HYDRAULIC EXOSKELETON

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Abstract : This study is undertaken keeping in mind the existing exoskeleton and their limitations and to give relief to the Military personnel's, civilians and for the working conditions where the aim is to carry loads beyond human capacity with an improved hydraulic exoskeleton. The improved hydraulic exoskeleton works on Pascal's law. With this theory the transmission of load is done through the oil and the flow is controlled by actuators.

I. Introduction

In today's world military combats are becoming very common. These combats require the military personnel to reach and push their limits. They have to carry very heavy loads in very harsh and hostile conditions. These heavy loads make them very fatigue, stressed and unable to perform their assigned task in an effective manner. Sometimes the conditions are so unfavorable that the personnel suffers injury before reaching the actual battleground. To help and overcome such problems various attempts have been made to make a wearable frame which assists the personnel to lift the load without using their own energy. Such a frame or outer skeleton is named as the Exoskeleton.

An exoskeleton is a wearable external frame or suit that may be powered by various modes such as pneumatic, hydraulic, electric motors, etc. for increased strength of limb to assist in multiple situations. They may be used for carrying heavy loads without fatigue, by a paralyzed patient, etc.

EARLY EXOSKELETON:

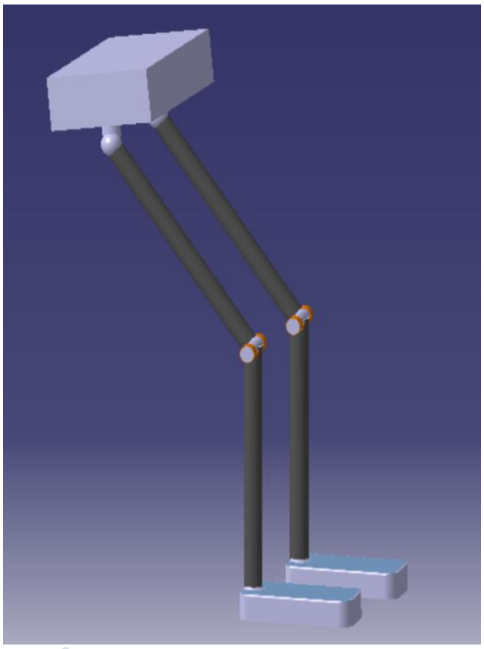
The earliest known exoskeleton was developed in 1890 by a Russian named Nicolas Yagin. The suit used energy stored in compressed gas bags to assist with movements, although it was passive and required human power. Leslie C. Kelley developed a exoskeleton named PEDOMOTOR, which is operated on steam power.

Similar to this another exoskeleton was made in 1960s based on mobile machine integrated with human movements, developed by General Electric and the United State Armed Forces and was named as HARDIMAN. It was powered by hydraulics and electricity made for lifting 110kg (220lbs). Another example of exoskeleton is Human Universal Load Carrier.

The existing exoskeleton depends hugely on inputting power through batteries which drain after some time, has highly sophisticated circuitry and are very costly. To overcome these limitations there is a need for development in exoskeleton with less complicated design, longer life and less circuitry equipment's.

Exoskeletons are used in military, industrial applications, rehabilitation, heavy lifting, civil defense and rescuing applications as well. This paper presents to design of a hydraulic lower-body exoskeleton assisting walking of a load carrying human. This exoskeleton system is designed to be appropriate mechanism with human and it operates synchronously with the human body. The purpose of exoskeleton is to provide forces against to external load carried by user during walking, sitting, and standing motions. Thus, it supports walking and large portion of load carrying by the human. Also it makes the user to spend less energy.

II. WORKING



The Existing Exoskeleton were either battery powered or computer powered.

The drawbacks of existing exoskeleton is that the current life suit prototype 14 can walk 1.6 km (1 mi) on a full charge and lift 92 kg (203 lb.) for the wearer. Its slow walking speed of 0.76 meters per second (2.5 ft./s) and frequently recharging is to be required in remote places which can be overcome by our project.

Our exoskeleton basically depends upon the human capability

The main concept is to lift load with the help of Pascal law.

Our exoskeleton runs on the principle of PASCAL'S law i.e. "Pascal's law is a principle in fluid mechanics that states that a pressure change occurring anywhere in a confined incompressible fluid is transmitted throughout the fluid such that the same change occurs everywhere".

Linkages will be provided to both the legs up to hip to transfer oil from foot padding to the tank which will be provided at the back above the hip of our body. A plunger will be placed in the tank on which load will be placed. Whole system including padding, linkages and the tank will be filled with oil. As soon as the padding under the foot filled with oil will be pressed by body weight, the oil will flow in the upward direction with high pressure into the tank and will lift the plunger and ultimately the load.

While removing the foot and pressure from the padding (while foot in air/walking), the oil will flow in the downward direction and the load will come on human body which will be disastrous. To avoid such situations hydraulic valves will be attached on each ankle. These valves will be closed when the foot is in air to avoid flow of oil under the feet in the padding and open when the foot is on the ground. The motion of these valves will be guided by sensors.

Since the area of the plunger will be greater than foot padding area, therefore weight greater than human weight will be easily lifted.

To avoid accidents sensors will open the straps of load in case of system malfunctioning.

III. METHODOLOGY

1. PROBLEM IDENTIFICATION

It has been seriously observed that the earlier exoskeleton were either computer or battery operated or are huge in shape as well as size. The initial cost of such exoskeletons are higher and is not affordable if to be used. To overcome this we have design an exoskeleton which is cheap and Hydraulic powered.

2. PROBLEM STATEMENGT

Considering above discussion we can state that, there are many disadvantages of the earlier exoskeleton in the market. In order to eliminate such drawbacks and to increase the working efficiency of the unit, the following system was designed.

3. OBJECTIVE AND SCOPE

The main objective of the system is to increase the human ability and capacity to lift heavy loads such that in case of by military personnel, factory labours, etc. with a very simple, cheap and effective system.Our current developed prototype can be useful by workers for lifting heavy weights and loads. Further developments in the current model will be applicable in wide ranges of jobs or duties including military purpose, civilians, industries etc.

4. DATA COLLECTION

Data collection plays an important role in methodology of the project. The data collection was carried out by doing market survey and carrying out the field research at different sectors such as industrial sector and defense sector.

5. DESIGN PARAMETERS

The required parameters for calculating the stress and forces on the system were concluded by market survey, studying anatomy of human leg and availability of the material that will be used for fabricating such type of system.

6. DESIGN MODEL

Based on the parameters obtained from calculations and survey all the requirements were considered and the basic model was created over the software named "CatiaV5r20".

7. REVISED DESIGN

The final design was created by doing some minor changes which were done in order to make the model more effective, creative and user friendly.

IV. MATERIALS USED

Table 1.

SR NO.	PARTICULARS	SPECIFICATIONS	QUANTITY
1	Hose pipe	ISO 18752-BC	2m
2	Oil	ISO 68 (20W)	5.5 liters
3	Aluminum sheet	AL5038	1kg
4	Bi-Directional Hydraulic valve		2
5	MS Sheet	2mm thick	1.5kg
6	Spring		6

V. CALCULATION

Foot area = 2 x 10 = 200 cm^2
Area, A_1= 0.02 m^2
Tank area, A_2 = 0.35 x 0.25
- Forces and Pressure

= 0.0875 m^2
Now,
By Pascal's law
$F_1/A_1 = F_2/A_2$
Assuming mass of average adult man = 70 kg
Therefore,
$A_2/A_1 = F_2/F_1 0.0875/0.02 = m_2/70$
$m_2 = 306.25$ kg
Therefore 306.25 kg of mass can be lifted.
Assuming 20% losses
Therefore,
m2 = 0.80 x 306.25
m2 = 245 kg

Pressure in the system, P1 = P2
P1 = (70 x 9.81)/0.02
= 34335 N/m2
= 0.34335atm
= 0.034335 MPa

VI. RESULTS AND DISCUSSION

Table 2.

PARTICULARS	MIN.	MAX.	MEAN
Pressure	1.2943 bar	1.7455 bar	1.5199 bar
Area ratio	8.75	4.375	6.562
Load (applied)	60 kg	76 kg	68 kg
Load (lifted)	210 kg	266 kg	238 kg

From the calculation we obtained the following results which states that as the weight of the person increase his capacity to lift loads increases by 3.5 times his weight for a given ratio of areas of padding and tank plunger.

Advantages over conventional exoskeleton

1. Simple mechanical components
2. Economical
3. Simple in design
4. Light in weight than conventional exoskeleton
5. Reliable

VII. CONCLUSIONS

The basic idea for developing this project is to build an economical and simple and reliable system to carry heavy loads. The project is simple in construction, design and is very economical. It is flexible compared to its predecessors with rigid frame and relies less on electronic systems. All these benefits can be achieved without compromising ease in use, simplicity and easy maintenance.

Our project is not only used to lift weights but also is applicable in rescue operations, military, industries.

VIII. REFERENCES

1. Human Universal Load Carrier (HULC), US Army
2. Gopal Krishna, Design and fabrication of pneumatic powered exoskeleton suit for arms, IRJET
3. https://youtu.be/aQsAHhRxwvw
4. https://youtu.be/VORuQ97SMNE
5. https://youtu.be/VSzvVXiWkSg
6. https://youtu.be/EPt2G69NT-U