Research Paper On 'VIRTUAL CHAIR: An Exoskeleton'

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Abstract- A chair is a device used regularly as a part of routine life for the purpose of taking rest. Normally chairs used in daily lives cover a specific area on the floor. Also it is not always possible to carry them to the specific locations we desire, owing to their weight and size. If the workplace is congested and lacks proper area to rest and work, it will be difficult to continue working in standing position for prolonged hours. As a result the person may develop MSD (Musculoskeletal Disorders) which may adversely affect his/her overall health in the future. In these conditions one needs to take rest periodically to ensure consistent and effective work.

Today's workforce is diverse and includes people of differing sizes, statures and disabilities. Safety concerns must be addressed for all groups representing the workforce, especially those related to injuries due to awkward postures or repetitive stress. Such injuries result in heavy costs, including medical expenses, operations down time, workers compensation premiums and retraining. These costs are a major burden for companies and their employees and can be reduced by using adequate preventative measures.

Thinking on these lines, we came up with an alternative which will facilitate sitting and working and even carrying the chair anywhere anytime we want.

1. INTRODUCTION

This device, we call as 'Virtual Chair' is without legs, possess minimum weight as compared to a normal chair and is mobile and portable. A virtual chair, which can be imagined as an exoskeleton can be worn on a person's lower body part. With the help of this he/she can move anywhere and sit anywhere and anytime he/she wishes to.

We obtained this idea from the recent technology (using high performance hydraulic damper) developed by an organization named "noonee" who have filed a patent for the same. The concept and methodology used in this project is slightly different. In this project we have focused on making the design simple with emphasis on reducing the cost so that it will be affordable for all, including workers and patients with leg injuries.

The use of 'Virtual Chair' is likely to bring down the cases of MSD (Musculoskeletal Disorders) which develops in workers indulged in prolonged standing conditions.

Virtual Chair also offers the possibility to:

- Support injured workers to return to work faster
- Reduce, if not, eliminate the need for microbreaks, rotation of workers among tasks, and other inefficient practices
- Give a wider range of employees (such as older or smaller workers) the ability perform tasks safely

In the present work, a prototype of this chair has been developed. A Virtual chair can be a good product which will ultimately enhance productivity at the workplace across various industries.

2.LITERATURE REVIEW

We have studied some literature of the company "noonee" followed by valuable inputs from experts in the relevant field along with vital information from the scholarly articles on internet.

www.noonee.ch/index.php/why-chairless-chair

The concept initiated by this organization makes the process of work more comfortable. Reducing the risk of exposure to muscle related disorders, employees will work more efficiently and effectively. As a result of this production level will increase. Chairless chair gives employees to rest essential muscles during the most demanding tasks. The Chairless Chair® is a convenient and usable tool for factories workers of industries. Furthermore, our technology creates significant value for industrial enterprises. Once acquire, the Chairless Chair can be utilized within existing infrastructure and processes. We have adopted this idea for our product development project.

Mr. Kulkarni (Industry: Kalakruti Industries, Gokul Shirgaon, Kolhapur)

After having a preliminary discussion on our project idea with Mr. Kulkarni, we had been consented to work according to their feedback. A human while working on shop floor or any prolonged standing job, he/she may suffer from musculoskeletal disorders, especially in the legs, knees and lower back. Also to avoid sleepy instances while working a human should alleviate his muscles for some time. So designing this exoskeleton should feel a human relaxed. Use of gas spring instead of our mechanical locking design was also justified with their guidance. We stepped forward to collect data for Ideal posture for a human in partial sitting position.

Dr. Pranjali Dhamane (Physiotherapist)

The project idea was discussed with Dr. Pranjali Dhamane to know about ideal posture concept to define our exoskeleton. The result of this discussion was ; a human body can't feel relaxed, if the body sits for prolonged time in same position. While sitting, if our buttocks get proper rigid support, we feel relaxed. Considering this physiotherapy data an exoskeleton can be imagined and designed perfectly.

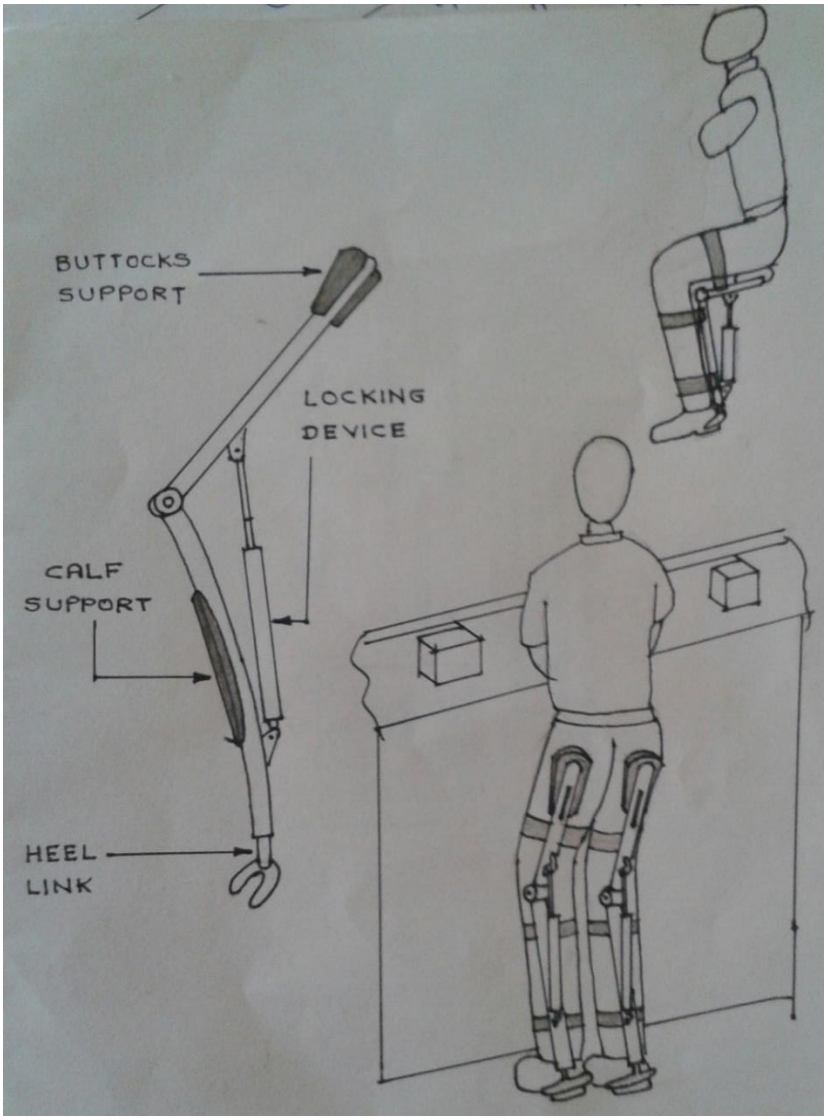
Assistive Mechatronic Posture Support

Using passive and low energy components the goal of this project is to develop a power efficient and comfortable posture support device which allows the user to stand for long periods of time as well as walking and climbing stair. The device absorbs the body weight of the user and redirects it away from the knee. This reduces the stress on the knees and muscles and therefore the risk of pain and injuries. The device is equipped with a high performance variable hydraulic damper. The damping can be varied from very low to very high damping and ultimately brake. The control of this damper allows different applications of the device in the industrial, rehabilitation and medical field.

Musculoskeletal Disorders

Work-related musculoskeletal disorders (WMSDs) are a group of painful disorders of muscles, tendons, and nerves. Carpal tunnel syndrome, tendonitis, thoracic outlet syndrome, and tension neck syndrome are examples.
For the purpose of developing injury prevention strategies, many health and safety agencies include only disorders that develop gradually and are caused by the overuse of the above constituents of the musculoskeletal system. The traumatic injuries of the muscles, tendons and nerves due to accidents are not considered to be WMSDs or are considered separately. However, there are organizations, such as the European Agency for Safety and Health at Work, that include acute traumas and fractures within in the WMSD group.
This document will discuss those injuries resulting from overuse and those that develop over time. Work activities which are frequent and repetitive, or activities with awkward postures cause these disorders which may be painful during work or at rest.
Almost all work requires the use of the arms and hands. Therefore, most WMSD affect the hands, wrists, elbows, neck, and shoulders. Work using the legs can lead to WMSD of the legs, hips, ankles, and feet. Some back problems also result from repetitive activities.

3. SCHEMATIC LAYOUT



Virtual Chair devised with:

- Locking Mechanism
- Buttocks Support
- Calf Support
- Heel Link.

4.DESIGN CALCULATION

(I) Anthropometric data collection:

This data is collected from the workers working in different industries situated at Udyamnagar.

Sr. No.	Total Height (160-180) cm	Weight Up to 100kg.	Buttock to Knee Length (cm)	Knee to Ankle Length (cm)	Ankle to Feet length (cm)	Buttock length (cm)
1	172	57	49	42	7	32
2	169	54	44	42	7.5	33
3	165	80	42	43	7.5	31
4	166	56	43	43	7	32
5	164	74	46	42	7	34
6	166	58	43	44	6.5	38
7	174	65	45	42	7	35
8	173	64	46	46	6	38
9	172	61	45	42	8	35
10	173	70	44	44	7.5	38
11	171	59	45	42	8	35
12	166	72	46	40	7.5	33
13	163	50	45	45	6.5	32
14	174	60	45	43	7	32
15	177	59	42	46	7.5	32
16	164	62	43	44	6.5	33
17	166	68	40	43	7	34
18	174	69	43	43	8	33
19	179	85	45	46	8	36
20	175	78	40	43	8.5	33
21	168	70	41	43	7	32
22	172	72	43	44	7	34
23	165	65	42	42	7.5	31
24	174	65	45	42	7	35
25	163	50	45	45	6.5	32
26	167	58	43	44	6.5	34
27	170	60	45	43	7	34
28	172	62	45	43	6.5	33
29	166	58	44	42	6.5	32
30	167	58	43	43	7	33

(II) Design Calculation for Locking Mechanism for Stainless Steel material:

a) Length of Cylinder: 250mm
b) Length of piston: 230mm
c) Number of holes according to positions equidistant: 8 holes.
Diameter of holes: 12mm
d) Diameter of pin: 10mm
e) Outer diameter of piston: 18mm
f) Thickness of piston: 3mm
g) Outer diameter of cylinder: 25mm
h) Thickness of cylinder: 3mm
i) Position of locking pin from upper side: 10mm
j)Length of upper link: 380mm

k) Length of lower link: 400mm
l) Diameter of link: 24mm

(III) Fixing of locking mechanism on link:

a) On Upper link:

1) 200 mm 2) 190mm 3) 160mm

Drawback: The piston did not move thoroughly in cylinder. It gets locked after travelling some distance.
Solutions:

1) So it was decided to fix the locking mechanism at 155mm from bottom end of upper link.
2) When it was at distance of 220mm or180mm and 170mm it tends to bend due to excessive load.

b) On Lower link:

It was observed that when it is fixed at 155mm on upper link, the cylinder positioned near the ankle of person. To transfer the load of body without giving stress on legs, it was necessary to fix the cylinder end near the ankle. So a distance of 75mm from the bottom end was found appropriate to fix the cylinder near the ankle.

- Distance of cylinder from bottom end : 75mm

5.MATERIAL SELECTION

a) Material for Links & Locking Mechanism

Stainless Steel (Grade 304) for Locking Mechanism:

Tensile Strength: 550 MPa
Young's Modulus: 200 GPa
Poisson's Ratio: 0.27
Yield strength: 670 MPa

Stainless Steel (Grade 202) for Links:
Tensile Strength: 515 Mpa
Young's Modulus: 275 MPa
Poisson's ratio: 0.29
Yield strength: 580 MPa

Grade 202 stainless steel is a type of Cr-Ni-Mn stainless with similar properties to A240/SUS 302 stainless steel. The toughness of grade 202 at low temperatures is excellent.
It is one of the most widely used precipitation hardening grades, and possesses good corrosion resistance, toughness, high hardness, and strength.

b) Material for Joints : Nylon

Benefits of using Solid Nylon Bar include:

- Solid Bar in round & rectangular shapes which is ideal for a variety of uses
- This type of plastic rod is sometimes used for machining. Being a plastic bar made from a strong material like nylon 66 it can be used as a pivot on some applications
- This solid bar could be used for tools, as a replacement lever or as a pole.

6.MANUFACTURING AND ASSEMBLY

A) Manufacturing

1) Following are the operations carried out on **locking mechanism**:

a) Cylinder (2 Nos)

- Drilling of holes from top end.
- Welded attachment for lock pin.
- Pressing of bush for smooth movement of piston while walking.

b) Piston (2 Nos)

- Drilling of 10 holes equidistant.
- Fitting of bush on piston bottom end to avoid its deflection in cylinder.

c) Nylon bar of 50mm each (4 Nos)

- Turning of dia. up to length 20mm.
- Surface milling to make male part of eye joint.
- Grinding of upper end for achieve circular counter.
- Drilling on upper end perpendicular to axis.
- Turning of dia. up to length 15mm.
- Surface milling to make female part of eye joint.
- Grinding of upper end for achieve circular counter.
- Drilling on upper end perpendicular to axis.

2) Following are the operations carried out on **Upper link** : (2Nos)

a) Drilling throughout. (2Nos)

b) Nylon bar (2 Nos)

- Turning up to length 20mm.
- Surface milling to make male part of eye joint.
- Grinding of upper end for achieve circular counter.
- Drilling on upper end perpendicular to axis.

3) Following are the operations carried out on **Lower link** : (2Nos)

a) Drilling throughout. (2Nos)
b) Nylon bar (2 Nos)

- Turning up to length 20mm.
- Surface milling to make male part of eye joint.
- Grinding of upper end for achieve circular counter.
- Drilling on upper end perpendicular to axis.

4) Following are the specifications of seat : (2Nos)

a) Wood cutting of circular shape for base of seat.
b) Dia. Of seat 146mm.

7.COST BREAKUP

Raw material

Sr. No.	Particulars	Rs.
1	Links and locking mechanism	500
2	Pivots and bushes	280
3	Supports and straps	230
4	Heels	300
5	Nut and bolts(M6,M8,M9)	90
	Total	1100

Manufacturing

Sr. No.	Particulars	Rs.
1	Pivots and links	400
2	Locking mechanism	700
3	Supports and straps	100
4	Heel making	100
	Total	1300

Total cost of prototype =1100+1300 = Rs.2400

8.TEST AND PILOT RUN

9. CONCLUSION

The prototype suffers from a few limitations which can be taken care of as listed below:

a) The weight of the prototype can be further reduced which will add an extra value to the comfort aspect of the product.

b) Design of Buttocks support can be improved to have an extra comfort zone.

c) The heel design can be improved to give ease while walking.

d) The material of the prototype can be replaced with fiber reinforced type composite that will improve the stiffness to weight ratio.

e) The cost of the project can be minimized by replacing the materials and reducing its machining costs.

10.REFERENCES

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