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Design and Fabrication of Chairless Chair

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Abstract: ***The chairless chair is a kind of ergonomical product which is actually a chair that is based on exoskeleton support. The primary work behavior of workers who have been listed as prolonged occupational standing reported that the worst health outcomes. A small study concluded that there stands a higher chance of significant and prolonged lower limb muscle fatigue while standing five hours or more than that a day. This might increase the risk for long-term back pain and musculoskeletal disorders. In mean time, the researchers found that people who primarily stand at work are several percentages more likely to develop heart disease than "predominantly sitting populations". The traditional chair is inconvenient to carry to different working locations due to its large size, and its heavy weight (5 to 7 kg approximately) and rigid structure and thus, they are inappropriate for workplaces where enough space is not available. The ultimate aim of this project is to develop a lower body cost efficient external skeletal structure that supports sitting, walking and partial standing posture. Flexible wearable chair may have gross weight of 3 kg as it utilizes lightweight members. It is to be fabricated in such a way that the workers can be cozy during their tasks and can alter their sitting postures at any angles between ninety degree to hundred and sixty degree. A person can utilize this exoskeleton like an extra pair of legs to give him or herself as support to sit without a chair or to adopt a more comfortable position for different tasks. Workers can walk about as typical, but if they want to sit or lean, adjust and fix the supporting structure in the required position. Then the weight is supported on the ground by means of their adjustable structures. It aids to save space in the working place as the workers wear it on their legs. It reduces bad health impacts that occurs due to excessive standing.***

Keywords : adjustable sitting positions , excessive standing, exoskeleton structure, health risk

I. INTRODUCTION

Excessive sitting is also dangerous as it badly affects the body's metabolic rate, leading to the risk of disease such as diabetes, cancer, depression, high blood pressure, etc. Standing for some time is good for health.

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In workstations, the first concern is to enhance productivity but very few concerns are given to the effect of work fatigue on the worker' s body. Till now in the present era of fast-growing technology, workstations don't have a device that could provide comfort to the workers.

It is apparent that sloping/kneeling chair preserves lordosis and sacral slope with upright as well as slumped posture as compared with a flat one; it results in less tissue strain that in turn lowers back pain. Darcy Robert Bonnet invented a wearable chair that allows users to sit on two legs, which was not clear. But the suggestion of design by them has some demerits such as, it allows a single sitting position, irrespective of user desire, also there is a huge stress on lower leg as a result of reaction force imposed by the lower bar. The fundamental idea is that introducing internal hinges to the mechanism (structures while sitting) releases joint moment and providing these hinges consistent with worker lower body joints helps in relieving severe joint stresses which occur while working. But this approach brings some ergonomic challenges, the major problem with such design ensures that workers can move freely and after sitting, it is in stable equilibrium. Two important functions of legs are to support a trunk in the grounding phase, and to step quickly in the swing phase. In humans, the double S - shaped vertebral column acts as a shock-absorber that shifts the weight from the trunk over the load-bearing surface of the feet. The human legs are especially long and powerful as a result of their absolute specialization to support and locomotion. The aim of this work is to design and fabricate a low cost lower body exoskeleton or in a simple word is chairless chair device. This project can help to improve user posture, allow them to sit anywhere and comfort their leg muscles. This solution is to keep the workers working with standing posture but can also help them to relax their legs.

II. LITERATURE REVIEW

A mechatronic wearable posture aiding device covering associate higher support for connecting to the thigh of someone, a lower support for connecting to the shank of the person and a joint pivotably connecting each supports, and a damper with connectors for pivotably connecting the damper to the support [1]. The Centre of gravity of the upright human body and the base of support. Another characterization for depicting forward and in reverse leanings of the straight human body with the feet fixed on the ground. During the motion of static balance steadiness of the upstanding human body depends upon the fundamental parameters, for example, facilitates X Centre of Gravity and Y Centre of Gravity of the focal point of gravity of the body in the upstanding position and the range R of the base of help [2]. Current methods in product plan simplifies the complicated requirements of the human higher limb, thereby compromising the remedy and security of the injured patient.

In rehabilitation robotics, it is essential to consider the consumer desires and requirements of such a machine early in its design phase. Their learn about established how the evaluation of person wants participate in the sketch of a wearable robot for the rehabilitation of Filipino and Asian patients. The effects of the find out about and dialogue later on had been translated into a list of consumer requirements for wearable robots in neurorehabilitation. After which, corresponding significance scores from each the sketch engineers and their scientific collaborators were assigned to arrive with a matrix that determines the remaining layout priorities and specs of the device [3]. Many sufferers with spinal injuries are restricted to wheelchairs, main to a sedentary life-style with secondary pathologies and accelerated dependence on a career. Increasing evidence has proven that locomotor training reduces the incidence of these secondary pathologies, but the bodily effort worried in this education is such that there is terrible compliance. This paper reports on the control of a new “human friendly” orthosis (exoskeleton) and diagram, powered by high strength pneumatic Muscle Actuators (pMAs). The aggregate of a exceptionally compliant actuation system, with an clever embedded manage mechanism which senses hip, knee, and ankle positions, velocity, acceleration and force, produces powerful but inherently safe operation for paraplegic patients [4]. The exoskeleton based hydraulic support being extremely light in weight causes very little obstruction while walking and the user can easily get used to it. It was observed on testing the chair while doing some work that, they had difficulties in changing the degree level of the chair [5]. On contrary to the customary seat, it comprises of kinematic sets which empower taking stops between constant traits at any working role alongside these lines. It is outfitted for reducing the chance of the bodily musculoskeletal trouble considerably among industrial workers. It pays attention on the mechanical shape and limited thing investigation (FEA) of the instrument making use of ANSYS programming [6]. A quantitative way to deal with examining human biomechanics, displaying standards of traditional mechanics utilizing contextual investigations including human development. Vector variable based math and vector separation are utilized to portray the movement of articles and 3D movement mechanics are treated inside and out. Graphs and programming made groupings are utilized to show human development [7]. Wearable devices increase the efficiency of workers and decrease the rate of fatigue [8]. The lower limit exoskeleton is a wearable automated gadget that should empower a human to stroll with a substantial burden for a delayed timeframe without diminishing the human's spryness. The exoskeleton is included two human legs and a spine that gives an adaptable stacking interface. The gadget is to be structured and controlled so that the human can lead a wide range of exercises without feeling the gadget [9]. The design structure on how the human exoskeleton can be controlled. These types of devices with the ergonomic background can be easily upgraded with the use of more advanced technologies and culminating various facilities into one body and be constantly modified. It has several major applications in a real-time scenario where it can be worn in crowded trains or public places with space constraints [10]. By alluding to human seating and strolling trademark a leg system has been imagined with as kinematic structure whose mechanical plan can be utilized by representatives as a wearable exoskeleton. According to the Specified Design parameters the body can reasonably bear the 100Kg of Human Body weight. In the later part to decrease the cost, Oil was additionally gotten the weight continuing system hence giving better outcomes. These sorts of gadget with

ergonomical foundation can be effectively overhauled with the utilization of further developed innovations and coming full circle different offices into one body and be always adjusted. An essential thought of how an exoskeleton utilizing Pneumatic or Hydraulic Cylinder can be utilized to decrease the weariness by utilizing basic kinematic components [11]. A wearable chair in 1977 allowed users to take a seat on two legs, which was once not obvious. But the design proposed by them using their methodology has some de-merits as follows: it permits solely one sitting position, irrespective to the user desire, also there is giant stress on decrease leg resulting from the response pressure imposed with the aid of the decrease bar. But the approach to poses some ergonomic challenges, the biggest problem with such a design is ensuring that workers can move freely and after sitting, it is in stable equilibrium [12]. The impacts of mellow leg length imbalance on stance and step has been the wellspring of much discussion. Numerous assessments have been communicated both for and against the requirement for intercession to lessen the size of the disparity. Their paper underscores the requirement for exact and dependable appraisal of leg length contrasts using a clinically utilitarian radiographic system, and audits biomechanical ramifications of leg length disparity as identified with the improvement of stress cracks, low back torment and osteoarthritis [13]. This is a compact starting soft cover that gives reasonable procedures to applying learning of material science to the investigation of living frameworks and presents material in a clear way requiring almost no foundation in physical science or science [14]. Assistive gadgets, for example, exoskeletons are fit for giving rehabilitative improvement and autonomy to people experiencing musculoskeletal conditions. Run of the mill gadgets utilize either dynamic help strategies, for example, DC engines or inactive techniques, for example, springs or hole valves or switches. Dynamic strategies require a persistent power input, while aloof techniques are restricted by client capacity. This work presents an Active/Passive Exoskeleton system. This gadget can latently give ceaseless help, just expecting vitality to change the dynamic properties of the inactive state [15].

III. PROBLEM STATEMENT

There is an insufficiency of the seat when we want to sit anywhere and anytime. It is often troublesome to provide seating equipment for all workers in every field of aspect. Excessive sitting is dangerous as it badly affects the body’s metabolic rate, resulting in the risk of disease like high blood pressure, diabetes, cancer, depression, etc., Correspondingly, excessive standing also results in worst health outcomes. In workstations, the essential concern is to enhance productivity, but very few concerns are on the effect of work fatigue on the worker’s body. Despite the work environment is ergonomically designed they are not successful in soothing laborer weariness since most of the time they got to work for hours in a specific pose.

IV. OBJECTIVES

The predominant objective is to

- Help workers to mitigate the microgravity of bones and muscles occurring due to excessive standing
- Support injured workers to return to work faster
- Provide mechanical ergonomic device for all workers in an industry to be useful even in cramped spaces
- Design and fabricate a low cost assistive device that allows normal movements like walking and running
- Provide movements when we wear it too
- Allow people to sit anywhere in an industry

V. DESIGN CALCULATION

A. Calculation for loads on Cylinder

Let us assume on an average of 100kg weighing human body. Therefore, the average percentage of weight for each body part is as follows;

Total body weight = W = 100kg

Head = 7.30% of total body weight = 7.30/100 ∗ W

= 7.30/100 ∗ 100 = 7.30 kg

Trunk (abdomen, back and chest) = 50.80% of total body weight =50.80% ∗ W = 50.80/100 ∗ 80 = 50.8kg

Upper arm = 2.7% of W= 2.7/100 ∗ 100 = 2.7kg

Fore arm = 1.80% of W= 1.80/100 ∗ 100 = 1. 8 kg

Total arm = 4.3/100 ∗ 100 = 4.3 kg

Hand = 0.66% of W= 0.66/100 ∗ 100 = 0.66 kg

Thigh = 9.88% of W =9.88/100 ∗ 100 = 9.88kg

Lower leg = 4.65% of W= 4.65/100 ∗ 100 = 4.65 kg

Foot = 1.45% of W= 1.45/100 ∗ 100 = 1.45 kg

Total effective weight on chair

Total effective weight of body parts that tends to act on chair = [weight of head + weight of trunk (chest, back and abdomen) + weight of two thigh + weight of two arms+weight of hand]

Therefore, Total weight = 7.30+50.8+2*9.88+2*4.5+0.66

= 87.52 kg

We have use two supports.

Therefore, Force distributed on each support = total weight/2

=43.76 kg

Newton's second law of motion states that,

Weight force = Mass * Acceleration due to gravity

F = m * g.

F = 43.76* 9.81 = 429.2856 N

Therefore, the weight force to be supported by each support, F = 429.2856 N

B. Calculation involved is calculation on the stress of the aluminium rod:

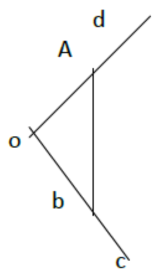

Fig. 1.Schematic sketch of the model

CD – top frame ; CB – bottom frame ;
OA – damper support

Fig. 1. Shows the schematic sketch of the proposed model in which the terms CD, CB, OA represents the structure of top frame, bottom frame and the damper support respectively. Here the term L1 and L2 gives the length of the top and bottom frame respectively. 'm' is the assumed weight that needs to be supported by the whole setup of the project. 'b' is the breadth of the frame

- L1=50cm; L2=42.5cm; m=100kg; b=15cm

  Hence, force due to the assumed weight
- F=mg = 100×9.81 = 981 N

  F (in each support) = 491N

  Area of the frames used for this work are
- A1 = L1×b= 50×15=0.075m2 (area of top frame)
- A2 = L2×b=42.5×15=0.06375m2 (area of bottom frame)

  Stress in the respective frames of the support
- σ1=F/A1 = 981/750=13.8KN/m2 (stress in the top frame)
- σ 2=F/A2=981/637.5=15.4KN/m2 (stress in the bottom frame)

C. Damper angle

In order to fix the damper to the interlinked top and bottom frame the length of the damper should be known. It is calculated by assuming the angle of the damper to be fixed as constant.

The term Ø represents angle of the damper to be fixed to the support.

- when Ø =135
- $OA^2 = CA^2 + CB^2$ - 2×CA×CB×cos135
- $OA^2 = 10^2 + 17.5^2$ - 2×10×17.5×cos135

  Here the term OA gives the length of the damper to be used for this work

  OA=25.57 cm (inside)

  i.e., nearer to the hinge
- $OA^2 = 42^2 + 39^2$ -2×42×39×cos135

  OA=74.84 cm (near end)

  i.e., nearer to the free end of the frames
- $OA^2 = 30^2 + 30^2$ - 2×30×30×cos135

  OA=55.43cm (middle)

  i.e., at the middle length of the both frames
- when Ø =90
- $OA^2 = 10^2 + 17.5^2$ - 2×10×17.5×cos90

  OA = 20.16cm (inside)
- $OA^2 = 42^2 + 39^2$ - 2×42×39×cos90

  OA=57.3cm (near end)
- $OA^2 = 30^2 + 30^2$ - 2×30×30×cos90
- OA=42.42cm (middle)
- The damper size on fixing some particular angles were calculated as above. Now, the damper size is fixed constant and its respective angle is calculated.

- Fixing damper length as constant:
- $45^2 = 40^2 + 35^2 - 2\times40\times35\times\cos \phi$
- $\phi = 73.40$
- For 45 cm length of damper, the respective degree is less than 90 degree. Hence it is clear that to have seating degree above 90 degree the length of damper and its corresponding support positions at the frames are to be adjusted. From the above calculations the approximate damper size is selected. In this work we are about to fix the damper length as constant and vary the degree of user postures.

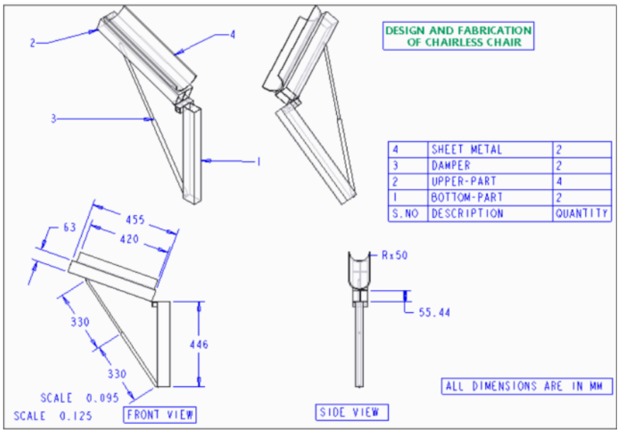

Fig. 2. Modelling of the model

The above figure 2 is a three-dimensional model created before the commencement of the work. It is modelled and assembled in Creo 2.0. It shows the main components of the model. The top frame and bottom frame are connected by butt hinges. The dampers are attached to the individual frames to support the load. A metal sheet is bent and made to fix at the interface at contact surface of frames and human body parts. This part is provided to act as a support guideline for thigh muscles. Sponges are made available above the sheet metal setup to comfort the muscles.

VI. RESULT AND DISCUSSION

Without any additional support, the model was comfortable support with a lean against a structure that provides good working posture. Easy to wear and operate. It decreases human endeavors and fatigue-free work. Adjustable sitting postures with high effectiveness and an increase in the production rate. It ensures null frequent maintenance and service. All the parts of this project were removable and replaceable. In case of any failures, the defective part can be easily replaced.

A. Future Scope

The decision of the material utilized for this task was constrained because of its accessibility. In the future, the composite material can be used to further minimize the weight and increase the strength of the structure. Different locking mechanisms may be adopted for providing better and smooth functioning of the chair. This chair is capable of relieving fatigue that develops on the lower body parts and needs further modification to give the best of it. It can be modified to help even the disabled (i.e., a person with no legs), persons.

VII. CONCLUSION

The model could sustain the anticipated load of approximately 100kg. It is found that the gross weight of the mechanism for both legs is approximately 3 kg and the prototype fulfills the criterion of lightweight when compared to the traditional chairs. It reduces the chance of musculoskeletal disorder and is convenient to work with the equipment as per client prerequisite. Implementation of the design and testing in a real-world environment is to be done and effectiveness in daily scenarios is to be determined. The expected outcome of the product indicates that the flexible wearable chair satisfies equilibrium and stability criteria and is capable of reducing fatigue during working. It reduces the health impacts experienced by the workers in an industry and enhance the performance of the workers.

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