Design and Fabrication of Wearable Chair

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Abstract: It is observed that worker operating machines on production line need to stand for long period of time which may create body fatigue and MSD (Musculoskeletal Disorders). So the aim of present work is to provide to provide support to legs without violating working rules and regulation. In present work an attempt is made to design a simple and low cost wearable chair. Wearable chair can be used by workers as well as patients with leg injuries. The use of wearable Chair is likely to bring down the cases of MSD (Musculoskeletal Disorders) which develops in workers indulged in prolonged standing conditions. Wearable chair also offers the possibility to Support injured workers to return to work faster. A prototype is fabricated and actually given to workers and testing is done. This wearable chair may enhance the productivity of workers at workplace as may help patients having leg injury.

***Index Terms* – wearable chair, Musculoskeletal Disorders (MSD), Productivity.**

I. INTRODUCTION

The world is getting compact day by day & we know the most useful devices are compact in size. If you are working in a restaurant kitchen, factory you will know you are tired for many hours. In manufacturing company keeping employee healthy has been major problem and challenges for companies around the world hence it needs to manufacture the "wearable chair" or “lower body exoskeleton based pneumatics support". It is not possible to carry a stool around with you at every time that's why we are introducing this lower body exoskeleton based pneumatic support. This exoskeleton based support helps to stand for long times. It improves walking and running economy and reduces the joint in pain or increases the strength in joint. It transfer load directly to ground. The exoskeleton is powerful mechanical devices. In pneumatic support, a pneumatic cylinder is used to engage and hold the person body it only wraps around thighs, so it reduces fatigue and increases the productivity.

Standing for some time is good for health, but only if you’ve not been forced to do it for hours. Excessive sitting is also dangerous as it badly affects the body’s metabolic rate, resulting in the risk of disease like high blood pressure, diabetes, cancer, depression, etc. In workstations, main concerned is to enhance the productivity but very less concerned is given to the effect of work fatigue on the worker’s body. Even though the workplace is ergonomically designed but, in fact, they are not successful in relieving worker fatigue since most of the time they have to work for hours in a particular posture. Till now in the present era of fast growing technology, workstations do not have a device which can provide comfort to the worker. It is evident that sloping/kneeling chair preserves lordosis and sacral slope with upright as well as slumped posture than a flat one; it results in less tissue strain which in turns lowers back pain. So why it is preferable to sit on a sloping chair than flat one this means flexible wearable chair provides better comfort than that of flat one for the same working posture.

Exoskeletons have been constructed to assist human locomotion and provide medical rehabilitation. In particular, the field of medical rehabilitation has utilized exoskeletons in an increasingly effective manner, and several relatively compact powered exoskeletons for mobile applications have recently been demonstrated, but the duration of usage is often limited due to power constraints. In other words, the exoskeleton should effectively assist the natural human motion while ensuring the safety and comfort of the user, and that his/her agility is not affected. Simply wearable chair can be described like a chair that isn't there, but magically appears whenever you need it. It is well known as the Wearable Chair and you use it on your legs like an exoskeleton: when it's not activated, you can walk normally. This idea also came over the last several years. Some researcher found that over the last several years, office workers have begun to see the error of their sedentary ways. Study after study has shown that sitting down all day can contribute to a bunch of health problems, including diabetes and to relax their legs.

A control method is proposed for exercising specific muscles of a human’s lower body. This is accomplished using an exoskeleton that imposes passive force feedback control. The proposed method involves a combined dynamic model of the musculoskeletal system of the lower-body with the dynamics of hydraulic actuators. The exoskeleton is designed to allow for individual control of bi-particular muscles to be exercised while not inhibiting the subject’s range of motion. The method implemented is designed to resist the motion of the human knee but works in principle similar to that of inverted four bar chain mechanism. The two lower limbs will assist to sit a human being without any chair and back support. The Velcro strips will be provided so as to clamp the assembly with human limbs.

II. LITERATURE REVIEW

Cyril Varghese et.al. proposed that the Exoskeleton Based Hydraulic Support was successfully fabricated and it was found to be suitably safe under Fluctuating Load during walking as well as under Dead Load when the user sits/rests on it. (Tested the Extra Large Size Variant for a user weighting 116 kgs for a span of 43 days).

The entire cost of making the EBHS is Rs. 8540 ($ 126.84) thereby making is very economical for the general public as well as for Industrial use and also for the Military. The EBHS being extremely light in weight causes very little hindrance while walking and the user can easily get used to it.

Mithil R. Mogare, et.al. Proposed that the prototype suffers from a few limitations which can be covered by this way, weight of the prototype can be further reduced which will add an extra value to the comfort aspect of the product. Design of Buttocks support can be improved to have an extra comfort zone. The heel design can be improved to give ease while walking. The material of the prototype can be replaced with fiber reinforced type composite that will improve the stiffness to weight ratio. The cost of the project can be minimized by replacing the materials and reducing its machining costs.

Prof. Amit Bhagat et.al proposed the design and development of exoskeleton chair with the pneumatic support. In which two pneumatic cylinders are used to give support near back of the knee. The use of pneumatic cylinders gives smooth suspension to the workers. That design project was a success based on tilting device.

Mr. Bagawade Siddharth et.al. proposed the design and fabrication of chairless chair. The main goal of their project was to give the comfort to workers, who work on production line for hours. Also to make the model at least cost, that has been achieved. The work started with designing of model and procurement of required material. ANSYS Software used for analysis. Finally fabricated Chair less Chair at workshop. The model was working satisfactorily.

Mr. Prafulkor, Mr. Nileshhembade et.al. Their proposed Chair uses a dynamic model of the musculoskeletal system of the lower leg combined with the dynamics from a hydraulic actuator to provide resistive forces to the muscle forces. The exoskeleton will use a qsuasi-dynamic (useful for slow to moderate human movement speed) force-feedback control method to determine how the pneumatic actuators should apply forces at desired positions and times.Objective of this project into design the exoskeleton assistive device which allow for normal movement like walking and running when we wear it.

Dittakavi Tarun1, V. Mohan Srikanth et.al. Designed wearable devices which help in increasing the efficiency of the human and decrease the rate of fatigue of human during work. The device discussed here is the passive device. This device is known as Chairless Chair which helps the wearer to work effectively at any location in a sitting posture.

III. PROBLEM IDENTIFICATION AND OBJECTIVE OF PRESENT WORK

In industries Problem is the standing operating condition of workers on the line. The aim is to, do not violated industrial policies, as we are providing support to legs. Helping workers to more effectively exercise to mitigate the effects of microgravity on bones and muscles.

The objective of our project is to enable the worker to have the ability to move around with absolute ease, with the use of a wearable chair. In this work we have focused on making the simple design with emphasis on reducing the cost so that it will be affordable for all, including workers and patients with leg injuries. The use of 'wearable Chair' is likely to bring down the cases of MSD (Musculoskeletal Disorders) which develops in workers indulged in prolonged standing conditions. Wearable 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 performs tasks safely. In the present work, a prototype of this chair has been developed. A wearable chair can be a good product which will ultimately enhance productivity at the workplace across various industries.

IV. DESIGN

For designing purpose, it is assumed that average height of Indian male is 5feet and 5(1/2) inches or 166.3 cm and weight is 52.943 kg. Weight is acting directly downwards on the system. Maximum pressure limit of the pneumatic dampers used is 1MPa and their maximum travel is 200 mm. Length of upper limb is 300 mm and lower limb is 320 mm.

We have investigate and doing some calculation before starting to design the product. Vertical Force on the system exerted by human body,

Fv = mg = 70 x g (g = 9.8$m/s2$)

Fv = 686.7 Newton

As there are 2 lower limbs thus the load on the pneumatic dampers becomes half therefore load on each damper becomes,

Fv1 = Fv2 = 686.7 / 2 = 343.35 Newton

Cross sectional area of the pneumatic damper is (Φ 32mm)

$A = \pi d^2/4$

$A = (\pi 32^2)/4$

A = 804.24 mm2

Load on each pneumatic cylindrical damper,

Pd = Fv1 / A

Pd = 343.35N / 804.24 mm2

Pd = 0.427 N/mm2 = 0.427 MPa

V. CAD MODELLING

Fig. 1 CAD Drawing of Wearable Chair

Fig.2 Actual use of Wearable Chair at Workplace

VI. ADVANTAGES, DISADVANTAGES AND APPLICATIONS

ADVANTAGES

- Adjustable height.
- Reduces human body stress due to standing.
- Auto controlled.
- Easy to operate.
- No maintenance.

DISADVANTAGE

- Possibility of cramps due to long use
- People may face difficulty in walking while wearing the chair

APPLICATIONS

- This wearable chair would helpful to workers and anyone who needs to stand for long hours at stretch.
- In food and manufacturing industries, for labours who work standing hours and hours
- This chair would helpful to the elderly as they need rest a while after walking some distance

VII. CONCLUSION

The wearable Chair Exoskeleton system is successfully designed and fabricated. A prototype is developed to use at lower body external skeletal structure to support sitting and partial standing posture. Maximum displacement, maximum stresses and deformations are analysed and safe load is determined. Future work will focus on making the design lighter and using high grade materials for greater strength at smaller dimensions and weight. Implementation of the design and testing in real world environment is to be done and effectiveness in daily scenarios is to be determined.

VIII. FUTURE SCOPE

The choice of material was limited due to its availability. In the future, carbon-fibre-reinforced polymer (CFRP) can be used to further minimize the weight and increase the strength of the structure. In present work, no full attention is given to locking mechanism so different locking mechanisms can be used to involve providing better and smoothing functioning of the chair. The sensor can be attached to the body for locking of the mechanism by itself as per user needs.

This chair is capable of relieving fatigue of lower body parts and needed further modification so that upper body parts. The portability of the chair can be improved by converting it into a foldable flexible wearable chair. With Additional links between the legs, can convert it into a totally self-balancing chair. With a focus on damper, electronically control, it could be a walking assist device. For military applications, it could be converted into a weaponry support, load distribution device and so on.

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