

Work facilities design for people with paraparesis at hemming machine work station using TRIZ Method

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Abstract. The number of disability employee in Indonesia increases every year due to traffic accidents, natural disasters, and diseases. It reached 16.81 percent of the total Indonesian workforce until 2017 [1]. According to the law which explains disability, each private company must employ disabled employee for at least 1 percent and state-owned companies must employ disabled employee for at least 2 percent from all employees. In fact, the regulation has not been implemented due to negative society views on disability. Therefore, it is necessary to empower paraparesis people to work independently so that negative views from the society can be eliminated. Empowerment of people with paraparesis at Balai Besar Rehabilitasi Sosial Penyandang Disabilitas Fisik (BBRSPDF) Prof. Dr. Soeharso Surakarta was conducted by training on the development of the hemming machine. Their legs are not able to use pedals, so they need work facilities to accommodate the design of work facilities based on participatory approach to determine user needs. Participatory approach was conducted with distributing questionnaires. Change of operation hemming machine which previously used feet changed using the elbows cause technical contradictions in design of work facilities. Technical contradiction problem can be solved using TRIZ method.

1. Introduction

Disability people are those who experience physical, intellectual, mental, and/or sensory limitations for a long time. Their interaction with the environment can experience obstacles and difficulties to participate fully and effectively. People with physical disabilities are disability people who are easier to recognize compared to other disability people because their limitations are clearly appeared. The number of people with physical disabilities has the highest percentage that is 33.74% of all types of disabilities [2]. However, people with physical disabilities are considered the same as the perspective of sick people, helpless, not independent, and other negatives [3]. This assumption limits disability people to get a job. The Government through the Ministry of Social Affairs provides skills training and labor distribution for disability people at Balai Besar Rehabilitasi Sosial Penyandang Disabilitas Fisik (BBRSPDF) Prof. Dr. Soeharso Surakarta. The most demanded skill training by paraparesis is sewing skills, that is because many people are distributed into mass industries such as convection companies by 53% of BBRSPDF total partner companies.

The Empowerment of sewing skills for disability people include how to operate a machine that consists of a sewing machine, a hemming machine, and an ironing machine. Based on three machines, a hemming machine is an important part of the garment products making process. Hemming machine is used to tidy up pieces of cloth so that the cut off fabrics are not defect [4]. The design of the hemming



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machine operated by operators in the garment industry is more intended for normal workers. The operation of this machine is obstacle for paraparesis workers. Paraparesis is a disturbance between two lower limbs. Paraparesis workers cannot operate the hemming machine pedal using feet, so that it can be replaced with the addition of work facilities which are operated using the elbow. This obstacle appears while operating the hemming machine pedal, it previously used the soles of the feet then replaced using elbows. This problem can be overcome by making work facilities according to the need of paraparesis in accommodating limb function change while operating the pedals.

Work facilities are physical work areas equipped with facilities to facilitate users, so that user's needs can be met [5]. Work facilities at the hemming machine work station can be designed by paying attention to the interaction between humans and machines or human-machine systems. Changing the operation of hemming machine motor and foot lifter pedal from feet into elbows will cause discomfort for user. Errors in the design of this work facility can reduce the worker's comfort [6].

The work facility design is based on anthropometry and ergonomic with participatory approach determine user's needs. The participatory approach involves the active participation of users and other stakeholders to improve performance from the product design process to the application of finished products [7]. Stakeholders form a team to discuss work problem solving. Stakeholders analyses user needs and determine measurements/assessments that will have an impact on effectiveness in designing work facilities. Measurements in the design of work facilities with distributing questionnaires to users and stakeholders.

Change of operation hemming machine which previously used feet changed using the elbows cause technical contradictions in design of work facilities. This technical contradiction problem can be solved using the TRIZ (Teoriya Resheniya Izobreatatelskikh Zadatch) theory [8]. The TRIZ method gives the designer to observe and design according to his idea, so that design considerations are not only from the customer's demand but also user's needs. Based on this problem, this study purpose to design operation of motor pedal and overlock foot of the hemming machine work station for people with physical disabilities to facilitate the user in operating hemming machine.

2. Methodology

2.1. Problem identification

The problem occurred because paraparesis could not operate hemming machine during the sewing training at BBRSPDF Prof. Dr. Soeharso as stated in Figure 1.

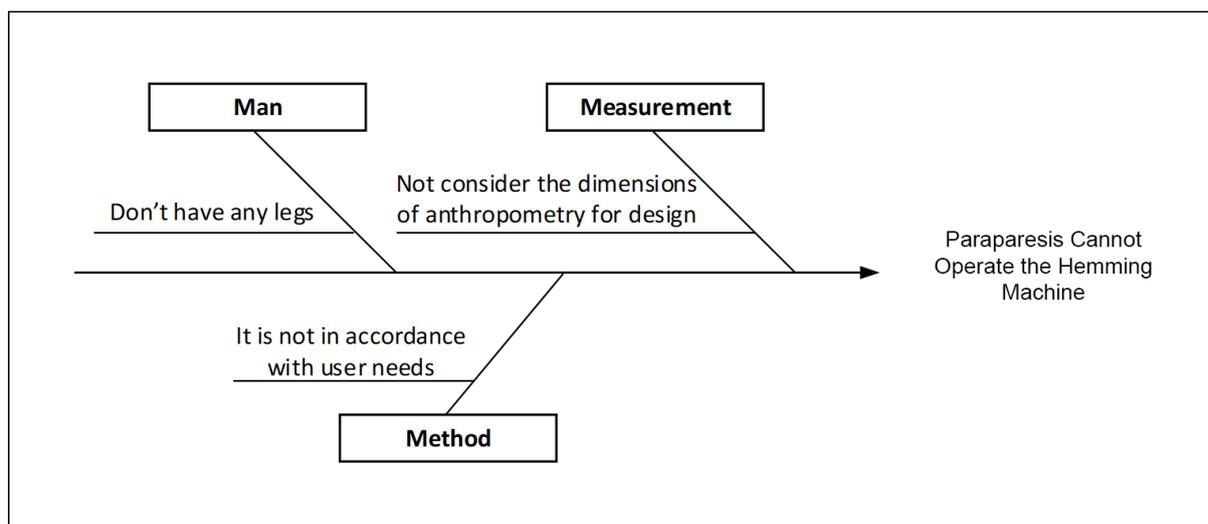


Figure 1. Cause effect diagram.

2.2. Identification dimensions of anthropometry

The identification of anthropometry dimension is used to know the structure dimension of paraparesis body as the basis for designing work facilities of the hemming machine. The dimensions needed by paraparesis legs are sitting elbow height, upper arm length, and forearm length.

2.3. Participatory approach

The participatory approach is conducted by distributing questionnaires to determine what design criteria are needed in designing work facilities. The questionnaire was distributed to users and stakeholders. Stakeholders in designing work facilities are user and trainers as stated in Table 1.

Table 1. Criteria and attribute hierarchy.

No.	Criteria	Attribute
1	Operation	Work facilities operated manually
2		Work facilities easy to operate
3		Work facilities adjust user requirements
4	Setting	Work facilities installation
5		Work facilities can be used portable
6		Work facilities can be applied to all types of hemming machines
7	Comfort	Work facilities can be used comfortably
8		Work facilities has low physical effort
9		Work facilities does not cause elbow pain
10	Quality	Work facilities has weight material
11		Work facilities has light spring strength
12	Materials	Work facilities has light material
13		Work facilities has strong material
14	Shape	Work facilities has simple design
15		Work facilities can save space
16	Sustainability	Work facilities can be used long term
17		Work facilities has eco-friendly material
18		Work facilities easy to maintenance

The 7 criteria and 18 attributes above are the result of identifying user needs. Not all-important criteria can be applied to the hemming machine design process. Therefore, 5 of the most influential criteria and 10 attributes were determined in designing the hemming machine after reliability and validity test as stated in Table 2.

Table 2. Most influential criteria and attribute.

No.	Criteria	Attribute
1	Operation	Work facilities operated manually
2		Work facilities easy to operate
3	Setting	Work facilities installation
4		Work facilities can be used portable
5	Comfort	Work facilities can be used comfortably
6		Work facilities has low physical effort
7		Work facilities does not cause elbow pain
8	Quality	Work facilities has weight material
9		Work facilities has light spring strength
10	Sustainability	Work facilities can be used long term

2.4. Functional analysis diagram

Functional analysis diagram aims to identify the relationship between the functions of each element contained in the operation process of the engine, functions and problems as shown in Figure 2.

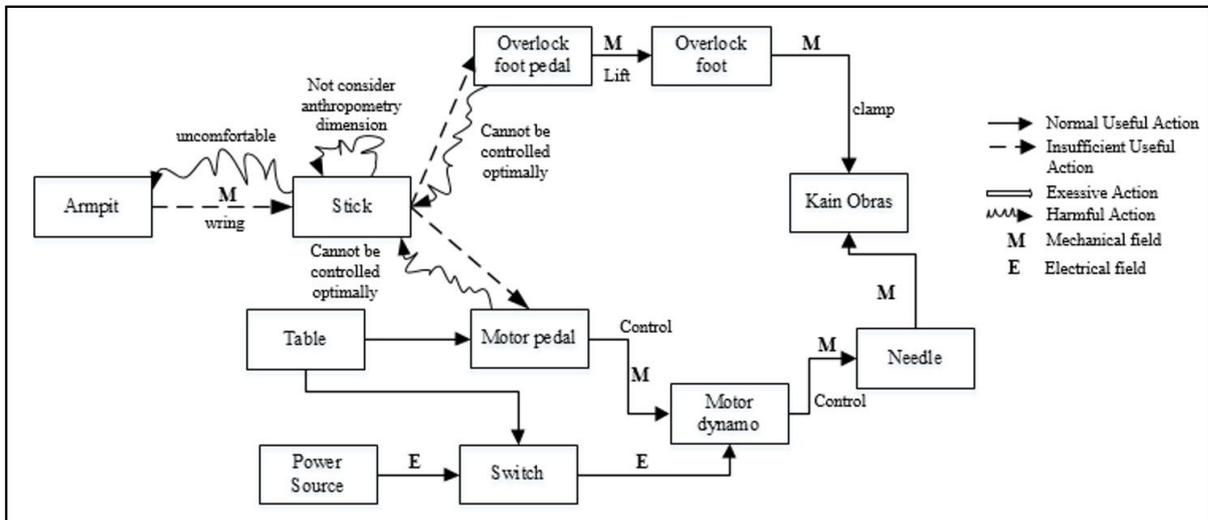


Figure 2. Functional analysis diagram of hemming machine.

2.5. Technical contradiction (TRIZ)

2.5.1. Technical requirement. Technical requirements are criteria for technical needs which are the needs of paraparesis. Technical requirements are obtained from participatory questionnaire and functional analysis as stated in Table 3.

Table 3. Technical requirement.

No	Part	Technical Requirement	Source
1	Main frame	Strong	Participatory questionnaire
		Can be used long term	Participatory questionnaire
		Doesn't block the other component	Functional analysis
2	Lever	Operated manually	Functional analysis
		Easy to operate	Participatory questionnaire
		Appropriate function	Functional analysis
3	Pad	Light pressure on lever	Participatory questionnaire
		Portable	Participatory questionnaire
		Comfort	Participatory questionnaire

2.5.2. Improving feature. Improving feature is a stage after classification technical requirements. This stage using 39 problem parameters to development product based on TRIZ as stated in Table 4.

Table 4. Improving feature.

No	Part	Technical Requirement	Source
1	Main frame	Strong	Weight of Stationary object (2)
		Can be used long term	Duration of action by a stationary object (16)
		Doesn't block the other component	Area of stationary object (6)
2	Lever	Operated manually	Ease of operation (33)
		Easy to operate	Ease of operation (33)
		Appropriate function	Reliability (27)
		Light pressure on lever	Weight of moving object (1)
3	Pad	Portable	Adaptability (35)
		Comfort	Shape (12)

2.5.3. *Worsening feature.* The worsening feature analyse the impact of improving features. The determination of the worsening feature is taken based on 39 problem parameters in the TRIZ and considers the impact that occurs as a result of improving the applied previous criteria as stated in Table 5.

Table 5. Worsening feature.

No	Part	Technical Requirement	Improving Feature	Worsening Feature
1	Main Frame	Strong	Weight of Stationary object (2)	Strength (14) Force
		Can be used long term	Duration of action by a stationary object (16)	Ease of operation (33)
		Doesn't block the other component	Area of stationary object (6)	Length of stationary object (4) Measurement accuracy (28)
2	Lever	Operated Manually	Ease of operation (33)	Complexity device (36) Ease of manufacture (32)
		Easy to operate	Ease of operation (33)	Shape (12) Ease of manufacture (32)
		Appropriate function	Reliability (27)	Productivity (39)
		Light pressure on lever	Weight of moving object (1)	Ease of operation (33) Loss of substance (32)
3	Pad	Portable	Adaptability (35)	Shape (12)
		Comfort	Shape (12)	Area of moving object (5) Area of moving object (5) Weight of moving object (1)

2.5.4. *Contradiction elimination.* Contradiction elimination aims to resolve and eliminate the contradictions that occur in the design of work facilities, the TRIZ method provides tools in the form of 40 inventive principles to help resolve existing contradictions as stated in Table 6.

Table 6. Inventive solution.

No.	Part	Technical Requirement	Inventive Solution
1	Main Frame	Strong	Mechanics substitution (28) Periodic action (19) Preliminary action (10)
		Can be used long term Doesn't block the other component	Mechanics substitution (28)
2	Lever	Operated Manually	Copying (26) Taking out (2) Dynamics (15)
		Easy to operate Appropriate function	Parameter change (35) Pneumatics and hydraulics (29)
		Light pressure on lever	Local quality (3)
3	Pad	Portable	Anti-weight (8) Flexible shells and thin films (30)
		Comfort	Preliminary action (10)

2.6. Conceptual design

Conceptual design aims to explain the design concept in detail, accompanied by illustrations of the design. Paraparesis anthropometric data forms the basis for the dimensions of the conceptual design of the overhaul facility. The design concept is based on the solution interpretation produced at the technical contradiction stage. At this stage explain alternative solutions which are compared and selected the most appropriate solution for the design of work facilities.

3. Results and discussion

Results and discussion aim to find out the needs that need to be developed in the work facilities based on questionnaire. Based on these calculations, the criteria that have a low rating for the user are obtained, it can be seen in Table 7.

Table 7. Criteria hierarchy.

Criteria	Attribute	Mean	Σ Mean
Operation	Q1	3	3.8
	Q2	4.5	
	Q3	4	
Setting	Q4	4	3.75
	Q5	3.5	
	Q6	3.75	
Comfort	Q7	4.75	5.25
	Q8	5.75	
	Q9	5.25	
Quality	Q10	3.75	3.5
	Q11	3.25	
Materials	Q12	3	3
	Q13	3	
Shape	Q14	3.25	3.375
	Q15	3.5	
Sustainability	Q16	4,5	3.67
	Q17	3.5	
	Q18	3	

Based on Table 7, There are 7 criteria processed in the questionnaire namely operation, setting, comfort, quality, materials, shape, sustainability. Therefore, in the research development of work facilities design focused on the 5 highest criteria, namely operation, setting, comfort, quality, and sustainability as stated in Table 8.

Table 8. Dimension of work facilities.

No	Size	Dimension of product (mm)
1	High of work facilities	589.5
2	Length base frame	425
3	Lever height	25
4	Length lever	25
5	Width pad	55.79
6	Length pad	140
7	Length frame pad	154.69
8	Length main frame	347.58
9	Hight main frame	514.48

The results of evaluation are used to development improvement based at the main criteria of the design, namely operation, setting, comfort, quality, and sustainability. The visualization design is adapted to Figure 3 and 4.

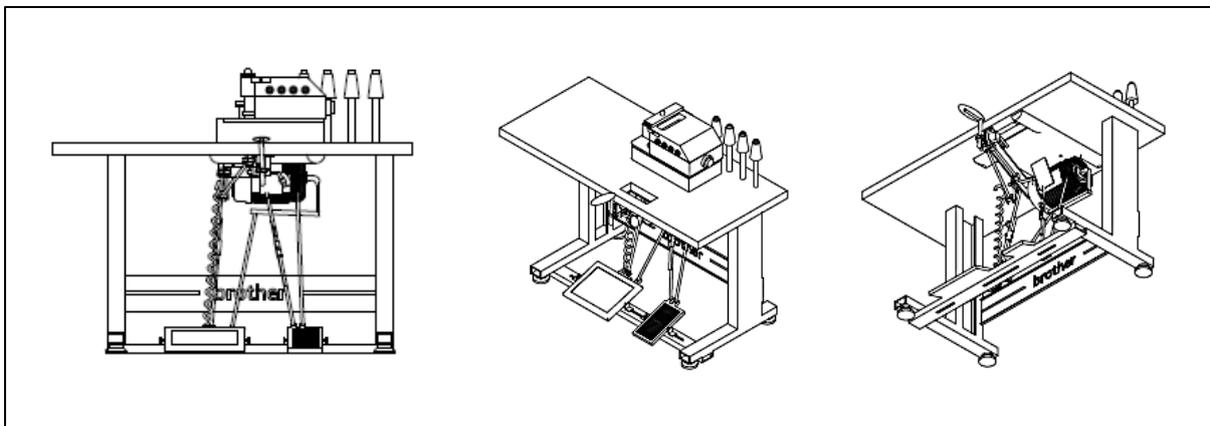


Figure 3. Conceptual design of work facilities.

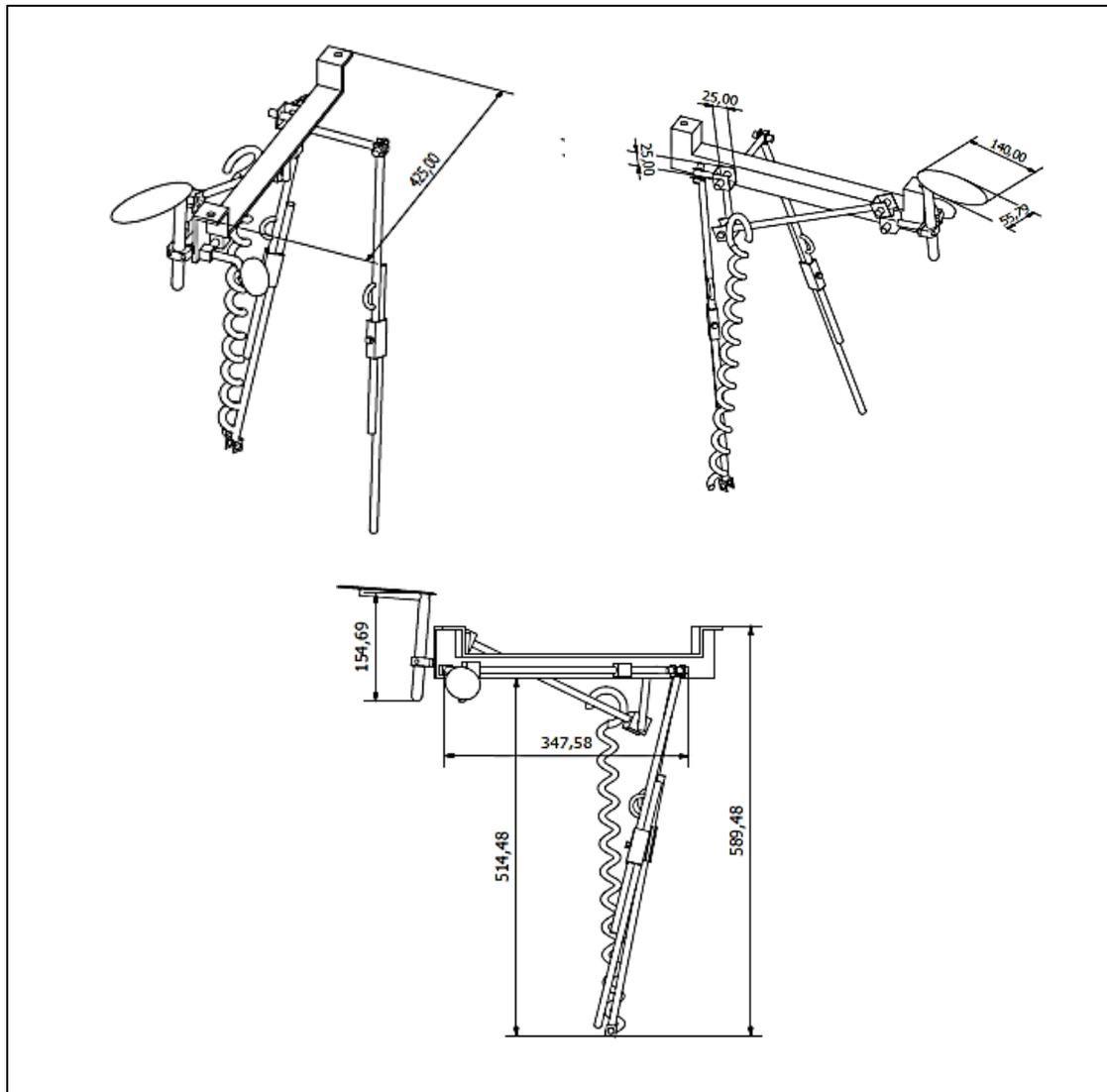


Figure 4. Conceptual design of work facilities.

4. Conclusions

The basis for determining dimensions in the design of hemming machine work facilities is the form of questionnaire results based on a participatory approach. This design of work facilities focused on the 5 highest criteria, namely operation, setting, comfort, quality, and sustainability. Design of work facilities based on TRIZ method with technical contradiction and result 13 inventive solution to design work facilities. The results of the TRIZ method are used as a basis for designing the work facility for hemming machines.

5. References

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