Human Universal Load Carrier for Enhancing Physical Capacity

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Abstract - *Physical activities such as lifting and transporting goods are still a restricted area as far as human physical capabilities are concerned. Job areas such as laborers and grinders still has to undergo extreme fatigue as well as stress for fulfilling respective job opportunities. Human body has a measurable yet meager amount of strength which at times falls apart while doing extreme physical activities which are beyond their capacity. Exoskeleton, briefly an overall mechanism containing a sole purpose of minimizing the fatigue and stress observed by humans up to a great level is still a rare research as well as manufacturing field in India. Being a developing country, many job opportunities such as construction, manufacturing as well as related job, humans tend to require extra capacities to gain results. Exoskeleton eventually increases external capabilities and helps in increasing output work in respective requirements. Increasing in efficiency is fulfilled by the mechanism served by a typical exoskeleton.*

Key Words: Exoskeleton, Fatigue, Stress, Efficiency.

1. INTRODUCTION

Inspired by science fiction, that has very persuasively been brought out in books and movies, researchers have, for quite sometimes, put in efforts to make an effective exoskeleton which can be used for assistance. The exoskeleton robot is essentially a wearable robot; the term exoskeleton comes from biology exoskeleton. In the interpretation of biology and bone for provide biological protection and support the hard outer structure such as crustaceans or Kun worm shell.

Human Exoskeleton enhances people's strength, endurance and speed in many activities. The key concept of this innovative system is based on its mobile and mechanically passive components that can be adapted to one's body shape enabling users to carry the load or lift the load. It is fully articulated and made of metal that extend from the head to lower limbs.

Exoskeletons are of two types:

a) Active Exoskeletons

b) Passive Exoskeletons

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.

The main purpose of designing this passive exoskeleton is to decrease the human effort to carry the load and also to decrease the wear and tear on worker's body such as welders, grinders, labors. It is also used for military purpose. Exoskeleton amplifies human strength by applying assistive torques to the joints and reduces muscle work.

The passive exoskeleton does not have any electrical power source and can be used for weight redistribution by providing springs and locking mechanism to divert the weight of an object around the user and into the ground. Passive exoskeleton can also give energy capturing, dampening, locking, strength.

The exoskeletons present in market are made of mostly carbon fiber material and they are costly. Hence we will use tubes/pipes of MS, SS, Al or of composites materials. They are cheaper than carbon fiber and have enough strength to withstand the load. SS pipes are lighter in weight than MS pipes. Also the ductility of SS pipe is more than that of MS pipe.

We aim for manufacturing an economical exoskeleton. By an economical exoskeleton we mean an exoskeleton with no actuators and motors because that will increase the price. An economical exoskeleton is an exoskeleton manufactured with the help of mechanical components like springs and locking mechanisms, it means building a passive exoskeleton.

1.1 Motivation

As we can see in our daily surrounding we found that a large group of people who are working in either various industries or else doing any kind of occupation in which they have to carry large amount load. Few examples are labour carrying heavy sacks while transporting, workers holding heavy tools, farmers holding heavy equipment. Hence to relieve the fatigue on body and to improve work efficiency we seek the cheapest but effective method which is passive exoskeleton.

1.2 Objectives

Reduction in fatigue while carrying weight for human. Increased load carrying capacity for human.

To increase endurance.

Reduction in human efforts.

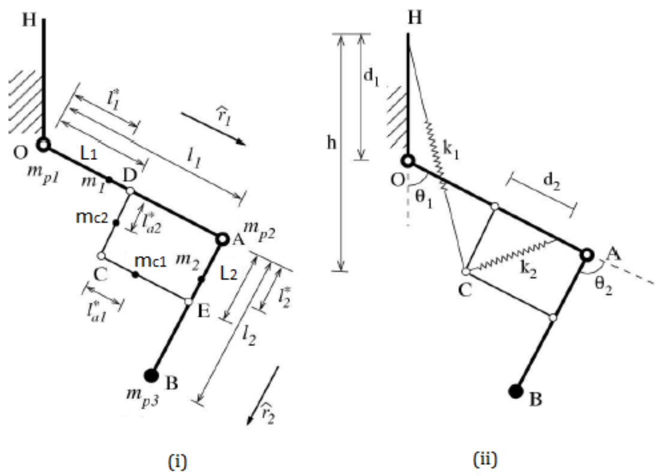
To provide assistance.

Cost effective.

2.0 Design Procedure

2.1 Principle

The principle involved in removing the weight of the leg is to place springs at suitable mathematically calculated positions such that they completely balance the effect of gravity. The device could balance its own weight along with the weight of the person wearing it. A gravity balancing mechanism using hybrid method could contain more than one spring. Among these springs, one spring always goes from a point on the waist of the person to the center of mass of the leg. The center of mass of the leg is geometrically located using a parallelogram mechanism.



Let us define the
Following terms:
l_i =length of i^{th} link,
l^*_i =distance of center of mass of i^{th} primary link from the joint on the previous link,
l^*_{ai} =distance of center of mass of i^{th} auxiliary link from the joint on the previous link,
m_i =mass of i^{th} primary link (mass of leg segments included),
m_{ci} =mass of i^{th} auxiliary link,
m_{pi} =mass of i^{th} point mass.
$\hat{r}_i$ =unit vector along i^{th} primary link
r_i =position vector from point O to center of mass of i^{th} primary link,
r_{ai} =position vector from point O to center of mass of i^{th} auxiliary link,
r_{pi} =position vector from point O to center of mass of i^{th} point mass.

L_1 =distance OD in Fig. i,
L_2 =distance AE in Fig. i,

To calculate L_1 & L_2 :

$$L_1 = l_1(m_1\alpha_1 + m_2 + m_{p3} + m_{c1}\beta_1 + m_{p2}) \div (m_1 + m_2 + m_{p1} + m_{p2} + m_{p3} + m_{c1}\beta_1)$$

$$L_2 = l_2(m_2\alpha_2 + m_{p3}) \div (m_1 + m_2 + m_{c2} + m_{p1} + m_{p2} + m_{p3} - m_{c2}\beta_2)$$

To calculate Stiffness of spring:

$$k_1 = (M*g) / (d_1)$$
$$k_2 = (M*g* L_1) / (d_1*d_2)$$

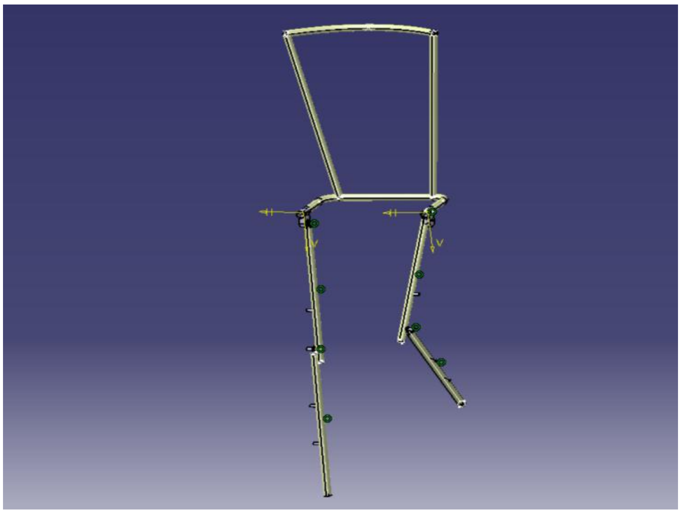


Fig. CAD Model of Exoskeleton

2.2 Material Selection

Table -1: Material Properties

Material :	Ultimate Tensile Strength
SS304	505 Mpa
AISI1010	365 Mpa
AISI1018	440 Mpa
AISI1108	380 Mpa

According to the ultimate tensile strength and the ductility of material, SS304 is selected. It is also light in weight as well as cheaper in cost.

While designing the exoskeleton we have to keep in mind about the weight transfer, if there are flaws in design then the weight will not take place. Also proper weight balancing is to done or counter balancing is to be provided else the person wearing it will sense more weight on one side. Welds and joints should not be sharp. They should be made smooth or else it will hurt the person wearing it or the people passing by. The welds should be done properly or else it will break at the welds. The pipes used should be strong enough to carry weight and also transfer the weight or else they may buckle. The bolts and nuts used should of standard grade, so that the bolts don't get sheared.

2.3 Ansys Results

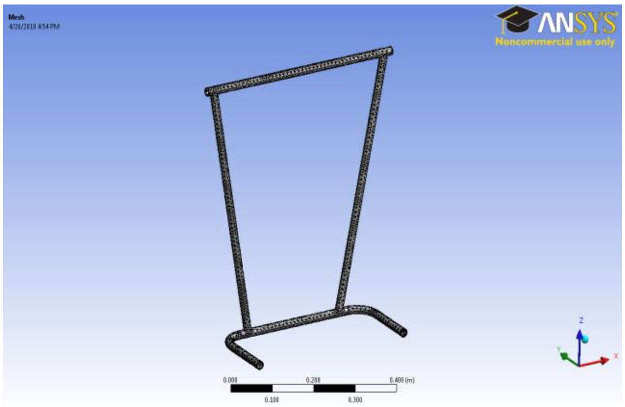


Fig. Meshing

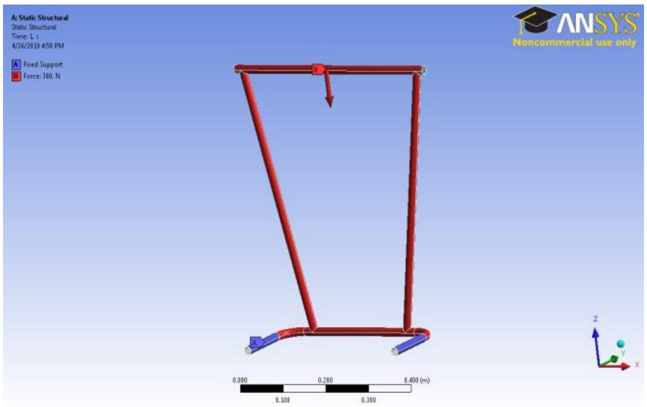


Fig. Loading Diagram

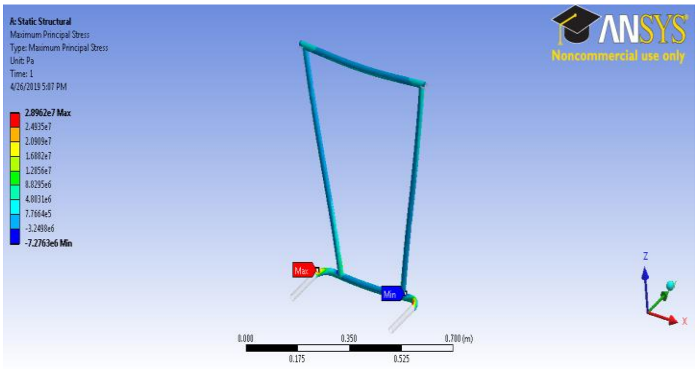


Fig. Maximum Principal Stress

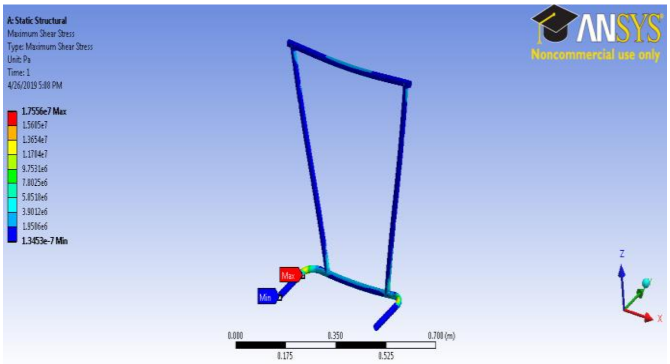


Fig. Maximum Shear Stress

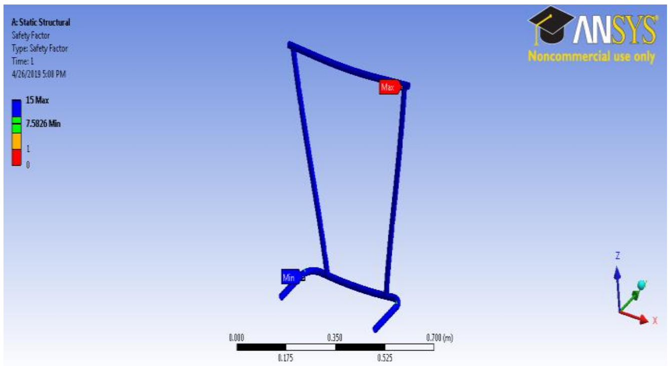


Fig. Safety Factor

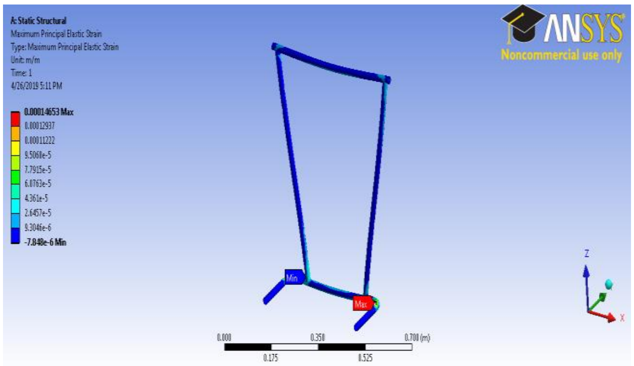


Fig. Maximum Principal Elastic Strain

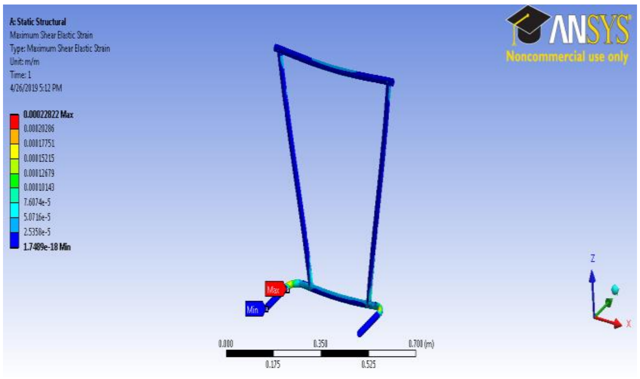


Fig. Maximum Shear Elastic Strain

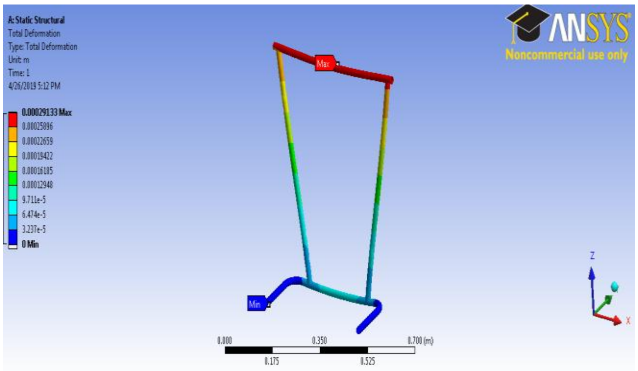


Fig. Total Deformation

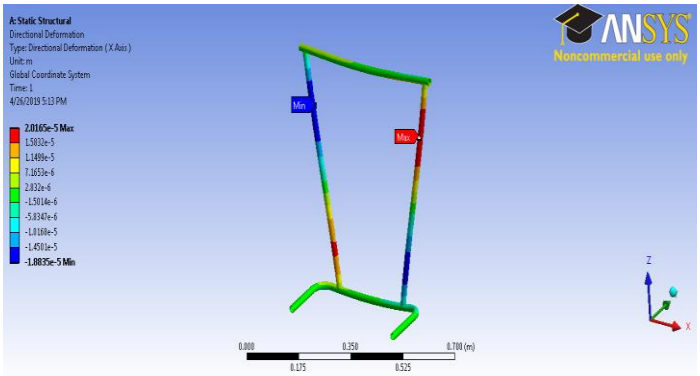


Fig. Directional Deformation

3.0 Components

Sr.No	Component	Quantity
1.	SS304 Tube(6m)	1 nos
2.	Bearings	2 nos
3.	Heim Joints	4 nos
4.	Brass Bush	2 nos
5.	Allen Bolt	16 nos
6.	Lock Nut	16 nos

4.0 CONCLUSIONS

- We have discussed all the possible ways to manufacture an economical exoskeleton.
- Possible ways to improve the reliability of the exoskeleton have been discussed.
- Various modes of failure have been discussed.
- By thoroughly studying the available research papers and above points, we conclude that an economical, reliable and durable exoskeleton can be successfully manufactured by implementing proper steps in the process of manufacture.

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