January-February 2020
ISSN: 0193-4120 Page No. 11003 - 11005

Modelling of Pneumatic Exoskeleton Arm for Heavy Load Lifting

[1]Arunkumar. P.M, [2]Lalith Athithya N.K, [3]Anand Balaganapathy, [4]Abhinav. S, [5]Karthick. R
[1]Assistant Professor, Department of Mechatronics Engineering, Sri Krishna College of Engineering and Technology, Coimbatore, India
[2,3,4]UG Scholar, Department of Mechatronics Engineering, Sri Krishna College of Engineering and Technology, Coimbatore, India.
[5]Assistant Professor, Department of Mechanical Engineering, M. Kumarasamy college of Engineering, Karur, India

Article Info
Volume 82
Page Number: 11003 - 11005
Publication Issue:
January-February 2020

Abstract:
This paper discusses about using the pneumatic exoskeleton arm in the field of construction and heavy load lifting areas. Every year, close to 6 lakh people are being diagnosed with back pain and arthritis. And nearly half of them are suffering from this problem at a very small age .The problem that caused these people to get affected is that they used to carry weight on a regular basis, which has lead to their bones becoming weak over a long duration of time. By using pneumatic power we can easily transfer the load of human carries to the external frame attached to his body, which makes the work easier. This paper mainly focus on the reduction of human efforts to lift weights. The pneumatic cylinder is attached to the frame and it is operated using solenoid valve. By using different cylinders we can increase the load carries.

Article History
***Article Received**: 18 May 2019*
***Revised**: 14 July 2019*
***Accepted**: 22 December 2019*
***Publication**: 19 February 2020*

***Keywords*: Pneumatic exoskeleton arm; rehabilitation; back pain & arthritis.

1. Introduction

In this paper we focus on the development and design of pneumatic powered exoskeleton arm which helps in increasing the human strength. For an instance a French man was parallised in an accident and has walked again with a brain controlled exoskeleton which provides gives him hope to lead the life joyfully. He trained for months to harness his brain signals to control a computer simulated robot to perform basic moments like walking. This arm can be used as a means of rehabilitation. This have become widely popular in the military field as well, helping soldiers to carry armaments over challenging terrain.

The exoskeleton arm is designed with one degree of freedom with the help of ball bearing and a shaft, and is welded to the pneumatic cylinder. This setup helps the arm for the extension and retraction movement in a easier way to lift the loads. In such a way our arm helps people who are in need. We wanted our arm to be affordable to all.

2. Need For Exoskeleton Arm

Heavy physical work leads to leads to weakness of human internal organs like bones and muscles. Though machines are used to do work, there are still certain areas where human labours are employed for heave work. They cannot do the heavy work continuously for long time. They need some rest. Physical treatment or medicines have many side effects, even though they relieve the pain temporarily. It would be helpful if anything helps human labours while doing heavy works. So we designed an exoskeleton arm which aids and gives strength to the labours while doing heavy work.

The advantage of this exoskeleton arm is that the labours can carry the system on their backpack which is very easy to transport from one place to another place. The designed exoskeleton arm model is of lightweight, strong and powerful. It helps the labours to do work beyond their limit. It also supports the back part of the body which is used to maintain a proper body balance.

For patients with physical inability, the exoskeleton can increase the range of motion and rebuild muscle strength. The significance of the exoskeleton arm is that, it replaces the use of wheel chairs and sticks. It replace the conventional methods and it provides more mobility to the humans. This also avoids the use of heavy machines which is not easy to be transported.

3. 3D Design Analysis

The exoskeleton arm has been made with Mild Steel. It has good malleability, great conductor of electricity, withstands the heavy loads and reduces the vibration caused when lifting a heavy weight. Fig.1 and Fig.2 shows the 3D model of our Exoskeleton Arm. Fig.3 shows the fabricated model of Pneumatic Exoskeleton Arm.

Figure 1: Isometric view of exoskeleton arm (Extension)

Figure 2: Isometric view of exoskeleton arm (Contraction)

Figure 3: Fabricated model of Pneumatic Exoskeleton Arm

4. Stability Condition and Derivation

Design calculation for choosing frame dimension and cylinder is given below. Mild steel is chosen as the material for frame due to its good properties as stated in 3D design analysis.

5. Frame Design

Frame dimensions are obtained using bending equation.
Bending equation is given by $M/I= \sigma/Y$
Working stress=Ultimate stress/Factor of safety
Ultimate stress for steel = $841*10^6$
Factor of Safety=1.5
$\sigma=841*10^6/1.5$
W=15*9.81kg
Length, L=30cm=0.3m
Moment of Inertia for Square section is $b^4/12$
Distance from neutral axis is taken as b/2.
$W*L/ (b^4/12) = \sigma/ (b/2)$
$44.145/ (b^4/12) =560.666*10^6/ (b/2)$
$529.7/b^3=1121.333/b$
$b^3=529.7/1121.333$
$b^3=0.472$
$b=0.6*10^6$
b=6mm for lifting the weight of 15 kilograms

Therefore we have decided to go for a thickness of 8mm to lift more than 15 kilograms.

6. Cylinder Design

Pressure, P=mg/A
m=mass of cylinder
g=gravitational constant
A=area of cross section
$P=25*9.81/ ((\pi/4)*d^2)$
$d^2=25*9.81/ (5*10^5)[4/\pi]$
$d^2=.000624m$
d=.024997m
d=24.99mm
d is greater than 25mm

Therefore, we have chosen a cylinder of diameter 35mm, which translates to a power input of 3bar for the same mechanical output.

7. Result and Discussion

From the design calculation, it is clear that exoskeleton arm is better suitable for carrying heavier loads, which reduces the human effort. By using a pneumatic cylinder, which is attached to the exoskeleton, we can have a smooth extension and retraction movement of the arm. This model has also been an eye opener as it has shown the advantages in using a microcontroller based pneumatic exoskeleton. The microcontroller has simplified the complex functions and it also integrates various functions in a single chip. That reduces the complexity of the components to be used.

8. Conclusion

In this paper a prototype of the exoskeleton is proposed. This exoskeleton is useful for the stroke patients, who have lost their strength of their arm. To perform the rehabilitation exercise based on guidance from patient's own healthy arm. Above figure 3 shows the prototype of the microprocessor-controlled exoskeleton arm. The major point inferred from this prototype is to develop a low cost based design exoskeleton which can be used by the people who are not only financially well sound but also by others. The prototype has shown great results and this indicates that it has a lot of scope in the near future.

The ultimate aim of this design is to develop a exoskeleton with bionic sensors in the future. This paper is just a basis for our future, which will be useful for the patients who are affected with impairment of their limbs. These devices boost the confidence of such people and also gives confidence to lead a happy life again.

Acknowledgment

We thank our associates from department of Mechatronics Engineering at Sri Krishna College of Engineering and Technology who provided insight and expertise that significantly assisted the research, although they may not agree with all the interpretation of this paper.

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