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Design and Fabrication of Lower Body Exoskeleton

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Abstract: ***Millions of people that work in factories, assembly line, public places and distribution centers around the world suffer from muscle related disorders. Due to constantly bending there back and knee muscle related problem. Considering the aspect, the objective of this work is to develop a new mechanism which assist the human locomotion, to learn in details about how the lower body exoskeleton works and understand the concept involved. The solution to problem is to have a portable device which has an ergonomic design. It is a mechanical ergonomics device that is design around the shape and function of the human body. The proposed device serves as an effective device to any kind of person to work them for long time without fatigue. This device will provide comfort and safety to user while working than any other method.***
Index Terms: Exoskeleton1, Ergonomics2, Productivity3, etc.

I. INTRODUCTION

A chair is piece of furniture with raised surface supported by legs commonly used to sit a single person. Aim of the chair is to sit anywhere and anytime every comfortably and safely without any hesitation.

Fig. 1: Ordinary Chair

Afterwards the chair was used where human want to sit. This led to use of chair in industrialization. But unfortunately due to various kinds of projects and environmental conditions, normal designed chair was unsuccessful model to use at work or site. To overcome the problems like comfort, safety, work space, work volume, fatigue, reliability and some hindrances an invention is done. We thought about design of a model which will overcome these kind of problems as well as drawbacks of existing models.

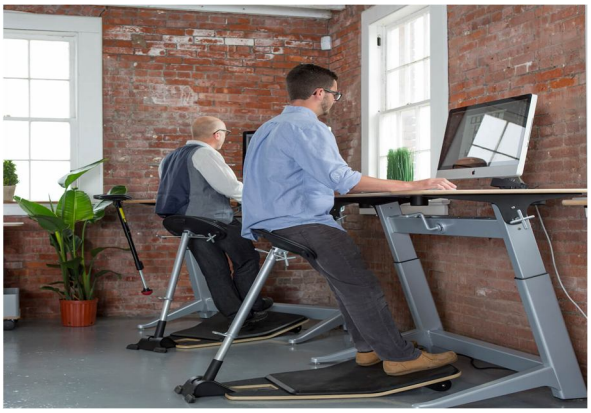

Fig 2: Workers in packing industry

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Fig. 3: Worker in Software Company

II. STATEMENT OF PROBLEM

Conventional chair is not suitable to use 5 to 6 hours continuously for user, so user get tired and feel uncomfortable. At the same time muscle related problem to knee, back are increased. So, keeping in view decreasing the time required for work to be done, quality of work, productivity, efficiency of worker, it is important to develop a lower body exoskeleton to achieve desired objective.

A. Drawbacks In Various Existing Chair Models

1) As the chair is a rigid and one piece structure so it has less flexibility in work space.
2) After some time, the chair feels awkward while work.
3) The ordinary chairs are only useful in domestic works and only for comfort purpose.
4) With the help of these chairs, it is hard to sit straight and difficult to work because of minimum work volume.
5) Present chair has four legs and two handle so that it occupies more work space as well as cover more area.
6) These situations lead to harm the comfortable working environment and the long term employee commitment.
7) Because of these drawbacks, physical strain in human body starts so that problems like muscular disorder occur.
8) These problems result in decrease of productivity and quality of work as well as fatigue to human body.

B. Objectives Of Project

Based on limitation for conventional chair models, following objectives have been decided to carry present work given below. To offer an effective mechanism for sitting.

1) To safeguard the operator from health problems.
2) To provide efficient sitting technique, this will require least efforts.
3) To develop an affordable sitting mechanism for all kind of users.
4) To understand the user need and so design a human centred product.
5) To reduce fatigue in human body.
6) No external drive will be required to drive the mechanism
7) To make a sitting mechanism in minimum cost.
8) To develop simple and less space occupying device for industrial applications.
9) To increase the overall productivity.

C. Data Collection

Information was collected while interacting with users. During the interaction questions were asked to users, these one on one interviews helps in to know what does the user wants and what sort problems they are facing while carrying out their routine day to day work, during the one on one interviews.

1) Most of the workers they are using ordinary fiber made chair or hydraulically operated exoskeleton.
2) The product and maintenance cost so high and also fluid required working the dampers used in the mechanism.
3) Hydraulically operated exoskeleton, life span is more but sometime due to failure in hydraulic damper the work which is to be done will not complete and also cost is very high.
4) The conventional chair models and the hydraulically operated exoskeleton have less operating cost but the product cost is more as well as the present sitting mechanism are not enough comfortable that there is risk of falling backside or sideways.
5) The hydraulically operated exoskeleton have high cost normal user are not affordable.

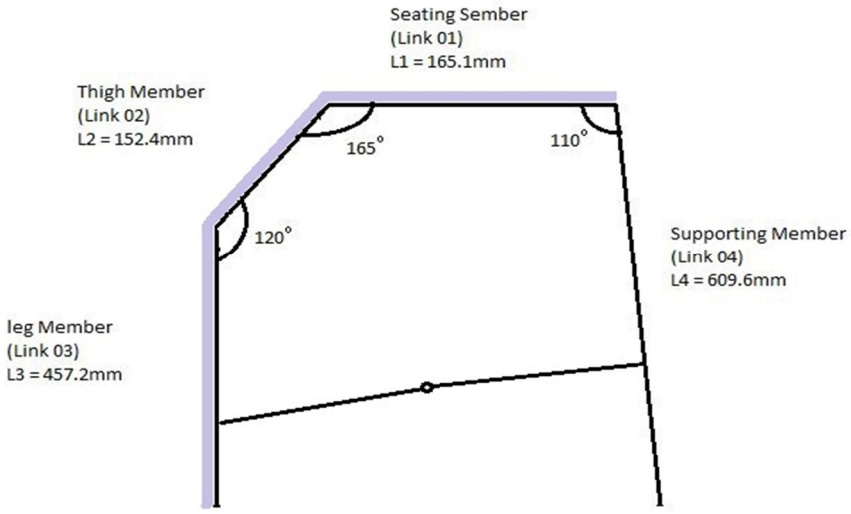

Fig.4- Five bar mechanism

III. METHODOLOGY

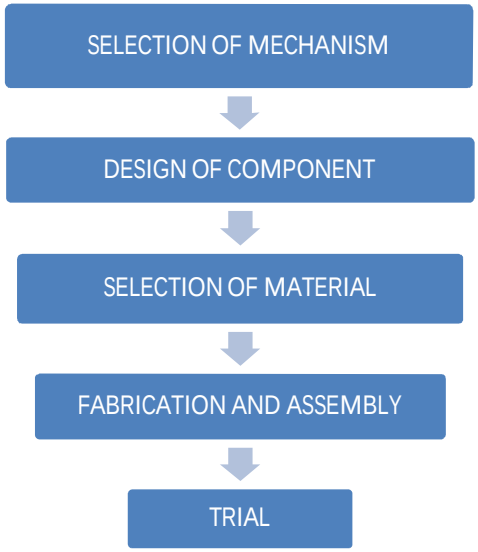

Fig. 5: Flow chart of methodology

A. selection of Mechanism

1) Five bar mechanism: As we know, any machine consists of structure (frame) and mechanism. In our project, mechanism is required to stretch out the supporting member towards back side. Thus, it can rest on the ground and support the whole weight acting on it. The mechanism which do them to and fro motion of this supporting member is called as "Scissor Mechanism" as shown in fig.

B. Design Consideration

In order to design lower body exoskeleton the human ergonomics are taken in consideration by which components and frames were designed by following method.

1) Design of frame

2) Procedure

a) Firstly, measure the weight of the model.

b) Taking under consideration, weight of human body to be seated.

c) According to human ergonomics, taken the length of the seating member.
d) Further the problem is solved using formulae of the reaction forces method.
e) Calculate each force on each member which will affect the frame design.
f) After getting the force, find the stress which is to be act on the cross-section of frame.
g) Compare the calculated stress with the permissible stress.
h) Again, for bending stress calculation, first calculate the bending moment and then section modulus for the cross-section.
i) Compare the calculated bending stress with the permissible material stress.

C. Construction

The four members were constructed for the lower body exoskeleton. These members of frame are as follow:

1) Leg member
2) Thigh member
3) Seating member
4) Supporting member
5) *Leg member:* Leg member is use to support the leg. It is attached to thigh member with the help of 2 inch hinge and screws. It touches human leg from behind. The bushes are provided at bottom for preventing the slippage on ground. According to the human ergonomic, the length of the leg member is 457.2 mm.

Fig. 6: Leg member

6) *Thigh member:* Thigh member is use to support the thigh. It is attached between leg member and seating member with the help of 2 inch hinge and screws. It touches human thigh from behind. The grooves are provided to seat for convenient movement of thigh member. According to the human ergonomic, the length of the thigh member is 152.4 mm.

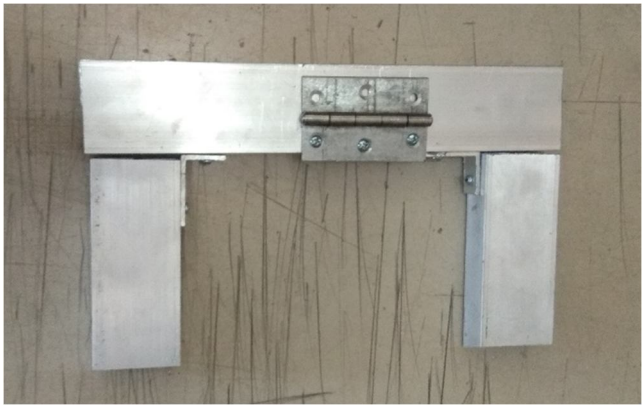

Fig.7: Thigh member

7) *Seating member:* Seating member is use to support the seat. It is attached to seat from bottom side with the help of screws. It holds thigh member and supporting member with the help of hinge and screws. To cover the seating member, an auxiliary seat with foam is attached to the frame for extra comfort and safety.

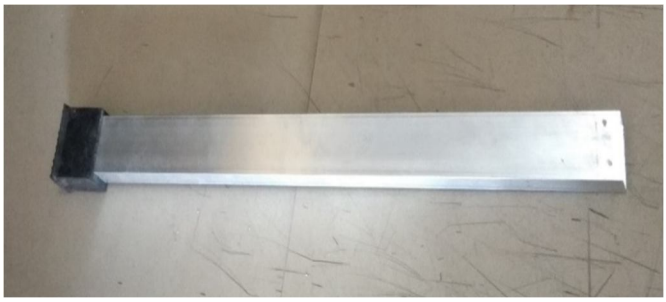

Fig.8: Seating member

8) Supporting member: Supporting member is the largest member of frame and use to support the whole frame as well as person who is using the lower body exoskeleton. It is attached to seating member with the help of 3 inch hinge and screws. It touches ground from behind. The 6 mm diameter holes are provided to mount the scissor mechanism with the help of nut and bold. According to the human ergonomic, the length of the seating member is 609.6 mm.

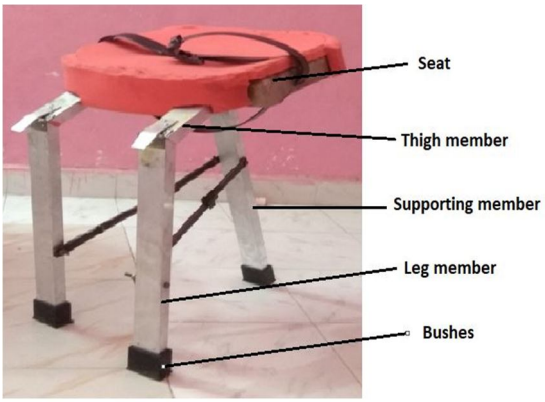

Fig.9: Supporting member

D. List Of The Component

Sr. No.	PARTS	SPECIFICATION	QUANTITY
1	Leg Member	50.8×25.4×457.2	2
2	Thigh Member	50.8×25.4×152.4	2
3	Seating Member	-	1
4	Supporting Member	50.8×25.4×609.6	1
5	Hinges	50.8×18×18	`5
6	Nut And Bolt	Ø6 M10	3
7	Screws	No.6× 13mm	60
8	Belt	-	1

Table 1- List of components

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E. Fabrication

1) material : aluminium
2) Frame size : 50.8mm × 25.4mm
3) Total members : 4 (leg member, thigh member, seating member, supporting member)

Fig.10- Labelling with actual model of Lower Body Exoskeleton

F. Working

In order to test the present lower body exoskeleton two phases are as fallows

1) User while Sittin
2) User while Standing

G. User while Sitting

After wearing the frame, the frame feels little bit heavier. To sit the user just has to bend towards rear side. While sitting the supporting member is stretched out or pushed back because of the scissor mechanism. This supporting member rests on the ground to support entire frame as well as user.

Fig 11- Phase 1- User while Sitting

When user wants to stand, he or she will just stand without any hesitation. While standing, the seating member rises simultaneously with the human body pulling the supporting member with the help of foldable scissor mechanism. This results the closing of lower body exoskeleton.

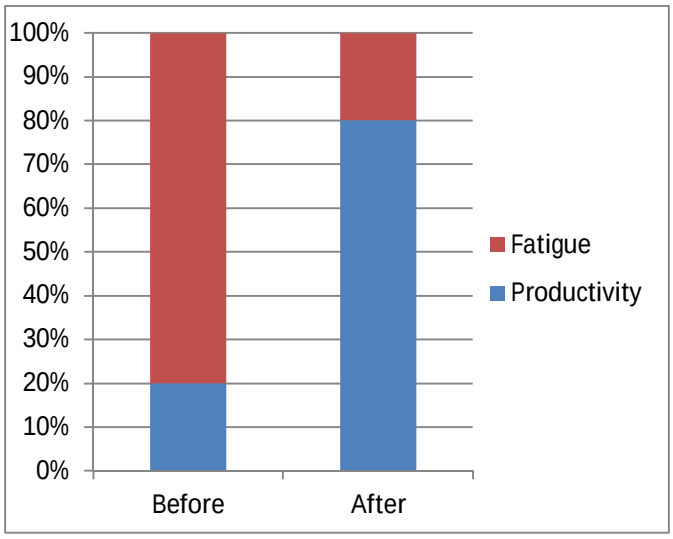

Fig 12- Phase 2- User while Standing

IV. COMPARISON BETWEEN PERCENTAGE OF FATIGUE AND PRODUCTIVITY USING BAR GRAPH

	BEFORE	AFTER
FATIGUE (%)	70	30
PRODUCTIVITY (%)	30	70

Table 2- Data from Study of usage of LBE

V. BENEFITS AND LIMITATIONS OF LBE

A. *Benefits of lbe*

1) It is automatic.
2) It is powerless.
3) It provides maximum comfortable working environment.
4) It is light in weight.
5) It is compact in size hence portable.
6) It can be adjust in seconds.
7) It is very reliable.
8) It increases productivity as well as quality.

B. *Limitations of LBE*

1) It is not adjustable to different size of people.
2) It is not used for handicapped people.
3) After spending time on it, backache may occur because absence of the back support.

VI. CONCLUSION

In this work, design and fabrication of lower body exoskeleton has been done. The main goal of work was to give the comfort as well as safety to workers, who work on production line for lot of hours. And the cost required for lower body exoskeleton found be less. Achieving lot of advantages over the present sitting method made this model very successful and useful to the world.

VII. ACKNOWLEDGEMENT

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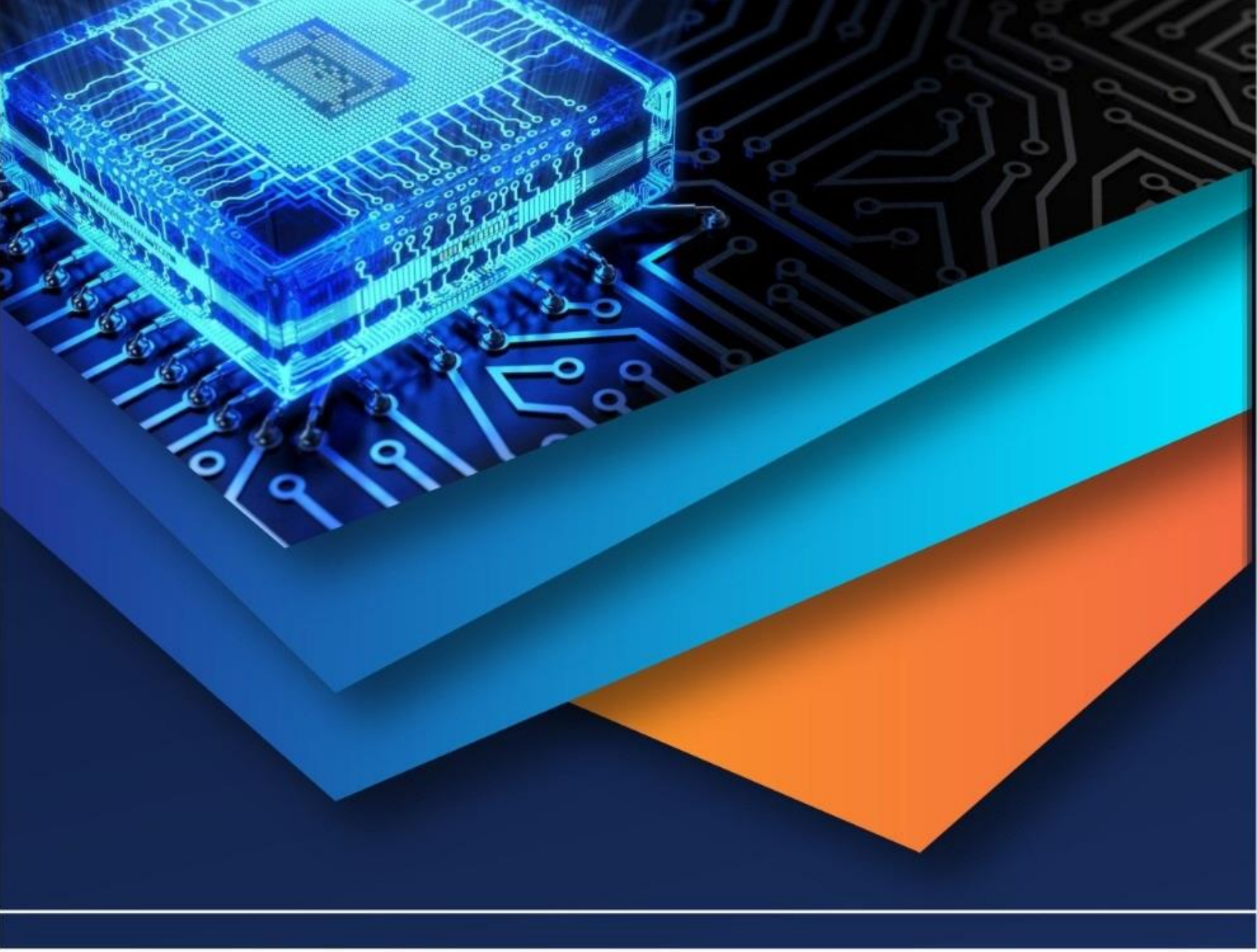

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