DESIGN, ANALYSIS and DEVELOPMENT of CHAIR-LESS CHAIR EXOSKELETON SYSTEM

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***Abstract* --The 'chair-less chair exoskeleton system is a hydraulic based Exoskeletal support which is basically a 'chair' that is like an exoskeleton, allowing users to walk or move at certain speed with the device while they work. It is a mechanical ergonomics device that is designed around the shape and function of the human body, with segments and joints corresponding to those of the person it is externally coupled with. This support helps users to rest their leg muscles by directing their body weight towards a variable damper attached to the frame and directs the weight to the ground. This exoskeleton system is designed to be appropriate mechanism with human lower extremity and it operates synchronously with the human realizes. It consists of two identical 'supports', one strapped to each of the wearer's legs. Simply bend the knees to a comfortable stance to activate its damper that supports the body weight. The Exoskeletal support not just provides a comfort lower body support, but also has several other purposes with this being a skeleton for newer products.**

I. INTRODUCTION

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.

II. METHODOLOGY

To support human lower body part which is an exoskeleton especially worker need to stand more than 5 hours per day, methodology of this work is concentrated on the need to developed the simple chair. When a worker wants to seat, pushing a button, by which at the desired angle the frame locks. Through the frame to the floor or the heels, the weight of the body is transferred. To hold the limbs tightly a rubber band will be used, in order to fix the position to the exoskeleton. This product worn on the legs, which allows the user to walk or run when no activated. When the device is activated it uses a variable damper to engage and hold person's body weight, relieving the stress on leg muscles and joints. The wearer just need to move into the desired pose, this activates the device.

III. LITERATURE REVIEW

1) Pneuro portable chair for employees:

Aditya bhalerao worked on Pneuro portable chair for employees to seat while working. By referring to human seating and walking characteristic a leg mechanism has been conceived with as kinematic structure whose mechanical design can be used by employees as a wearable exoskeleton.

Fig.1 Mechanism of Pneuro Portable

2) Robot-assisted rehabilitation systems:

Paul dominick e. Baniqued1 and Nilo presented on how the Robot-assisted rehabilitation systems have been clinically proven to be just as effective in stroke rehabilitation as with the traditional methods. In particular, robotic exoskeletons for the upper limbs are powered wearable devices designed to be aligned with the user's joints and linkages. Current methods in product design simplifies the complex requirements of the human upper limb, thereby compromising the comfort and safety of the injured patient. In rehabilitation robotics, it is important to consider the user needs and requirements of such a device early in its design phase. Their study demonstrated how the assessment of user needs participate in the design of a wearable robot for the rehabilitation of Filipino and Asian patients

3) The flexible wearable chair:

Ashutosh bijalwan, Anadi misra Analysed design of a flexible chair like mechanism. The flexible wearable chair is like a light weight mobile exoskeleton that allows people to sit anywhere in any working position. The traditional chair is difficult to move to different working locations due to its large size, heavy weight (~5 - 7 kg) and rigid structure and thus, they are inappropriate for workplaces where enough space is not available. Flexible wearable chair has a gross weight of 3 kg as it utilizes light-weight aluminium alloy members. Unlike the traditional chair, it consists of kinematic pairs which enable taking halts between continuous movements at any working position and thus, it is capable of reducing the risk of the physical musculoskeletal disorder substantially among workers. The objective of this paper is to focus on the mechanical design and finite element analysis (FEA) of the mechanism using ANSYS software

4) Wearable devices:

H.zurina Paper was of interest in 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. The device is known as virtual Chair which helps the wearer to work effectively at any location in a sitting posture. In their paper an attempt had been made to evaluate the possibility of using the virtual chair that will help in increasing the energy efficiency and offer weight support when the user feels tired rather than continuously taking on the weight. Other than that, in term of ergonomics, and the objectives to give comfort to user has achieved by give choices to user to choose their comfort degree level from 45° to 90.

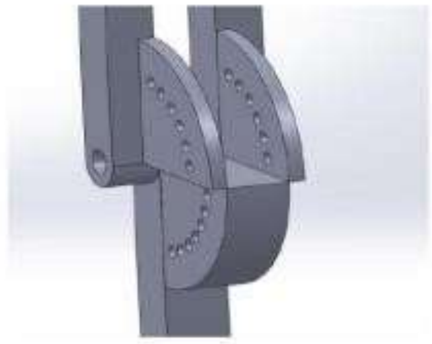


Fig.2 Knee locking mechanism developed by H. Zurina

5) The exoskeleton based hydraulic support:

Cyril Varghese and Vedaksha josh Worked on 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 kg 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

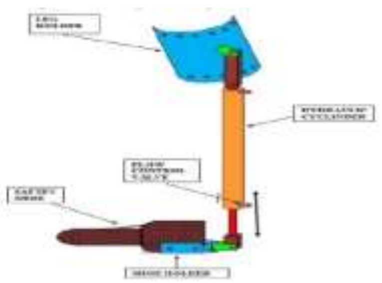


Fig.3 Schematic diagram of hydraulic mechanism support

IV. DESIGN ANALYSIS AND DEVELOPMENT

A. *Material Selection and Properties*

Mechanism can be portable if it is light weight, for this one have to choose high specific strength material. Additional to this considering hollow section further reduces weight and making beam/column stiffer. As most of the load is carried by column and it increases with width which in turn increases the possibility of penetration of column via locking pin if an appropriate material is not selected. Considering all these aspects and material availability, proposed material for

B. *Design*

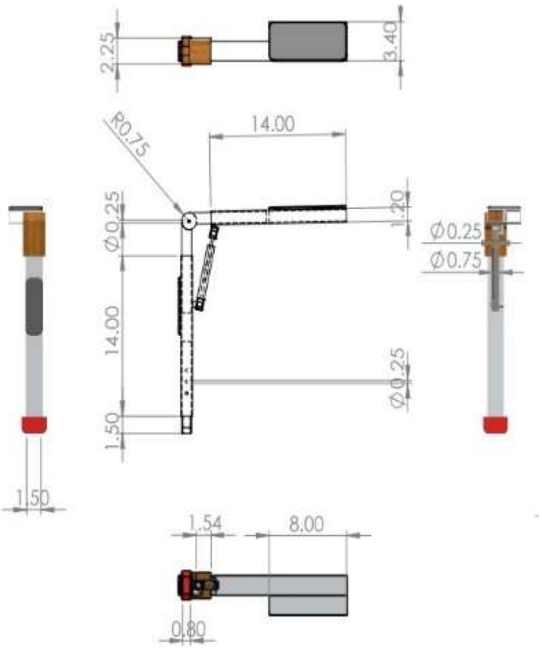
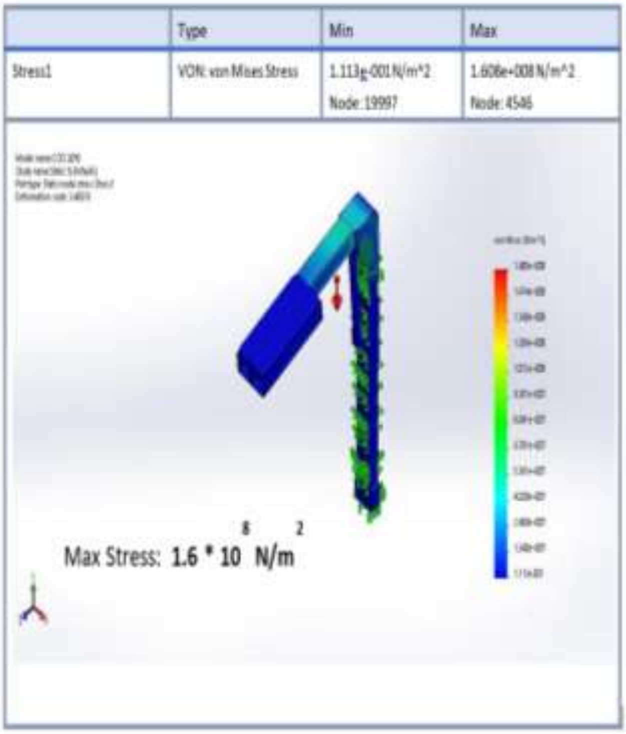


Fig.4 Dimensional Design of CCES

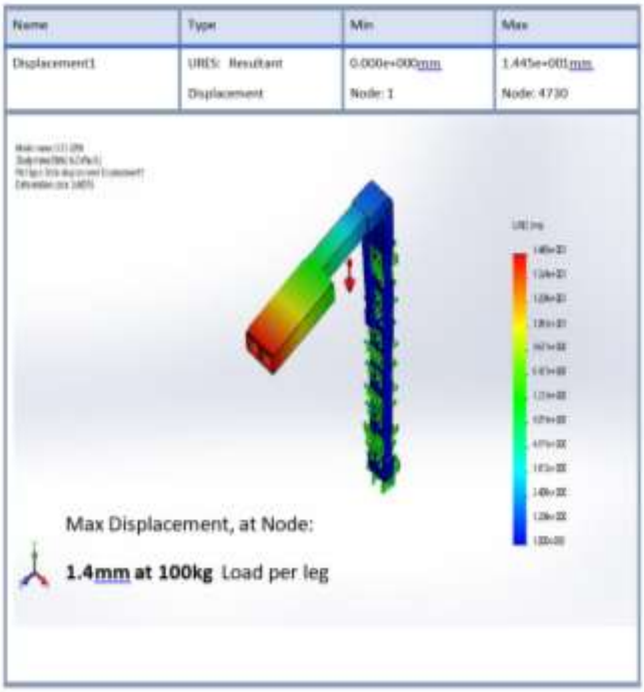
C. *Computer analysis*

Finite element analysis in using Solid works Simulation addon is used. Upon Analysis of the model, Applying 100kg to each leg individually. The analysis was done at 90 degree position which would be where maximum strain on the joints as well as beams would take place.



	Type	Min	Max
Stress1	VON: von Mises Stress	1.113e-001 N/m^2 Node: 19997	1.606e+008 N/m^2 Node: 4546

Fig.5 Von Mises Stress at 90degree



Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0.000e+000mm Node: 1	1.445e+001mm Node: 4730

Fig.6 Resultant Displacement at 90degree

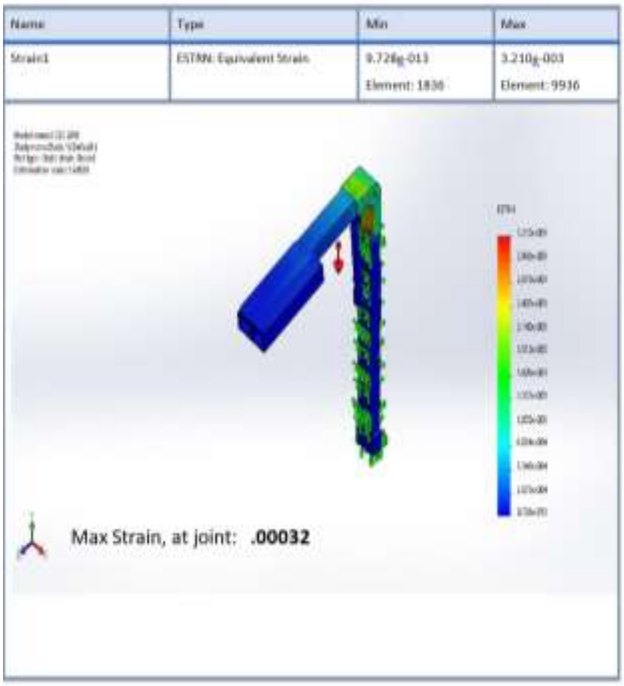


Fig.7 Equivalent strain at 90degree

Maximum strain experienced is about $3.21*10^{-3}$ at the knuckle joint. Most of strain occurs at these region and also at the damper joints to the beam. These occur due to load distribution and these are within limits of material used.

D. DEVELOPMENT

Fig.8 All parts before assembly.

Fig.9 CCES under final development.

All parts were collected, and final assembly is done with all necessary fixings by screws. All the parts are removable and replaceable, in case of any art failing, that defective part can be removed easily and replaced. Final product weights 1.84kg per leg, provides comfortable seating and Velcro based straps which provide quick and proper strapping of CCES to body. Whole of the product can be folded and put in a backpack for portability.

E. Advantages

Adjustable position as per desire. Reduces human efforts and fatigue free work.Easy to wear and operate. No frequent maintenance and service.High efficiency and increase in production rate. Can be used for seating and lifting support.

F. Disadvantages

Possibility of cramps due to long use. In case, failure if weight is high than designed value.Requires getting used to, due to the extra weight in legs.

G. Applications

This portable chair would helpful to workers and anyone who needs to stand for long hours at stretch. Once into mass production, a company can completely alternate the usage of portable chairs to CCES and maximize efficiency. In food and manufacturing industries, for labours who work standing hours and hours. Can be used by commuters standing in a crowded trains or metro to relax themselves without occupying much space. With assist from a wall, It can be total relive as it gives feel of a complete chair. Upon a high jump, the damper absorbs the impact reducing strain.

V. CONCLUSION

The Chair-less Chair Exoskeleton system is successfully designed and analysed. The aim of this project is to develop a lower body external skeletal structure to support sitting and partial standing posture. The finite element analysis is performed on the chair-less chair, using Solid works Simulation add-on to find total deformation. 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.

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