

## Optimization of ergonomic coffee bean peeling machine design using anthropometric measures

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### Abstract

The findings of observations conducted at the Home Industry indicate that one of the procedures that is thought to be highly significant is the stage of coffee bean peel separation. The lengthy process of separating coffee beans involves two separate machines; the first machine is still used to mix the peel and coffee beans, and the second machine is used to clean any remaining peel mixture.

To solve the issues mentioned above and increase production, the time and motion study method as one of the methods of designing machine operator work systems, is used. It is accompanied by data uniformity tests, data adequacy tests, and cycle time, standard time, and standard output measurements. The design of this coffee peeling machine is to design a combination of machine one and machine two using anthropometric measurements including: standing elbow height, hand reach forward, sideways hand reach, standing navel height, standing knee height.

The standard time for the existing machine is 23.87 seconds per kg, while the standard time for the new machine is 12.60 seconds per kg. The existing machine's standard output is 151.2 kg per hour, while the new machine's standard output is 216 kg per hour, resulting in an 89% increase in productivity.

**Keywords:** Design; Optimal; Anthropometry; Ergonomic; Coffee Bean

### 1. Introduction

The design of this coffee bean peeling machine is carried out in the coffee bean processing home industry center which is carried out in one of the production sections, namely in the stripping of coffee beans before further processing. Stripping by using an existing machine tool that still uses two machines, the first process of coffee beans is still mixed with peeled peel while the second machine is to clean the remaining mixture so that it is clean. Therefore, the stripping is less than optimal. Optimal in question is to efficient and effective resources owned, one of which is the time of stripping coffee beans [3,4].

The first thing to consider in Coffee Production Process the word coffee itself. Coffee is derived from the Arabic word qahwah, which means strength, as it was originally used as a high-energy food. The word qahwah evolved into kahveh, which is derived from Turkish, and then into koffie in Dutch. The word koffie was quickly absorbed into the Indonesian language, eventually becoming the word coffee as we know it today. Coffee is a beverage made from roasted coffee beans that have been ground into powder. Coffee is one of the world's commodities that is grown in over 50 countries. Robusta Coffee (*Coffea canephora*) and Arabica Coffee (*Coffea arabica*) are the two most widely recognized varieties of coffee trees.[5]

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The processing of coffee before it can be drunk goes through a long process, namely from harvesting ripe coffee beans either by machine or by hand, then processing the coffee beans and drying them before they become bagged coffee. The next process is roasting with varying degrees. After the roasting the coffee beans are ground or pulverized into coffee powder before the coffee can be drunk [5]. The design of an ergonomic coffee bean peeling machine using anthropometric measurements is to be more effective, efficient, safe and comfortable to increase productivity for the coffee home industry business.

## 2. Material and methods

### 2.1. Stages of Product Design and Development

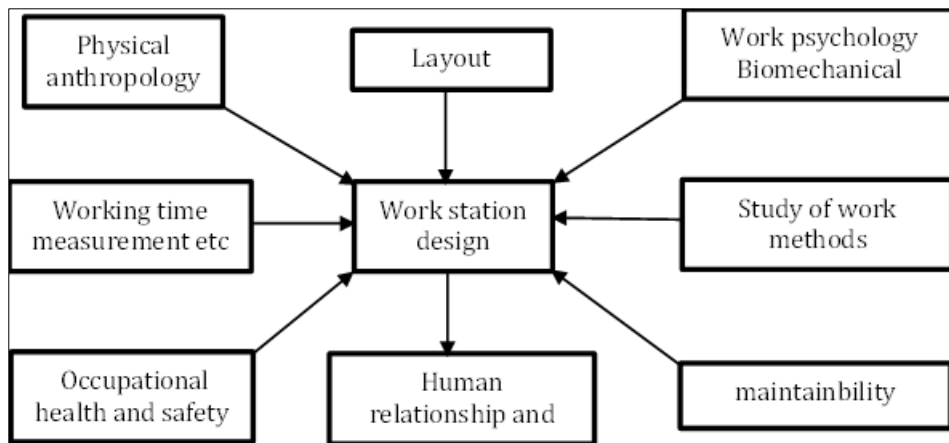
#### 2.1.1. Designing

The design function becomes more important in defining the physical form of the product in order to meet customer needs. In this context, the tasks of the design department include engineering design (mechanical, electrical, software, etc.) and industrial design (aesthetics, ergonomics, user interface). [2,9]

- b. Aspects that affect how work facilities are designed

Work facilities can be influenced by several aspects that come from various disciplines of expertise [1,9].

Physical Anthropology, Working time measurement, occupational health and safety, layout, work station design, Human interactions and conduct, work psychology and biomechanical, work method study, maintainability



**Figure 1** Diagram of the factors influencing work environments

#### Tahapan Ergonomi Ergonomic Stage

Basically, ergonomics is a branch of science that is systematic to utilize information about human nature, abilities and limitations to design a work system so that people can live and work on the system properly, namely to achieve the desired goals through the work effectively, efficiently, safely and comfortably [3,6].

In designing or designing an ergonomic work system, there are five design principles that need to be considered, namely [7,9]:

- Making machines adaptable to humans
- Minimizing presentations that are outside the design.
- Designing the work to be more balanced, and less physical and less procedural.
- Emphasizing the importance of machine communication in augmenting human capabilities
- Using machines to enhance human capabilities
- Some of the main conclusions regarding the discipline of ergonomics are as follows [7,8]:
- The focus of ergonomics is closely related to human aspects in the planning of "man-made objects" and the work environment.

- The ergonomics approach will be able to cause "functional effectiveness" and enjoyments of the use of equipment, facilities and work environments that are designed.
- The main objective is directed at improving human work performance such as increasing work speed, accuracy, safety, reducing excessive energy, speed and minimizing tool damage.
- Systematic application of all information related to human behavior in the design of equipment, facilities and work environments related to the anatomy (structure), physiology (work) and anthropometry (size) of the human body.

Designing a workstation that is good and suitable for operators has been considered by engineers in the industry, many studies have been tested to get a good workstation. One of them applies the principles of ergonomics and economy of movement divided into three types of discussion. [7,9]

- Principles of movement economy associated with limbs.
- Principles of movement economics associated with workplace organization.
- Principles of movement ergonomics are associated with equipment design.

## 2.2. Tahapan Antropometri Anthropometry Stage

Anthropometry can be defined as a science that specifically studies matters relating to the measurement of the human body, which is used to determine differences (features or characteristics) in individuals, groups and so on. In connection with measuring the shape and certain characteristics of the human body, anthropometry can also be interpreted as a science specifically related to the investigation of the human body which is used to determine differences in individuals and groups. This measurement is of course in accordance with the planning of working tools [7,9].

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## 3. Results and discussion

### 3.1. Anthropometric Measurement Analysis

The overall machine dimensions are as follows, derived from anthropometry calculations: machine length of 85 cm, machine width of 49 cm, total machine height of 105 cm, height of the on/off button position 60 cm, input funnel length of 25 cm, input funnel width of 30 cm, and output position height of 45 cm. [6,9]



**Figure 2** Coffee bean peeling machine

#### 3.1.1. Machine Specifications

- Capacity: 2 kg
- Frame Material: Iron Plate with Elbow 2mm 12m
- Machine Material: Stainlees Iron Plate
- Shaft / center base material: Solid steel / sphere
- Van Belt: A-30 Mitsubhisi
- Electric Motor: 1 phase ½ Hp
- Motor rotation speed: 1400 rpm
- Motor voltage: 220 Volts
- Dimensions: 85 cm x 49cm x 105 cm

- Overall Machine Weight: 85 kg
- Time Analysis
- Peeling calculation when using the existing machine is shown as the following [6,7]:
- Given number:
- $Ws = 15.25 \text{ minutes}$

$$P = 1.11$$

The amount of normal time (Nt) :

$$\begin{aligned} Nt &= Ws \times P \\ &= 15.25 \times 1.11 \\ &= 16.93 \text{ second i k/kg} \end{aligned}$$

The amount of standard time (St) :

$$\begin{aligned} St &= Nt \times \frac{100 \%}{100 \% - Allowance \%} \\ &= 16.93 \times \frac{100 \%}{100 \% - 29 \%} \\ &= 16.93 \times \frac{100}{71} \\ &= 16.93 \times 1.41 = 23.87 \text{ second/kg} \end{aligned}$$

The amount output standard (Os) :

$$\begin{aligned} Os &= \frac{1}{St} = \frac{1}{23.87} \\ &= 0.042 \text{ kg/second} \\ &= 2.52 \text{ kg/minute} \\ &= 151.2 \text{ kg/hour} \end{aligned}$$

New machine usage calculation[6]:

$$\begin{aligned} Ws &= 8.10 \text{ second/kg} \\ P &= 1.11 \end{aligned}$$

The amount of normal time (Nt) :

$$\begin{aligned} Nt &= Ws \times P \\ &= 9.17 \times 1.11 \\ &= 8.9 \text{ second/kg} \end{aligned}$$

The amount of standard time (St) adalah :

$$\begin{aligned} St &= Nt \times \frac{100 \%}{100 \% - Allowance \%} \\ &= 8.97 \times \frac{100 \%}{100 \% - 29 \%} \\ &= 8.97 \times \frac{100}{71} \\ &= 8.97 \times 1.41 \\ &= 12.60 \text{ second/kg} \end{aligned}$$

The amount output standard (Os) :



$$\begin{aligned} Os &= \frac{1}{St} = \frac{1}{12.60} \\ &= 0.079 \text{ kg/second} \\ &= 4.74 \text{ kg/minute} \end{aligned}$$

$$= 216 \text{ kg/hour}$$

$$\text{The productivity} = \frac{Os \text{ new} - Os \text{ existing}}{Os \text{ existing}} = \frac{4.74 - 2.52}{2.52} = 89 \%$$

### 3.2. Comparison of Time calculation result

**Table 1** Comparison

Comparison	Existing Machine	New Machine
1. Standard time of peeling process	23,87 second/kg	12,60 minutes/kg
2. Output standard peeling process	151,2 kg/hour	216 kg/hour
3. Operational process	Slow	fast
4. Quality	The coffee beans produced is not clean instantly	The coffee beans produced is clean instantly
5. Output	 consist of peel residue	 Peel off perfectly

### 4. Conclusion

- From the engine testing, the following conclusions can be obtained:
- Testing using the existing machine obtained a standard time of 23.87 seconds / kg and testing using a new machine obtained a standard time of 12.60 seconds / kg.
- Testing using the old machine obtained a standard output of 151.2 kg / hour and testing using a new machine obtained a standard output of 216 kg / hour.
- Based on the test results obtained an increase in production productivity of 89%.

### Compliance with ethical standards

#### Disclosure of conflict of interest

No conflict of interest to be disclosed.

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