Vibrating Floor Design For The Climate Room With Ergonomics Aspect and Safety Approach

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***Abstract**.*
Vibration as a part of the physical work environment that can have an impact on increasing work productivity and health for workers, it is necessary to study the impact of exposure to the human body. The climate room is one of the learning facilities in the Ergonomics and Work System Design Laboratory of the Industrial Engineering Study Program. However, this climate room does not have a vibration simulation yet, so it is necessary to have a vibrating floor design that can simulate vibration as part of the conditions in the work environment. In designing the vibrating floor design, the ergonomics and safety aspects are considered by using the Ergonomic Function Deployment (EFD) method where the requirement attribute is derived from the ENASE aspect. From this research, it was found that the contribution value for each of the required attributes can be determined so that the order of priorities that must be met in the design of the vibrating floor design can be determined. The highest contribution value which shows priority 1 is 3.80 users are comfortable in operating the vibrating floor, in this case the vibrating floor design is based on the user's anthropometric data. For the lowest contribution value, namely 1.42 as priority 9, the vibrating floor treatment process is easy to do so that the target specification for the vibrating floor uses iron and painted plywood. From the design of the vibrating floor based on the attributes of the needs so that it can provide a real vibration simulation like industrial conditions

Keywords: *Vibration floor, Ergonomic and Safety, Ergonomic Function Deployment* (EFD).

I. INTRODUCTION

Every human being in work or activity will try to achieve good productivity. There are many factors that affect work productivity, one of which is a good working environment. Physical environmental factors such as noise, lighting, and ambient temperature can affect human productivity at work, considering these factors have a direct impact on the human body. However, apart from these physical environmental factors, humans also cannot avoid the impact of vibrations that appear around the workplace. Vibration is an effect produced from a certain source using the unit of measure Hertz [1]. Vibrations can occur as a result of humans themselves and some come from machines or other mechanical devices where some of the mechanical strength is channeled to the human body in the form of mechanical vibrations [2].The impact of vibrations felt by humans, one of which is discomfort at work, health problems to accelerate the occurrence of fatigue. The influence of mechanical vibrations can have an effect on workers, both long-term disturbances such as changes in bone structure, while short-term disturbances such as dizziness, pain, discomfort, blood circulation disorders [3]. The climate room as one of the facilities in the Ergonomics and Work System Design Laboratory of the Industrial Engineering Study Program, Faculty of Engineering, Muhammadiyah University of Palembang, where in this climate room there is a simulation of the work environment which includes lighting, setting room temperature (temperature), noise, and color.

However, the climate room does not have a vibration simulation, considering the need for vibration simulation as part of the conditions in the work environment and studying the impact of vibration on the body, it is necessary to present a vibration simulation in the climate room in the form of a vibrating floor equipped with a vibration frequency controller. The designed vibrating floor is a vibrating floor that can provide a vibration simulation by applying ergonomic aspects and paying attention to safety when used. Functionally, the existence of a vibrating floor will provide a more real work environment situation so that it can contribute to studying the impact of exposure to vibration on the human body [4].The design of the vibrating floor by applying ergonomic aspects aims to consider the human aspect as a user where humans have limitations both physically and mentally psychologically and their interactions in an integral human system [5]. Ergonomics includes the study of systems in which humans, work facilities, and their environment interact with each other with the main goal of adapting the work atmosphere to humans [6].The design of this vibrating floor also pays attention to safety aspects in its use, where when operated it must provide a sense of security and not cause injury to humans who are on it. To help design a vibrating floor that pays attention to ergonomics and safety aspects, the Ergonomic Functional Deployment (EFD) method is used, which is a method that facilitates the design process, making decisions that are conveyed in the form of a matrix so that it can be re-examined and modified in the future [7].

In a previous research [8]where a vibrating floor has been designed on a laboratory scale using a system of unbalance motors, where the vibration mode produced has vertical, horizontal, and combination directions so that the resulting vibration is integrated throughout the user's body. The design of the vibrating floor that has been carried out has not been equipped with a seat as a means of support in the vibration position (sitting, standing, and supine) as well as a handle for users so as not to fall during operation. In this research the author will design a vibrating floor design that applies ergonomics and safety aspects in order to get a simulation of the vibrations that occur in the work environment.The problem in this research is how to design a vibrating floor design for a climate room in the laboratory by applying ergonomic and security aspects that are able to provide a sense of comfort and safety when using it and do not cause injury to humans. The purpose of this research is to obtain a vibrating floor design for a laboratory climate room. The design of the designed vibrating floor is expected to provide an overview of vibration simulations that occur in real conditions in the physical environment into the learning process and can be used as study material to analyze the impact of vibration on the human body and its influence on work productivity.

II. METHODS

This research was conducted at the Ergonomics and Work System Design Laboratory, with the object of research being to design a vibrating floor that can be used in the learning process. The subjects of this research were 27 samples consisting of students, laboratory assistants, and lecturers.The data used in this study are primary data in the form of consumer desire data on the specifications of the vibrating floor, anthropometric data from users of this vibrating floor, while secondary data in the form of supporting data obtained from literature studies related to the object of research.Vibrating floor design for the laboratory with an approach to ergonomics and security aspects in this case using the EFD method which will be linked between consumer desires with ergonomics and security aspects. This relationship will be illustrated in the form of a House of Quality matrix. The stages in this EFD method are as follows:

1. Identify product attributes

Aims to determine product attributes to be designed and in accordance with consumer desires. The attributes used are based on ergonomic aspects, namely ENase (Effective, Comfortable, Safe, Healthy, Efficient) [9]

2. Questionnaire Design

Questionnaire to find out the needs of vibrating floor users, as well as to find out which attributes are considered important by users.

3. Formation of the House of Ergonomics

As for making the House of Ergonomics, the steps are

a. identification of consumer needs, consumer needs are obtained from the voice of the customer in the form of questions and then arranged based on the level desired and needed.
b. Make a planning matrix, aims to determine the priority of meeting consumer needs, it includes the level of consumer interest, level of satisfaction with the product, target value, improvement ratio, selling point, raw weight, Normalize raw weight
c. Product technical specifications, the determination of product specifications is carried out to explain what the product can do
d. Relationship is a relationship between technical requirements and consumer needs
e. Technical correlation is used to show the relationship between Technical characteristics
f. The technical matrix aims to determine the priority of technical characteristics, where this is based on the normalized contribution of the relationship matrix value

4. Vibrating Floor Design Design

At this design stage the aim is to develop a vibrating floor design based on consumer needs. In this case, making a vibrating floor design using the Sketch up software

III. RESULT AND DISCUSSION

Identification of Vibrating Floor Requirement Attributes

The product requirement attribute is the result of observations and interviews with users regarding the user's desired needs for the vibrating floor, this user desire is derived from the ergonomics aspect of ENASE which is shown in Table 1 Attribute Characteristics of the product

Table 1. Product Characteristic Attributes

Variable	Attributes	Statement
Effective	Functional	Vibrating floor produces vertical and horizontal vibrations
		Vibrating floor can be adjusted the size of the vibration
		The vibrating floor can place tables and chairs on it
Comfortable	Size	Dimensions according to the user's anthropometry
Safe	Work Risk	Vibrating floor with handles all around
Healthy	Materials	The vibrating floor is made of materials that do not injure the user
Efficient	Economy	Vibrating Floor made of materials and components at affordable prices
	Care	Vibrating floor is easy to maintain
	Raw Material	Raw materials use materials that are durable and strong

Preparation of the House of Ergonomics (HOE)

The preparation of the planning matrix is a strategic design that is carried out when designing the product to be made [10]. To make the HOE, firstly, the level of importance and level of user satisfaction is determined based on the data from the questionnaire. The level of user interest aims to determine the user's performance assessment of the vibrating floor design. The highest performance value for the importance level is 3.35 on a vibrating floor capable of producing vertical and horizontal vibrations. Meanwhile, the level of satisfaction aims to assess the user's response to the vibrating floor. The value of the highest level of satisfaction is 3.46 with a vibrating floor attribute capable of providing vertical and horizontal vibrations.From determining the level of importance and satisfaction of vibrating floor users, then proceed with setting targets (Goals). The goal value is to determine the goals to be achieved by researchers with how far researchers want to fulfill consumer desires by considering consumer needs can be met or not. The goal value is based on the value of the level of importance and level of satisfaction. In this study, the highest goal value was 3.35 on the vibrating floor providing vertical and horizontal vibrations, and the lowest goal value of 3.12 on the vibrating floor made of materials and components at affordable prices.

Table 2. Performance value of importance level, level of satisfaction, and value of goal

Criteria Attribute	Value of Importance Level	Level of Satisfaction	Value of *Goal*
Vibrating floor produces vertical and horizontal vibrations	3,35	3,46	3,35
Vibrating floor can be adjusted the size of the vibration	3,27	3,42	3,27
The vibrating floor can place tables and chairs on it	3,15	3,27	3,15
Dimensions according to the user's anthropometry	3,31	3,27	3,31
Vibrating floor with handles around it	3,27	3,35	3,27
The Vibrating Floor is made of materials that do not injure the user	3,15	3,27	3,15
Vibrating floors made of materials and components at affordable prices	3,12	3,15	3,12
Vibrating floor is easy to maintain	3,19	3,31	3,19

Raw materials use materials that are durable and strong	3,15	3,27	3,15

From the goal value obtained, the improvement ratio value is determined, which shows how much effort must be made to achieve the goal. The greater the value, the greater the level of change that must be made. From the calculation results, the largest improvement ratio value is 1.01 in the dimensions according to the user's anthropometry. Then proceed with determining the selling point (sales point) to show how much influence in meeting consumer demand for the product. Determination of selling points based on the value of the level of importance. In this study, researchers used a value of 1.5 (strong sales point) because the design has a high added value to the product.Raw weight value is the overall importance level of consumer needs. The greater the value of raw weight obtained, the more important this need is to be met. The largest raw weight value is 5.02 in the dimensions according to the user's anthropometry. Meanwhile, the largest normalized raw weight is 0.1148 with a vibrating floor producing vertical and horizontal vibrations. From normalizing raw weight, it can be continued by determining a technical response that contains user requirements in the form of technical terms. The technical response indicates the design plan in realizing user requirements. Table 3 shows the technical characteristics of the vibrating floor

Table 3. Vibrating Floor Technical Characteristics

Level of Interest	Technical Characteristics
Vibrating floor produces vertical and horizontal vibrations	Vibrating floor using a vibrating motor
Vibrating floor can be adjusted the size of the vibration	The vibrating floor is equipped with a feature that regulates the size of the vibration generated
The vibrating floor can place tables and chairs on it	The vibrating floor has an upper dimension that can support tables and chairs
Dimensions according to user's anthropometry	The user is comfortable in the operation of this vibrating floor
Vibrating floor with handles all around	The vibrating floor features a handle all around
The vibrating floor is made of materials that do not hurt the user	Vibrating floor is safe to use
Vibrating floors made of materials and components at affordable prices	The vibrating floor is made of competitive materials
Vibrating floor is easy to maintain	Easy vibrating floor maintenance process
Raw materials use materials that are durable and strong	Using raw materials that are durable and strong

The relationship between technical responses and user needs is shown in symbols that symbolize how strong the relationship between technical responses and user needs is, the more symbols an element has on technical characteristics with user needs, the more elements of technical characteristics affect the fulfillment of user needs. After knowing the value of the relationship, it can be determined the value of the contribution and the order of priority of the vibrating floor attribute, the following table 4 shows the value of the contribution and the order of priority.

Table 4. Contribution value and order of priority

Technical Importance	Value Relationship	Value Contribution	Priority Order
Vibrating floor using a vibrating motor	27	3,10	3
The vibrating floor is equipped with a feature that regulates the size of the vibration generated	13	1,44	8
The vibrating floor has an upper dimension that can support tables and chairs	18	1,94	7
User is comfortable in vibrating floor operation	32	3,80	1
The vibrating floor features a handle all around	27	3,06	4
Vibrating floor is safe to use	25	2,7	5
The vibrating floor is made of competitive materials	23	2,51	6
Easy vibrating floor maintenance	13	1,42	9

process			
Using raw materials that are durable and strong	30	3,24	2

The relationship between needs matrices is carried out by analysis that aims to determine the quality level of the exchange of a characteristic between one need matrix with another need matrix. The target specification is a result that is developed from the development of technical characteristics obtained from the identification of user needs.

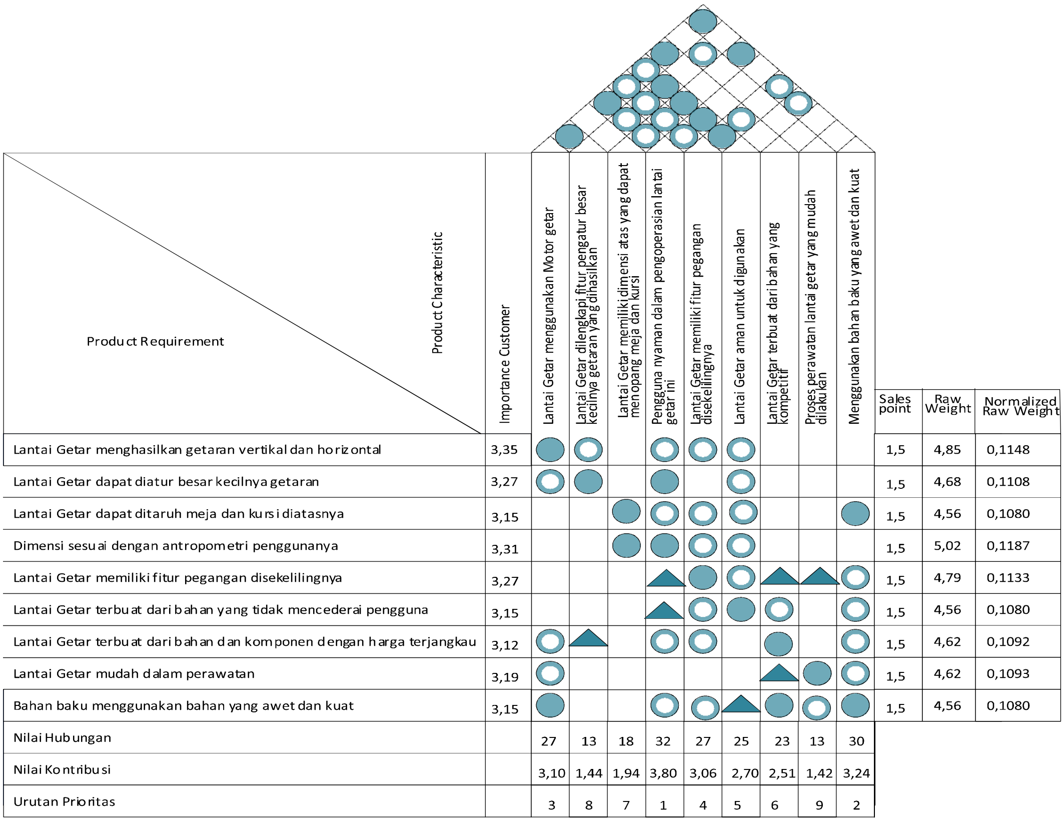

Fig 1. House of Quality of Vibrating Floor

Table 5. Target Specification

Technical Characteristics	Target Specification
Vibrating floor using a vibrating motor	The vibrating motor mount adjusts the dimensions of the motor used, using two motors
The vibrating floor is equipped with a feature that regulates the size of the vibration generated	The feature for adjusting the size of the vibration is made separately
The vibrating floor has an upper dimension that can support tables and chairs	The size of the vibrating floor mat is bigger when it is placed on a table and chairs
The user is comfortable in the operation of this vibrating floor	Width based on arm span, half span length, as big as tables and chairs, stairs are also adjusted to anthropometric measurements
The vibrating floor features a handle all around	The handle adjusts to the height of the standing elbow and hand grip
Vibrating floor is safe to use	The frame is made of holo iron and L iron, the base is made of iron plate and plywood, consisting of 4 springs
The vibrating floor is made of competitive materials	Prices below Rp. 12,000,000
Easy vibrating floor maintenance process	Using painted iron and painted plywood
Using raw materials that are durable and strong	Lasts more than 5 years

Product Design

Based on the results of the target specification of the vibrating floor that is adjusted to the user's wishes, a vibrating floor design is made based on the attributes of the need, so that the vibrating floor can provide a simulation of the vibration of the existing work floor in the industry and provide early information about the dangers of continuous exposure to vibrations on the body [11] In the vibrating floor design process, a 3D design is made using the Sketch Up software. Using Sketch Up to get a vibrating floor design based on the attributes that have been compiled and can help reduce the risk of errors during the manufacturing process of vibrating flooring products. The following below Figure 2 shows the design of the vibrating floor truss.

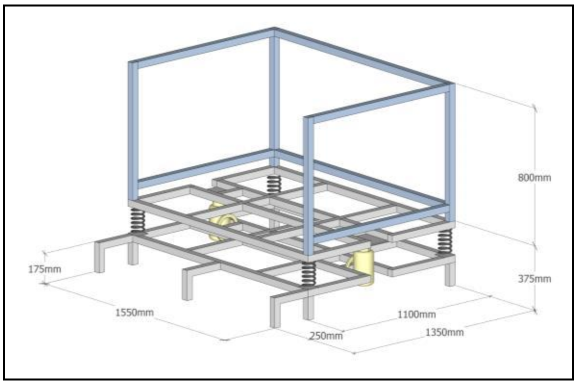

Fig 2. Design of vibrating floor truss

The vibrating floor is designed by using two parts of the frame, namely the lower frame and the upper frame. The lower frame is the frame where the vibrating motor engine mounts and the frame that supports the top of the vibrating floor, while the upper frame will be used as a foothold for the user. The vibrating floor is equipped with four springs that act as elastic supports. In the drive system, the vibrating floor uses a vibrating motor capable of producing vertical and horizontal vibrations, in this design 2 motors are used with 1 HP power.The dimensions of the vibrating floor design are based on user anthropometry, where for the length of the vibrating floor based on anthropometric data the span of the hand is 155 cm and the width is 110 cm, in its later use the vibrating floor can be given a table and chairs on it as an illustration of the working environment conditions, for the height of the vibrating floor design, namely 37.5 cm adjusts to the dimensions of the motor, springs and its constituent frame, so that for the floor design one stair is used to climb it.The vibrating floor design is equipped with handrails around the vibrating floor, aiming to keep the user from falling off the vibrating floor. This is an aspect of user safety and security in the operation of the vibrating floor.In the design of this vibrating floor product, the vibrating floor will use materials such as holo iron, U iron, and L iron for the frame, while the top part is made of plywood with a thickness of 1.6 cm. The use of this material is also able to facilitate the maintenance of the vibrating floor so that the vibrating floor can provide maximum function. The following is a picture of 3 vibrating floor designs.

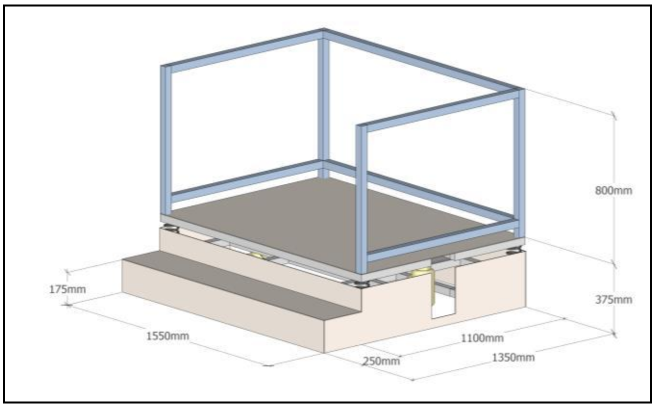

Fig 3. Vibrating Floor Design

Functionally, the existence of a vibrating floor will provide a more real work environment situation so that it can contribute to studying the impact of exposure to vibration on the human body.

IV. CONCLUSION

The design of the vibrating floor by paying attention to the ergonomics and safety aspects using EFD obtained a priority order of technical characteristics based on the user's wishes, namely the user is comfortable in operating it with the target specifications. with the user's anthropometric measurements. The vibrating floor uses durable and strong raw materials with a target specification of the vibrating floor can last for 5 years, the motor used can produce vertical and horizontal vibrations.

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