Design And Development of Chairless Chair Exoskeleton System For Better Ergonomics At Workplace

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Abstract- *Chairless chair is a portable contraption that looks nothing like a chair and allows you to sit on it whenever you want and wherever you want. This flexible, ergonomic device looks more like an exoskeleton and extends from the hip to the backs of the feet and adapts to different body sizes and safety shoes. This device, we call as chairless chair 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.*

Its intended use is for employees at manufacturing firms who have to stand for long periods of time at work and sometimes bend into unnatural positions to assemble a product. For the user's quality of work life is improved while for the factory, there will be reduction of the work-related pain of the workers. With the chairless Chair the users walk together with the sitting support while wearing it, without obstructing the workspace, at the same time avoiding strenuous postures such as bending, squatting or crouching. It is meant to reduce worker fatigue and work-related accidents while improving productivity. It can be customized to fit all sizes and outfits.

For an Industry, space management is an important factor. Unnecessary chairs and resting places can be avoided by maximizing the use of chairless chair. Such spaces can be utilized for several other purposes.

Keywords- Ergonomics, Chairless Chair, Exoskeleton, Productivity, Flexible

I. INTRODUCTION

Ergonomics is a branch of science that aims to learn about human abilities and limitations, and then apply this learning to improve people's interaction with products, systems and environments. Ergonomics aims to improve workspaces and environments to minimize risk of injury or harm. So as technologies change, so too does the need to ensure that the tools we access for work, rest and play are designed for our body's requirements. 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. A leg exoskeleton could benefit people who engage in load carrying by increasing load capacity, lessening the likelihood of leg or back injury, improving metabolic locomotors economy, or reducing the perceived level of difficulty. Exoskeletons are of two types:

Active Exoskeletons

They are powered by external sources like a motor, battery powered etc. They work along with the passive exoskeletons to help in its functioning.

Passive Exoskeletons

These are not powered by external power sources but work on the basis of mechanical linkages, pneumatic and hydraulic mechanisms, spring-controlled devices etc. Since active exoskeletons pose a restriction to the amount of external energy that can be supplied in terms of quantity, quality and time we have focused purely on passive type of exoskeletons. Passive elements are implemented in the exoskeleton to either store or dissipate energy with the objective of reducing the residual energy that the human would have to expend for locomotion. This device, we call as chairless chair 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.

The use of chairless Chair is likely to bring down the cases of MSD (Musculoskeletal Disorders) which develops in workers indulged in prolonged standing conditions. By using this device, you can walk or even run as needed, but can be

locked into a supporting structure when you go into a sitting position at different angles.

Fig. 1.1 Chairless Chair

II. LITERATURE REVIEW

Workers in workshops and industries need to undergo several sitting and standing postures for long hours depending on their work load. We came across a worker in a local manufacturing industry. He mentioned that he suffers from severe muscle pain every day after his work. So, as a remedy to reduce muscle stress and to work freely, providing a support below the hip was a solution. Finally, we heard about an exoskeleton support that can be provided to the body as a support while doing work.

Several Journals were published related to this topic earlier. Noonee, a swiss start-up introduced the chairless chair for BMW and Audi in the year 2015. It's working was controlled by mechatronics system. H. Zurina and A. Fatinhas worked on the Design and Development of Lower Body Exoskeleton. Aditya Bhalerao and Sandesh Kamblehave worked on the Pneu portable chair for employees to seat while working.

Apart from that our chairless chair is based on simple link mechanism and does not require any battery or power for successful working and is manually controlled. So this makes it acceptable and affordable for every common people.

Productivity is the measure of efficiency of a person or a machine or a factory in converting inputs into useful outputs. It is the ratio of the actual output produced to the actual input. Worker's efficiency is an important aspect in productivity. So, increasing the efficiency of worker is a way to increase the productivity in an industry.

A worker's efficiency can be increased by providing him with a better working condition, providing him incentives and extra pay for extra works. For doing the extra work the productivity of the individual was unmatched in the department so we decided to keep him during lay-offs. If there is any device which helps him to reduce the workload or working condition in any way, his efficiency can be increased, hence, productivity also increases.

III. OBJECTIVES

The general objectives of our project are,

1. To design exoskeleton system entitled chairless chair to improve the ergonomics at Industry by using Catia V5.
2. To develop a user friendly kit and this can be affordable by everyone, especially the workers from Industry.

IV. WORKING PRINCIPLE

In this project the movement of system is controlled manually for changing angle in knee locking system and changing height of system by means of height adjuster suitable to user. Knuckle pin used for adjusting three different angles provided in knee locking system.

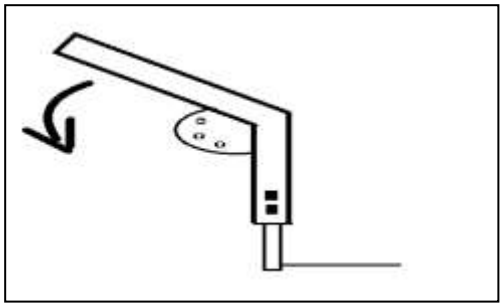

Fig.4.1 Working Principle

V. DESIGN OF A PROJECT

Design Considerations

The following considerations were made while designing the project.

1. Making existing mechanisms less complicate
2. Safe to users
3. Affordable price
4. Compact & User Friendly

Methodology

The present case study or project aims to design and develop a lower body exoskeleton. Usually in production line, the workers are standing while doing their work. This cause them a several fatigue on their back. So our group has design and developed a chairless chair which the workers can sit

freely whenever they feel tired and still can do their work while sitting. This lower body of exoskeleton is not being well known yet and majority from the existing chairless chair is made of mild steel which is very heavy. Therefore, we decided to use Iron. Besides that, it also can be securely welded. We also use strap in order to tighten between our leg to the simple chair (exoskeleton).

Other than that, other equipments that we use to make this simple chair are rivet, shaft, nut, bolt, whereas, for machine we are using drilling machine, grinding machine and arc welding machine. To improve the comfort of the user, we are using seat. CATIA V5 is used in order to design our chairless chair. Other than that, the Finite Element Analysis also carried out in order to find the find the maximum weight that the product can accommodate. The fatigue analysis is used to compute the fatigue life at one location in a structure.

Outline of Project

1. Calf support

Calf support is made of cast iron with 36 cm length. It provides support to thigh portion. One hole is drilled in it to connect to the thigh support.

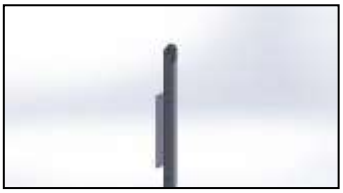

Fig.5.1 Calf Support

2. Thigh Support

It is made up of cast iron sheet which is 36 cm long and 20 cm wide. It supports thigh of the person which is connected to calf support. It is slightly bend at centre of line to adjust it to thigh of the operators.

Fig. 5.2 Thigh Support

3. Knee Locking System

Knee locking system is locking system in which 3 stages are provided for different sitting position this three stages are provided with gap of 22.5 degree i.e it provides angle 180 degree, 157.5 degree, 135 degree, 112.5 degree.

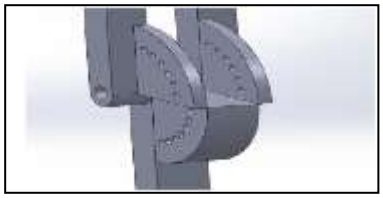

Fig 5.3 Knee Locking System

4. Height Adjuster

A pipe was cut and a bended piece was welded to towards the end so as to provide base support and to increase stability when the user activates the chair.

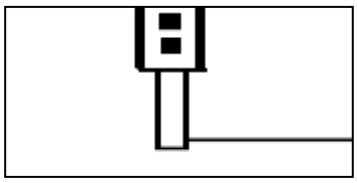

Fig 5.4 Height adjuster

5. Assembly

The calf support and thigh support are joined together using M6 bolts and tightened. So that it can be rotated up to 180˚. Then the height adjuster is bolted towards the calf support and is tightened according to required height. The design was done in CATIA V5 for our project is as follow,

Fig 5.5 Design of Chairless chair

VI. METHODOLOGY

Procedure

Firstly, we need to design the work piece metal chairless chair as plan by using CATIA V5. Then, cut the work piece metal into parts. After that, the work piece is welded and assembled in order to combine the parts of the product and link bar. Run the project and the discussion is made based on the result of the chairless chair. Some

precaution steps need to take in action while conducting experiment to avoid any unnecessary accidents for example during the welding, we have to protect our eyes by using the protection that provided by the lab.

Flowchart

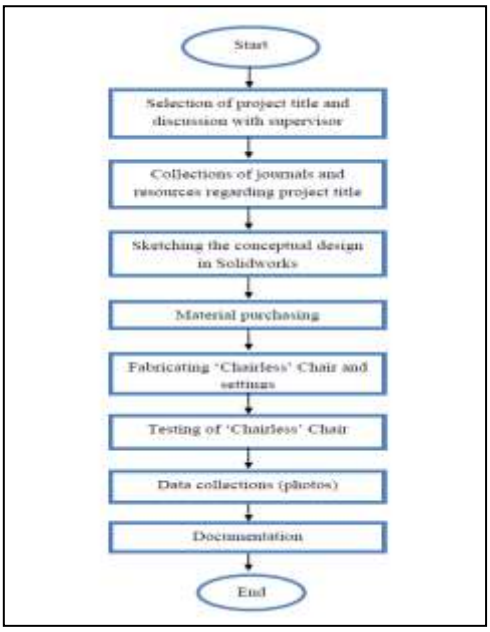

Fig. 6.1 Flowchart

VII. TESTING OF A PROJECT & DISCUSSION

Testing Of Project

The experiment testing has been conducted for our prototype to our group member with weight of 70kg and height around 170cm. From the result of experiment testing, it can be observed that for height and weight, the chairless chair doesn't give any effect in lack or over measure in its height dimension because it has an extension on the lower side of the prototype. It suits the user which proves that this chair can be wear by people from any height range.

Discussion

The objective of chairless chair is to let user sit whenever they want and can be carried anywhere as in portable. Compared to previous cases of prototypes, where the limitation was it wasn't portable because of the heavy weight mild steel material selected. Therefore it was uneasy to be carried around anywhere. However to solve that problem, our new prototype is made up iron which is much lighter and its almost portable to anywhere. User just needs to fold it and keep it into their bags or into any vehicles.

In term of ergonomic, it is found that this chairless chair do give people a comfortable posture due to its ability in changing the degree of seating based on their level of comfort from 90°, 120° and 150°. From previous semester cases, while changing the degree of this mechanical chair, the user might have some difficulties in adjusting the level of degree. This is cause by the designation of the chairless chair which is does not really meet the requirement of the real chairless chair which need the user to independently change the level of degree. In that case, we have designed an improvement to the locking system which is much simpler and innovative where user can just simply lock into desired angle with ease as shown as in Figure. It is does not look strong but it can hold a maximum weight of 100kg.

Overall, the result can be consider as success because it had achieve the goal which is to seat anywhere with 90°, 120° and 150°degree level. It does help the user to gain more comfort while doing job that required a lot of standing rather than seat or when no chair available at the moment.

VIII. ADVANTAGES & DISADVANTAGES

Advantages of Chairless Chair

The main advantage of this chairless is that it is portable. It can be carried anywhere easily by keeping in a bag. The user can even walk to some distance chairless chair attached to their legs. So that the user doesn't need to detach the exoskeleton every time he moves from one place to another. Next, it is proven to be suitable with a range of height up to 183cm.In addition, our prototype offer user to comfort themselves with three levels of degree depends on their comfort level. This can help the user to do their work with high serenity compare to chair with constant degree because some work not required the user to be seated but if its longing for a long time, it might be a problem to their muscle or having leg cramp, therefore, this is where chairless chair play it important role.

Disadvantages Of Chairless Chair

Despite of listing all of the advantages, the disadvantages that this prototype gives also cannot be ignored because it will affect the user. So, it is important to notice the entire disadvantage so that it can be fixed in the future. After do some analysis, we conclude that the materials need to do some improvement by replace iron with materials such as aluminum so that the weight of the prototype can be reduced significantly to ensure that user can carry it anywhere with no difficulties.

In our product, we didn't use aluminum materials due to advice from technician that aluminum might be hard to be welded and cannot hold much weight. Other than that, the system also can be improved by upgrade to auto adjusting level of degree's ability. This can be more user friendly and help the user to seat without having any difficulties to adjust the lock system which will meet the requirement of designation of chairless chair at a first place. When the locking system change to automatic adjustment it can ease the movement of user from one place to another which will increase the ergonomic standard in this chair.

IX. APPLICATIONS

The chairless chair being compact, user friendly and cheap in price is having wide scope of applications as listed below

1. Medical /Rehabilitation purposes where the devices are aimed to support physically weak, injured, or disabled people to perform a wide range of motions.
2. A small number of exoskeletons have also been designed for military applications for soldiers.
3. For Industrial applications to lift or carry heavy loads.
4. In civilian areas, exoskeletons could be used to help fire fighters and other rescue workers survive dangerous environments.
5. It is useful for old people who have back pain, knee pain.
6. It is used for industrial worker for doing work for long time.
7. It is used for house wife for doing work in kitchen for long time.
8. It is used to reduce back pain.

X. CONCLUSION

The chairless chair is successfully fabricated, assembled and analysed. The aim of this project was to develop an exoskeleton with simple link mechanism to support human walking, sitting and standing motions synchronously with human. It also helps to take significant portion of external load carrying by the user. Once this is achieved, exoskeletons can be made as a part of everyday life to reduce down the cases of MSD (Musculoskeletal Disorders). Since the cost of fabrication is comparably less, so this can be made affordable to the workers in small scale industries also.

In this project, a lower extremity exoskeleton mechanism is designed to support human walking, sitting, and standing motions synchronously with human and also it is developed to take significant portion of external load carrying by the user. Once this is achieved, exoskeletons could become practically useful and start to appear in everyday life after make some improvement.

SCOPE FOR FUTURE WORK

If in the future we want to reduce the weight, we can replace the iron steel structure with fiber glass or plastic. Fiber glass is a good strength to weight ratio component but it is quite expensive. Others alternative is to use plastic but the selection of plastic must be analyze wisely. Sharp edge at the chairless chair must be removed in order to prevent injuries to the users. Besides that, we have to encounter our safety when using this chairless chair as this chairless chair built based on the theory that said most suitable angle for balanced seating is 135 degree in between femur bone and lumbar curve. This will cause difficulty in order to make sure that our body is straight during use this chairless, if we cannot follow the rules, we might be fall of and this will cause danger to the user.

Thus, the safety might be increasing by adding some safety issues in the future. Our objective is to solve ergonomic problem occur during work for long term of period. So, any extra ergonomic problem should not occur while using this chairless chair.

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