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ERGONOMIC WORK SYSTEM DESIGN USING KANSEI ENGINEERING APPROACH

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Abstract -- *Work fatigue is a problem that most often arises in the workplace and can affect work productivity. That problem also occurs at PT ASA Yogyakarta, many workers who complain of aches in the upper muscles and waist at work. Based on this, the research aims to design an ergonomic work system on the sewing production floor of PT. ASA Yogyakarta. The design of the work system is done to fix the problems done by workers so that it is expected to increase productivity. The method used is Kansei Engineering. The results of this study indicate that the proposed work system design meets the desires of workers with Stuart-Maxwell values testing marginal homogeneity of Z> 0.05. Work system designs made include sewing chairs and tables adjusted in size to worker anthropometry, approved backrests on chairs, lighting lamps replaced with LED lights, plug lamps on sewing machines, and plug bulkheads as sound dampers.*

Keywords: *Golf Gloves; Work System; Productivity; Kansei Engineering*

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INTRODUCTION

In this global era, every company is required to always increase its competitiveness to survive. A company needs to have the ability to manage its resources to produce maximum results. The factor often used in determining the effectiveness of a company is productivity. A company will not be able to develop if its productivity does not increase. Increasing productivity is the key for a company to be able to catch up to compete at a higher level.

Work fatigue is common in the workplace. This can affect productivity at work and make a significant contribution to work accidents [1]. Based on the data released by the International Labor Organization, two million workers experience work accidents due to fatigue every year. The organization also explained that 32.8% of 58,118 hard workers experienced work fatigue, which had a significant effect on productivity at work [2]. The causes of work fatigue vary greatly, such as noise, lighting, work climate, and vibration [3], sex, age, workload, body size, and work time [4].

The problem of work fatigue is also widely experienced by workers at PT. ASA Yogyakarta (ASA Limited Liability Company), a company is manufacturing golf gloves. Based on the field research, many workers have complained of aches in the upper muscles and waist at work. Consequently, the workers cannot work efficiently to achieve the targets.

Ergonomics is the study of the correlation between humans and their work environment. Bridger stated that the purpose of ergonomics is to ensure that humans can work safely and efficiently in a working system [5]. In general, the application of ergonomics is to prevent fatigue, injuries, and illness resulting from work and also reduce physical and mental burdens [6]. Working conditions with long-duration require a safe and comfortable work environment. However, this is often neglected, which leads to work fatigue.

The number of researches about work system improvement is quite a lot. One of the research is about designing classroom furniture to reduce the negative impact of poor posture in the classrooms [7]. Another research is about designing an ergonomic chair to reduce musculoskeletal disorders in students [8]. Work system improvement can also be made by changing the layout of facilities and by re-arranging work equipment [9]. Purnomo mentioned a working system with a total ergonomic approach is a good effort to optimize the work system [10].

Based on the questions above, the purpose of this study is to design an ergonomic work system on PT. ASA Yogyakarta. The design of the work system is done to improve the problems that have been solved by workers so that it is expected to increase productivity. The method used is Kansei Engineering. This method can translate user needs into a design parameter [11] [12] so that the design is made or by the needs of its users [13]. This method can also be used to solve physical facility problems such as facilities of inpatient hospital [14], elementary school desk and chairs [15], dining stalls [16], and supermarket trolleys [17]. Also, this method can also be used to design mass products such as product packaging [18], and sports shoes products [19].

METHOD

This research uses the Kansei Engineering System. This method can translate the emotional needs of consumers into product parameters so that products are made following consumer desires [11] [12]. This method can be applied to designing a product and also a working system. Principle works of the Kansei Engineering System is illustrated in Figure 1.

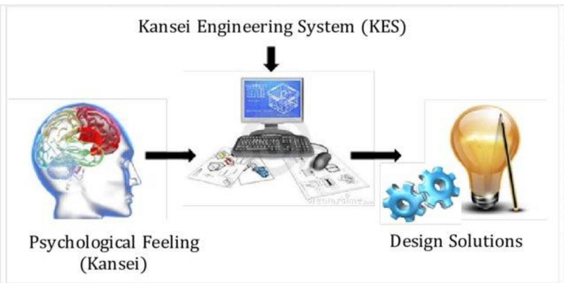

Figure 1. The Kansei Engineering System

The object of this research was designing an ergonomic chair and table for the golf gloves tailors at PT. ASA. The subjects of this research were 30 tailors of golf gloves at PT. ASA Yogyakarta. 30 samples constitute the minimum number in Kansei Engineering research [20]. Meanwhile, the tools and materials used of this research were: (1) anthropometric data forms, (2) a meter with the Butterfly brand, (3) Nordic Body Map questionnaire with 28 questions [21], and (4) open questionnaire.

The step of this research describes as in Figure 2.

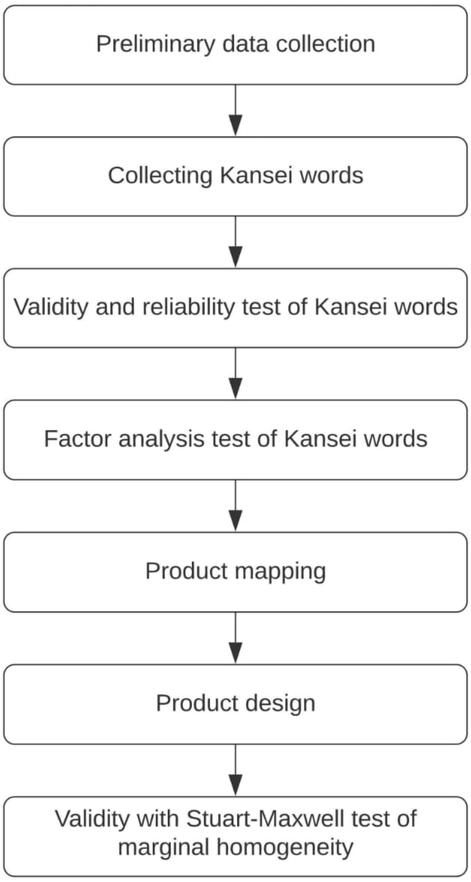

Figure 2. Flow chart research

(1) Preliminary data collection. Nordic body maps and interviews to find out complaints from body parts of employees and make percentation of the highest complaint that is felt ; (2) Collecting Kansei words. Questions asked openly about 30 tailors in the Sewing Division of PT. ASA, the results of this questionnaire obtained kansei word are valid and reliable; (3) Validity and reliability test of Kansei words. Kansei's words were collected later in the validity and reliability test using SPSS, the data is valid when the validity criteria $R_{value}>R_{table}$ [22], while reliable if the reliability of the criteria with a Cronbach's alpha value > 0.7 [23] [24]; (4) Factor analysis test of Kansei words. Said to group Kansei's words into groups based on their similarity [25]. Test were carried out using SPSS software, Factor analysis is used to simplify the collected kansei word to make it easier when mapping products; (5) Product mapping. The Kansei words that have been collected are then mapped into several levels to produce the specifications/characteristics of the product to be made; (6) Product design. Product specifications/characteristics obtained are then visualized in the form of 3D products; (7) Validity with Stuart-Maxwell test of marginal

homogeneity. This test is to assess wether the proposed design is appropriate or not to the user's wishes. It is expected to use the Stuart Maxwell test of marginal homogeneity with a validity criterion of Z> 0.05 [26].

RESULTS AND DISCUSSION

The Preliminary Data Collection

Based on the Nordic Body Map questionnaire distributed to the 30 subjects, the results show that 15.18% of the subjects experienced neck pain, 9.82% experienced left shoulder pain, 8.93% experienced right shoulder pain, and 8.93% experienced waist pain.

The Collection of Kansei Words

The Kansei words ware collected by distributing the random questionnaires to 30 tailors in the sewing division of PT. ASA Yogyakarta. Based on the validity and reliability test, the result obtained 10 valid and reliable Kansei words for a sewing chair and 9 valid and reliable Kansei words for a sewing table. The results of the validity and reliability test can be seen in Table 1 and Table 2.

Table 1. Kansei words and the validity and reliability tests for sewing chair

No	**Kansei Words**	**Validity**			**Reliability**	
		R-value	**R table**	**Results**	**Cronbach's Alpha**	**Results**
1	Tiny	0.801	0.361	Valid	0.748	Reliable
2	Good quality	0.423	0.361	Valid	(0.748 > 0.7)	
3	Comfortable	0.732	0.361	Valid		
4	Soft	0.685	0.361	Valid		
5	Good	0.643	0.361	Valid		
6	Innovative	0.542	0.361	Valid		
7	Attractive colors	0.753	0.361	Valid		
8	Strong	0.446	0.361	Valid		
9	Durable	0.443	0.361	Valid		
10	Safe	0.448	0.361	Valid		

Table 2. Kansei words and the validity and reliability tests for the sewing table

No	**Kansei words**	**Validity**			**Reliability**	
		R-Value	**R Table**	**Results**	**Cronbach's Alpha**	**Results**
1	Strong	0.655	0.361	Valid	0.869	Reliable
2	Eye-catching	0.456	0.361	Valid	(0.869 > 0.7)	
3	Wide	0.874	0.361	Valid		
4	Durable	0.466	0.361	Valid		
5	Comfortable	0.767	0.361	Valid		
6	Innovative	0.680	0.361	Valid		
7	Adjustable	0.440	0.361	Valid		
8	Safe	0.839	0.361	Valid		
9	Moveable	0.572	0.361	Valid		

Factor Analysis

Factor analysis is used to classify the Kansei words into several groups/factors based on the similarity [25]. In other words, factor analysis is useful to simplify the collected Kansei words and make the product mapping easier. Based on the factor analysis, the Kansei words for the chair and sewing table are grouped into three factors, as shown in Table 3 and Table 4.

Table 3. Result of factor analysis from the sewing chair

Factor 1		**Factor 2**		**Factor 3**	
Tiny	0.805	Strong	0.603	Not slippery	0.667
Comfortable	0.707	Durable	0.573		
Soft	0.661	Safe	0.750		
Good	0.811				
Innovative	0.579				
Attractive colors	0.737				

Table 4. Result of factor analysis from the sewing table

Factor 1		**Factor 2**		**Factor 3**	
Strong	0.783	Adjustable	0.924	Fine design	0.871
Proportional Size	0.723	Moveable	0.840		
Durable	0.662				
Comfortable	0.833				
Innovative	0.635				
Safe	0.668				

Next, the factors of each category of the Kansei words were identified. For the sewing chair, factor 1 was categorized into the "Chair Design" factor, factor 2 was categorized into the "Durability" factor, and factor 3 was categorized into the "Not Slippery" factor.

Meanwhile, for the sewing table, factor 1 was categorized into the "Durability" factor, factor 2 was categorized into the "Table Setting" factor, and factor 3 was categorized into the "Fine Design" factor.

Product Mapping

Product mapping was carried out to determine the design specifications of the products. The product mapping process can be seen in Table 5 and Table 6.

Table 5. The product mapping of the sewing cha

No	Level 1	Level 2	Level 3	Design Specification
1	Design	Shape	Backrest	Rectangular, Curved
			Seater pad	Circular
		Size	Backrest	46.9 cm x 20 cm; R27 cm
			Seater	48 cm x 40 cm x 34 cm
			Seater pad	R23 cm
		Color	Backrest	Red
			Seater pad	Red
			Frame	Silver
2	Durability	Material	Backrest	Foam
			Seater pad	Foam
			Frame	Stainless steel
3	Not slippery	Chair legs	-	Rubber pad

Table 6. The product mapping of the sewing table

No	Level 1	Level 2	Level 3	Design Specification
1	Durability	Material	Sewing table	Stainless steel
			Table legs	Stainless steel
			Footrest	Stainless steel
				Rubber pad
2	Table setting	Adjustable	-	Adjustable table height
3	Fine Design	Shape	Sewing table	Rectangular
			Table legs	Rectangular
			Footrest	Rectangular
		Size	Sewing table	118 cm x 52 cm
			Table legs	77 cm x 50 cm
			Footrest	27 cm x 22 cm
		Color	Sewing table	Light brown
			Table legs	Light brown
			Footrest	Light brown

The characteristics of the mapping above are described as follows: (1) The size of the rectangular and curved-shape backrest is 46.9 x 20 cm with the diameter of the curve of 27 cm. It is adjusted to the average shoulder width of the operators with a 95th percentile for the comfort of every tailor. The red backrest matches the seater pad to make it attractive according to the demand of the users. The seater is 34 cm in height. It is adjusted to the sitting elbow height of the operators with a 95th percentile—the purpose of using the 95th percentile for the comfort of every tailor. The chair frame is made of stainless steel with foam pad expected to be strong [27] [28], soft, and durable so that the users feel comfortable when sitting for a long time. The chair legs added with a rubber pad, so not slippery. (2) Sewing table, table legs, and footrest are made of stainless steel expected to be strong and durable [27] [29]. The footrest added with a rubber pad, so not slippery. The size of the rectangular sewing table is 118 x 52 cm, with the legs of 77 x 50 cm and the footrest of 27 x 22 cm, which is adjusted to the table used by the tailors. The light brown color is used to make it attractive to the users. The table can be setting adjustable so that the users can adjust the height of the chair. With an additional lamp that is easily shifted, it is expected to add an aesthetic value.

Product Design and Work System Design

The final stage in Kansei Engineering is to visualize the results of the design in the form of 3D product designs. The design of the chair and sewing table can be seen in Figure 3 and Figure 4.

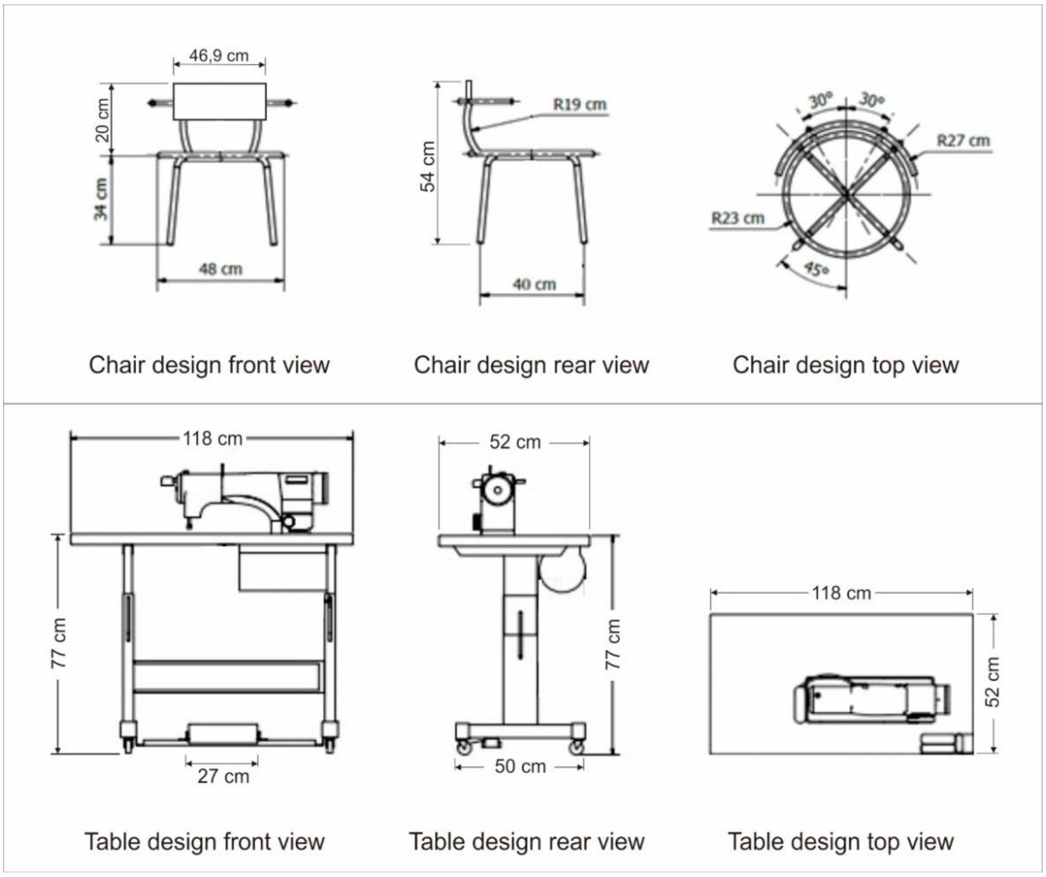

Figure 3. The Concepts of the Chair and Sewing Table

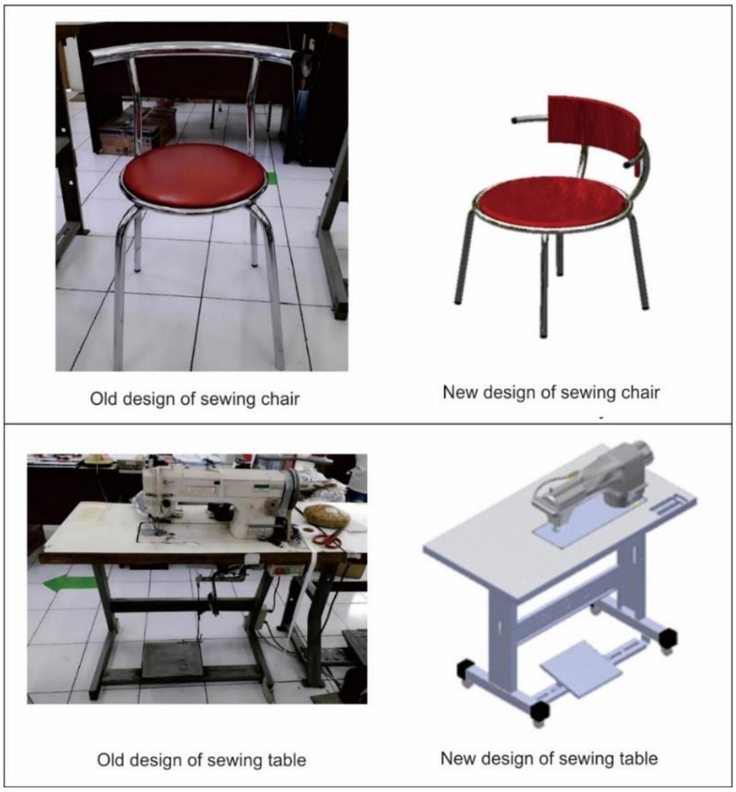

Figure 4. The Comparison between the Old Products and the Concepts of the New Products

Proposed Work System Design

From the results of the meeting and data processing above, it was conveyed that the work system design that could be provided by researchers can be seen in the following Table 7.

Table 7. The proposed work system design

No	Factor	Present State	Design Proposed
1	Chair	- Chair size - There is no seatback	- Chair size is adjusted to the anthropometric dimensions of the worker - Addition of foam backrest that is adjusted to the anthropometric dimensions of the worker
2	Lighting	- Too bright exceeds NAB - There is no lighting on the machine	- The lighting is replaced with LED lights to be more efficient and not exceed the NAB limit - Adding lights in the engine so that workers are more focused
3	Noise from the engine dynamo	There is no silencer engine dynamo	- Adding a bulkhead as the engine silencer

Design Validation

Design validation is done to assess whether the design is in accordance with the wishes of the user. Testing using the Stuart-Maxwell test of marginal homogeneity for 30 research subjects. Made by comparing the initial design with the design made. The results of the Stuart-Maxwell test of marginal homogeneity can be seen in Table 8.

Table 8. The result of the Stuart-Maxwell test of marginal homogeneity

The Kansei Word for the Sewing Chair	Value	The Kansei Word for the Sewing Table	Value
Chair design	0.217	Durability	0.273
Durability	0.116	Table setting	0.317
Not slippery	0.251	Fine design	0.289

Based on Table 8, with a significance level of 5%, the Z value of >0.05 is obtained. This shows that the design meets the demand of the users.

CONCLUSION

Based on the results of the research, it was concluded that the design of the work system that was made already meets the demand of workers with Stuart-Maxwell values testing marginal homogeneity of Z> 0.05. Work system designs made include: (1) sewing chairs and tables are adjusted in size with worker anthropometry; (2) approve seatbacks; (3) lighting lamps are replaced with LED lights; (4) Buy lights on a sewing machine; (5) use insulation as a silencer.

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