

# Ergonomic Trolley Design for Increasing Productivity in PG Jatibarang Brebes

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**Abstract.** Work position is one aspect that must be considered in work. An uncomfortable work position will quickly cause fatigue and can reduce productivity. At the Jatibarang Brebes PG Finishing Station, there is a work position that does not pay attention to ergonomic aspects, namely the trolley operator carries sugar to the scale using a single wheel trolley. so that it will cause fatigue and decreased productivity. The research method used is the trolley operator anthropometry measurement, namely standing elbow height and hand grip diameter. Whereas production can be done by comparing output before and after using ergonomic trolleys. The results of this study produce ergonomic trolleys with trolley height 101.79 cm, hand diameter 3.81 cm, trolley width 50 cm and trolley length 70 cm. Productivity generated after the ergonomic trolley application is 25.2%.

**Keywords:** design, ergonomic, productivity, trolley.

## 1 Introduction

Sugar Factories are assets owned by post-independence Indonesia. One of the sugar factories which is a legacy of the Dutch heritage is the PG Jatibarang Brebes. The PG Jatibarang is located in Jatibarang Subdistrict, Brebes Regency, Central Java Province, which is based in PTPN IX. In general, the process of making sugar in the sugar factory of the Dutch heritage is divided into several stages, namely the stage of sugar cane grinding at the grinding station, the purification stage at the middle plant station, the crystallization stage at the princess station, the packing stage at the final station.

At this finishing station, the sugar that comes out of the puteran station is then packed in a 50 kg sack and then the sugar is carried by the operator using a one-wheel trolley to the scales. Looking at the working position of the sugar carrier operator by using a trolley with one wheel, it can be seen from the ergonomics aspect that the work position will quickly cause fatigue and quickly cause a decrease in the level of productivity.[1] To overcome the problem of work position, it is necessary to improve the work facilities used, namely designing an ergonomic trolley for the sugar carrier at the finishing station.[2]

## **2 Research Method**

Ergonomic trolley design research to increase productivity is carried out with anthropometric measurement methods on sugar transport operators. The object of this research is PG Jatibarang Brebes. The variables used in this research are trolley operator anthropometric data measurement, measurement of trolley operator process time and measuring productivity levels.[3] The stages of the research that will be carried out are as follows:

- 1) Data collection  
Anthropometric data (elbow standing and hand-held diameter), sugar transport time data before and after the application of ergonomic trolley, performance rating before and after applied the ergonomic trolley, allowance before and after applied the ergonomic trolley[4]
- 2) Data test  
Normaly distribution anthropometri data test, Uniform anthropometri data test, adequacy anthropometri data test, Uniform sugar transport time before and after the application of ergonomic trolley data test, and adequacy sugar transport time before and after the application of ergonomic trolley data test.
- 3) Data processing  
Anthropometric data used to determine percentile values. If the percentile value has been obtained, then the size of the ergonomic trolley can be design. To determine the value of productivity, the comparison value was calculated from before and after the application of ergonomic trolley.[5]
- 4) Trolley design  
Use autocad software to design ergonomic trolleys.
- 5) Conclusion

## **3 Result and Discussion**

### **3.1 Anthropometric Data Trolley Operator**

Anthropometry data for trolley operators needed for trolley design are high elbow standing and hand held diameter. Table 1 shows anthropometric data from the trolley operator.

**Table 1.** Anthropometry Data For Trolley Operators.

Operator	High Elbows Standing (Cm)	Hand-Held Diameter (Cm)	Operator	High Elbows Standing (Cm)	Hand-Held Diameter (Cm)
1	105	6	16	104	6
2	106	7	17	102	6
3	107	5	18	103	7
4	103	7	19	102	5
5	103	5	20	102	5
6	102	6	21	105	7
7	105	6	22	107	6
8	107	7	23	106	6
9	105	5	24	103	7
10	108	5	25	104	5
11	104	6	26	104	6
12	106	5	27	107	6
13	106	7	28	107	5
14	103	6	29	106	7
15	107	5	30	105	5

After the trolley operator anthropometric data was obtained, the next step were:

- 1) Measure the dimensions of sugar sacks  
Dimensions of the sack sugar were used to determine the length and width of the trolley to be designed. For the size of the sack of sugar = 50 cm and for the length of the sack of sugar = 70 cm.
- 2) Test the normality of trolley operator anthropometric data  
SPSS software is used with a 95% confidence level, and with the Statistical Test using the Kolmogorov-Smirnov Test. then the data was declared to be normally distributed if Sig. >  $\alpha$ , then H0 is accepted and If Sig. <  $\alpha$ , then H0 is rejected.

**Table 2.** Test the normality of trolley operator anthropometric data.

Anthropometric Data	N	Sig.	$\alpha$
Elbow Standing	30	0,559	0,05
Hand grip diameter	30	0,072	0,05

- 3) Anthropometric data uniformity test for trolley operator  
Uniformity test Anthropometric data on trolley operators is carried out with the aim to test whether the data obtained is uniform or not. the data is declared uniform if the data is between the upper control limit and the lower control limit. Table 3 shows the results of the trolley operator anthropometric data uniformity test.

**Table 3.** Result of Anthropometric data uniformity test for trolley operator.

Anthropometric Data	$\bar{X}$	$\sigma$	BKA	BKB
Elbow Standing	104,8	1,83	108,4	101,2

Hand grip diameter	5,9	0,8	7,5	4,3
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- 4) Adequacy test of anthropometric data on trolley operator  
 Adequacy test of anthropometric data trolley operator aims to test whether the data used is sufficient or not. Table 4 shows the results of the calculation of the adequacy test of the anthropometric data of the trolley operator.

**Table 4.** Results of the anthropometric data adequacy test from the trolley operator

Anthropometric Data	N	N'
Elbow Standing	30	1
Hand grip diameter	30	29

- 5) Calculate the percentile value  
 Percentile size was the size used as the basis for determining the trolley size to be designed. The percentile measure used in the design of trolley was a 5-th percentile, 50-th percentile, 95-th percentile. Table 5 shows the value of the percentile of trolley design.

**Table 5.** The value of the percentile of trolley design.

Anthropometric Data	Percentile (cm)		
	5 <sup>th</sup>	50 <sup>th</sup>	95 <sup>th</sup>
Elbow Standing	101,79	104,8	107,81
Hand Grip Diameter	3,81	5,9	7,53

- 6) Ergonomic trolley design  
 Ergonomics trolleys are designed based on percentile values. for high size the trolley is taken from the 5-th percentile value of the standing elbow that is 101.79 cm. while for the diameter size the trolley handle is taken from the 5-th percentile value of the hand grip diameter of 3.81 cm



**Fig. 1.** Ergonomic Trolley Design.

### 3.2 Productivity Analysis

Productivity values from the application of ergonomic trolleys can be calculated by the following steps:

- 1) Calculate Trolley operator Time Data before and after the application of ergonomic trolleys.

**Table 6.** Trolley operator Time Data.

Trolley Operator	Before The Application Of Ergonomic Trolley	After The Application Of Ergonomic Trolley
1	19	16
2	20	15
3	20	16
4	21	16
5	18	15
6	19	17
7	19	15
8	18	17
9	17	18
10	21	17
11	17	18
12	20	17
13	21	17
14	19	18
15	19	16
16	18	15
17	17	15
18	18	17
19	18	16
20	21	16
21	21	18
22	20	17
23	19	16
24	17	15
25	17	15
26	18	16
27	21	18
28	20	18
29	17	17
30	18	15

- 2) Time Data uniformity test for trolley operators before and after applied ergonomic trolley.

**Table 7.** Results Time Data Uniformity Test For Trolley Operators Before And After Applied Ergonomic

Data	$\bar{X}$	$\sigma$	BKA	BKB
Before the applied of ergonomic trolley	18,93	1,44	21,81	16,05

After the applied of ergonomic trolley	16,4	1,1	18,6	14,2
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- 3) Calculate the value of performance rating before and after applied the ergonomic trolley

**Table 8.** Performance Rating Before And After Applied The Ergonomic Trolley.

Perfonmance Rating	Before the applied of ergonomic trolley	After the applied of ergonomic trolley
Skill	0,00	0,00
Effort	0,05	0,05
Conditions	-0,03	-0,03
Consistency	0,00	0,00
Total	0,02	0,02

Total value of peformance rating before and after the applied of ergonomic trolley was  $(P) = 1 + 0.02 = 1.02$

- 4) Calculate the allowance before and after applied the ergonomic trolley.

**Table 9.** Allowance Before And After Applied The Ergonomic Trolley.

Adequacy test	Before the applied of ergonomic trolley	After the applied of ergonomic trolley
Strength	20 %	16%
Work attitude	1,5%	1%
Movement	3%	2%
Fatigue	1%	1%
Temperature	5%	5%
Atmosphere	2%	2%
Environmen	4%	4%
Total	36,5%	31%

- 5) Calculate the standard time before and after the application of ergonomic trolleys.

- a. Before applied the ergonomic trolley

$$\text{Cycle Time} = \bar{x} = \frac{\sum_{i=1}^{n=30} x}{n} = \frac{568}{30} = 18,93 \text{ second/sack} \quad (1)$$

$$\text{Normal Time} = W_s \times PR = 18,93 \times 1,02 = 19,31 \text{ second/sack} \quad (2)$$

$$\begin{aligned} \text{Standard Time} &= W_n \times \left( \frac{100\%}{100\% - \text{Allowance}} \right) \quad (3) \\ &= 19,31 \times \left( \frac{100\%}{100\% - 36,5\%} \right) \\ &= 30,31 \text{ second/sack} = 0,0084 \text{ hour/sack} \end{aligned}$$

- b. After applied the ergonomic trolley

$$\text{Cycle Time} = \bar{X} = \frac{\sum_{i=1}^{n=30} x}{n} = \frac{492}{30} = 16,4 \text{ second/sack} \quad (4)$$

$$\text{Normal Time (Wn)} = Ws \times PR = 16,4 \times 1,02 = 16,73 \text{ second/sack} \quad (5)$$

$$\begin{aligned} \text{Standard Time} &= Wn \times \left( \frac{100\%}{100\% - \text{Allowance}} \right) \\ &= 16,73 \times \left( \frac{100\%}{100\% - 31\%} \right) \\ &= 24,26 \text{ second/sack} = 0,0067 \text{ hour/sack} \end{aligned} \quad (6)$$

- 6) Calculate the standard output before and after the application of an ergonomic trolley.
- a. Before Applied The Ergonomic Trolley.

$$\text{Output Standart} = \frac{1}{Wb} = \frac{1}{0,0084} = 119,04 \text{ sack/hour} \approx 119 \text{ sack/hour} \quad (7)$$

- b. After Applied The Ergonomic Trolley.

$$\text{Output Standar} = \frac{1}{Wb} = \frac{1}{0,0067} = 149,2 \text{ sack/hour} \approx 149 \text{ sack/hour} \quad (8)$$

- 7) Calculate the value of productivity

Productivity can be calculated by the following equation:

$$\text{Productivity} = \frac{\text{Output2} - \text{Output1}}{\text{Output1}} \times 100\% = \frac{149 - 119}{119} \times 100\% = 25,2\% \quad (9)$$

There was an increase in the number of products with 30 sacks / hour and an increase in output productivity of 25.2%.

## 4 Conclusion

The conclusion of this research is ergonomic trolley design with trolley height size of 101.79 cm, trolley hand grip diameter size of 3.81 cm, trolley width size of 50 cm and trolley length size of 70 cm. Then after the application of ergonomics trolleys obtained an increase in productivity of 25.2%.

## References

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