DEVELOPMENT OF AN AUGMENTED EXOSKELETON

Ekanshu Khurana
UG Scholar, Department of Aeronautical Engineering, Veltech Dr.RR & Dr.SR University, Chennai, India

T. Harsha Vardhan Reddy
UG Scholar, Department of Mechanical Engineering, Veltech Dr.RR & Dr.SR University, Chennai, India

Shreshth Gupta
UG Scholar, Department of Aeronautical Engineering, Veltech Dr.RR & Dr.SR University, Chennai, India

R.B.S.V Siva Kumar
UG Scholar, Department of Mechanical Engineering, Veltech Dr.RR & Dr.SR University, Chennai, India

ABSTRACT

This paper describes the conceptual design of an arm (right or left) powered exoframe (exoskeleton) which can be used in rehabilitation or by an army soldier who are debilitated to move their hands freely, and to lift the weight. This machine is designed for the application of teleoperation, virtual reality, military and rehabilitation. The option is put forward for a mechanical structure kinematical equivalent to the structure of the human arm. The elbow joint rotation is about -90 to 70 degrees. This arm can be used in both hands. This is a wearable robot i.e. mechatronic system with Velcro straps along with that it is a light weight device. It will also work mechanically with a push of a button as well as electrically with the help of solenoidal valve. Here the energy conversion is done using Pneumatic Cylinder (double acting) which is given the flow of compressed air through Solenoidal Valve, which control direction of flow and movement of piston.

Key words: Exoskeleton, Pneumatics cylinder, Air Compressor, Solenoidal Valve, Joints, Robots, Augmented arm.


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1. INTRODUCTION
An analysis was made on requirement on augmenting the human strength in various life’s aspect so an arm Exoskeleton was designed for enhancing capabilities of the natural human skeletal system\cite{15}. A powered exoskeleton is wearable mobile machine that can be caused to operate using pneumatics, levers, hydraulics, a system of technology or a combination of these technology that allow for limb movement with ease, increased endurance and strength.

The system can help people who need rehabilitation or a little extra muscle or as assistant in Motor function, Walking, Running and lifting Weights.

It has an Economic Advantage over other exoskeleton and along with it can be used for various operations as well as by people with different sizes. Our aim was to create an arm exoskeleton using pneumatics that would enable us to lift heavy weights without applying much force\cite{3}. A powered exoskeleton (ARM) is powered by Air Compressor and the energy conversion is done using Pneumatic Cylinder (double acting) which is given the flow of compressed air through Solenoid Valve which diverts the flow into two and controls the movement of piston. The sole purpose of a powered exoskeleton is assisting the wearer by augmenting his/her strength and endurance\cite{12}. These are often designed for military uses, to assist army men or women in boosting their carrying capacity of heavy loads both in and out of combat. Another prime area for Exoskeleton Technology is the medical field.

2. MATERIALS AND METHODOLOGY
2.1. Aluminum Plate
Aluminum 5565 is used in this design for developing the casing for the better contact of the exoskeleton with user and ease in operation. Being a less denser and having a high strength to weight ratio it becomes optimal choice for casing of an light weight exoskeleton. It can also help in long life of exoskeleton because of its corrosion resistance.

2.2. Pneumatic Cylinder
The retract motion of piston rod is done by routing pressurized fluid into the rod end of a double-acting cylinder\cite{6}. If, the cap end is routed by the pressurized fluid then it causes the rod to extend with this fluid flows back into hydraulic reservoir from opposite side of piston\cite{8}. The range of our pneumatic cylinder is 1-10 bars.

![Figure 1 Pneumatic Cylinder](http://www.iaeme.com/IJMET/index.asp)

2.3. Air Compressor
The storage tank accumulates the potential energy in form of pressurized air which is converted through electrical power that is fed into the compressor. This device forces air into a storage tank which results in increasing pressure and is done by one of several methods and is then used till that is being held in tank\cite{9}. Energy contained in form of compressed air is
released for the further use after our device gets depressurizes. This compressor can handle a pressure range of 1–20 bar.

2.4. Pressure Regulator

There are 3 functional elements which could be comprised by a pressure regulator:

- A spring loaded poppet valve, a pressure reducing or restrictive element.
- Piston or diaphragm, a sensing element.
- Spring, a reference force element.

This pressure regulator is rated from 1-8 bars.

![Figure 2 Pressure Regulator](image)

2.5. Solenoidal Valve

Solenoidal Valve is an electronic device which here we are using to control the flow of fluids. Electric current which is passed through the coil is used for controlling operation. Magnetic field is resulted due to the electricity passed makes plunger to move. The design plays the vital role in either opening or closing of the valve by plunger. As the electric field is removed valve returns to the initial position. The Solenoidal valve used in our project ranges from 2-8 bars[18].

![Figure 3 Solenoidal Valve](image)

2.6. Pressure Gauge

A mechanical instrument designed to measure the internal pressure and/or vacuum of a vessel or system which is called by the name of pressure gauge[4]. It flexes and the resulting motion is transmitted as a measurement through a mechanical movement to the pointer, when the sensing element is under the pressure. The pressure gauge is able to withstand 1-10 bars.

![Figure 4 Pressure Gauge](image)
2.7. Applications and Safety of an Exoskeleton

![Flow Chart](image1)

**Figure 5** Flow Chart

2.8. Design and Layout of the Exoskeleton

![Layout of the Exoskeleton](image2)

**Figure 6** Layout of the Exoskeleton
3. RESULTS AND DISCUSSION

The exoskeleton mainly works on the principle of pneumatics. By controlling the flow of compressed air dual action pneumatics operates. Pneumatics use valves to control the flow of air, which can be triggered by other source of compressed air, much the same way that electronics control the flow of electrons. This enables the upward and the downward motion of the pneumatic cylinder. The air pressure is controlled by the pressure gauge operated by the person operating the exoskeleton.

The applied pressure is directly proportional to the amount of weight our exoskeleton can lift. Pressure gauge is used to monitor the amount of pressure that is being applied to the equipment. The equipment is connected to the air compressor using PVC hoses. The change in pressure triggers the pneumatic cylinder to perform upward and downward motion. This helps us lift heavy weight.

![Prototype of the exoskeleton](image)

Figure 7 Prototype of the exoskeleton

4. CONCLUSIONS

The design and development of the exoskeleton arm accomplished, one can carry it and with the use of air compressor it can be of use in various purposes. Though it is a weightless machine, it can lift more weight. This exoskeleton arm can used for military purpose, as a haptic device, in rehabilitation, virtual reality and in rescue. It could carry a weight of about 30 kgs at a pressure of 8 bar. Now it can be used as military equipment or as equipment for rescue and rehabilitation by each and every person as it has an adjustable casing, but we faced some minor technical and design glitches that is while pneumatic actuate a torque results about shoulder, so, a shoulder mount is required for better performance and safety.

REFERENCES


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