon, humans were in the ergotropic phase, where organs and functions of the body were ready to act. Some bodily functions that increased during the noon and decreased at night were body temperature, heart rate, blood pressure, physical capacity, mental abilities, and adrenaline production. Workers who work the night shift also often have complaints of lack of sleep and fatigue (Killgore, 2010; Winarsunu, 2008).

Many parameters could be used to measure the level of fatigue, one of which is the reaction time with light response. Reaction time is the time between giving a single stimulus to the response to the stimulus. Even so, reaction time could also be influenced by work motivation, gender, age, opportunity, and body parts used. In a state of fatigue, neurophysiologically the cerebral cortex has decreased activity. There was a change in influence on the activation system and the inhibition system so that the body could not quickly respond to signals from outside, including light and sound stimuli. (Kosinski, 2010).

Car Manufacturing was a large industry that continues to grow in the world. Not to mention the presence of a car manufacturing plant, PT. Toyota Motor Manufacturing

Indonesia (TMMIN) in Indonesia, which requires workers with an optimal level of health so that productivity continues to increase. PT. TMMIN has several production divisions to support branded car production, for Southeast Asia region, among them Stamping Division in Sunter Plant, Jakarta. This division as a place of manufacture and assembly of machine components in PT. TMMIN, whose production volume reaches per year 195,000 units engines and iron casting 12,000 tons and enforces a two-shift work system ie noon and night (Toyota Indonesia Manufacturing, 2018).

PT TMMIN, in particular The Stamping Division, continues to make efforts to improve and optimize labor productivity by reducing the risk of the work injury, including reducing work fatigue. This program was following one of the core principles of The Toyota Production System, namely Kaizen. Kaizen is an effort for continuous improvement and one word that summarizes the slogan 'Always a Better Way' from Toyota. In the Toyota Production System, Kaizen humanizes the workplace, empowers individual members to identify areas for improvement and suggests practical solutions (Toyota Indonesia Manufacturing, 2018).

Based on this background, it was necessary to conduct research related to work fatigue. The purpose of this study was to evaluate the shift work associated with the occurrence of fatigue experienced by workers, so it could be an input to TMMIN doing anticipatory steps to reduce the existing work stressor. The measurement of fatigue using the method of the reaction time of light response. In addition, it could provide information to the workforce to determine the level of work fatigue that is being experienced.

### **Method**

The Stamping Division has two groups of workers with a population of 334 shift workers and 61 non-shift workers. Samples used in data collection, ie 60 shiftwork workers (morning as shift I and night as shift II) and 10 non-shift workers. The sample characteristics between shift workers and non-shift were uniform. Measurement of worker fatigue level by using reaction timer to light stimulation (L77 series); Stamping Division of PT. TMMIN applies five working days in a week ie Monday, Tuesday,

Wednesday, Thursday, and Friday. In shift settings work, shift change was done every week. Workers in the Stamping Division, PT. TMMIN works for 8 hours 30 minutes with a total rest time of ± 75 minutes per day. The measurement of reaction time associated with work fatigue, performed for 2 consecutive weeks on the same shift workers during the workday, when workers do noon shift and next week when the workers do the night shift. The measurement of reaction time was also performed on non-shift workers as control. Measurements are implemented after the work schedule ends. The measurement of reaction time was 20 times of repetition. The data analyzed for calculating the fatigue rate was obtained by averaging the value of the 10 repetitions in the middle (Kosinski, 2010). The reaction time measurement results were compared with Table 1 (Tarwaka, Bakri and Sudiajeng, 2004) to see the level of fatigue experienced by the worker. The measurement data were statistically analyzed using multivariate logistic regression to see the relationship between work shift variables and fatigue expressed in the Odds Ratio (OR).

Table 1. Work Fatigue Level.

Level	Reaction Time (millisecond)
Normal	150 – 240
Light	>240 - <410
Medium	>410 - <580

Source: Tarwaka, 2004

**Result and Discussion**

Evaluation of reaction time values based on the standard measurement of work fatigue level, indicating that workers on shift I and shift II experience medium fatigue level, which has a range of values >240 - <410 milliseconds. Starting from Monday to Friday, the value of reaction time decreased. In addition, in Figure 1 it can be seen the difference in the mean value of reaction time between shifted shift workers I and shift II workers, where the average difference of mean reaction rate from Monday to Friday was 18.6 milliseconds; 19.26 milliseconds; 22.16 milliseconds; 24.84 milliseconds; 29.99 milliseconds, relatively. Table 2 can be seen the comparison of reaction time values between shift I, shift II and non-shift workers.

Table 2. Measurement of Shift and Non-Shift Worker Reaction Time (Average ± SD)

Workers	Reaction Time Value (mili seconds)	Fatigue Levels
Shift I	284.79 ± 27.98	Light
Shift II	307.76 ± 44.14	Light
Non-shift	205.85 ± 21.48	Normal

Source: Primary Data, 2019

The difference in mean reaction rates between shift I and shift II occurs because night shift workers generally have poor health, they usually suffer from indigestion and feel anxious or nervous. This is due to changes in eating or drinking habits. This change can lead to chronic

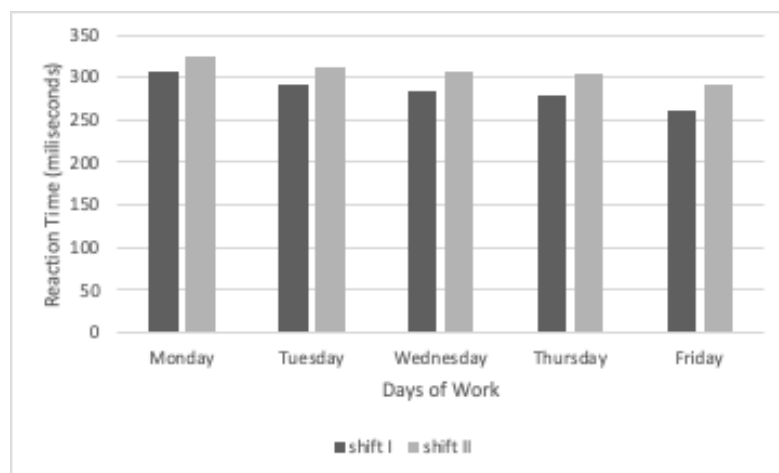


Figure 1. Comparison Reaction Time Values Between Shift Works

fatigue. Chronic fatigue is among others' loss of vitality, feelings of depression, feelings of irritability, and fatigue even though they are already sleeping. The anxiety and nervousness experienced by night shift workers are from chronic fatigue which, when combined with changes in eating habits, can cause digestive diseases. This affects the worker's response in response to the stimuli given during the measurement of reaction time. In addition, at night humans are in the trophotropic phase of the phase in which the body renews energy reserves or reinforcement. While during the day, humans are in an ergotropic phase where all the organs and bodily functions are ready for action. Workers who work on shift II (night), will be in the working atmosphere but their circadian rhythm is in the relaxed phase. This is also a factor affecting the difference in mean values of reaction time between shift works (Winarsunu, 2008).

The occurrence of a decrease in the average value of reaction time from day to day work is caused by the worker's body having an adaptation since the first day of shift work change. This adaptation process leads to the value of reaction time is getting smaller. This adaptation can be generated due to the pattern of work that has been regular with the workload and the amount of work is almost the same every day, coupled with the pattern of regular breaks (Berger & Hobbs, 2006; Mayasari, 2011)

The high value of reaction time on the first day of work after the shift of work was caused as a result of the lack of rest by the worker at 2 days which should be used as a break during the shift. Decreasing the mean value of reaction time from day to day can also be generated as a result of less optimal sleep time (staying up) on holidays during shift works. Over time, according to regular work activities and fixed workloads, the average value of the reaction time of the worker is decreasing and more stable (Dall'Ora, Ball, Recio-Saucedo, & Griffiths, 2016; Mayasari, 2011; Zhang et al., 2018). Based on observations in the field, some workers claimed to take overtime on Saturdays or Sundays, even with workloads and working hours that are different from normal working days. Then there are also workers who claimed during the day of shift work busy stay up, and

less rest. This results in a substantial additional burden on holidays that exceed work activity so that the first day of the shift work has the highest average reaction time value.

The average difference in mean reaction time from Monday to Friday between shift I and shift II indicates less maximal relaxation time of the body in order to achieve optimal conditions before workers start work. Although the worker's body was adaptable to the shift of work changes, which is marked by decreasing the average value of reaction time from day to day, due to the difference in the quality of the rest experienced by the worker, the difference in mean values of the reaction time tends to increase.

Based on statistical analysis with The Kruskal-Wallis test known p-value for work fatigue during the working week between shift I with shift II of 0.005 ( $p < 0.05$ ). This means that the average value of work fatigue on the working days for the shift I and shift II is significantly different. This could be due to the effect of shift works resulting in changes in activity patterns and worker rest periods. This change affects a worker's performance. Less optimal worker performance becomes an indication of work fatigue.

The result of statistical analysis using The Wilcoxon test note p-value for reaction time value with the working day is 0.297 ( $p > 0.05$ ). This means that the working day has no real effect on the change of reaction time value. It can be stated that fatigue that arises in every workday can be said equivalent. This is considering the type of activities performed and the time of the activities of the workers is classified almost the same from day to day, thereby affecting the absence of differences in reaction time value significantly between working days.

Based on statistical analysis with The Kruskal-Wallis test method obtained p-value value for job fatigue attribute based on shift and non-shift of 0.000 ( $p < 0.05$ ). It shows that there is a very significant difference in the mean value of reaction time between shift workers and non-shift workers. This shows, although the number of working hours performed is similar to that of shift workers, but the types of activities and resting patterns that are almost constant each

week, leaving these non-shift workers with normal levels, when compared to the average shift workers belonging to light work fatigue due to changes in working hours are different between weekends.

The essential function of circadian rhythm was sleep. The sleep without being disturbed was a requirement for health, comfort, and efficiency. Healthy adults generally need to sleep at night for 8 hours/day, although it remains on individual differences. For night shift workers, the hours of sleep at night usually changed to naps. However, in terms of quantity and quality, many naps were disrupted, among others by the noise of the living environment so they generally cannot rest. The average night shift worker usually sleeps for 6 hours (Wickwire, Geiger-Brown, Scharf, & Drake, 2017; Winarsunu, 2008; Yogisutanti, 2015).

Sleeping at night was an ideal time because naturally, the body secretes the hormone melatonin produced by the Pineal body that helps the body to sleep therefore sleeping during the day is not sleeping at night. The sleep quality of workers with shift works was different from those of non-shift workers. Adequate rest will affect the level of fatigue experienced by workers (Arora et al., 2006; Baulk et al., 2007; Kodrat, 2011). Taking into account the workload and physical work environment (Ferri et al., 2016; Ihsan & Salami, 2015; Suliswati, Setiani, & Joko, 2007), the greatest strength of the relationship between the variables studied to increase reaction time is shift work with OR (Odds Ratio) = 3.222. This means the increased risk of reaction time 3.222 times is due to shifting works compared to non-shift workers

The night shift workers generally have reduced health; they usually suffer from indigestion and feel nervous (Chang, Yang, & Hsu, 2019; Revalicha & Sami'an, 2013). This condition was due to chronic fatigue or unhealthy eating or drinking habits. Chronic fatigue includes loss of vitality, feelings of depression, feelings of irritability, and fatigue even though they were sleeping. So the anxiety experienced by night shift workers was from chronic fatigue which combined with unhealthy eating habits could cause digestive ailments. The symptoms of the diseases in each individual was

different. One of the factors that influence was age. Workers who were over 40 years old were less able to adapt to working night hours and are more easily tired. They were also less able to enjoy sleep because it was very easily disturbed (Deng, Kohn, Lipshultz, & Pastuszak, 2018; Vallières, Azaiez, Moreau, LeBlanc, & Morin, 2014; Winarsunu, 2008; Zhang et al., 2018).

Based on the average value of reaction time obtained from the measurement from Monday to Friday, the extrapolation step can be done with linear regression, to estimate when the right day for the worker to change shift work. This is with the consideration that there are still workers who use Saturdays and Sundays to take overtime and not used as time off when the shift changes.

The extrapolation of the average value of reaction time is done to see when the value of the reaction time of the worker leads to the normal category. When referring to the standard fatigue level measurement with reaction timer according to Tarwaka (Tarwaka et al., 2004)

In Figure 2 and Figure 3 show that for shift I, the average value of the reaction time has been below the lower limit value of the mild working fatigue level, during the eighth working day, which is 232.87 milliseconds, whereas in the shift II, the mean time value reaction below the lower limit value of light work fatigue level, after working on the 12th day with a value of 239.81 milliseconds. On Stamping Division PT. TMMIN, shift work changes once a week. Based on the calculation of the approximate change of reaction time, the shift of work should be shifted every two weeks, so that the worker can start his activity on the first day of the shift in a condition where the estimated reaction time is below the threshold level of light work fatigue. But seen from some research, actually, the value of normal human reaction time is very diverse. Sex, age, type of activity and occupation as well as nutritional status and methods of measuring reaction time, will certainly provide various values of reaction time in each person. if summarized in its entirety, by combining variations of factors that can cause different values of normal reaction time, it can be taken from 190 to 200 milliseconds for the young adult / 20-40 age

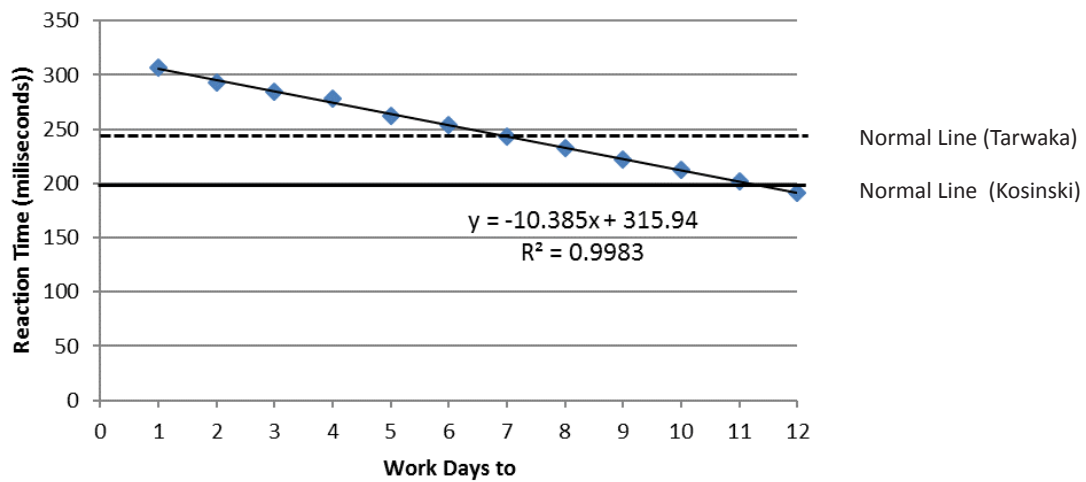


Figure 2. Estimated Change of Reaction Time Value to Working Day on Shift I

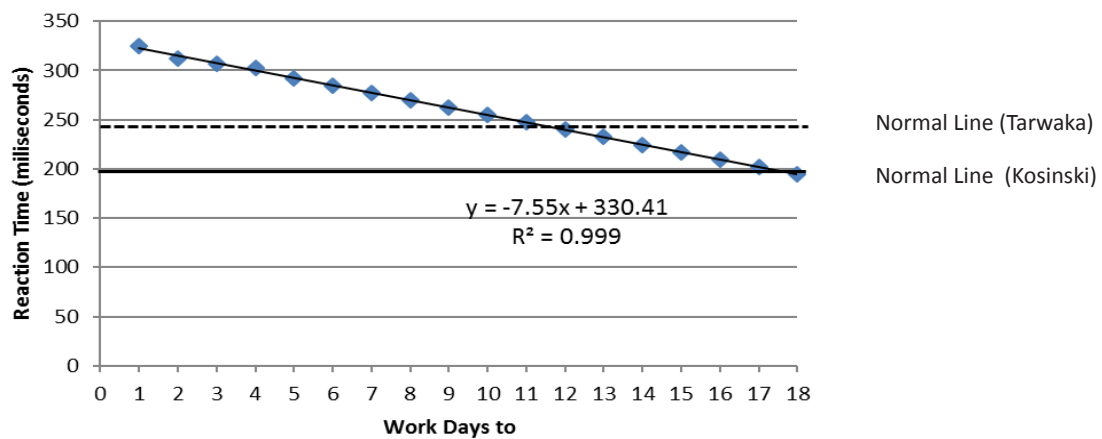


Figure 3. Estimated Change of Reaction Time Value to Working Day on Shift II

group. (Boivin & Boudreau, 2014; Setyowati, Shaluhyah, & Widjasen, 2014).

Based on Kosinski (Kosinski, 2010) the average value of the reaction time of the worker entered within the normal range on day 12 for shift I (191.33 milliseconds), and on the 18th day for the shift II (194.51 milliseconds). Based on these estimates, it could be a shift change once a week in the Stamping Division of PT. TMMIN can be done once three weeks so that the condition of workers can be optimized because the value of reaction time is within the

normal range.

Two requirements must be considered in shift settings, namely the loss of sleep as much as possible, and this will minimize fatigue, and there must be sufficient time for family life and social contact. The best shift planning following the above requirements is a work shift that directly gives rest or vacation time for 24 hours after working night (Kervezee, Shechter, & Boivin, 2018; Kim & Frangopol, 2018; Winarsunu, 2008).

Economic and organizational reasons

often influence the choice of work shift model. A person accepting a particular work shift system was determined by a balance of professional and personal considerations, including physiological, psychological, and social aspects. Health problems could also stem from the use of specific work shift systems. Workers who work nights permanently also often have complaints of lack of sleep and fatigue. Criteria that were often used to consider the use of a work shift system include the length of work every day must not exceed 8 hours, the number of consecutive night shifts must be as small as possible, each night shift must be followed by at least 24 hours of rest, each shift plan must have an end the free week, the number of free days at the end of the year must be at least as much as the worker's sustainability days (Cheng & Drake, 2019; Riethmeister et al., 2019; Winarsunu, 2008).

### Conclusion

The result of measurement of reaction time at shift I (morning) is  $284,79 \pm 27,98$  millisecond and at shift II (night) equal to  $307,75 \pm 44,14$  millisecond. The value of reaction time is based on the standard of fatigue level belong to the level of light work fatigue. The variables studied that have an effect on work fatigue based on the value of reaction time is the age of the worker, temperature, noise and shift work. The strength of the largest relationship between the variables studied to increase reaction time is shifting work with OR (Odd Ratio) = 3.222. This means the increased risk of reaction time 3,222 times sifting due to shift works compared to non-shift workers. Based on the value of the reaction time, the worker is estimated to have a value of measuring reaction time below the lower limit value of the normal level of light work fatigue level in terms of reaction time after working on the eighth day for shift I and the twelvth day for shift II. Thus, changes in shift work in the implementation at PT. TMMIN once a week should be done every two weeks so that the worker begins his / her work activity after the shift of the work is not at the level of light work fatigue.

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