Fabrication of Body's Exoskeleton Weight Lifter and Wearable Chair

Vyankatesh Raut
Department of Mechanical Engineering
Sipna College of Engineering and Technology, Amravati, Maharashtra-444607

Narendra Raut
Department of Mechanical Engineering
Sipna College of Engineering and Technology, Amravati, Maharashtra-444607

Abstract

Compressed air is another form of renewable energy sources, we developed a prototype called exoskeleton which loads lifting capacity of human up to 20-45 kg depending upon, the pressure supplied through the compressor using pneumatic cylinder Basically, the main purpose is that more work is done with the help of this machine with less human effort & that's actually we try to achieve it we named it weight lifter. Secondly, the wearable chair which will assist to provide comfort in various positions by setting an angle for workers to overcome their fatigue. An apparatus for supporting the weight of an individual body from the ground surface includes a unit for attachment to each leg. This paper deals with upper extremity, lower extremity, power assist and degree of freedom (DOF). Thinking on these lines, we came up with an alternative which will facilitate sitting and working and even carrying the whole exoskeleton anywhere anytime we want.

Keywords: Upper Extremity, Exoskeleton, Wearable Chair, Power Assist

I. INTRODUCTION

Every project has a particular aim to achieve their purpose & by implementing it becomes easier than previous. The name clearly suggests that it is skeleton assembly which can wear or attach to the body to its weight and gives relief to our leg muscle while wearing in sitting position for long periods. The main purpose of the project is that to reduce human effort & make desired work at every same energy level. This project divided into two portions that is one an upper extremity and lower extremity. Our project's upper extremity we called weightlifter. It is a simple supporting mechanism to hand to reduce efforts of the human hand while lifting heavy weights by using maximum labor working efficiency. It can lift heavy weights up to 20- 45 kg or transporting material from one place to another place for some distance &so many works can be done with the help of this lifter. The weightlifter basically consists of a frame which is made up of MS square rod. Universal joints are used at near shoulder to give free 2 degrees of freedom of motion to hand. Also, the solenoid valve is provided to regulate the flow of compressed air, hands are given for gripping and to carry the air, pipes and pneumatic fittings are fitted. As well as there are four pneumatic cylinders are used to give upside down a motion by extracting and retracting of cylinders' stroke, fitted parallel to upper link joint of the arm. For proper working, it requires multi-stage compressor which provides compressed air to pneumatic cylinders through pipes which is a clean process as compared to hydraulic. By controlling solenoid automatically, we can control the amount of airflow. At near to the fingers via handle the push to on/off button is provided & by pressing it we can control the lifting and releasing the weight. Now the lower extremity, we called as wearable chair. Basically, some workers, labors as well as employees need to spend longer hours at work standing on their feet, complaints of back pain, muscle injuries, leg fatigue are extremely common. The wearable char is a skeleton similar to human leg anatomy which allows him to sit wherever as possible without straining their muscle. By using it, improving body posture also solves & prevents certain occupational health & safety challenges and provides appropriate working conditions for ageing workers. Mostly for older works who are working for hourly periods. It is more effective and has many advantages that is improving labor working capacity in production industry, decrease fatigue rates. That's why to reduce such problem we made wearable chair which is the inner lower portion of the body.

II. LITREATURE SURVEY

A. History

The first exoskeleton structure to assist walking, jumping and running was invented by Nicholas Yagn in 1890. It contained compressed gas bags to power it. The first totally functional and powerful exosuit was developed by General Electric in association with United States Military in 1960s which lifted 110kg with effort reduction by the factor of 10. Most of the early work related to exoskeletons were concept studies that were put on the drawing board, but never actually built or tested. It was a simple bow/leaf spring operating parallel to the legs and was intended to augment running and jumping. Each leg spring was engaged during the foot contact to effectively transfer the body's weight to the ground and to reduce the forces borne by the stance leg. During the aerial phase, the parallel leg spring was designed to disengage in order to allow the biological leg to freely flex and to enable the foot to clear the ground [1].

B. Comparison with existing technology

The existing technology is far ahead with the power, material, efficient, purpose of adaptability in any situation but the main reason that rather more expensive and not affordable for ordinary use, our device is inspired from the works of Noonee. Swiss start-up noonee has created the chairless chair which is worn as an exoskeleton on the back of the legs [2]. The design described in this project is better and reduced the cost required to design and manufacturing. But the main difference selection of use of pneumatic cylinders instead of power actuator devices, hydraulic fluid actuators. The implementation was to use the exoskeleton arm and wearable chair together as well as single use for multiple purposes. We use 4 pneumatic cylinders of 10bar, 20mm bore diameter, and 100mm stroke length which through the supply of compressed gas can lift the load where the wearable chair attached to leg has v shaped groove in which tool of similar shape as space width of ratchet gear, tool is mounted between the gear so that different sitting angles can be obtain. Wearable chair has pneumatic damper attached to specific positions of chair, it is being used for two tasks; one for sitting comfort when being pushed inward it provides stationary position to user and secondly when lifting heavy weights more than 20 to 45kg, user bend his leg so that he can lift the load as the pneumatic damper is situated at thighs, when chair is in unlock position the damper actuates center of gravity of its cross section. The axial force pushes legs upward and helps to reduce the effort and can lift heavy loads through exoskeleton weight lifter. The cost of this project design is feasibly less than any other exoskeleton which is affordable for any ordinary man to purchase and use it efficiently.

III. MATERIALS AND COMPONENTS

A. Material

Mild steel hollow square rod, IS 4923 YST 310 grade one of the most widely used precipitation hardening grades, and possesses good corrosion resistance, toughness, high hardness, and strength

Dimension : 25.0 X 25.0 X 2.6mm.
Thickness : 2.6mm
Minimum yield stress : 310mpa
Minimum ultimate tensile stress : 450Mpa
Axial stress in tension : 186Mpa
Shear stress : 140Mpa
Bearing stress : 232Mpa
Bending stress : 205Mpa

Fig. 1: Mild steel hollow square rod

B. Components

Table - 1
Components

Sr.no	*Particulars*
1	*Double acting Pneumatic cylinders*
2	*Gas springs*
3	*Bushes*
4	*Drive Universal Joints*
5	*T-Union pneumatic push connectors 8mm*
6	*Push in joint pneumatic connector 8mm*
7	*Pneumatic Exhaust silencer muffler*
8	*Throttle valve*
9	*Solenoid (5 way 2 ports)*
10	*Nuts and bolts 4D, 6D, 8D, 10D*
11	*Brackets*

12	*Crank cotter pin*
13	*Push to on/off button*
14	*Standard cable*
15	*Pipes 8mm*

IV. CONSTRUCTION OF EXOSKELETON WEIGHT LIFTER AND WEARABLE CHAIR

Upper extremity of human can be categorized into upper arm and forearm while the links involved includes spinal cord frame, shoulder joint, elbow joint. Different parts of upper extremity corresponding to the exoskeleton has been developed for the purposes of weight lifter and lower extremity involved includes knee joint, foot and ankle joint.

A. Upper Extremity

1) Spinal Cord Frame Connected to Shoulder Joint

In the upper extremity, the frame of the spinal cord that mostly balances the body and weight of the load to be lifted. The frame is made with the consideration to reduce lower back engagement when lifting by as much as 45 percent. The back frame has been made for all users using suitable dimensions.

Fig. 2: Back frame

Shoulder joint is the most complex joint among human joints. Thus, the control and actuation of a shoulder joint is very challenging and complex. Unlike other joints such as elbow and wrist have simple rotation along their axis, the center of the rotation of a shoulder will be changed.

Fig. 3: Shoulder joint connected with universal joint

Most of the existing exoskeletons are having a similar structural frame in term of articulated rigid links regardless of the application of the exoskeleton. The shoulder joint is rigid link with an attached parallel with of universal joint. Unlike other exoskeletons, this mechanism provides 2 degree of freedom to the shoulder joint instead of 3 degree of freedom. This mechanism still has some room of improvement such as mechanical component and its control system.

B. Elbow Joint

The design has presented a wearable elbow exoskeleton with double acting pneumatic cylinder. Since, elbow has only 1 DOF. The system comprises of two cylinders which work in pair to produce force required by the flexion and extension of elbow. The Double acting cylinder provides several advantages such as cylinder alternates cycles of pressurized fluid to both sides of the piston and

creates extend and retract forces to move the piston rod, permitting more control over the movement, low cost and clean. Furthermore, the system was powered with solenoid which transfer amount of air to be required for extension and retraction of cylinder.

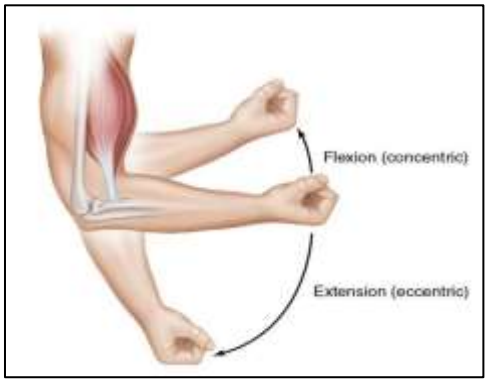

Fig. 4: Elbow joint when in action

The position of 2 cylinders welded on arm is such that the two cylinders of one is kept at stroke of 50mm whereas the other one is kept 100mm as original stroke. Cylinders are kept parallel with arm muscles. By this position, the valve is fully shifted first to extend, and then to retract clearly, retraction will be done at higher speed than extension when it comes in case of lifting heavy weights when compressed is made pass through it.

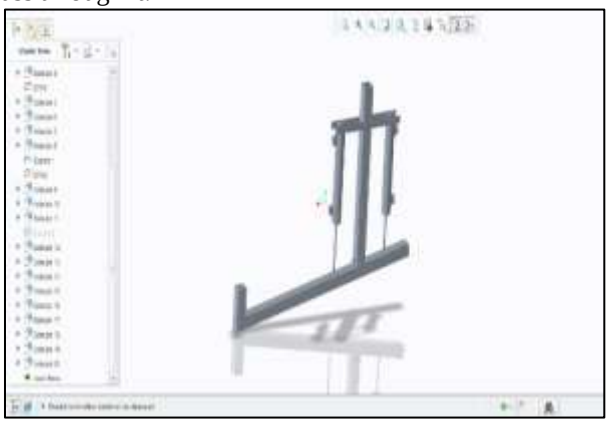

Fig. 5: Position of arm at rest

The elbow joints are bolted with half threaded nut and bolt (ø10mm) for free, eccentric and concentric movement. The cylinder rod is screwed and in forearm rod with the help of rubber bushes, as the cylinder stroke end are threaded the bush were screwed to it. The bushes are bolted to forearm rod. The two of the holes of double acting pneumatic cylinder with one was threaded with pneumatic fittings exhaust throttle valve so as to control the compressed air coming from compressor and acts as discharge. These valve are threaded with opposite position and the other holes are threaded with push in joint connectors with Teflon threaded so as to reduce the leakage of air. One of the left handed handle is where a push to on/off button is provided and it controls and commands the solenoid to pass the amount of air. With the passage of air through pipes connected to cylinders, this control unit of solenoid commands the compressor to actuate the pneumatic cylinder to extension and flexion of rod.

Fig. 6: Front side and left hand side view of weight lifter

C. *Lower Extremity*

1) *Knee Joint*

For understanding the wearable chair first we got to read the leg anatomy. The position of person in sitting posture. The leg joint consist of two links lower leg which is connected by knee. The wearable chair is made in such a way that it is locked at 180o, 120o, 90o with the help of gear with addendum of 25.4mm and angle of 17o. A special tool is made so that it can fixed in addendum of gear. The tool is controlled by aluminum wire attached to it at top to uppermost joint rod through mechanism we made by bicycle brakes. So, if we press the brakes the tool gets lifted from gear and we can walk to another position. For fixing the sitting angle, the brakes must be pushed by to same position and the tool fixed is fixed in 'V' shape ratchet gear

Fig. 7: Ratchet gear

The tool is fixed in taper shape bucket and on the tool the is spring which when brakes are pressed the spring gets compress and lifts the tool up freeing the gear to walk. To fix it in gear brakes are brought to original position, extract the spring in taper bucket and tool is fixed in gear addendum. The knee joint and the gear are bolted with cotter pin. The upper link has an adjustable strap which acts as a belt to leg.

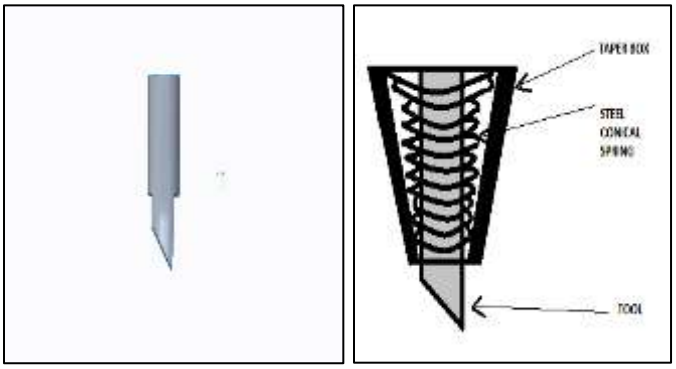

Fig. 8: Tool inside the taper box with compressed spring when brakes pressed.

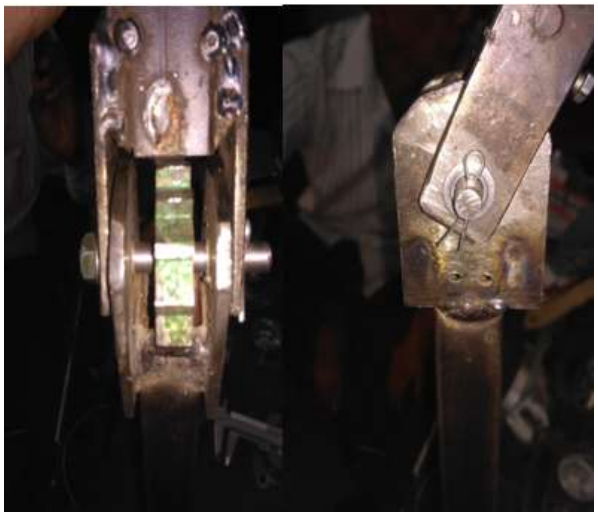

Fig. 9: Ratchet geat connected to knee joint by cotter pin.

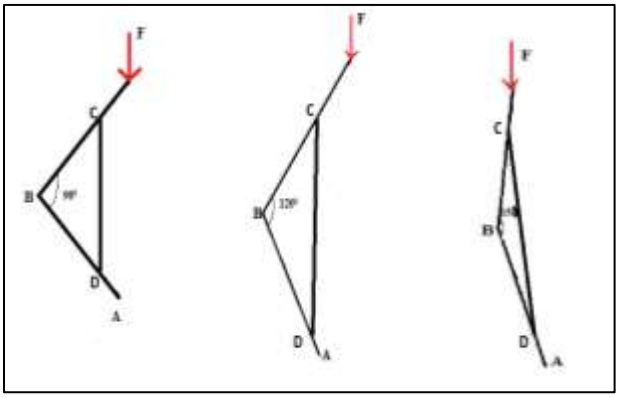

Fig. 10: Mechanism for 90º, 120º and 150º

Fig. 11: Wearable chair.

V. CONCLUSION

The main objective of this project is to enhancement and the assist of natural upper body motion of the human skeleton. Here, calculation of the required forces and estimation of the dimension required were finalized. After the prototype test and fabrication of the mechanical harness for the pneumatic cylinders, the potential application would be in diverse field such as defense, physiotherapy and manufacturing. The proposed method to use full body exoskeleton suit which comprises two functions: To lift the heavy weights by using compressed gas which acts as renewable source of power which enables people with muscular defects to still be able to perform daily tasks like a fully functional human and secondly the lower portion which works as a wearable chair

which fully dedicates to the goal to give comfort to workers, who work on production line for hours. Also to make the model at least cost, that has been achieved. The model is working satisfactory with new concept and new mechanism compared to other chairless chair have been invented. There are some modifications possible.

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