THE INFLUENCE OF ERGONOMIC CONCEPT TO THE WORK POSTURE AND THE PHYSICAL WORK ENVIRONMENT AND ITS IMPACT ON THE WORKER PERFORMANCE (A Case Study On The Manufacturing Process Division at PT. Sinar Terang Logamjaya Bandung)

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ABSTRACT

The design of reliable product needs an integrated system design and the importance of ergonomic concept. One of the references is the high performance of workers; it needs a good work posture and physical work environment to reduce accidents.
Based on path analysis method, it can be concluded that most of accidents are happen due to bad work posture during the work is running and lack of support from the environment, so that the workers are not comfortable to doing their jobs. Things to do to develop high performance are environment infrastructures improvement, conducting a well plan and continue training of ergonomic concepts, so that these concepts will be a good work culture among the workers.

Keywords *: Ergonomic Concept, Work Posture, Physical Work Environment, Worker Performance, Path Anaysis.*

1. INTRODUCTION

1.1. Research Background

To meet the customers demand, the producers are need to produce reliable products that come from an integrated system design that cannot be separate from the importance of ergonomic concept. Many ergonomic concept was applied only based on common sense, it was not fully achieved as a tools to design process and work system improvement.

One of the indicator of how importance of ergonomic concept applied on a company is a high of work accidents, and it cause a high cost for dealing with those accidents. The cost is a tangible effect, but the intangible effect is psychological impact and trauma which are felt by the workers and could affecting work performance and good cultural organization. Thus to obtain a good advantage, then the ergonomic concept must be applied since the design was made on good structure and integrated.

The company should notice an existing physical work environment such as room temperature, humidity, clean air, lighting, and noise level which were produced from the machines and tools. This could causing a decreasing of productivity target, and this can contribute to unnecessary work accidents, and decreasing of man hours.

1.2. Research Identification

Based on the research background, then the research identifications are as follow:

1. How the influence of ergonomic concept to work posture and physical work environment at PT. Sinar Terang Logamjaya.
2. How the influence of work posture and physical work environment to worker performance at PT. Sinar Terang Logamjaya.

1.3. Research Goal

1. To find how the influence of ergonomic concept to work posture and physical work environment at PT. Sinar Terang Logamjaya
2. To find how the influence of work posture and physical work environment to worker performance at PT. Sinar Terang Logamjaya.

2. THEORITICAL BACKGROUND

2.1. Human–machine systems

A system is a set of elements, the relations between these elements and the boundary around them. Most systems consist of people and machines and perform a function to produce some form of output. Inputs are received in the form of matter, energy and information. For ergonomics, *the human is part of the system* and must be fully integrated into it at the design stage. Human requirements are therefore system requirements, rather than secondary considerations and can be stated in general terms as requirements for: (Bridger, 2003)

- Equipment that is usable and safe
- Tasks that are compatible with people's expectations, limitations and training
- An environment that is comfortable and appropriate for the task
- A system of work organization that recognizes people's social and economic needs.

Ergonomics is the study of the interaction between people and machines and the factors that affect the interaction. Its purpose is to improve the performance of systems by improving human machine interaction. This can be done by 'designing-in' a better interface or by 'designing-out' factors in the work environment, in the task or in the organization of work that degrade human–machine performance.

All work systems have a physical or functional boundary around them that separates them from adjacent systems. *Systems analysis* is the name of the discipline that studies the structure and function of work systems and provides the means by which simple systems may be combined to form more complex systems. Systems analysis is an integral part of all advanced work in ergonomics.

The human body is part of the physical world and obeys the same physical laws as other animate and inanimate objects. The goal of ergonomics at this level is to optimize the interaction between the body and its physical surroundings. This means ensuring that physical space requirements are met (using data on human 'anthropometry') and that internal and external forces acting on the body are not harmful. Ergonomic problems often arise because, although the operator is able to carry out the task, the effort required overloads the sustaining and supportive processes of the body and causes fatigue, injury or errors. This refers to the place and the circumstances in which work is carried out and consists of the physical workspace, the physical environment and the social and technical constraints under which the work is done. Many aspects of the physical environment can effect workers. Ergonomists are most interested in those that have an influence on the way the human and machine components interact. Noise, vibration, lighting and climate are of most concern to the ergonomist. Contamination and pollution of the environment are matters best dealt with by industrial hygienists, because they presumably have direct effects on health irrespective of any other work system factors. However, an awareness of these aspects is also important from an ergonomic perspective because they may have effects on human abilities and motivation as well as on health.

2.2. Work Area Design

One of the major tasks of an industrial ergonomist is design of work area. Since such areas must comfortably accommodate workers while offering an arrangement for maximum human effectiveness, the task of work area design id a prime candidate for extensive ergonomic involvement. The primary objective is to accommodate the workers in the resulting design such that they can work with the equipment, machinery, panels, and other people effectively with no health or safety hazard (Pulat, 1992).

It is easy to overlook the fact that the human body is a mechanical system that obeys physical laws. Many of our postural and balance control mechanisms, essential for even the most basic activities, operate outside of conscious awareness. Only when these mechanisms break down – as in slipping or losing balance – are we reminded of our physical limitations. An understanding of these limitations is fundamental to practically all applications of ergonomics (Bridger, 2003).

There is a relatonship between work area design and the expected work posture in that area. In general, an operator will either sit or stand during work, although both postures should be allowed for in the ideal design. In a seated posture, there will be more design considerations in terms of visibility, clearances, and so on. A seated posture allows for reduced static load to maintain body postures, improved blood circulation, and a feeling of balance along with less fatigue development. A standing operator will experience greater physiological load. Standing for extended periods in the absence of leg movement may lead to blood and body fluid accumulation in the legs. This will result in swelling and posibly varicose veins. If the operator is allowed to move around, the problem potensial will be minimized (Pulat,1992).

2.3. Design of the Work Environment

The two major components of the work environment that effect the behavior of a human-machine systems are the physical environment and the social environment (Pulat, 1992). Elements of the social environment include isolation, task pressure, group dynamics, and the like. Although human performance has been studied and reported under a variety of environmental factors, the ones that most concern an industrial ergonomist are the physical factors that exist in industrial environments, such as illumination, noise, vibration, and ambient temperature (heat and cold). However, the visual environment, noise, vibration, and ambient temperature are the physical environmental stressors that are most important in industry. For best human performance and minimal effects on the body, their levels must be kept within comfortable ranges. The immediate physical environment has a significant impact not only on the operator's and supervisor's performance, but also on reliability of the process (Niebel, 1988). The principal environmental factors that influence the productivity of the working personnel and dependability of the process include the visual environment, noise, vibration, humidity, temperature, bad atmospheric contaminants.

Despite automation and computerization of work, Work-related Musculoskeletal Disorders (WMSDs) are still prevalent in society. Repetitive work is common. The characteristics of the person, including age and skill level, can interact with the requirements of tasks and the design of tools, leading to excessive demands being placed on the musculoskeletal system. Neck and shoulder strain can be reduced at work by appropriate design of the visual requirements of tasks. Any beneficial effects are likely to be greater in older workers, where the background prevalence is higher and symptoms and more likely to be amplified by task-induced stress. Muscle and tendon problems such as cramp, tenosynovitis and tendonitis have been shown to be associated with highly repetitive activities. Musculoskeletal stress can be reduced and the efficiency of task performance increased by careful task and tool design (Bridger, 2003). Researchers have recently become interested in problems of the wrist, elbow and shoulder and a number of well-documented syndromes exist that are often, but not always, associated with work activities.

2.4. Industrial Safety and Health

Industrial safety deals with hazard recognition and control with respect to acute or instantaneous cases, such as sudden release of energy and possible injury or fatality due to it. A fall, or getting a hand stuck between reciprocating machine parts, are examples. Industrial health deals with hazards that show cumulative effects. A natural result of health hazards is illness.

The worker/ task/ environment/ equipment/ organization system generally functions with no accidents. The reasons for accidents may be simple or complex. Sometimes a simple unsafe act such as not operating a control when it is required to do so may lead to an accident. Unsafe conditions that relate to the task, the environment, the equipment, and the organizational structure also may cause accidents. However, usually a combination of unsafe acts and unsafe conditions leads to incidents, which may cause a near accident or an accident. If an accident occurs, there may be only material damage or there may be physical harm to a worker or both.

Not only the working conditions, but also the personnel act must be controlled for the total job to be safe (Pulat, 1992). In general, a significant portion of the blame goes to the worker after an accident. One may argue that all accidents are due to unsafe acts. A person who designs and builds a machine that is not safe to operate is committing an unsafe act. However, the person who selects that equipment for use in the production process is also responsible. Equipment may be safe for use in certain conditions and unsafe others. Hence situational factors also play a role in determining whether or not an accident will occur.

2.5. **Human Performance**

Performance is *focused behavior* or *purposeful work* (Rudman, 1998 : 205). That is, jobs exist to achieve specific and defined results (outputs) and people are employed so that organizations can achieve those results. This is performed by accomplishing tasks.

Gilbert (1998) said that performance has two aspects—*behavior* being the means and its *consequence* being the end.

Managing performance has the dual purpose of 1) arranging situations (environment) so that employees can do their best and 2) growing the employees by educating, enlightening, and appreciating them. Its purpose is to achieve specific and defined results from people so that the organization can achieve its goals and objectives.

It is much easier to fix situations by making structural changes to the organization, rather than trying to fix or change people. These include such means as changing reporting relationships, enlarging the job, improving a process, or opening lines of communication.

Once performance barriers have been removed, employees can be educated, enlightened, and appreciated. This assumption is based on the premise that most employees try to do their best. They prefer harmony over conflict, action over inaction, and productivity over delays (Farson, Crichton, 1996).

Human performance is defined as the *result* of a pattern of *actions* carried out to satisfy an *objective* according to some *standard* (Bailey,1989 : 4).The actions may include observable behavior or nonobservable intelectual processing (e.g., problem solving, decision making, planning, reasoning). Things change when people perform.

The human is the most complex of all components in any system and rightly deserves to be singled out as the most likely reason an accident occurs or a system falters. However, human performance is often degraded because of poor design decisions pertaining to the activity being performed, including the tools being used or even the context in which an activity is performed.

3. RESEARCH METHOD

3.1. Modelling

Technique used in this research is path analysis. This method is used for describe a direct effect and indirect effect on the variables (Dillon & Goldstein, 1984), are the influence of ergonomic concept variable to work posture and physical work environment and the impact to worker performance. The paradigm is in figure 1.

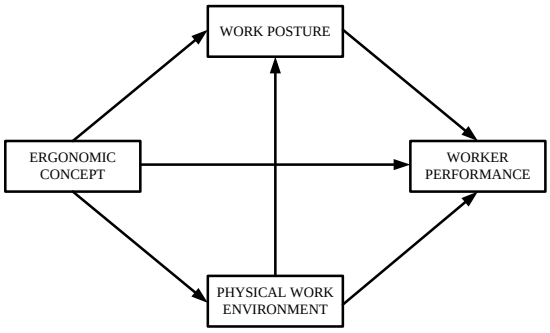

Figure 1. Research Variables Paradigm

3.2. Problem Solving

3.2.1 Variables Identification

The variables are as follow,

1. **Ergonomic Concept**

   It is a basic principle of a human existence to do the jobs. There are 4 factors, which are, (Linkbeck, 1995 : 196)

   a. Anthropometry factor, is physical human dimension.

   b. Physiology factor, is workers comfort due to physical effect.

c. Anatomy factors, the anatomy complaint from machinery effects.
d. Psychology factor, which felt by workers due to machinery effects

2. Work Posture

It based on OWAS method. There are 4 important aspects Karhu (1981: 2),
a. back
b. arms
c. legs
d. load

3. Work environment

There are 5 aspects, (Neibel & Freivalds (1999 : 224)),which are,
a. Illumination
b. Noise
c. Temperature
d. Ventilation
e. Vibration

4. Work Performance

The factors are, (Wignjosoebroto, 2000 : 7)
a. Output
b. Time.

3.2.2 Questionnaire

The data come from a close questionnaire, with 1 to 5 scale, from the lowest to biggest, based on Likerts scale.

3.2.3. Determining Variables Effect

Based on Dillon & Goldstein, 1984 : 430-453

1. Drawing path analysis
2. Calculation the correlation matrix among variables
3. Calculation the path coefficient
4. Calculating the determination coefficient
5. Calculating exogenous variables
6. Simultaneous testing.

4. RESULT AND DISCUSSION

4.1 Population and Sample Size

Questionnaires were deployed to operators in manufacture process division as much 131 operators, and sample was drawn as 100 operators. Estimated sample size was 77, in this case, number of drawn sample was greater than estimated sample, so that it can represent the population characteristic.

4.2 Characteristics Indicators Research

Based on deployed questionnaire, indicator characteristics are as follows only for 2 highest results,

Table 1. Ergonomic Concept Variable Indicator

ERGONOMIC CONCEPT			
Variable Indicators		**Frequency**	**Percentage (%)**
High machinary conformity to work posture	quite conform	63	63.0
	less conform	21	21.0
High machinary conformity to work posture	quite conform	50	50.0
	less conform	29	29.0
Comfort level of machinary uses by worker	quite comfort	45	45.0
	less nyaman	34	34.0
Comfort level to machinary visual	cukup nyaman	26	26.0
	little comformt	62	62.0
Understanding level of worker to machinary messege indicator	quite understood	11	11.0
	less understood	65	65.0
Effect level of distraction to body anatomy	quite distracted	28	28.0
	less distracted	50	50.0
Frequency of distraction felt by body anatomy	fair	16	16.0
	less	43	43.0
Effect of workers safety and healty	quite influencing	20	20.0
	less influencing	54	54.0
Effect of workers mental and behaviour	fair	53	53.0
	less	20	20.0

Table 2. Work Posture Variable Indicator

WORK POSTURE			
Variable Indicators		**Frequency**	**Percentage (%)**
Back pain before and after activity	sometime	58	58.0
	often	24	24.0
Back position when do the job	fair	43	43.0
	not important	43	43.0
Arm pain before and after activity	sometime	45	45.0
	often	23	23.0
Arm position when do the job	fair	29	29.0
	not important	56	56.0
Leg pain before and after activity	sometime	48	48.0
	often	27	27.0
Leg posistion when do the job	fair	40	40.0
	not important	50	50.0
The job couse dislocation and painful	sometime	51	51.0
	often	10	10.0
Focus on work	fair	36	36.0
	not important	50	50.0
Influence of environment on work	fair	20	20.0
	no influence	65	65.0
Product load and frequency to lifting ability	sometime	66	66.0
	often	6	6.0

Table 3. Physical Work Environment Variable Indicator

WORK PERFORMANCE			
Variable Indicators		**Frequency**	**Percentage (%)**
Productions are match to the target	hasitant	29	29.0
	not match	58	58.0
Understanding is affecting work performance	fair	10	10.0
	influenceless	80	80.0
Melakukan aktifitas dengan frekuensi yang sering disertai beban kerja dapat mempengaruhi kinerja	fair	18	18.0
	influenceless	74	74.0
Time is stated by company is match to the job	hasitant	35	35.0
	not match	47	47.0
Overload will decrease work performance	hasitant	34	34.0
	agree	12	12.0

Table 4. Work Performance Variable Indicator

WORK ENVIRONMENT			
Variable Indicators		**Frequency**	**Percentage (%)**
Lighting	fair	51	51.0
	good	34	34.0
Lighting is important to finish the jobPencahayaan berperan penting dalam menyelesaikan pekerjaan	fair	22	22.0
	not important	61	61.0
Irritating by noise	sometime	63	63.0
	often	17	17.0
Ear pain due to noise	sometime	55	55.0
	often	21	21.0
Communication in noisy environment	fair	44	44.0
	good	14	14.0
Temperature	fair	49	49.0
	cool	16	16.0
Temperature causing workers tired	hasitant	55	55.0
	agree	22	22.0
Ventilation	fair	27	27.0
	inadequate	54	54.0
Ventilation make dusty	hasitant	60	60.0
	agree	7	7.0
Vibartion	fair	55	55.0
	good	26	26.0
Vibration causing infocus	sometime	61	61.0
	often	26	26.0
Machinary vibration makes workers tired	hasitant	47	47.0
	setuju	26	26.0

4.3 Effects

The effects will be describe on path analysis as follows,

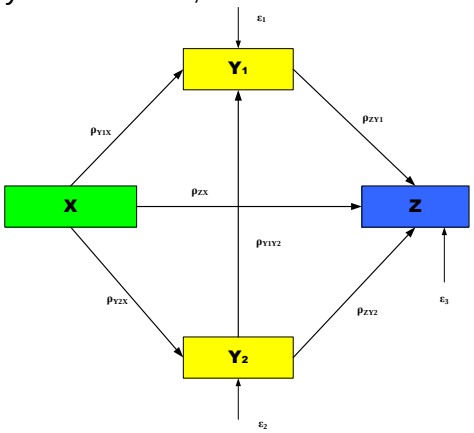

Figure 2. Structural Relationship

Notes :
X = Variable Ergonomic Concept
Y_1 = Variable Work Posture
Y_2 = Variable Physical Work Environment
Z = Variable Work Performance
ε_1 = Variable Residue of Work Posture
ε_2 = Variable Residue of Physical Work Environment
ε_3 = Variable Residue of Work Performance
ρ_{Y1X} = Path Coefficient of X to Y_1.
ρ_{Y2X} = Path Coefficient of X to Y_2.
ρ_{ZX} = Path Coefficient of X to Z.
ρ_{ZY1}= Path Coefficient of Y_1 to Z.
ρ_{ZY2} = Path Coefficient of Y_2 to Z.
ρ_{Y1Y2} = Path Coefficient of Y_2 to Y_1.

The path has 3 sub structures. The first sub structure is a causal relationship of X ke Y_1, the second sub structure is a causal relationship of X ke Y_2, and the third sub structure is a causal relationship of X, Y_1, Y_2, to Z. Calculation using Lisrel ver. 8.8, the result is as follows,

```
      Y1 = 0.30*Y2 + 0.44*X, Errorvar.= 0.65  , Rý = 0.35
Standerr  (0.084)   (0.084)           (0.092)
Z-values   3.56      5.20              7.00
P-values   0.000     0.000             0.000

      Y2 = 0.27*X, Errorvar.= 0.93 , Rý = 0.072
Standerr  (0.097)           (0.13)
Z-values   2.76              7.00
P-values   0.006             0.000

      Z = 0.22*Y1 + 0.35*Y2 + 0.26*X, Errorvar.= 0.59  , Rý = 0.41
Standerr  (0.096)   (0.086)   (0.091)           (0.084)
Z-values   2.27      4.12      2.84              7.00
P-values   0.023     0.000     0.005             0.000
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The relationship of X to Y_1, Y_2, dan Z, and the relationship of Y_1 and Y_2 to Z, are as follow,

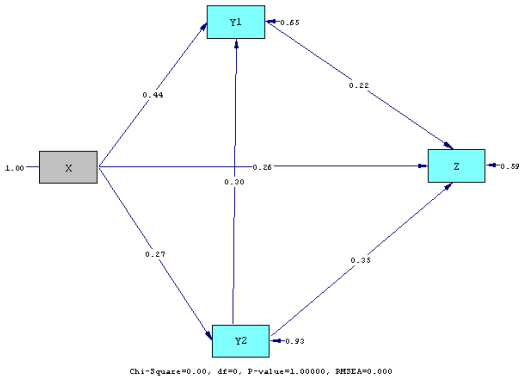

Figure 3. Path Coefficient Value

4.4 Proportion of Effects

Based on Figure 3, the value of proportion of the variables are,

- Variable X to Y_1 :
  Direct Effect X to Y_1= $(\rho_{Y1X})^2$ = $(0,44)^2$ = 0,1936 =19,36%
  Direct Effect Y_2 to Y_1= $(\rho_{Y1Y2})^2$ =$(0,30)^2$=0,09 = 9,0%
  Indirect Effect X to Y_1 through Y_2 =$(\rho_{Y2X})^2$.($\rho_{Y1Y2})^2$
  = $(0,27)^2$.$(0,30)^2$ = 0,006561 = 0,6561%
  Total Effects from X and Y_2 to Y_1 = 1- ε_1= 1- 0,65 = 0,35=35%.
- Variable X to Y_2 :
  Direct Effect X to Y_2 =$(\rho_{Y2X})^2$ =$(0,27)^2$ =0,0729=7,29%
  Total Effects from X to Y_2 = 1- ε_2=1- 0,93 = 0,07 = 7%.
- Variable X to Z :
  Direct Effect X to Z =(ρ_{ZX})^2 =$(0,26)^2$=0,0676 =6,76%

Direct Effect Y_1 to Z = $(\rho_{ZY1})^2=(0,22)^2=0,0484=4,84\%$

Direct Effect Y_2 to Z = $(\rho_{ZY2})^2=(0,35)^2=0,1225=12,25\%$

Indirect Effect X to Z through $Y_1=(\rho_{Y1X})^2.(\rho_{ZY1})^2$ $=(0,44)^2.(0,22)^2$ $=0,009370=0,9370\%$

Indirect Effect X to Z through $Y_2=(\rho_{Y2X})^2.(\rho_{ZY2})^2$ $=(0,27)^2.(0,35)^2=0,008930=0,8930\%$

Indirect Effect X to Z through Y_2 and Y_1 = $(\rho_{Y2X})^2.(\rho_{Y1Y2})^2.(\rho_{ZY1})^2$ = $(0,27)^2.(0,30)^2.(0,22)^2=0,0003175$ = 0,03175%

Total Effects from X, Y_1 and Y_2 toZ = 1- ε_3=1- 0,59=0,41=41%.

Based on the above calculation, the value of the path coefficients for the variable proportion of the research are clearly presented in Figure 4.

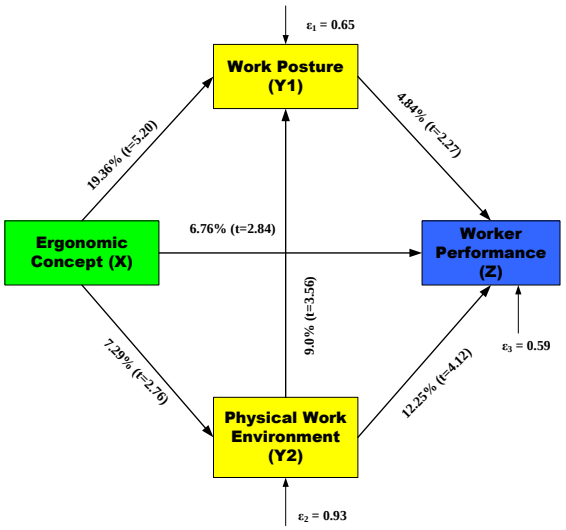

Figure 4. Proportion of Path Value and t_{value} to Variables

4.5 Effect of Ergonomics Concept, Work Posture and Physical Work Environment

The Ergonomic Concept (X) has a significant direct effect on the Physical Work Environment (Y2) at 7.29% with a residual variable by 93%, and to the Work Posture (Y1) at 19.36%, while the influence of Physical Work Environment (Y2) to Work Posture (Y1) by 9%. Total effects from Ergonomics Concept (X) to Work Posture (Y1) by 35% with variable residues of 65%. This demonstrates the principles of ergonomics concepts are built and executed in the company, ranging from a high compliance rate with the engine posture employees, the level of visual comfort of the machine, the influence of disturbances or complaints against employees of the body anatomy, and the level of mental and behavioral influences on employee, providing a real influence and impact on the employees attitude and work posture in doing his job. By building the employees attitude and work posture in working properly, it will support and improve employee performance, regarding both the quantity of products and product quality. Employee Performance Improvement work to be supported by an employee the right attitude in doing their jobs, and supported by the Physical Environment Working conditions and adequate support so that employees can do a good work posture. Thus, in order to support these two variables (Work Posture and Physical Work Environment) can be run properly, we need a strong and reliable foundation, namely the principles of Ergonomics concept applied in the enterprise as a sustainable and well planned.

4.6 Effect of Ergonomics Concept, Work Posture and Physical Work Environment to Worker Performance

Worker Performance (Z) is directly influenced by the Physical Work Environment (Y2) of 12.25%, by Ergonomic Concepts (X) of 6.76%, and by Work Posture of 4.84%. Total effect on Worker Performance (Z) is equal to 59%, with variable residues by 41%. To conduct an employee performance improvement, then the company can improve the working conditions of the physical work environment that can provide comfort to the employees in the work, such as lighting, noise, temperature, ventilation, and vibration of the engine, where the majority of employees as respondents in answering the questionnaire in the category enough (average score = 2.87) for all items of physical work environment variables. Thus the state of the physical work environment is still possible to be increased to an average condition score = 4. While for the ergonomics concept variable, the average employee to give an answer with an average score = 2.72. This indicates that the employees do not

understand correctly about the principles of ergonomic concept to be applied at the factory in order to provide working comfort, and reduce the rate of workplace accidents. The company needs to provide training ergonomic principles in the plant with a planned and sustainable programs, so that in the long run is expected to make a good work culture. As for the work posture variables, the average employee to provide answers to the questionnaire is still under score = 3, with an average score = 2.79. This shows the manner and work posture of employees at his job is still not right, it is still a lot of movement that would make a muscle or limb injury. Improved the behavior and work posture is done through understanding the principles of ergonomics concepts that serve as the basis or foundation of work system improvement, so it is expected that improved the performance of employees are getting better and stable.

5. CONCLUSION

1. The effect of Ergonomic Concept (X) to Work Posture (Y_1) is 19.36%, which is more dominant than Work Environment (Y_2), 7.29%, and the total effect is 35% (and the residue is 65%). This result show that accident was majority caused by bad Work Posture. To reduce it, an Ergonomic concept should be applied.
2. Work Performance (Z) was more dominant than Work Environment (Y_2) is 12.25% compare to Ergonomic Concept (X) 6.76% and Work Posture (Y_1) 4.84%. This result show that the company should make a priority improvement on Work Performance, and then the company should conducting a training on Ergonomic Concept

6. REFERENCES

(a) Bailey, Robert W (1989), *Human Performance Engineering*, Prentice-Hall International Inc, USA.

(b) Bridger, R.S (2003), *Introduction to Ergonomics*, Routledge, Taylor & Francis Inc, London and New York.

(c) Dillon, William R, and Goldstein, Matthew (1984), Multivariate Analysis : Methods and Application, John Wiley & Sons Inc, USA.

(d) Farson, R., Crichton, M. (1996). *Management of the Absurd*. New York: Simon & Schuster, p. 130.

(e) Gilbert, T. (1998). A Leisurely Look at Worthy Performance. *The 1998 ASTD Training and Performance Yearbook.* Woods, J. & Gortada, J. (editors). New York: McGraw-Hill.

(f) Karhu, O and et (1981), *Observing Working Postures Industri Examples of Owas Application*. Applied Ergonomics.

(g) Linbeck, John R (1995), *Product Design and Manufacture*, Prentice Hall.inc. New Jersey.

(h) Niebel, Benjamin W. (1988) *Motion and Time Study*, Irwin Inc, Homewood, Illinois, USA.

(i) _____ & Freivalds, Andris, (1999), *Methods Standars and Work Design*. Tenth Edition, McGrow - Hill, Newyork.

(j) Pulat, B Mustafa (1992) *Fundamentals of Industrial Ergonomics*, Prentice Hall. Englewood Cliffs, New Jersey.

(k) Rudman, R. (1998). *Performance Planning and Review*. Warriewood, Australia: Business & professional Publishing.

(l) Wignjosoebroto, Sritomo, 2000. *Ergonomi Studi Gerakan dan Waktu*, Guna Widaya, Surabaya. Edisi Kedua.

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