Proceedings of the International Conference on Applied Mechanical Engineering Research (IC-AMER2019)
NIT Warangal, India- May 02-04, 2019
Paper No. XXX

Design and Ergonomic Work Posture Evaluation of Garbage Disposal Pushcart

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Abstract

Garbage management is a continually growing problem both at global and regional frontiers. Solid waste arises from human, animal and industrial activities. User-friendly products are essential for garbage collectors and residents to improve the utility. In this study, the main concerns are addressed to design an economically frugal garbage transportation cart which would be viable for commercialisation. The new design is engineered keeping in mind present-day conditions and is built to cater to the needs of the pourakarmikas. The ease of operation of the proposed model will increase the efficiency by reducing effort and hence the fatigue on the operator. The revolutionary changes that are proposed to be incorporated in the new model are as simple as replacing steel with aluminium where ever necessary, yet having a significant impact on the overall ergonomics. Other such pivotal changes are equipping the cart with an economic motor and a battery to provide assistance in maneuvering the cart on challenging terrain. Also, a braking system is proposed to be integrated into the cart to prevent undue movement of the cart. A turntable to make the bins instantly accessible is also added which reduces the time while loading and unloading of garbage.

Keywords: ‘Ergonomic design’, ‘Pushcart’, ‘modelling’ and ‘fabrication’

1.Introduction

The survey study for the development of the product was conducted in Bangalore, India. Bangalore generates about 3000 - 3500 tons of Solid Waste daily. The city corporations carry out the collection, transportation, processing and disposal of Municipal Solid Waste, with a workforce of around 14,300 women pourakarmikas using 11,000 pushcarts. The primary issues with the pushcarts are the outdated design, inadequate capacity, non-adaptability to bad road conditions, difficult to operate, demands a high amount of manual labour. These drawbacks lead to a lot of health problems, especially the overexertion of the musculoskeletal system. The aim of the effort is to prepare an ergonomically designed push cart for the pourakarmikas, so as to make the carriage of waste easy and comfortable. The adoption of a wheeled cart for enabling the pushing of multiple units is discussed by Spindel et al [1]. A latching device mechanism for the push cart system is proposed by Krummel et al [3]. Latching mechanism for a push-back cart storage system includes an outer side member having a notch. Eberlein et al [4] presented a motor-assisted hand-movable cart, it has drive chassis with two front casters, two back casters, and an electromotor drive unit connected to a running wheel located in between the front and back casters. A system for motorizing a shopping cart or the like is designed by Martine Losego[5]. Paul H. Taylor [6] proposed a low-pressure operating liquid spring and shock absorber. The work involved developing a design for push carts considering the OSHA standards and ergonomic standard charts (RULA and REBA).

2. Ergonomic Analysis of the Existing System

In ergonomic analyses, employers are required to assess the health and safety risks of employees resulting from working tasks and activities, including manual handling. It is a technique that focuses on job tasks as a way to identify hazards before they occur and focuses on the relationship between the worker, the task, the tools, and the work environment. To identify the problem faced by the pourakarmikas with the existing system (shown in Fig.1), standard charts such as RULA and REBA charts were used for the risk assessment and a comparison survey was conducted for 10 pourakarmikas who collect garbage across the different regions of Bangalore City.

2.1. Rapid Entire Body Assessment (REBA)

This ergonomic assessment tool uses a systematic process to evaluate whole body postural MSD and the risks associated with job tasks. A single page worksheet is used to evaluate required or selected body posture, forceful exertions, type of movement or action, repetition, and coupling. The traditional, less adaptable existing pushcart system underwent a detailed study conducted from across Bangalore city. The case study system is shown in Fig. 2.

Fig.1 Existing traditional push cart

The scorecard sheet of the REBA assessment is shown in Fig.2 and the score is reached at a magnitude of 11. The REBA score of 11 indicates that there is a very high amount of risk involved and needs a change, which has been tried to implement in the current project.

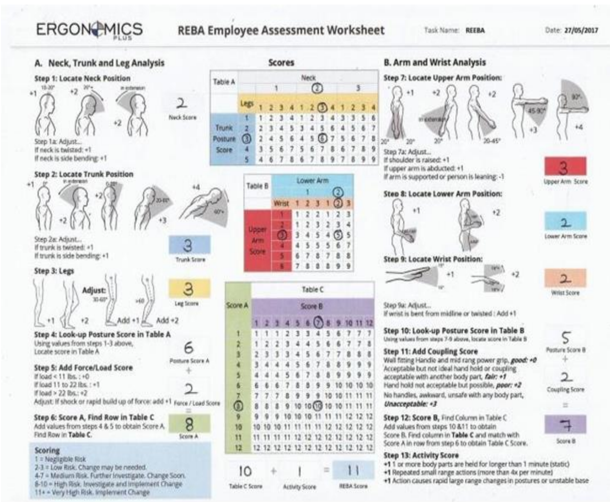

Fig.2 Existing cart REBA

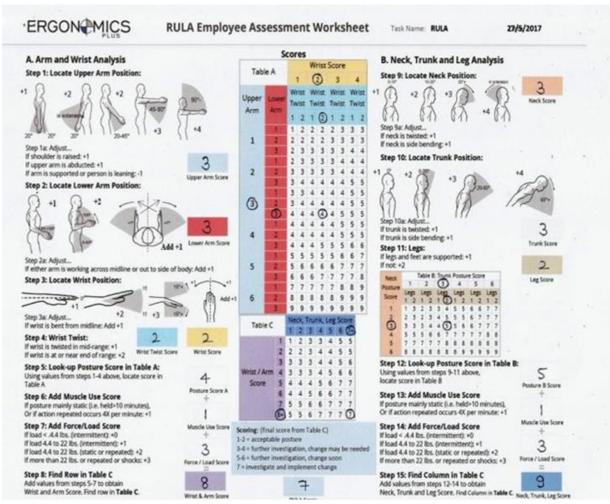

Fig.3 Existing cart RULA

2.2. Rapid Upper Limb Assessment (RULA)

The RULA Assessment Tool was developed to evaluate the exposure of individual workers to ergonomic risk factors associated with upper extremity MSD. The RULA ergonomic assessment tool considers biomechanical and postural load requirements of job tasks/demands on the neck, trunk and upper extremities. Using the RULA worksheet, the evaluator will assign a score for each of the following body regions: upper arm, lower arm, wrist, neck, trunk, and legs. A scorecard sheet of the RULA assessment is shown in Fig.3 and the score is reached at a magnitude of 7. The RULA score of 7 indicates that there is a very high amount of risk involved and needs a change that has been tried to implement in the current project.

3. Design & Fabrication

Before carrying out the fabrication process, a model was first designed using Solid Edge and TinkerCAD software. While Solid Edge is the most commonly used software for modelling, TinkerCAD is a browser-based 3D solid modelling tool for rapid prototyping known for its simple interface and entry-level ease of use. TinkerCAD has no specified dimensions. It is merely used to represent a model in all the planes. Fig. 4 & Fig. 5 show the different views of the cart in Tinker CAD modelling.

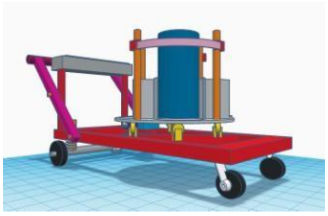
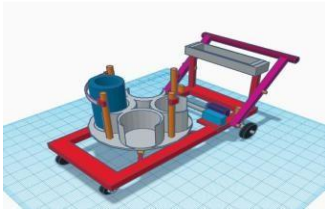

Fig 4 & Fig.5 Right hand side & Diametric view of the model (TinkerCAD)

Solid edge software was used to represent the dimensions of each component and finally assemble all the components together to get the final assembly of the model. The model was on the scale of 1:10 to the actual dimensions of the fabricated product. The Solid Edge models are shown in Fig.6 & Fig.7.

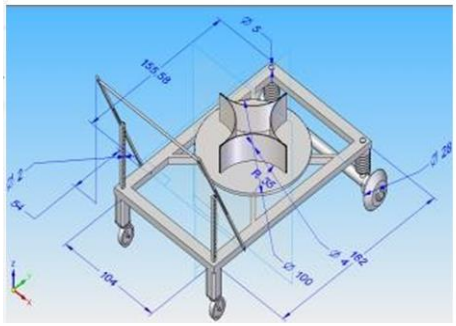
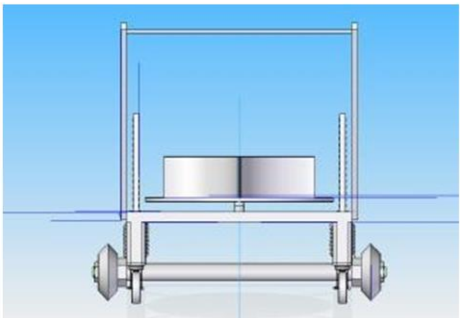

Fig.6 Isometric view of the model Fig.7 Front view of the model

3.1. Fabrication

The fabrication of the cart was made in-house on the campus. Before fabrication, the materials with the best quality were procured from the local suppliers. The fabrication process includes cutting, welding and fitting of the material to form the individual components. After the fabrication is completed, the components are assembled and the quality is checked. The component or part of the systems is explained in Table 1.

Table.1. List of components of the cart

S.N	PARTS & COMPONENTS	MATERIAL	SPECIFICATIONS
1	FRAME OF THE CART	MILD STEEL	Length x breadth 1.7m x 1m
2	X-CROSS SECTION ON THE FRAME	MILD STEEL	Length = 1.12m
3	HANDLE	MILD STEEL	4 different posture height according to the requirement
4	TURNTABLE	ALUMINIUM	Diameter of 0.98m
5	JOURNAL BEARING	-	Inner diameter of 28mm Outer diameter of 32mm

7	STORAGE BINS	Polyethylene FDA	75 liters each
8	SMALL SPROCKET	STEEL	4915 15T
9	MOTOR	DC TYPE	1.6 Nm, 100 rpm
10	SOLAR PANEL	-	12W output; charging time 5hrs
11	SOLAR PANEL CHARGER CONTROLLER	-	3A current and 14.8 maximum voltage with Lithium battery cells
12	SHAFT TO MOUNT BEARING	MILD STEEL	25mm in length 29mm in diameter
13	BATTERY TO STORE ENERGY	-	12V DC
14	SWIVELING CASTERS	POLYPROPYLENE	150mm diameter (2)
15	FRONT AXLE CASTERS	POLYPROPYLENE	150mm diameter (2)
16	SPRING FOR THE SUSPENSION	MILD STEEL	Offset of 5cm , 5c, diameter, 15cm length

4. Result

After the fabrication of the proposed model, the obtained results are compared with the existing model and tabulated, shown in table 2.

Fig. 8 & Fig.9 Different views of the assembled cart.

Table.2. Features comparison of existing and proposed system

Features	**Existing system**	**Proposed system**
Assistance to go up the elevations	No	Yes
Turn Table	No	Yes
Capacity	215Kgs - 240kgs	330kgs - 350kgs
Manual Labour	High	Medium
Suspension system	No	Yes
Number of wheels	3	4
Handling Conditions	Bad	Good

The standard RULA and REBA assessment charts have been used for the ergonomic analysis. The survey is conducted for ten workers in Bangalore city. A sample of case study chart shown in Fig. 10 for the reference of REBA score calculation and analysis. The assessment result and average RULA and REBA score for the ten workers are shown in table 3 and 4.

Tables 3&4 REBA & RULA case study for 10

Worker No	REBA Score
1	5
2	7
3	6
4	8
5	8
6	5
7	5
8	6
9	6
10	6
Average REBA score	6.2

Worker No.	RULA score
1	4
2	3
3	4
4	5
5	4
6	4
7	3
8	4
9	4
10	3
Average RULA score	3.8

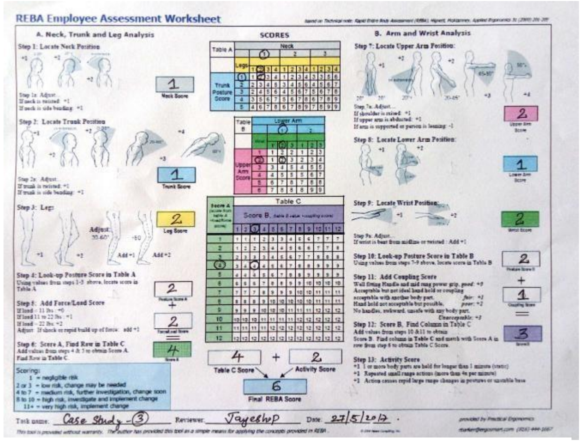

Fig.10 REBA sample for case study-3

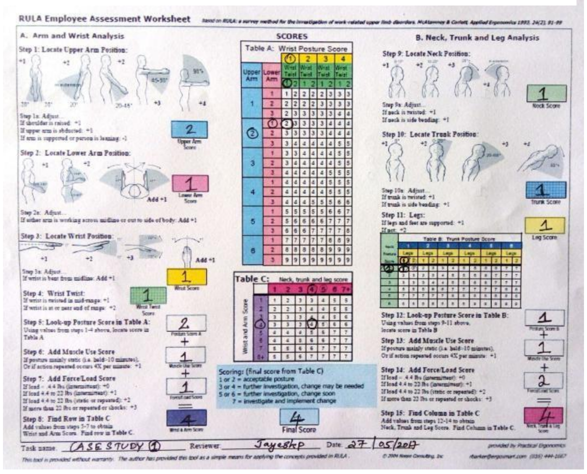

Fig.11 RULA assessment for case study-1

A sample of case study chart shown in Fig. 11 for the reference of RULA score calculation and analysis. A comparison of the proposed system with the existing system reveals a performance improvement with the proposed cart scoring 6.2 on the REBA chart, as compared to the previous score of 11. The RULA chart also shows a performance improvement with a new score of 3.8 against the score of 8 of the existing pushcart. The consistency of the proposed system is checked for an average ten workers using both the charts. Approximately 80% of workers score between 4-7 on the REBA score, with the remaining 20% scoring in the range of 8-10. A similar result for the RULA assessment was obtained, with approximately 90% of workers under a score of 3-4 and the remaining 10% with a score in the range of 5-6.

5. Conclusion

Ergonomic Analysis was done using RULA and REBA charts to assess Pourakarmikas body posture in 10 regions of Bengaluru city. The Score suggests that the existing system has a high amount of risk and needs immediate change. Based on the results, a new design is proposed which has better features compared to the existing system. This design is more Robust and more feature rich. With the new design, posture correction is done and avoids musculoskeletal disorders. There are a lot of improvements that can be incorporated into this project that makes it more complete and feature rich. The chance of theft could be the major issue on the cart. For addressing the energy conservation, further improvements could be made on automation, braking system etc to the cart.

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