CHAPTER I INTRODUCTION

As the years progressed, the industrial era grew very rapidly and further improved the health quality of workers working in their respective fields. However, many work accidents are caused by negligence, both from the workers and the system implemented by the industry. The causes of work accidents are very diverse and include some physical, chemical, biological, psychosocial (mental), and physiological disorders (ergonomics level). However, data shows that ergonomic or physiological disturbances cause musculoskeletal disorders in workers (Buchori, 2007). Physical workloads are highly considered to get a security and comfort system during the work process. The human body has limitations and is designed to be able to carry out daily activities. The involvement of muscles and joints will make our body move and do activities. The current condition of our body at work indicates that our body is receiving a load involving muscles and joints. However, if the physical workload exceeds the acceptable load limit of the body, then a work accident will inevitably occur. Musculoskeletal Disorders complaints are a frequent case when workers perform the work process. Musculoskeletal Disorders are a disease in the human muscle tissue system in the back, wrists, knees, and shoulders and have an increased risk as a result of activities carried out with the wrong posture, excessive coercion, and always done prolonged in a long period (Sanders & McCormick, 1993).

Musculoskeletal Disorders are diseases that will arise if our body is too forced to withstand excessive workloads, use improper posture, and our mental health is not maintained (Hancock P. A., Meshkati N., 1988). The best design of the workstation will provide better efficient and effective work. Ergonomics based will make it easier for workers to remain productive in line with the quality of health and safety of increasingly qualified workers (American Industrial Hygiene Association Ergonomic Committee, 2020).

Workplace design using ergonomic approach can improve the existing workspace and reducing physical workloads. Arranging an ergonomic environment according to the standards set by the method will make the occupational health

and safety system more qualified. It will make the comfort of the operators while working will be better (Sutalaksana, 2006).

I.1 Background

PT. XYZ has a severe problem regarding cases of injuries of operators. Moreover, the pandemic era will make it more difficult for operators to work with fairly limited conditions. The use of masks and face shields will make it difficult for the operator to breathe and get oxygen. The narrow workstation and the absence of precise distance measurements will make the spread of coronavirus faster. The cases are very varied, and the causes are different. Human error, poorly measured work environments, and not applying appropriate work environment standards will make workers feel uncomfortable doing their jobs. Here is the data on the total cases of work accidents that occur each year.

Table I. 1 Injury Cases at PT. XYZ

Year	***Work Accident Cases***	***Increasing Percentage***
2018	23 cases	-
2019	27 cases	17.39%
2020	38 cases	40.74%
2021-July	23 cases	Up to 72.73%

From the observations, it is stated that the accidents continue to increase. Therefore, the measurement must be precise and measured using the right methods to create an ergonomic workspace with the proper equipment, efficient, safe, healthy, comfortable, and effective (Sutalaksana, 2006).

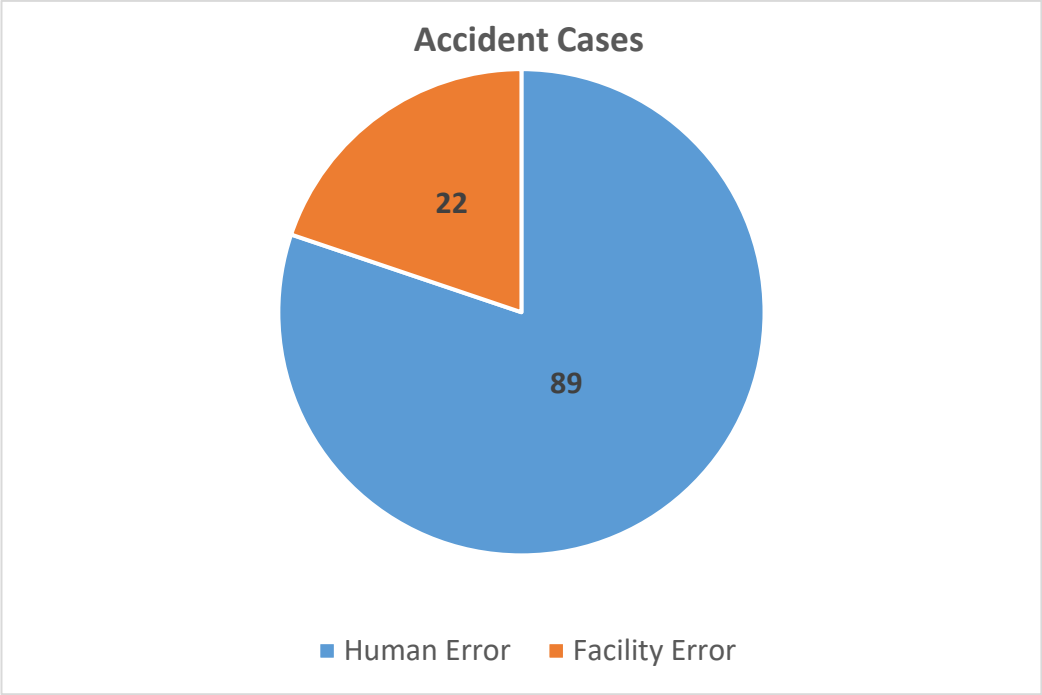

Figure I. 1 The Injuries Root Cause

The figure above shows historical of injuries internal data. If there is no further investigation, the number of injury cases will be increasing. PT. XYZ has had several cases of work accidents over the last four years (2018-July 2021). Ishikawa's Diagram theory stated that the root cause of MSDS has several factors. Ishikawa stated that the effect of the accident depends on many factors that can be divided into groups. The Ishikawa Diagram formulated by the 5M + E method, named from the letters from the English names of the factors: manpower, methods, machinery, material, management, and environment. The figure below is the Ishikawa Diagram model (Fig. I.2).

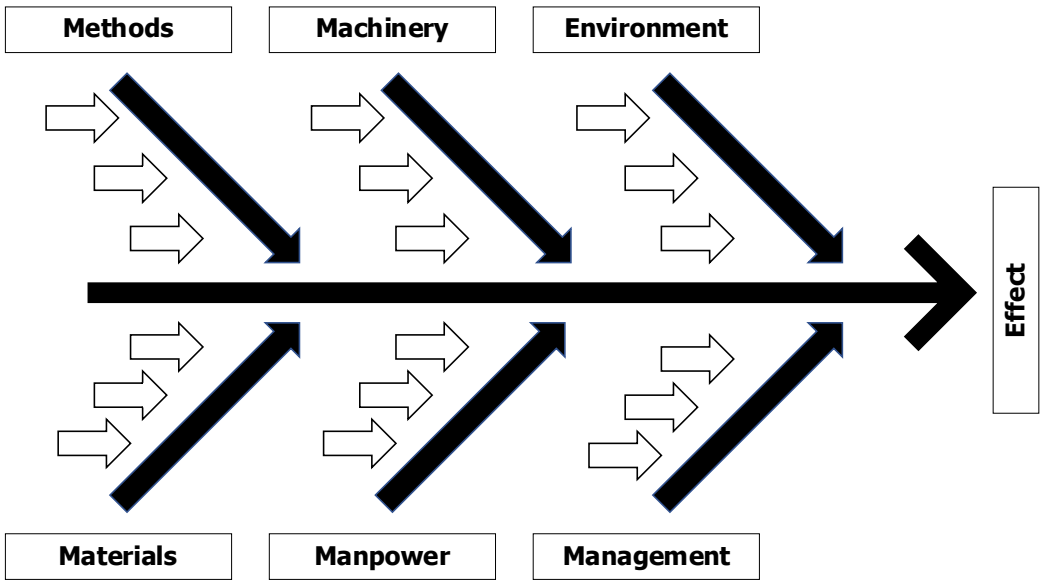

Figure I. 2 Ishikawa Diagram

Manpower, methods, machinery, material, management, and environment are considered as the sources of accidents (Bożena, 2017). These sources of accidents arise from unsafe situational and climate conditions and variations such as bad working conditions, rough/poor layout design, heat, humidity, dust, fume-laden atmosphere, and excessive noise (Xuqi & Wicaksono, 2020).

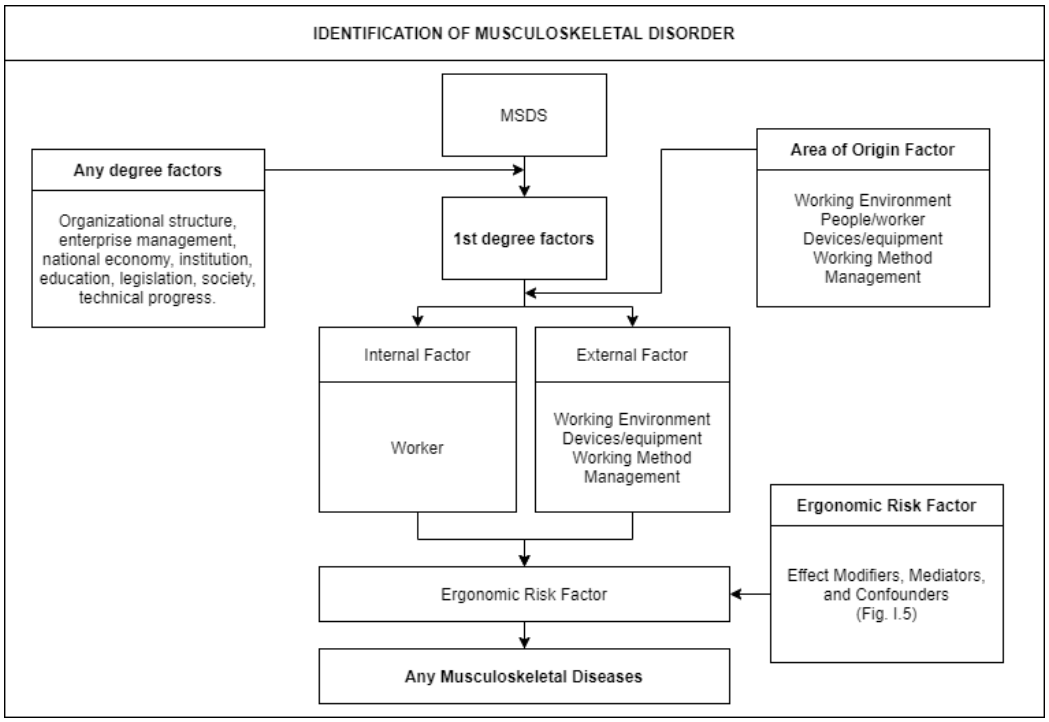

Figure I. 3 The Identification of MSDS

An extensive literature review of the subject was conducted to identify accident factors. The first group includes factors directly related to the MSDS risk factor. The following subgroups of factors were identified: Internal Factor and External Factor. The ergonomic risk factor formulates the Logic model of the possible causal relationship between exposure to occupational ergonomic risk factors and musculoskeletal diseases (MSDS)((Hulshof, 2021). Internal factors explain the abilities and limitations possessed by a person's body. If the body cannot withstand the load and exceeds capacity, there will be human error. Human error will cause cases of work accidents that occur caused by MSDS. Physical Workload Measurement and Fatigue Study must be considered carefully. Specific use of the technique of ergonomic assessment must be required (Hellig, 2018). Meanwhile, external factors explain environmental factors that will affect a person's body. This factor will continue to occur if there are no proper measurements and methods. Workspace and environment design significantly impact the operator while working (Natassi, Sharon, & Paul, 2019). Both internal and external factors may cause MSDS to the operator's body.

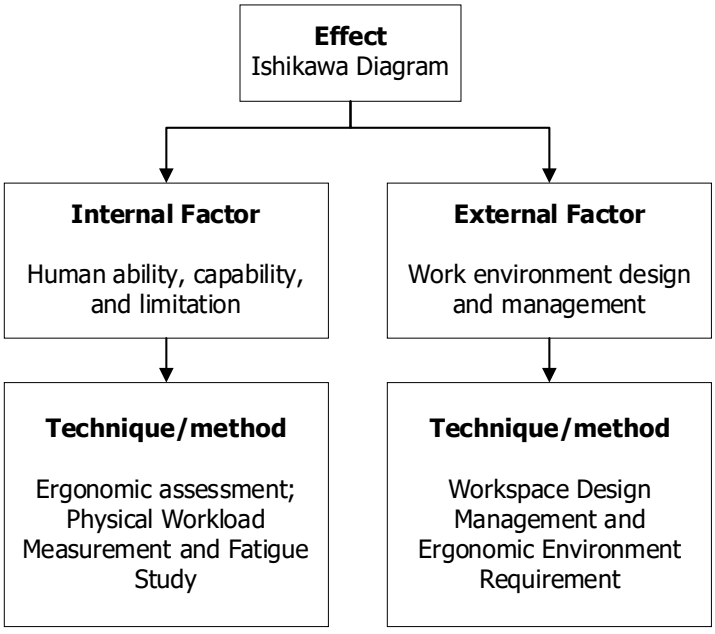

Figure I. 4 Ishikawa Diagram Problem Solving Technique

The effects of MSDS are various. The effects will have an impact on the human. The effect can be any selected other musculoskeletal diseases (MSDS), defined as one or more of: shoulder disorders: rotator cuff syndrome, bicipital tendinitis,

calcific tendinitis, shoulder impingement, bursitis shoulder; elbow disorders: epicondylitis medial, epicondylitis lateralis, bursitis elbow; hip disorders: trochanter and another hip bursitis; and knee disorders: chondromalacia patella, meniscus disorders, and bursitis knee (Hulshof, 2021). The methods are various to use for preventing the effect that might occur. Besides that, the risk also needs to be considered to know how big the root cause is and which scope to keep an eye on. There are three formulations to create the ergonomic design for the operator, there are;

1. Create an environmental ergonomic

   To create an environmental ergonomic need to consider the environmental factors. Environmental factors are critical elements to ensure the safety and comfort of the workers in manufacturing and assembly. The comfort, health, and performance of the workers are affected by temperature, noise, vibration, and lighting (Parsons, 2000).
2. Physical workload measurement for the operator

   To consider the physical workload of the operator, the first step is to collect the fatigue data from the operator. The Nordic Body Map Questionnaire contains all of the fatiguing detail. The Nordic Questionnaire also contains a few anthropometric data such as height and weight from a person. This data will be processed and calculated with the physical workload assessment. The result of the Nordic Questionnaire will be used for the proper assessment. Rapid Upper Limb Assessment (RULA) and Ovako Working Posture Analysis (OWAS) will be used in this research for the fatigue study.
3. Create an organized working layout with the best worktable design

   To create an organized working layout with the proper dimension of the worktable needs the Anthropometric Measurement approach. The observation from Anthropometric data sampling will be used as the reference dimension/size for the design and the working layout. The organized working layout will use the two-handed process chart as the main platform of working layout management.

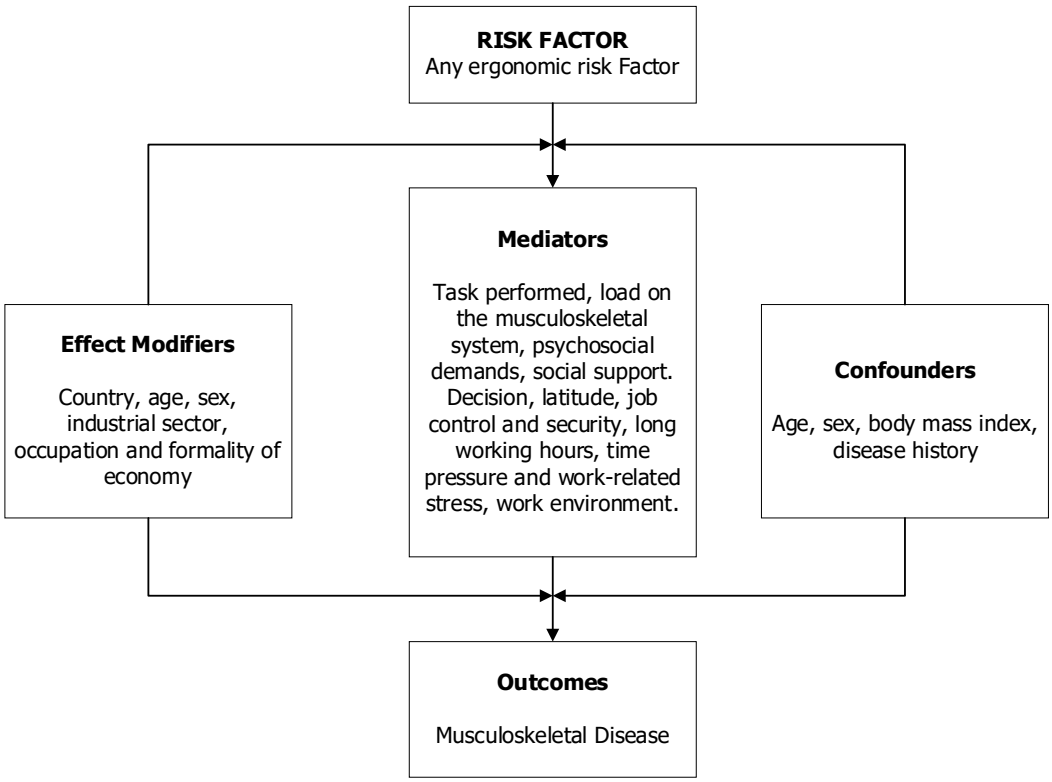

Figure I. 5 Risk Factor of MSDS

The effect modifiers and confounders will create different results/outcomes (Fig I.5). The effect modifier is the presence or absence of an effect modifier that changes the association of exposure with the outcome of interest (Hulshof, 2021). The confounders are situations where a person has a limitation, capability, and ability in his/her body (Baron & Kenny, 1986). The mediator is very similar to that of confounders, but the impact is completely different. Mediators are variables associated with both risk factors and outcomes variables.

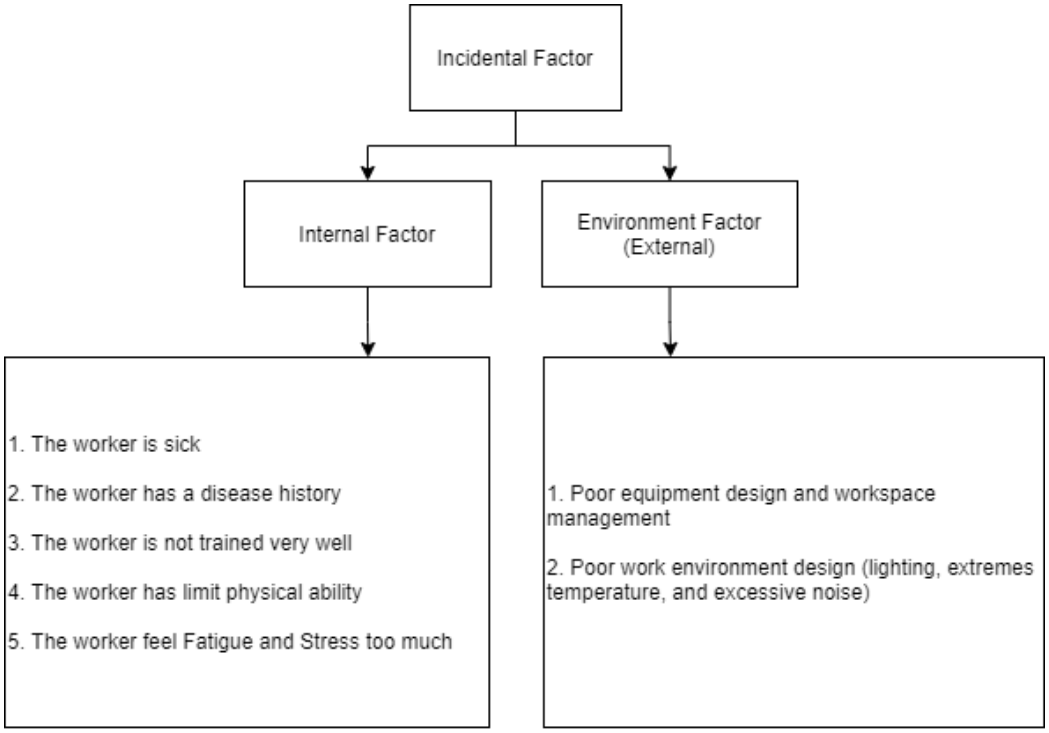

Figure I. 6 Incidental Factor

The factors that have occurred in the Production Line Division are Internal and External Factor (Fig. I.6). So many cases have happened PT. XYZ needs to consider many things to prevent work accidents from increasing each year. By determining incidental factors or the root cause, it will be able to produce solutions, and by that analysis may reduce the MSDS from the operator (Sanders & McCormick, 1993). Investigating the incidental factor will provide us with the root cause of the human error and the environment. The figure below provides the information about most cases found.

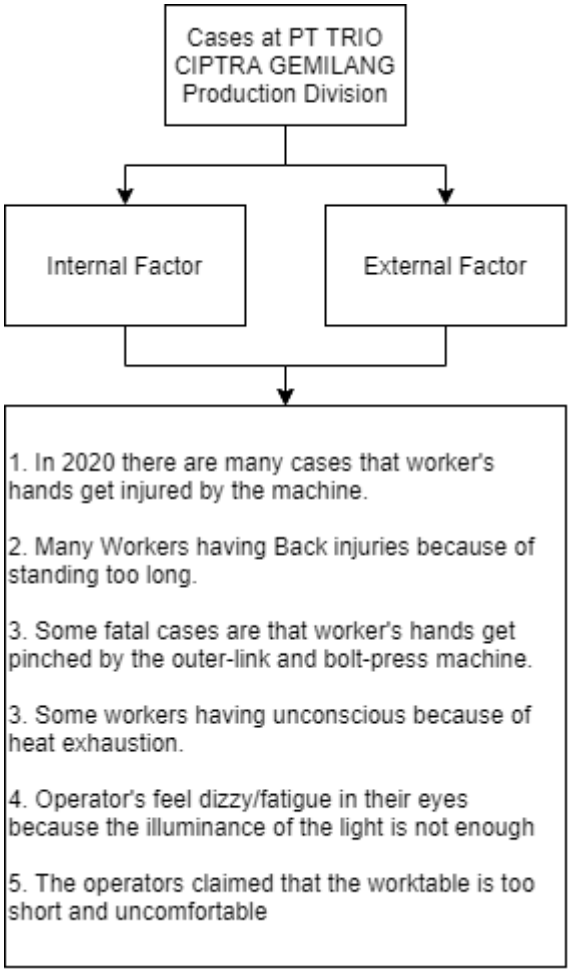

Figure I. 7 The Most Common case of Injuries

The accident rate at PT. XYZ is very high. The accident's effects varied from fatal category cases to light categories. Various accident cases occurred in PT. XYZ (Figure I.7);

1. Many operators had their hands hit by the machine while operating.
2. Standing too long causes some operators to experience back and waist pain
3. Many operators (especially women) are unconscious because of heat exposure
4. Operator’s feel dizzy/fatigue in their eyes because of the light intensity
5. The fatal cases where many operators get pinched and hit by the strain from the machines because the table does not design very well

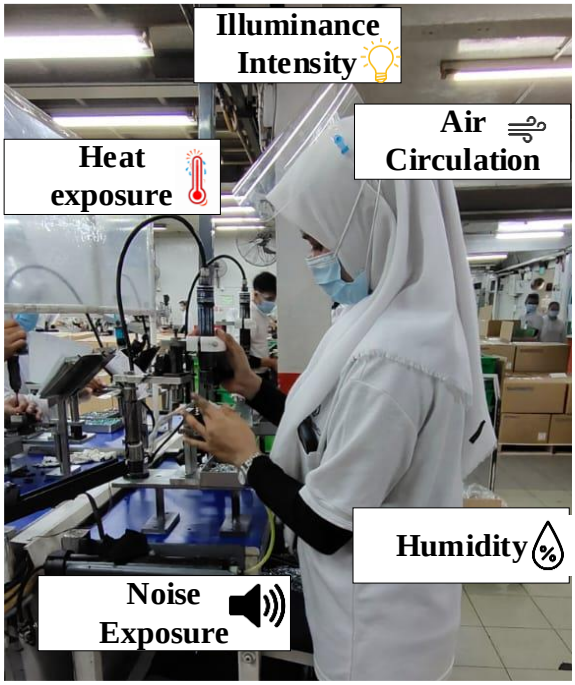

Figure I. 8 The Environmental Ergonomic Requirements

To design a workspace dimension need to consider the right measurement. Relative humidity, Indoor temperature, noise, ventilation of air, lighting, the design of the worktable with proper dimension, and organized working layout management will provide better performance and MSDS prevention (Xuqi & Wicaksono, 2020).

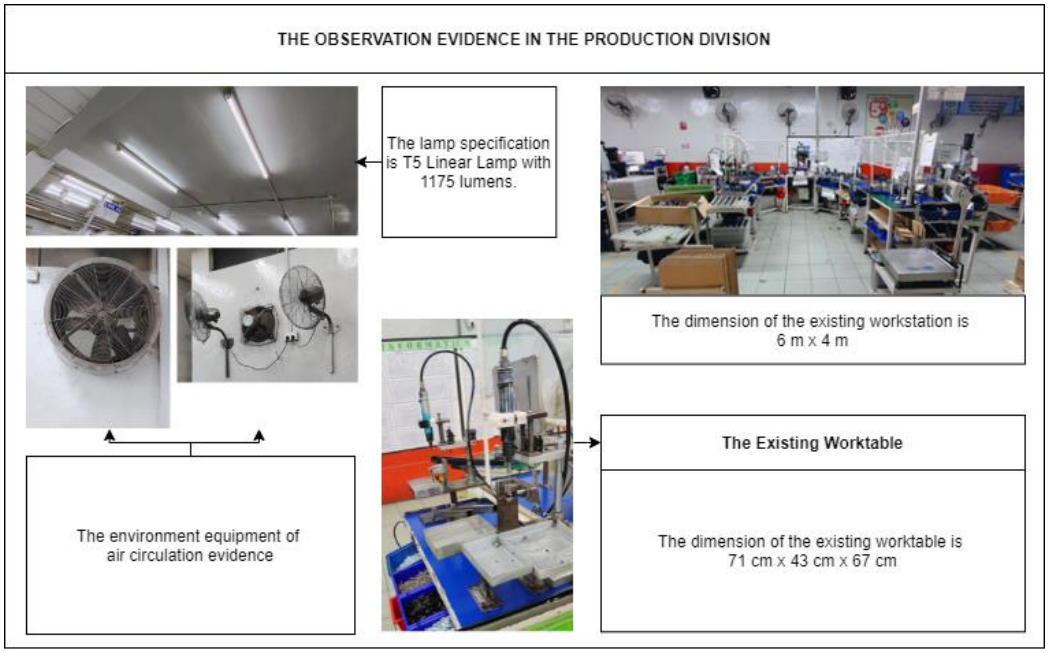

Figure I. 9 The Observation Evidence in the Production Division

The observation gathers the data from the existing workstation in the production division. The evidences are;

1. The dimension of the existing worktable is 71 cm (length) x 43 cm (width) x 67 cm (Height).
2. The lamp/lights specification is T5 linear lamp with 1175 lumens.
3. And the cooling system area in the workstation only using the blower and exhaust fan.

I.2 Problem Formulation

Based on the background describing the problems mentioned, the operator's need for a final solution is apparent. Previous studies like (Xuqi & Wicaksono, 2020), (Mistarihi, 2020), (Wiyono & Yusuf, 2015), (Ismail & Darshak, 2017), (Hellig, 2018), (Hulshof, 2021), provide information to solve the main problem of this research. Based on these facts, the problem formulation of this study is decided to be "**MUSCULOSKELETAL DISORDERS PREVENTION USING WORKPLACE DESIGN AND ERGONOMIC APPROACH (CASE STUDY IN PRODUCTION LINE DIVISION PT. XYZ)".**

I.3 Research Objective

Based on the formulation of the problem, the following are the objectives of this study:

1. Formulating the environmental ergonomic design that consists of the lights, noise, ventilation of air, and relative humidity for the operator workstation.
2. Formulating the physical workload measurement for the operator for better performance and postural of operator musculoskeletal system with Nordic Body Map Questionnaire after using the worktable design proposal.
3. Formulating the worktable recommendation design and organized working layout with an anthropometric measurement and two-handed process chart approach to fix the musculoskeletal system for the operator.

I.4 Research Limitation

There are several limitations in this research, some of which are:

1. This research is only limited to micro-level ergonomic (The operator, environment around the operator, and the table design and working layout for the operator)
2. The main focus in this research is those operators in the production line division.

I.5 Research Benefits

The benefits obtained from this research include:

1. PT. XYZ can utilize the findings of this research as the basis to improve their operator occupational health and safety.
2. The fatigue study of this research as the main scope can be developed for the next stages.
3. The Anthropometric data can be used as the main data for further measurement of ergonomic design.
4. The design of the work table and organized working layout can be used as a reference for further research.

I.6 Writing Systematics

This research is described in the form of systematic writing as follows:

BAB I INTRODUCTION

In this chapter, the background of the problem faced by the PT. XYZ operator is explained through problem formulation, research objectives, research benefits, and writing systematics

BAB II LITERATURE REVIEW

This chapter describes several theories that support the resolution of research problems such as, Musculoskeletal system, Environmental Ergonomic Design, Physical Workload Measurement, Anthropometric Measurement for Ergonomic Design, and Workspace Layout Management.

BAB III SYSTEMATICS

This chapter describes the stages of research used in detail related to systematic problem solving as well as the appropriate conceptual model in researching the problem.

BAB IV WORKPLACE DESIGN AND ERGONOMIC NEEDS

This chapter describes the process of collecting Nordic Body Map Questionnaire Data, Anthropometric data, Environment Data, and Physical Workload Data that has been previously designed. Then, the process of processing and recapitulation of all of the data will be carried out using the final design of ergonomic measurement.

BAB V ANALYSIS AND EVALUATION OF RESULTS

This chapter describes the analysis of the results of data processing and the final design of the Environmental Ergonomic, Worktable Drawing, and Workspace Layout Management for improving PT. XYZ operator in the Production Line division.

BAB VI CONCLUSION AND RECOMMENDATION

This chapter concludes the results of the research and provides suggestions for PT. XYZ and further research