<u>Title of the Project:</u> DESIGN AND FABRICATION OF EXOSKELETON USING PNEUMATIC CYLINDERS

<u>Name of College and Department:</u>

College: VIDYAVARDHAKA COLLEGE OF ENGINEERING

Department: DEPARTMENT OF MECHANICAL ENGINEERING

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<u>Keywords:</u> Exoskeleton, Pneumatic cylinder, Strength Enhancing, Frame, Stress-Strain Analysis, Simulation, Solidworks, FluidSIM-P.

<u>Introduction/Background:</u>

The term “Exoskeleton” refers to an external wearable robot that is worn by the user to enhance muscle strength and enhance body stability. It is designed in a skeletal manner i.e., the joints of the exoskeleton line up correspondingly with the joints of the human limb on which it is worn. Figure 1.1 shows the picture of a commercially available exoskeleton worn by a human operator. The force exerted by the exoskeleton is thus exerted on the joints of the human to create power-augmented motion. India has been working on this for the past 3-4 years and the development of the system is progressing rapidly in military applications. DRDO has taken an initiative for the production of powered exoskeleton mainly for military usage.

In our literature survey we came across a soft exoskeleton powered by motors which was capable of lifting 10 Kgs. It gave us valuable insight on the various calculations that are involved with the design of exoskeletons. We also referred to various other papers where lower limb exoskeletons and upper body were designed. Seeing a lack of work on full body exoskeletons we decided to build a full body prototype.

<u>Objectives:</u>

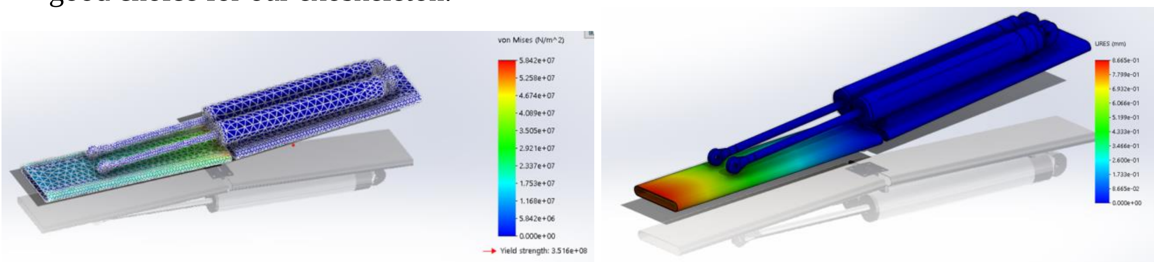
- To build a CAD model of the exoskeleton frame and conduct stress-strain analysis on itunder a suitable load.
- To build a pneumatic circuit and simulate the operation of the pneumatic cylinder using relevant software.
- Developing an exoskeleton having sufficient degrees of freedom for the arm, includingreleasing/grasping.
- To fabricate a working model of the exoskeleton capable of enhancing the load carryingcapacity of the operator.

<u>Methodology:</u>

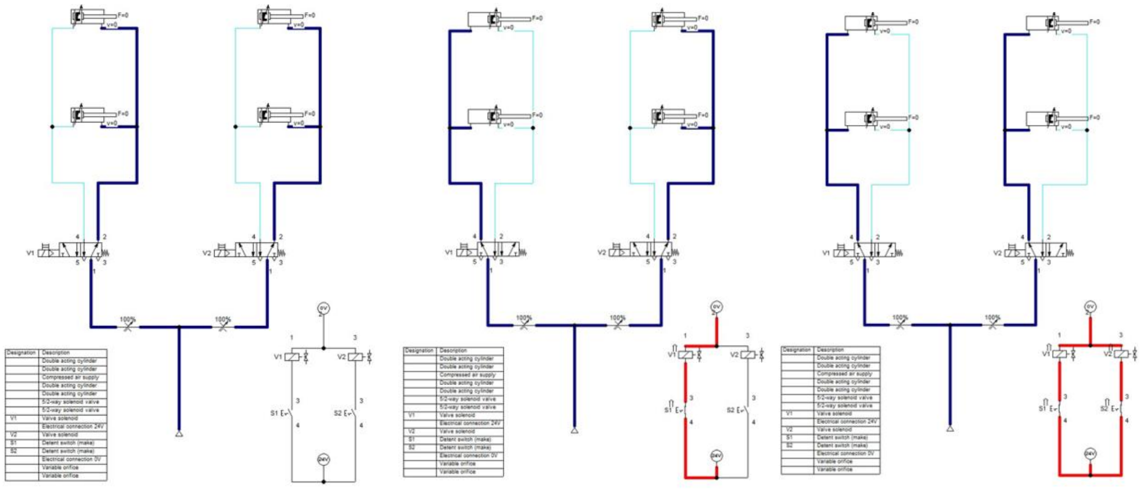
- We first performed calculations to ensure that at least theoretically this project is feasible and can perform the work we intend it to perform.
- An initial CAD model was built in Solidworks 2022 using measurements of one of our team members who would become the operator of the exoskeleton. This CAD model considered the ergonomics and an initial idea of the materials and joints we would use to fabricate the exoskeleton. However further research and market survey allowed us to

consider better joints and mounting which we implemented into a new CAD model which we finally fabricated.

- We then conducted material selection where we considered if materials such as aluminium, mild steel, stainless steel, etc., were suitable for our exoskeleton based on their strength, availability, cost and weight. We eventually chose mild steel as our material due to its strength, cost and availability.
- Using mild steel as the material, we conducted stress strain analysis on the arms of our final CAD model in Solidworks 2022. We used a load of 25 kgs acting downwards keeping the upper arm fixed and forearm free as boundary conditions. We obtained the maximum stress produced as 5.84x10^7 which was well within the tensile strength of mild steel which is 2.5x10^8. Hence in this way we could confirm that mild steel was a good choice for our exoskeleton.



- We designed and simulated a pneumatic circuit in FluidSIM-P software to ensure proper connections and control.



- Then we procured the materials for the exoskeleton and proceeded to start the fabrication.
- After fabrication was successfully completed we tested the exoskeleton with two 7.5 Kgs plates in two separate configurations.

Results/Conclusions:

Trial No	Weight Used In One Arm	Pressure	Result
1	7.5 Kgs	115 psi	Successfully Lifted
2	15 Kgs	115 psi	Successfully Lifted

Hence we can conclude that the exoskeleton can enhance load carrying capacity by about 30 Kgs.




What is the innovation in the project?:

- Our project is the first attempt at building a full body strength enhancing exoskeleton using pneumatic cylinders as actuators.
- Our prototype has been tested to lift 30 Kgs of load.

Scope for Future Work:

- Actuator control using brain waves. The advent of new technology has given rise better and effortless control systems. Brain waves can be used to control the exoskeleton movements. The user can wear the headgear and control the exoskeleton through thoughts.
- The exoskeleton can be built with an internal compressor which would allow the exoskeleton to be more portable. However this requires a more powerful compact air compressor which can produce pressure upto 300 psi which is currently unavailable.
- Actuator control using Electromyography Control (EMG)
- High capacity and miniaturized power supply. The lack of technology in miniaturized high capacity power sources is a major drawback for powering the exoskeleton. More research and development is required in this field to improve the power to weight ratio of the exoskeleton.
- More freedom of motion. There should be no restrictions for the user while wearing the exoskeleton. It should be more flexible and less strenuous during various movements.
- Stronger and lighter materials. The material of the exoskeleton has to be lightweight and stronger to be able to lift heavy loads without failure. vii. Investment in innovative control technologies There should be more emphasis and investment given on developing more innovative and cheaper control technologies.