DESIGN AND FABRICATION OF EXOSKELETON

A Project Report

Submitted in the partial fulfilment of the requirements for

the award of the degree of

Bachelor of Technology

In

MECHANICAL ENGINEERING

By

BATCH-17CD021

ID NO	NAME
170070177	HEMANTH. SANKU
170070248	D. SAI KUMAR

Under the supervision of

DR.B.V. DHARMENDRA

Professor

(DEEMED TO BE UNIVERSITY)

Koneru Lakshmaiah Education Foundation

(Deemed to be University estd., u/s 3 of UGC Act 1956)

Greenfields, Vaddeswaram, Guntur (Dist.), Andhra Pradesh - 522502

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KONERU LAKSHMAIAH EDUCATION FOUNDATION
DEPARTMENT OF MECHANICAL ENGINEERING

Declaration

The title of the project report is "**DESIGN AND FABRICATION OF EXOSKELETON"** is a record of bonafide work of **HEMANTH SANKU (170070177)**, **D.SAI KUMAR (170070248)** submitted in partial fulfilment for the award of B. Tech in mechanical engineering to the K L University. The results embodied in this report have not been copied from any other departments/university/institute.

HEMANTH SANKU (170070177)

D. SAI KUMAR (170070248)

KONERU LAKSHMAIAH EDUCATION FOUNDATION
DEPARTMENT OF MECHANICAL ENGINEERING

Certificate

This is to certify that the Project Report entitled "**DESIGN AND FABRICATION OF EXOSKELETON"** is being submitted by **Hemanth Sanku (170070177), D. Sai Kumar (170070248)** submitted as a partial fulfilment for the award of B. Tech in mechanical engineering to the K L University as a record of bonafide work carried out under the direction and supervision.

The findings in this study were not cribbed from other departments, universities, or institutes.

Signature of the Supervisor
(DR.B.V. Dharmendra)

Signature of the HOD
(Dr.D.V.A. Rama Sastry)

Signature of the External Examiner

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ABSTRACT

Exoskeletons are used in a various field, including medical, the military, and manufacturing. Exoskeletons are made to support and secure their wearers. Exoskeletons can be used to assist soldiers and construction workers, helps in the safety of people in hazardous conditions, help in the rehabilitation of patients, depending on the situation. Solidworks is a software that is used to create designs of exoskeleton. Fabricated Exoskeleton is durable and efficient to lift loads with less effort. This Exoskeleton is powered by two high quality pneumatic cylinders which will act as muscles for the arms.

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1. INTRODUCTION

The first Exoskeleton was Hardiman, a hydraulic and electrical bodysuit designed by General Electric in the 1960s, was the first exoskeleton kit, but it was too heavy and cumbersome for military use. DARPA (Defense Advanced Research Projects Agency) is currently working on exoskeleton production as part of their Exoskeletons for Human Performance Augmentation Program.

Our project was created in Solidworks and then fabricated using various metal cutting techniques. Two high-quality pneumatic cylinders power this Exoskeleton. It is often used to lift heavy loads with ease and less effort.

2. LITERATURE SURVEY

S. No.	Author	Title	Journal Details	Objectives	Methodology
1	Nikhil P. Shinde, Daji S.Shinde , Kirtisen R. Gaikwad , Abhijit V. Naik	Exo-Skeleton Arm Using Pneumatic Cylinder	MAT Journals 2019 Journal of Mechanical Robotics Volume 4 Issue 2	Type of device which can be worn over the human body to amplify the force of the operator and provide more strength.	Exoskeleton arm system is totally based on the mechanisms of the pneumatic cylinders and solenoid valves and the joints which will give different degrees of freedom to each part to provide easy motion for the human wearing it.
2	R. Goergen, A. C. Valdiero, IEEE Member, L. A. Rasia, M. Oberdörfer, J. P. de Souza, R. S. Gonçalves	Development of a Pneumatic Exoskeleton Robot for Lower Limb Rehabilitation	2019 IEEE 16th International Conference on Rehabilitation Robotics (ICORR) Toronto, Canada, June 24-28, 2019	New pneumatically driven robotic device for rehabilitation of lower limb	To assist in the activities of daily living, many support devices for upper and lower limb movement.

3	**Adam B. Zoss, H. Kazerooni, Member, IEEE, and Andrew Chu**	**Biomechanical Design of the Berkeley Lower Extremity Exoskeleton (BLEEX)**	**IEEE/ASME TRANSACTIONS ON MECHATRONICS, VOL. 11, NO. 2, APRIL 2006**	**Robotic system that can be worn by its operator and provides the ability to carry significant loads with minimal effort over any type of terrain.**	**BLEEX has 7 DOF per leg, four of which are powered by linear hydraulic actuators.**
4	**Gregory S Sawicki and Daniel P Ferris**	**A pneumatically powered knee-ankle-foot orthosis (KAFO) with myoelectric activation and inhibition**	**Journal of Neuro Engineering and Rehabilitation 2009, 6:23 doi:10.1186/1743-0003-6-23**	**Test the mechanical performance of a prototype knee ankle-foot orthosis (KAFO) powered by artificial pneumatic muscles during human walking.**	**Artificial pneumatic muscles to power ankle plantar flexion/dorsiflexion and knee extension/flexion, Air muscles.**

5	**Jun Ueda, Ding Ming, Minoru Shinohara, and Tsukasa Ogasawara, Member, IEEE**	**Individual Muscle Control Using an Exoskeleton Robot for Muscle Function Testing**	**IEEE TRANSACTIONS ON NEURAL SYSTEMS AND REHABILITATION ENGINEERING, VOL. 18, NO. 4, AUGUST 2010**	**Individual muscle force control and its application to a motor task planning for neuro muscular function tests using an exoskeleton-type robot.**	**Nominal muscle force prediction, Designation of muscle forces, Motor task planning.**
6	**Yong Zhu and Eric J. Barth**	**Impedance Control of a Pneumatic Actuator for Contact Tasks**	**Proceedings of the 2005 IEEE International Conference on Robotics and Automation Barcelona, Spain, April 2005**	**impedance control of a pneumatic linear actuator for tasks involving contact interaction**	**Pneumatic actuators, by contrast, are natural impedances with true mechanical compliance.**

7	**G. Yamaguchi**	**Dynamic Modelling of Musculoskeletal Motion**	**Kluwer Academic Publishers, 2001**	**Modelling of Musculoskeletal Motion introduces biomechanists to modern methods of modelling and analyzing dynamic biomechanical systems in three dimensions**	**Kane's Method builds upon the foundation of vector kinematics and represents one of the most exciting theoretical developments of the modern era.**
8	**Xiangrong Shen Michael Goldfarb**	**Simultaneous Force and Stiffness Control of a Pneumatic Actuator**	**Journal of Dynamic Systems, Measurement, and Control. Vol 129, 425-434 July 2007.**	**Modulation of actuator output stiffness can serve several purposes in robotic applications.**	**Pneumatic actuator controlled by pair of three-way valves**

9	**Gregory C. Henderson; Jun Ueda**	**Pneumatically Powered Robotic Exoskeleton to Exercise Specific Lower Extremity Muscle Groups in Humans**	**2012 4th IEEE RAS & EMBS International Conference on Biomedical Robotics and Biomechatronics (BioRob)**	**artificial limbs, force control, force feedback, handicapped aids, human-robot interaction, medical robotics, mobile robots, motion control, patient rehabilitation, pneumatic actuator**	**pneumatically powered robotic exoskeleton, specific lower extremity muscle group exercise, control method, active force feedback control.**

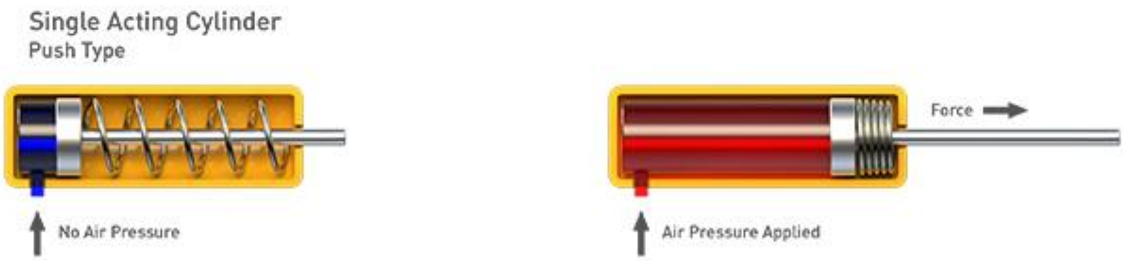
3. METHODOLOGY

The exoskeleton arm system's operation is entirely dependent on the mechanisms of pneumatic cylinders and solenoid valves, as well as the joints, which provide different degrees of freedom to each component to enable the person wearing it to move freely. The air from the compressor actuates the cylinder, which assists in lifting weights.

3.1 PNEUMATIC ACTUATORS:

Single acting and double acting operating principles are the two forms of operating principles.

3.1.1 Single acting: The thrust or output force of a single acting cylinder is produced in only one direction. A fitted spring or some other external means, such as a weight, mechanical movement, gravity, or an external spring, returns the piston. They only have one port for compressed air to enter the cylinder and transfer the piston to the desired position. Single-acting cylinders come in two varieties:



- 'Pull' type – where the application of air pressure produces a thrust, thus 'pulling' the piston.

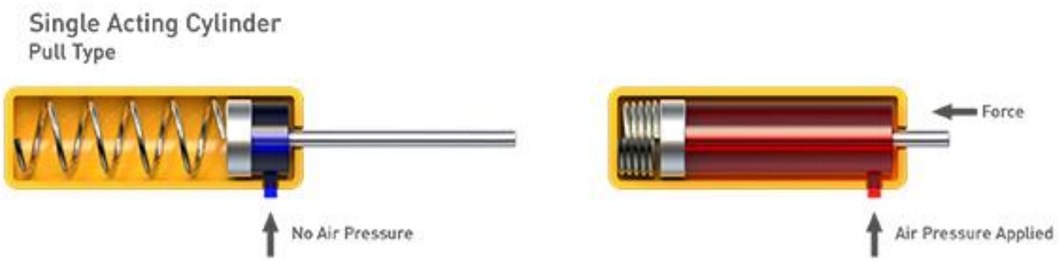


Figure i: Single acting pneumatic cylinders

3.1.2 Double acting: The thrust, or output power, of a double-acting pneumatic cylinder is produced in both the expanding and retracting directions. Double-acting cylinders have a port on either end and shift the piston forward and back by alternating which port receives the high-pressure air, which is needed when a load must be pushed in both directions, such as when opening and closing. Air pressure is alternately applied to the piston's opposite ends. The application of air pressure induces thrust in both the positive (push) and negative (pull) strokes. Double-acting cylinders are commonly used in applications where the necessary thrusts and stroke lengths are greater than those available from single-acting cylinders. Small double-acting cylinders are also used in applications where both strokes must have positive end-of-stroke positions.

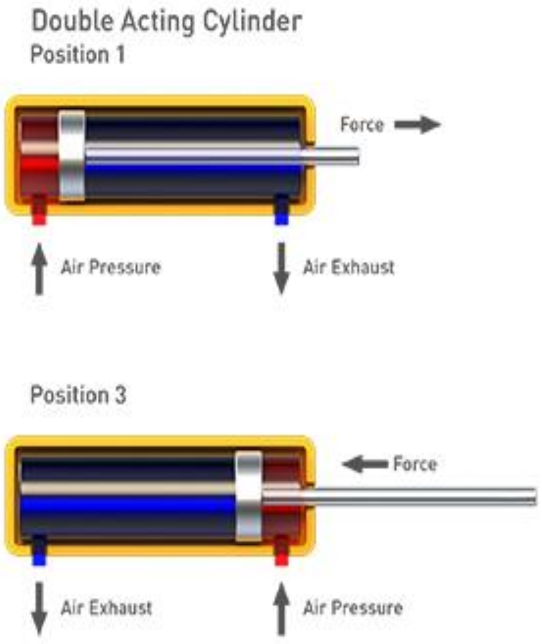


Figure ii: Double acting pneumatic cylinder

3.2 SOLIDWORKS:

From start to finish, SOLIDWORKS is used to build mechatronics systems. The platform is initially used for project management, planning, visual ideation, modelling, feasibility evaluation, prototyping, and feasibility assessment. The software is used to design and develop mechanical, electrical, and software components. Users may keep different copies of a component or assembly in a single file using SOLIDWORKS configurations. Changes in dimension values, feature suppression, and other parameters are used to differentiate between configurations.

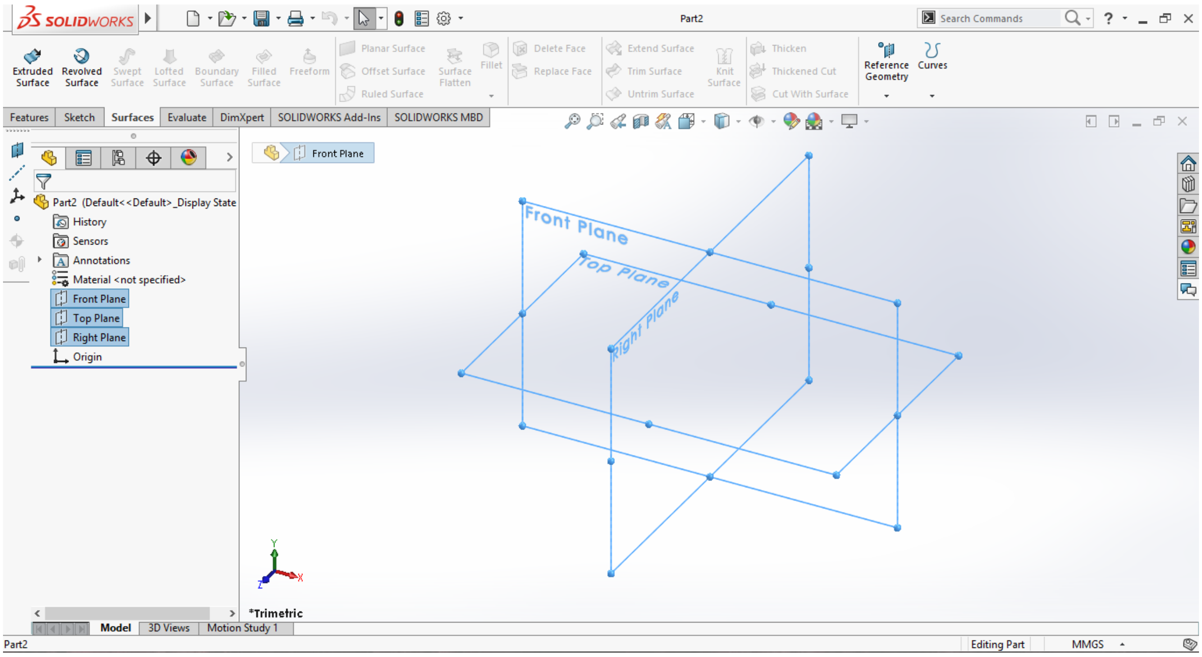


Figure 1: Solidworks part designing window.

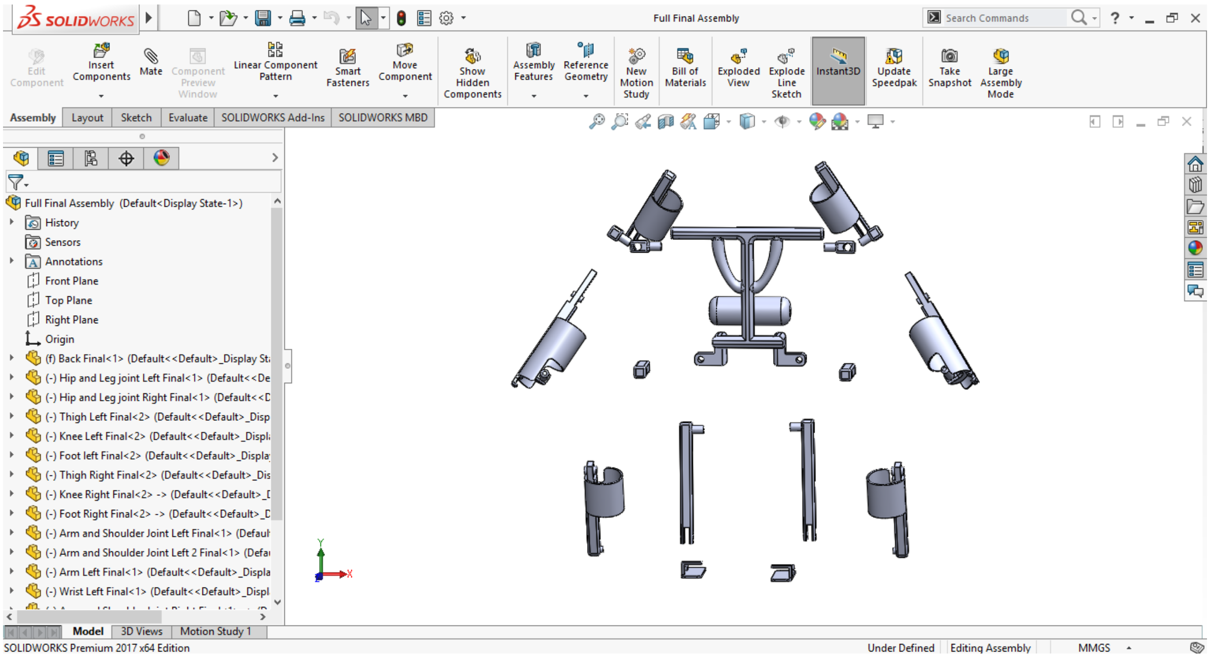


Figure 2: Solidworks assembly window.

3.3 DESIGNS:

Initial design started with a basic frame for exoskeleton after that the design is improvised according to the constraints to get the perfect final output. The design has got three versions.

3.3.1 Ver 1:

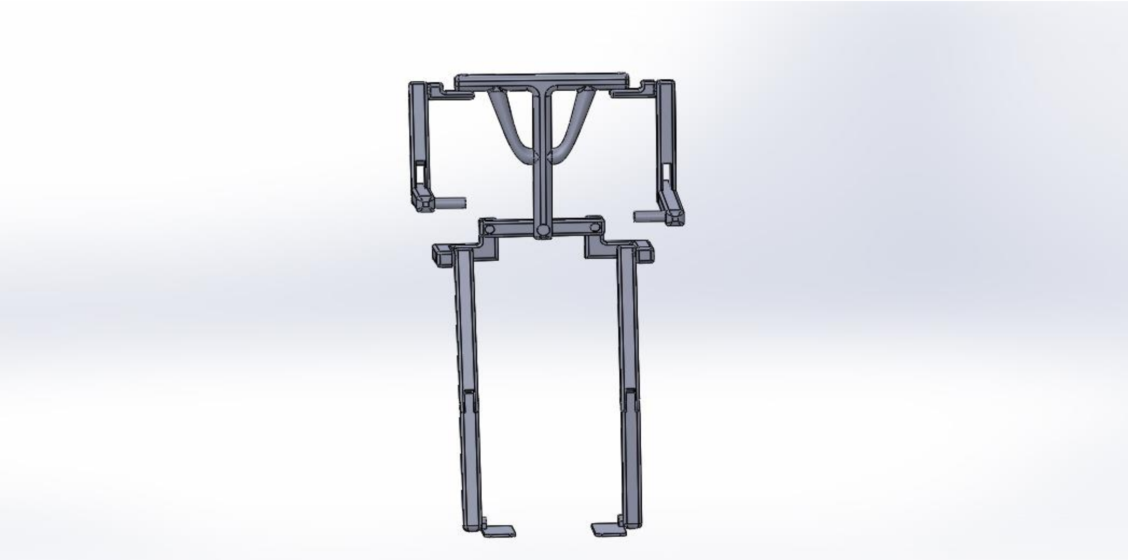


Figure 3: Version 1.

3.3.2 Ver 2:

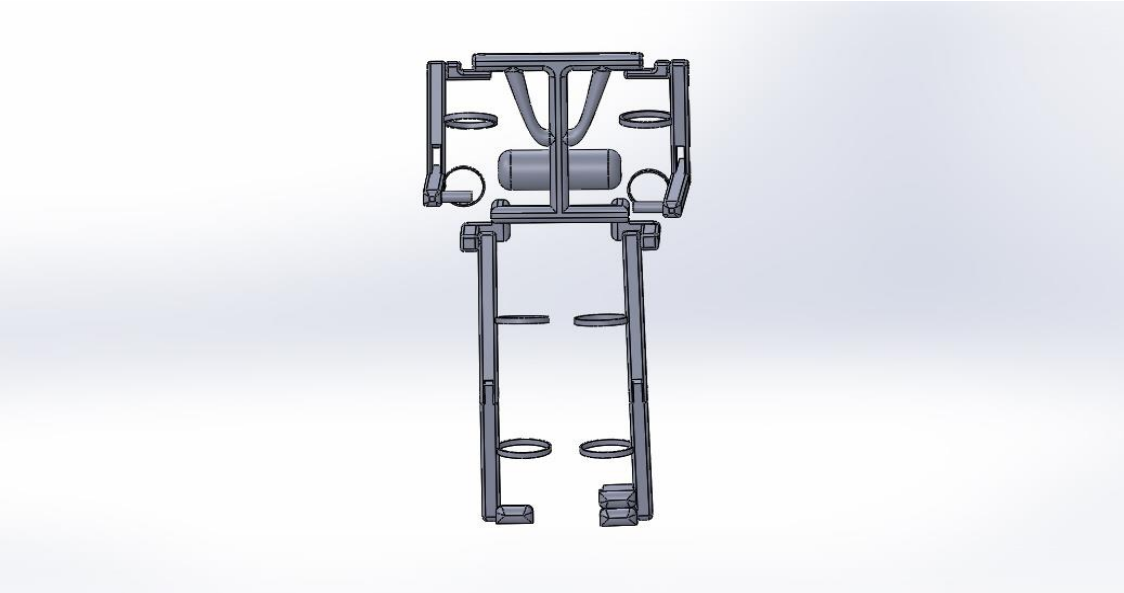


Figure 4: Version 2

3.3.3 Ver 3:

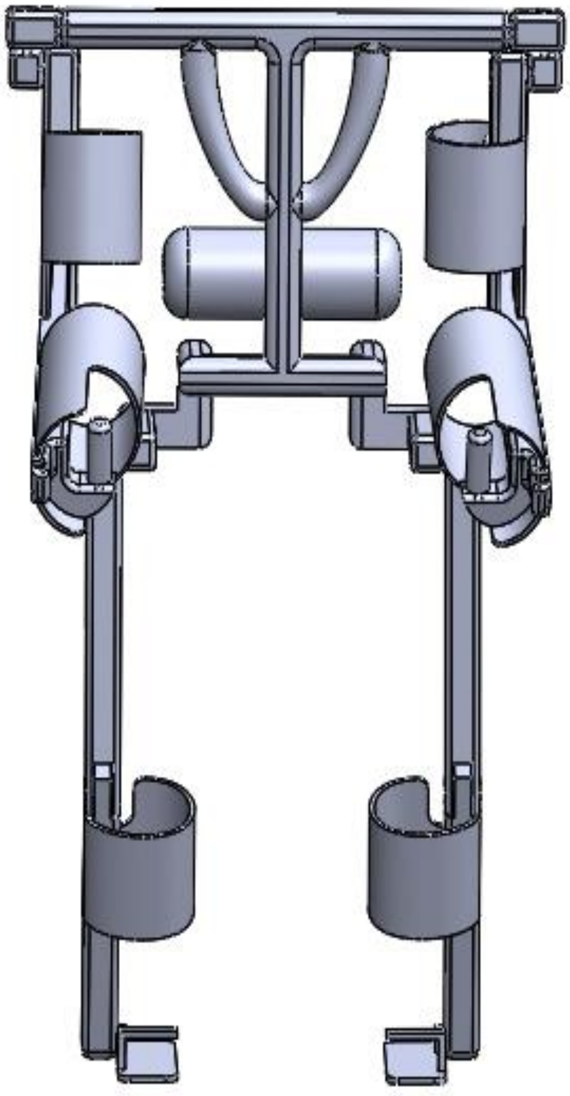


Figure 5: Version 3

3.4 MATERIALS AND COMPONENTS:

3.4.1 Materials:

3.4.1.1 Hollow square mild steel bars.

Figure 6: Hollow square mild steel bars

Fig 6: Full frame of the exoskeleton is made using this hollow square mild steel bars.

3.4.1.2 Flat mild steel bars.

Figure 7: Flat mild steel bars

Fig 7: Arms are made using flat mild steel bars.

3.4.1.3 G. I Sheets.

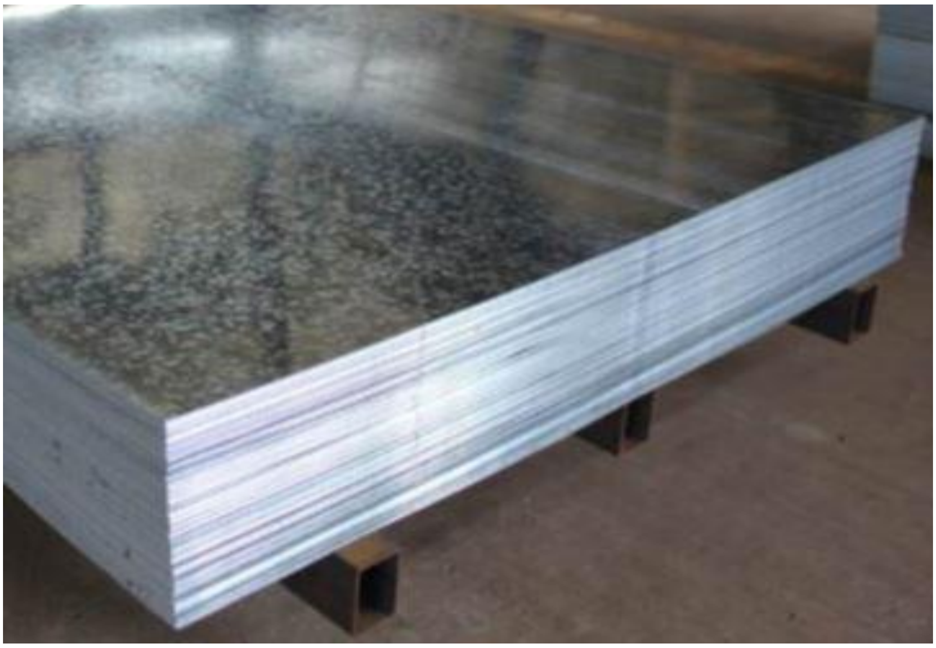


Figure 8: Galvanized iron (GI) sheets.

3.4.2 Components:

3.4.2.1 Pneumatic Cylinders (25mmx100mm), Max pressure 10 bar.

Figure 9: Pneumatic cylinder

3.4.2.2 Manual pneumatic directional control valves (5/2) x2.

Figure 10: Manual pneumatic directional control valves (5/2)

Fig 10: There is a lever attached to this manual pneumatic directional control valves which is used to control the air flow.

3.4.2.3 Hose (6mm) 5m.

Figure 11: Hose

3.4.2.4 Pressure Regulator up to 1MPa.

Figure 12: Pressure Regulator up to 1MPa

Fig 12: The pressure released from the air compressor tant is very high, so air pressure regulator is used to operate actuators within its limit.

3.4.2.5 T Junction Pneumatic fitting.

Figure 13: T Junction Pneumatic fitting

Fig 13: T junction pneumatic fitting is used to split the air pressure to two actuators.

3.4.2.6 Pneumatic nipple fittings.

Figure 14: Pneumatiic nipple fittings.

3.4.2.7 Mufflers.

Figure 15: Mufflers

Fig 15: Mufflers are used to limit the noise that manual pneumatic directional control valve makes when it releases air pressure.

3.4.2.8 Pneumatic flow control valves.

Figure 16: Pneumatic flow control valves

Fig 16: Pneumatic flow control valves are used to control the speed to the actuator.

3.4.2.9 Hook and Loop fastener.

Figure 17: Hook and Loop fasteners

Fig 17: Hook and loop fasteners are being used to make exoskeleton hold wearer body.

3.4.2.10 Air Compressor Tank.

Figure 18: Air compressor tank

Fig 18: Air compressor tank provides the air with pressure to power the actuators.

4. MODELLING

To represent what the prototype apparatus would look like, the exoskeleton was first developed in the computer modelling software SolidWorks.

4.1 PARTS:

4.1.1 Back.

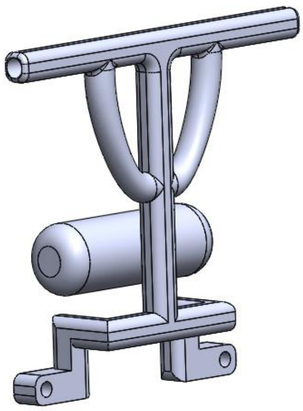


Figure 19: Back part

4.1.2 Arm.

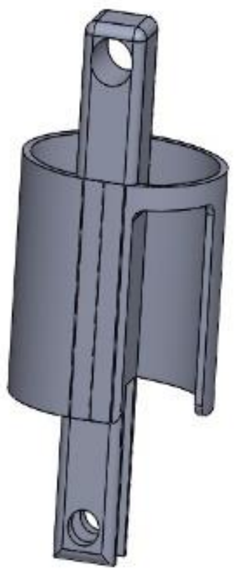


Figure 20.1: Arm part 1

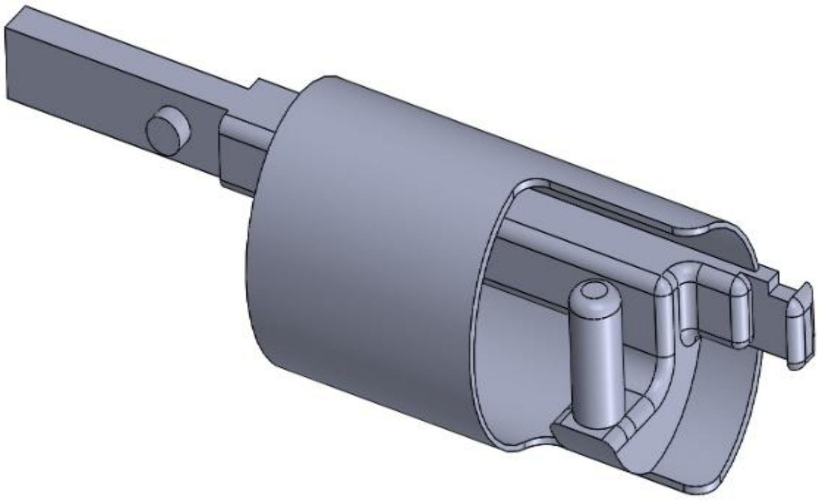


Figure 20.2: Arm part 2

4.1.3 Legs.

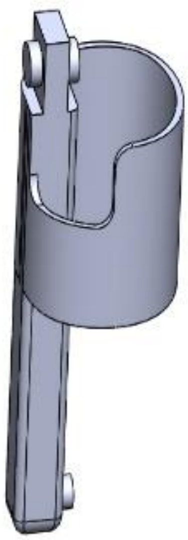


Figure 21.1: Leg part 1

Figure 21.2: Leg part 2

4.1.4 Foot.

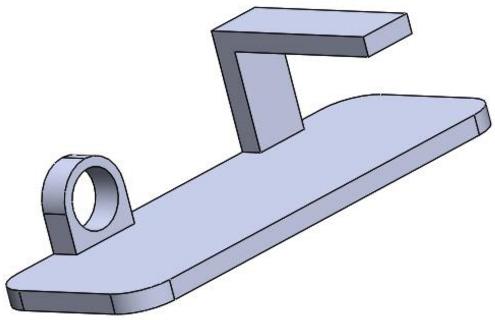


Figure 22: Foot

4.2 ASSEMBLY:

4.2.1 Assembled Arm.

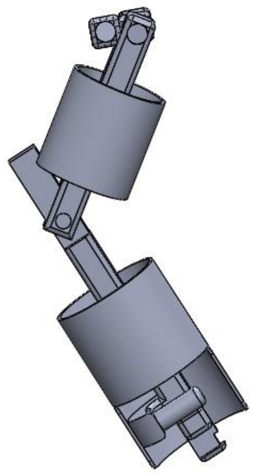


Figure 23: Assembled arm

4.2.2 Assembled Leg.

Figure 24: Assembled leg

4.2.3 Full body Assembly.

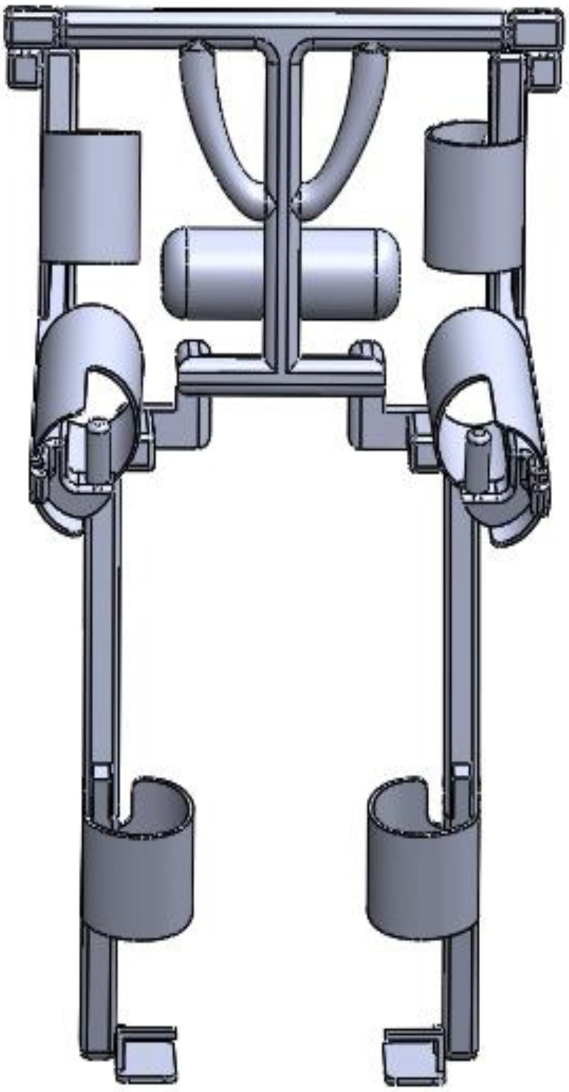


Figure 25: Full body Assembly

4.3 ISOMETRIC VIEW:

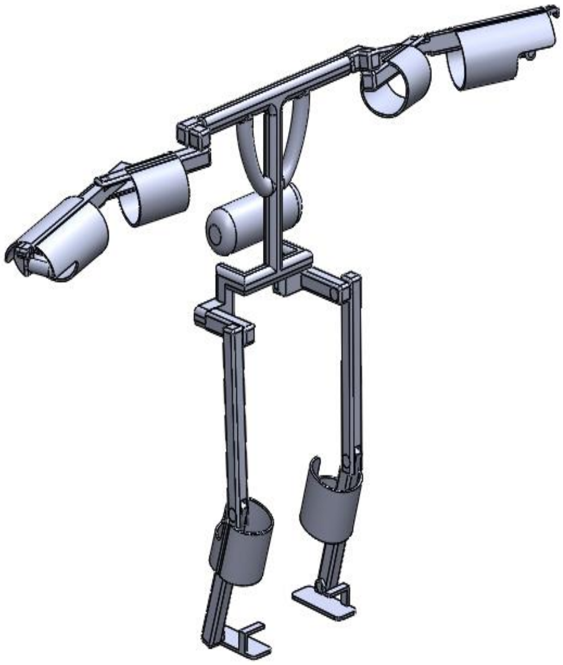


Figure 26: Isometric 1

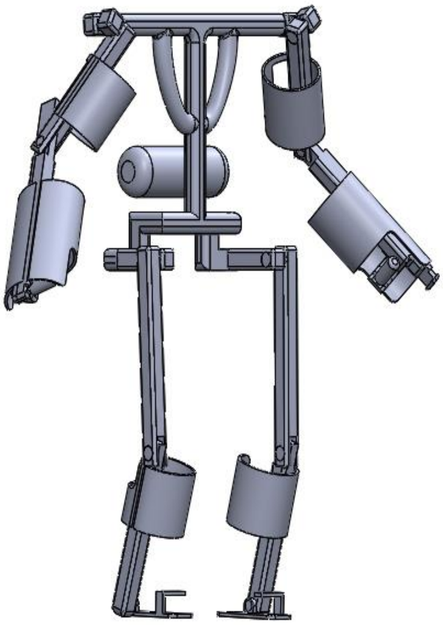


Figure 27: Isometric 2

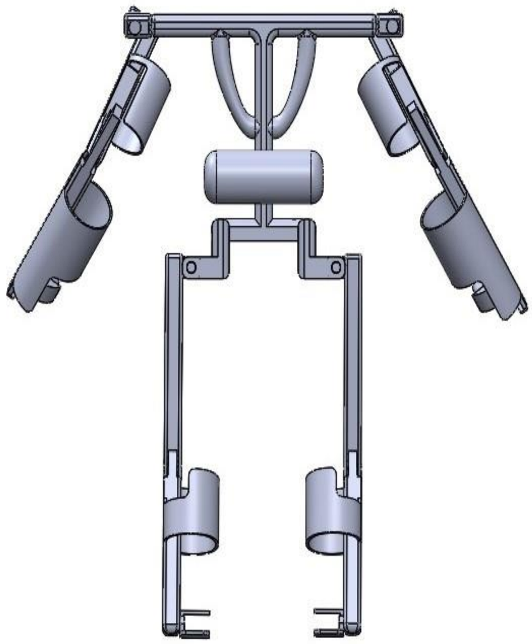


Figure 28: Back view

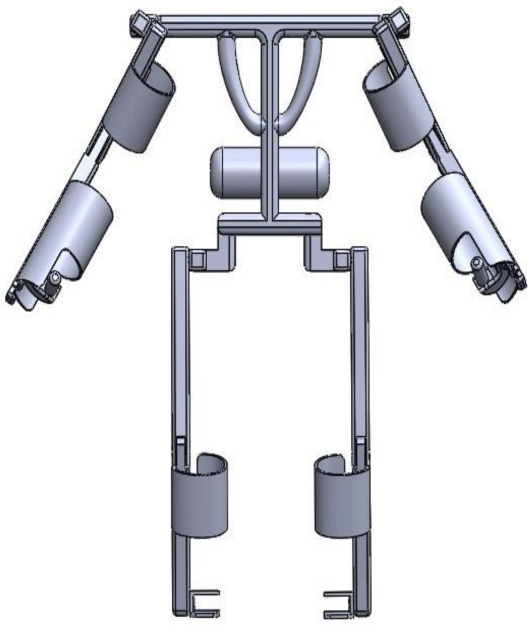


Figure 29: Front view

5. FABRICATING

The fabrication process began with cutting the metal bars which are cut according to the appropriate body dimensions and the design and with arc welding, all the cut parts of metal bars are welded together according to the model after that, at the appropriate locations, holes of various sizes were drilled using metal cutting methods All the individual components are joined with nuts and bolts and painted.

5.1 PROCESS:

5.1.1 Grinding: Grinding is a machining procedure that uses a grinding wheel to extract material from a workpiece. As the grinding wheel rotates, it removes material from the workpiece while still producing a smooth surface texture.

5.1.2 Arc Welding: Arc welding is a metal-joining fusion welding process. An electric arc produced by an AC or DC power supply produces a high temperature of around 6500°F, melting the metal at the joint between two work parts.

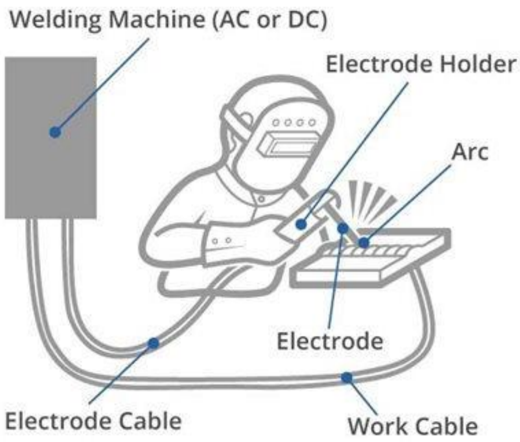


Figure iii: Arc welding

5.1.3 Drilling: Drilling is a cutting technique that involves cutting a circular cross-section hole in solid materials with a drill bit. The drill bit is normally a multi-point rotary cutting tool. The bit is pressed against the workpiece and rotated at speeds varying from hundreds to thousands per minute.

5.2 CUTTING USING GRINDING:

Figure 30: Cutting using grinding

5.3 DRILLING:

Figure 31: Drilling

5.4 WELDING:

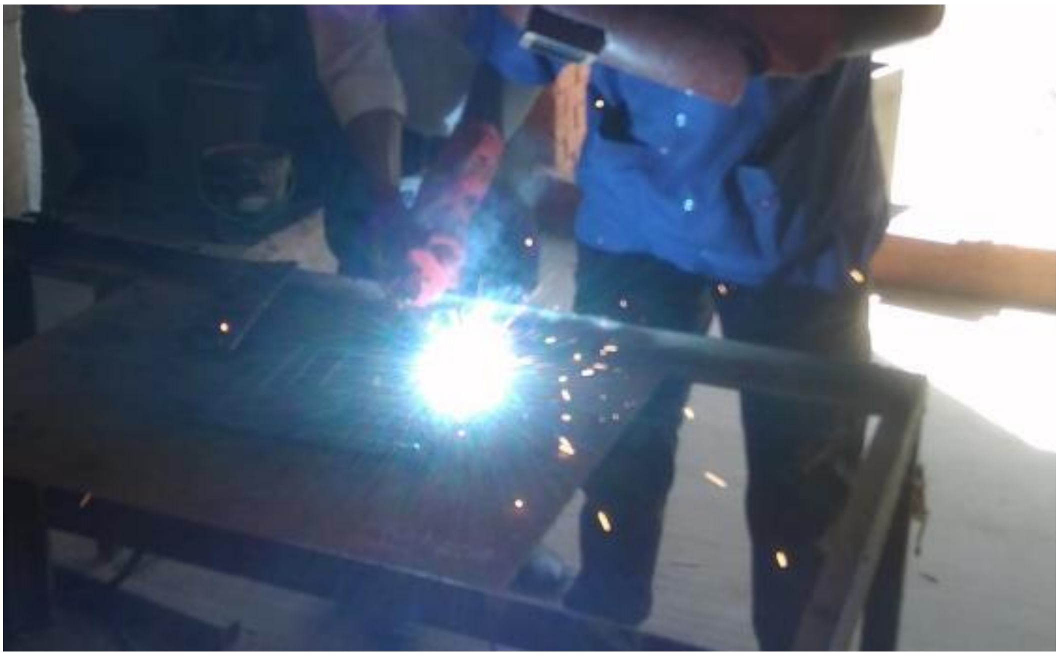


Figure 32: Welding

5.5 PARTS ASSEMBLY:

Figure 33.1: Parts assembly

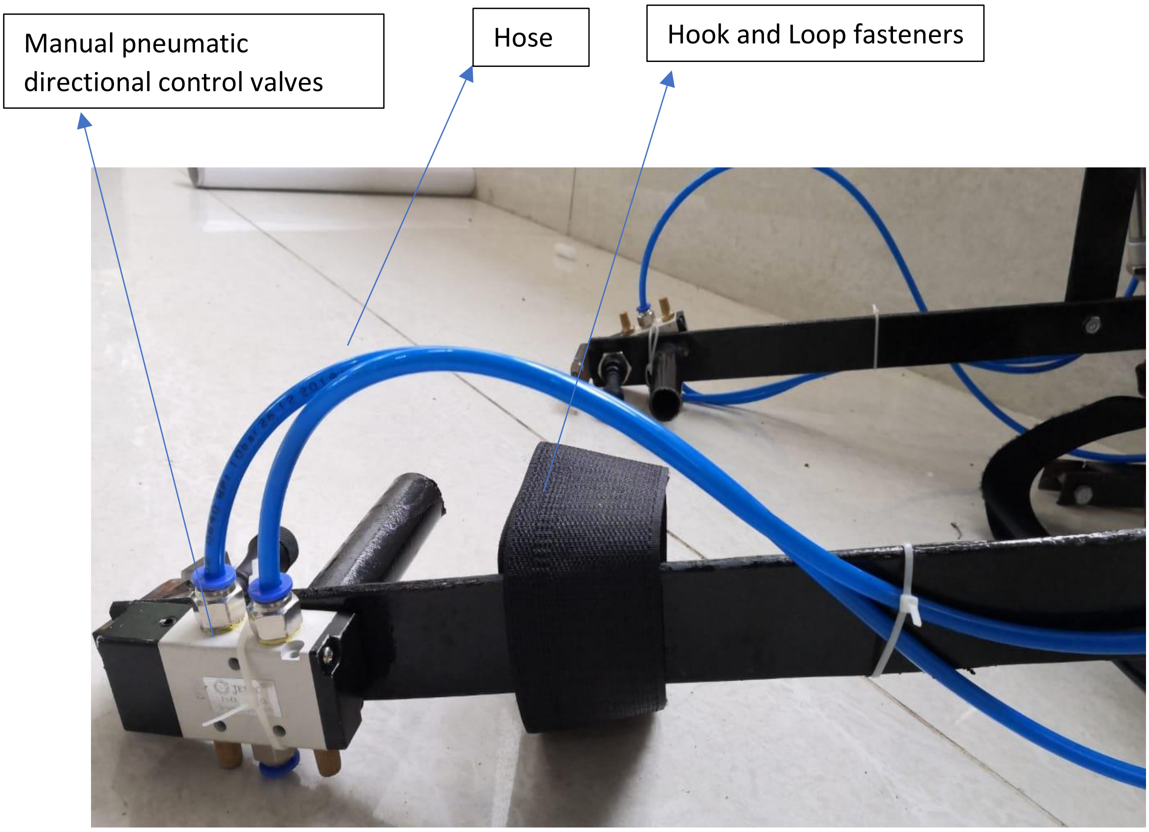


Figure 33.2: Parts assembly

Fig 33.2: All the components are assembled.

Figure 33.3: Components assembly

5.6 PAINTING:

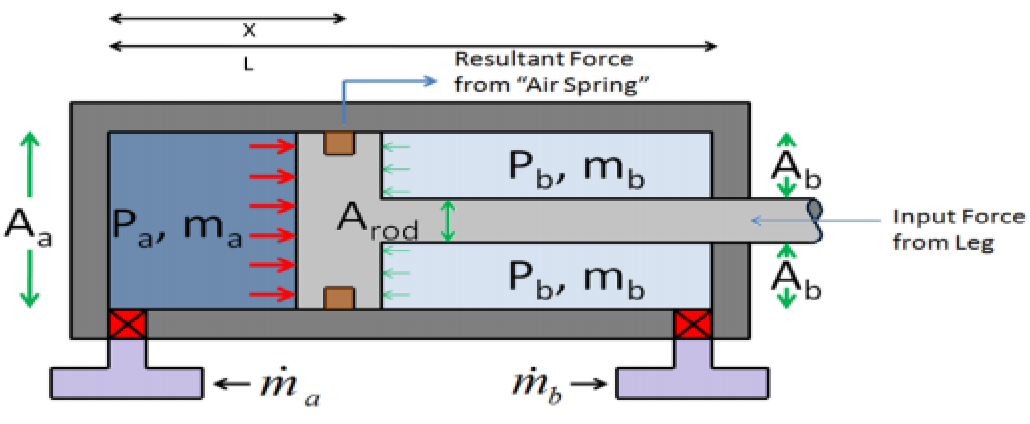
Figure 34: Painting

6. RESULTS

By using the above manufacturing techniques and design the exoskeleton is built with hallow square mild steel bars. The bars are attached by arc welding, this welding technique is used to make the weld easy and strong, the joints made by using nuts and bolts. After that, all the parts like pneumatic cylinders, pressure regulator, hose, valves are fitted.

6.1 WORKING OF PNEUMATIC ACTUATORS:

Pneumatic actuators were chosen to produce the resistive forces against the muscle forces because of their active stiffness properties. This helps them to adjust the forces they generate at any time.



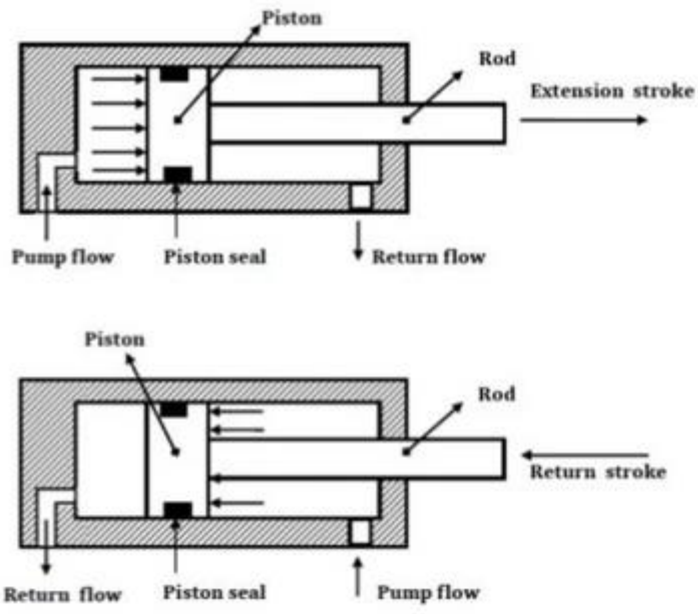


Figure iv: Working of pneumatic cylinder

6.2 JOINTS ASSEMBLED:

Figure 34: Joints assembly

6.3 COMPONENTS ASSEMBLED:

Figure 35: Components assembly

Figure 36:Body description

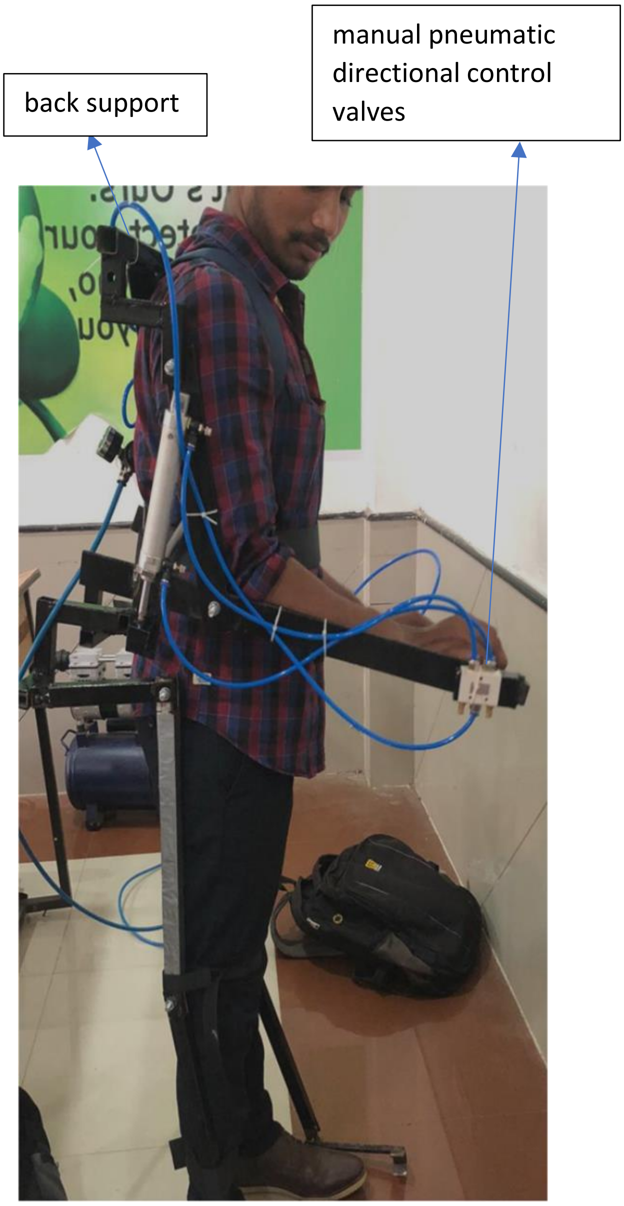


Figure 37: Body description

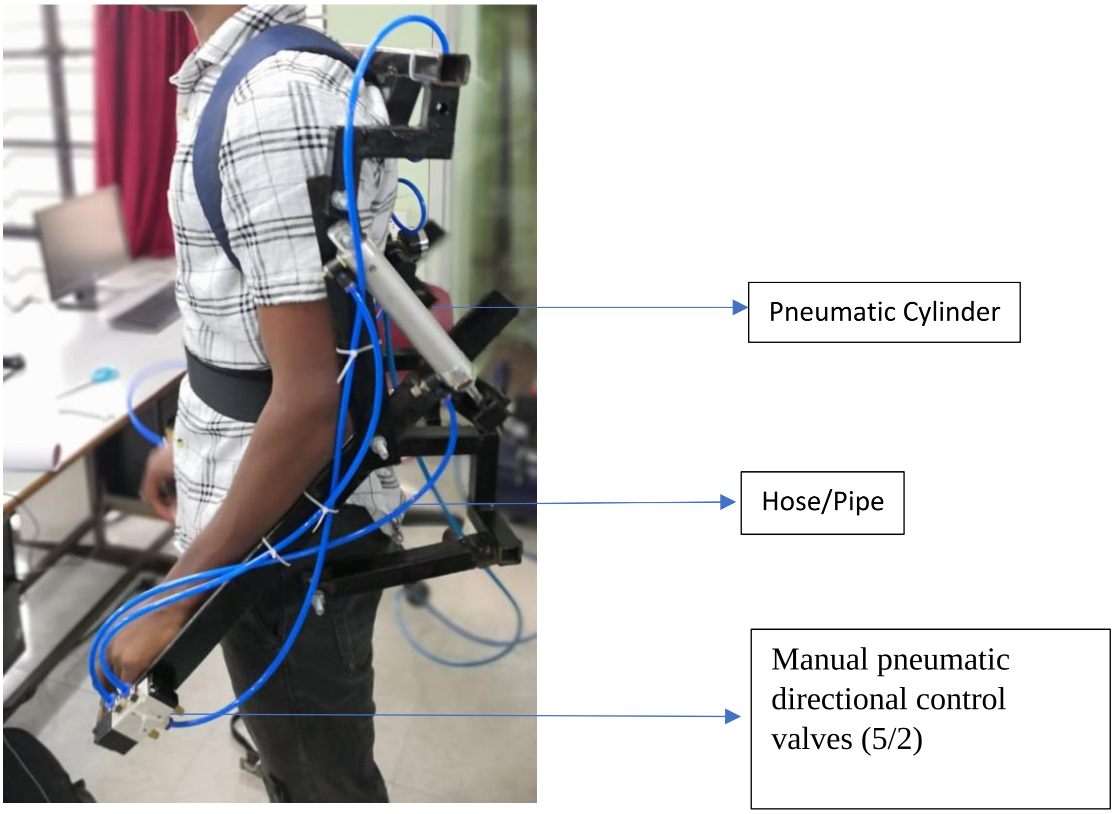


Figure 38: Parts description

6.4 EXOSKELETON PNEUMATIC ACTUATOR CONTROL SYSTEM:

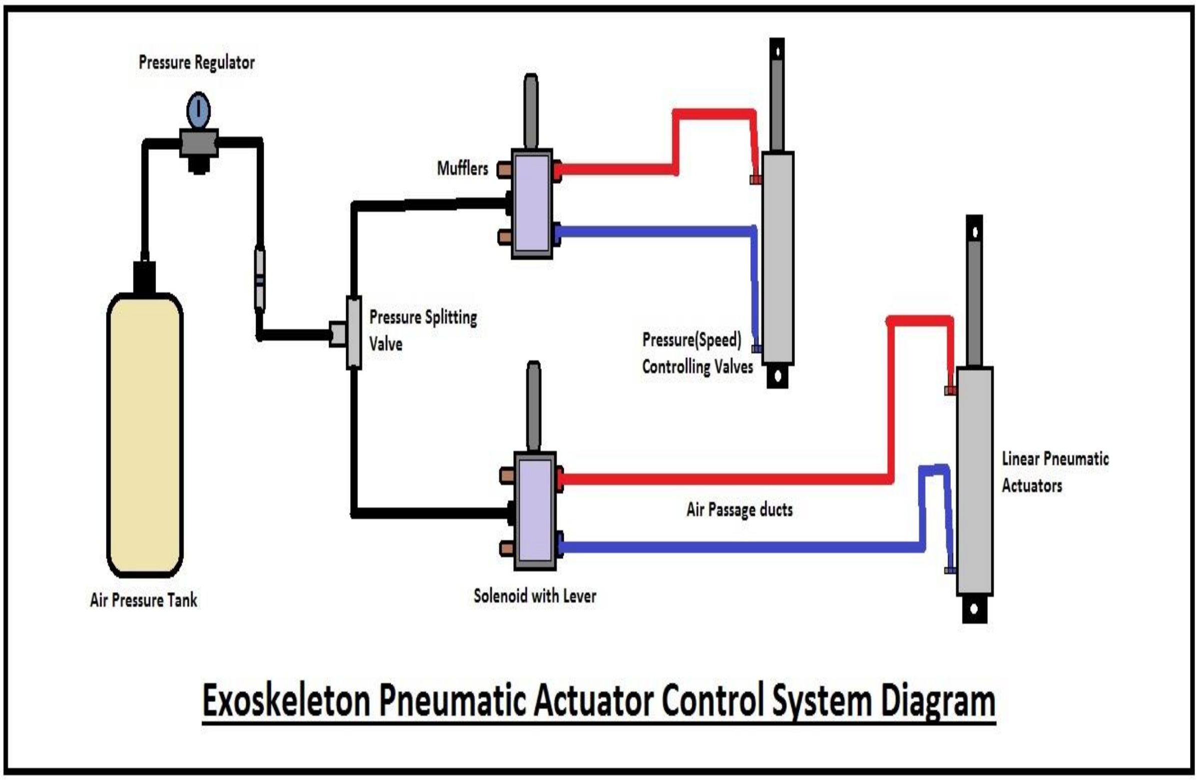


Figure 39: Exoskeleton pneumatic actuator control system

The air compressor tank is used to power the actuators. The pressure in air pressure tank is beyond the required, air pressure regulator is used to decrease the pressure up to 1 MPa to get the ample pressure. And the pressure passed through hose is split using T junction pneumatic valve from there the split pressure is passed through hose to Manual pneumatic directional control valves with lever (lever used to control flow of pressure.) for manipulating pneumatic actuators for lifting load.

7. CONCLUSION

This project's main aim is to develop a low-cost, user-friendly framework. This project is actually very simple in terms of construction, design, and value. It has a quicker response time and is more flexible than hydraulic and electrical exoskeleton arms. Our project can be applied to several circumstances, such as rescue operations, military operations, and industry. It may also be used in physiotherapy to help muscle strength be recovered. Physically disabled people can handle more weight in their daily lives and this pneumatic device can accommodate the entire load. This project entails the design and fabrication of exoskeleton which is low cost and will make user capable of lifting 30kg of load easily without taking load on his arms. The design of exoskeleton is completely made in solidworks. The whole fabrication process entails cutting, drilling, and welding. The capability of the exoskeleton can be increased by using more and high-powered pneumatic actuators.

8. ADVANTAGES & FUTURE SCOPE

8.1 ADVANTAGES:

8.1.1 By using exoskeletons humans can be able to lift heavy loads without any effort.

8.1.2 These exoskeletons can be used by employees in manufacturing industry to do their work easily.

8.1.3 Exoskeletons can also help astronauts by integrating exoskeletons into their space suits.

8.1.4 These exoskeletons can help people in rehabilitation and aged.

8.2 FUTURE SCOPE:

Exoskeletons will become increasingly relevant in the future. Employees in the automotive sector may use it., assist patients in rehabilitation, army soldiers can lift heavy guns easily, it can also be used by astronauts in space journey, and aged people, etc.

9. REFERENCES

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