Design And Development of Exoskeleton Power Suite

Prof. Nehe Sandip[1], Mr. Hadawale Dipak[2], Mr. Chikane Prathamesh[3], Mr. Gunjal Sagar[4], Mr. Tambe Akash[5]
[1] Professor, Dept of Mechanical Engineering
[2, 3, 4, 5]Dept of Mechanical Engineering
[1, 2, 3, 4, 5] Samarth College of Engineering, Belhe, Pune, Maharashtra, India

Abstract- *Exoskeleton has been developed as a leading body-enhancing tool that assists human mobility and restores lost limb function through bio metic design, a device that can be worn close to the body and transmit torque through powerful flexible joints and limbs and limbs. In the present work a complete design and construction of exoskeleton hand technology to revitalize auxiliary engineering is done from basic hand biomechanics to actuator technology with wind power involvement. The designed suit updates the state-of-the-art exoskeleton handcuffs of functional applications in the revitalization areas and auxiliary robots.*

Team Excelsoir's Prototype arm is a fully functional exoskeleton arm that moves in sync with user movement between 3 DOFs. Thanks to this device the user will no longer be able to feel tired from carrying heavy loads for long periods of time. Consumable, simple and durable materials are used in this project to achieve safety and environmental concerns. The ventilated muscles are integrated into the human anatomy to provide complete alignment with normal human movement. The biceps, triceps and deltoid are assisted by the device and are limited by their allowable angle of movement. The exoskeleton arm can be used exclusively in physiotherapeutic treatment and to help people with mobility problems and in the complex industry. The project officially established the Middle East market record by being the first of its kind. This project is sponsored by Festus. Festus is the world's leading supplier of pneumatic technology and electrical automation technology.

Keywords- Exoskeleton, arm, suit, pneumatic, robot.

I. INTRODUCTION

It is a type of upper skeletal structure that is worn over the body to do work in the field. Various parts learned during the study of the entire mechanical course, using elements such as air actuators, compressors, valves, circuits, etc. this product is designed. This type of design creates a natural interaction between man and machine where by using such a machine one can lift heavy loads easily. It is a combination of air cylinder system (Double acting), direction control valve, check valve, flow control valve, compressor and frame. By using this program a person with a disability can also lift or move a disabled limb. It can also be used by soldiers to carry heavy loads such as missiles etc. All parts are placed at the back of the building so that the user can feel the limits of movement. Machine designs should therefore take into account the potential for unintended operation of the telephone controller when the device is configured. Limits on the range of motion can be set using a mechanical shutter or associated structural design. So that the power suit can force the wearer to walk a very long distance.

1.1 Problem Statement :

In small industries where human dependence is much better than automation due to the investment costs required for automation and an integrated system. They are therefore highly dependent on human capacity, as small industries do not have much space to install cranes to lift the load and place it on the machine or in the desired location. And for a physically disabled person there is no provision for the limbs to carry the burden of daily work, which can keep the economy and weight low.

So in order to overcome these problems we design and make a powerful air suit that can increase the carrying capacity of people and people with physical disabilities. The main purpose of this work is to assist industrial workers in carrying heavy loads.

1.2 Objectives :

1. Reduce human effort while carrying heavy loads.
2. Giving limbs to a person with a physical disability in daily work.
3. Provide the option for the user to adjust the frame according to need or arm size.
4. Control the stroke of the piston rod according to the user.
5. Use of material of rich and lightweight structure.
6. Read and analyze the various links involved and failures.
7. Readable story.

1.3 Scope of the future :

In the current world climate, people are trying to make their efforts more reliable and less efficient, by using new technologies. So in small industries or new beginnings, such powerful suits can reduce a person's effort to carry a load at minimal cost. By adding various sensors like ECG, etc., it can make the suit more reliable and comfortable to use.

1.4 How to do it

The above objectives are achieved through:

The design and modeling of the system will be based on pressure behavior and analysis of a robust model of a wind power suit using appropriate analytics software such as ANSYS. Adjusted model analysis will be performed using boundary conditions as well various parameters such as angle, loading status, location etc.

Design Solid Model: SolidWorks

Meshing and Analysis: ANSYS, SolidWorks Design pneumatic System: FluidSIM

II. LITERATURE REVIEW

The literature referendum plays a role from other countries in the design of any project. There are many papers available for designing and analyzing the Air Energy Suit based on the relevance of the project statement. Based on these research papers, a different approach to the design of the power suit is selected. The papers in question are summarized as below, referring only to the author's contribution.

The concept of pneumatic powered suit and its advantages, theoretical background, design complexity and design process were summarized by: -

Nikhil P. Shinde1, Daji S. Shinde1. [1] read about the "Exo-Skeleton Arm Using a Pneumatic Cylinder" The concept of the pneumatic exo-skeleton and its benefits is summarized, it is a type of device that can be worn on the human body and carry or reduce weight. effort. The structure of the exo-skeleton arm is made mainly of a combination of steel and aluminum. Explain the use of robotic devices in recycling, the robotic system and its key sub-systems. This exoskeleton arm is lightweight and low in cost. It uses aluminum frame material. It consists of an air cylinder, directional control valve and compressor power supply. The main purpose of this work is to help staff carry the heavy load. That kind of robot creates a natural interaction between machine and human. Another important use of the exoskeleton is that it allows a soldier to carry a heavy object while climbing stairs or running. Aluminum materials are used to produce a frame to reduce the weight of the material. The compressor used in this project requires a capacity of 4-8 bars and the ability of the compressor to lift weights up to 5-20 kg. These four cylinders are used for 120mm stroke operations. The main objective of this project is to develop an inexpensive and easy-to-use system to carry heavy industrial work.

Gopal Krishna U B1, Prajwal Hosmutt H R2 [2] learned about the "Design and Design of the Exoskeleton Air Force Armor" It says all about the powerful shoulder rejuvenating suit. Design process, kinematics activators, liquids regions and analysis. The type and process of selection of actuators, which will greatly assist us in this project. This project proves to be easy to build, design and cheap. It provides a faster and more flexible response compared to a hydraulic and electrical powered suit. It enables people with physical disabilities to carry weights in their daily lives. In industrial use it requires additional human resources in the day-to-day work and process of carrying the load. The most important parts used in this suit are compressor unit, solenoid valve, double cylinder. The directional control valve is used to control the direction of the compressed air in this pneumatic system. For this project a 5/2 valve made of right hand solenoid. They used soft metal materials to make the frame. They use a vacuum pipe 25mm wide, an actuator 25mm wide. They used a three-hole solenoid valve with two positions. They use an air compressor with a pressure limit of 4-8 bar and an AC or DC controller. The pump capacity used in this suit is 4-8 bars. This project proves to be easy to build, design and cheap. It provides a faster and more flexible response compared to hydraulic and electric exoskeleton type. It enables people with physical disabilities to carry weight in their daily lives.

Abdulla Almomani, Faisal Miqdadi. [3] learned about "The 1st Pneumatic Fluidic muscles based on Exoskeleton Suit" The exoskeleton arm structure is made mainly of a combination of steel and aluminum. The energy system was delivered by a set of fluid muscles. They also describe the app in various fields such as social, medical, community, etc. Provide appropriate information on the materials to be used and the movement for personal comfort. They offer three degrees of suit freedom. It carries a heavy load for a long time. In this suit are recyclable, lightweight, and durable materials. Use the liquid muscles in this suit. This muscle is composed of fluidic tubes, elastomers, which are reinforced with rain by aramid fiber, a living man-made polymer. This suit can be used for military use to help soldiers carry heavy loads, firefighters, and other rescue workers to survive in a dangerous area. It is also used in the medical field to allow nurses in critically ill patients. In keeping with the

suit, they used a combination of controls, sensors and an actuator. The US Department of Defense has expressed its interest in developing nuclear weapons. They use electromyography (EMG) signals, potentiometer combined measurement angles, ground reaction sensor power, gyroscope and accelerometer to measure angle.

R. A. R. C. Gopura, Student Member, IEEE, Kazuo Kiguchi, Member, IEEE [4]. learned "Exoskeleton State-of-the-Art Equipment and Design Difficulties he learned. They also describe the various hand position controllers. Difficulty is researched while designing a suit, as the upper leg is a complex part of a person. The weight of the over-the-counter robot system also affects the robustness of the robot. Shoulder join complex is one of the most complex areas in the human body. Its center of rotation changes with movement. The elbow joint is shaped like a uniaxial hinge joint, with three bones called the humerus, ulna and radius. The shoulder joint is shaped like a circular joint and is located inside the body of the users. The PID controller is used to control the position of the hand exoskeleton. The structure of the upper robot should be biomechanically investigated for light weight and active force, actuators and transmitters are essential for the development of exoskeleton robots in the upper legs.

III. ERGONOMICS STUDY

Affected parts of the body due to lifting weights without using a wind energy suit Fig.3.1 Parts of the body affected by a heavy pie chart [10]

The pie chart above provides information about which body parts are affected. Due to lifting heavy weights. The lower part of the human body is severely affected by the lifting of heavy loads. Usually the hip joint is not affected by lifting heavy weights. This study was conducted by the SSU Center. By using this reference you can avoid back injuries. Number of workers injured during industrial lifting and losses. According to a study by the NSC (National Safety Council) every 7 seconds one worker is injured on the job. This is a very dangerous condition in preventing such injuries to others measurement prevention should be done in companies. It is involved in the production of the company. To avoid such damage a pneumatic power suit can be used effectively.

According to the Bureau of Labor Statistics (BLS), more than a million workers receive back injuries each year. One-fourth of workers' compensation claims are the result

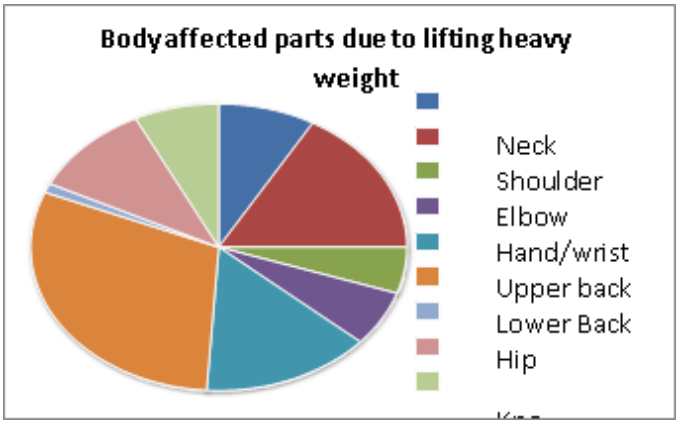

Figure 2.1 A safe place to carry a heavy load Figure 3.4 Proper lifting mechanism

of back injuries. Low back pain is one of the most common reasons why people miss work, second only to the common cold. In the United States, they spend more than $ 100 billion a year on medical bills, disability and loss of productivity at work due to back injuries and illness. More importantly, this problem causes unnecessary discomfort and pain to workers who may have a negative impact on their lifestyle and ability to work. A BLS study shows that 75% of back injuries occur while performing lifting activities, emphasizing the importance of reducing back injuries caused by lifting.

The picture above shows which is the safest place to lift weight around the human body. The red area is the most dangerous place to lift weights. Although the yellow area is very safe for weight lifting. The green area is ideal for holding or lifting weights. By using the Pneumatic power suit we lift the weight in the most beautiful area which is the green color.

Fig.3.2 Workplace Injuries

There are some common weight lifting methods provided by the ergonomics plus company as described below:

Plan Ahead: Know what you are proposing and how you will present it. Note the weight of the object. Decide whether it is safe to do so or not. Make sure the workplace is flat, dry and free of debris.

Examine your method: Make sure the lifting method is clear. Eliminate any risks of stumbling. Check for any wet or slippery surfaces.

Ergonomic equipment: Use lifting equipment, forklift, doll, cart, hand truck or hoist. Make sure you are trained before using the equipment.

Get help when needed: When lifting light or heavy loads, use a two-person elevator.Make sure you lift at the same time and maintain the load level. Wear appropriate protective footwear and gloves.When suggesting there are some rules to avoid danger:

Do:

• Know or check the weight of the object.
• Use ergonomic lift equipment if possible.
• Set up a lift and clear your path.
• Get help with heavy or heavy loads.
• Save the object for energy.
• Use a broad position to find balance.
• Use your legs to lift.
• Turn your feet to avoid twisting.

DON'T ...

• Do not hold your breath.
• Do not bend or turn.
• Do not use half handle (1-2 fingers).
• Do not block your vision when handling.
• Do not shake or raise immediately.
• Do not pinch your fingers or toes.
• Do not pull the load if you can push it.
• Do not forget to wear appropriate PPE. Basic diagonal lifting method:

1. Get as close to an object as possible.
2. Use a wide position with one foot in front of and around the object to get a good balance.
3. Keep your back straight, push your buttocks out, and use your legs and buttocks to lower yourself.
4. Slide the object as close to you as possible.
5. Put your hand on the side of the object farther away from you.
6. Use this basic lifting technique when you are able to unload and use a wide stand.
7. Put one hand on the side of the object next to you. Your hands should be in the opposite corners.
8. Hold the object firmly with both hands.
9. Prepare to lift, strengthen your main muscles, look forward and upward, keep your back straight and strong.
10. Lift slightly and follow your head and shoulders. Hold the load close to your body. Lift by stretching your legs and your back straight, and breathe as you lift.

IV. MANUFACTURING OF PROJECT

Project process planning:

Before the modeling process is done. Process planning is a pre-production preparation step, which determines the sequence of tasks or processes needed to produce a segment or assembly.

The results for this application are: Route sheet and worksheet. A route sheet is a sheet of paper that shows the exact sequence of tasks.

Next image 1 Indicates the route sheet that we will use to present the sequence of tasks to produce a model.

The various steps involved in planning a process are:

1. Fixing a working drawing.
2. Material selection.
3. Buying raw materials.
4. Selection process
5. Text editing.

Step1. Active drawing correction:

A working drawing is the geometric shape of a part or part that will be a product, its size.

After the modeling is completed the model is divided into three parts namely, the assembly diagram showing the complete product and all its components, the subassembly diagram with a specific group of components and a detailed diagram showing each component and showing the size, material specifications and information.

Each component sheet is a product, name and numbered accordingly. Such are all drawings produced with all the necessary information.

Step2. Material selection:

In our model there is a body frame and various links where the story is selected in the form of a weight point.

Step3. Purchase of goods and parts:

After the completion of the painting work a decision was made to purchase the goods and parts with expert advice. Items affected when purchasing equipment and parts:

1. Product budget.
2. Availability of goods.
3. Specific segment specification.

Step4. Process Selection:

The choice of process determines how the product will be produced. Includes:

1. Great technology option:
Is there a special manufacturing process required for the production of the part, is the technology available to make the product and all other factors are taken into account.
2. Small selection of technology:
There may be a small number of process technologies available such as welding, turning, piercing, etc. in this process the different types are out of any better combination of process in terms of cost and overall performance selected.
3. Selection of specific equipment:

What kind of equipment should be used? Should the equipment be hand-made or automatic? etc.

Factors to consider when selecting a process:

- Project budget.
- Completion date.
- Availability of equipment.

Step5. Document editing:

The chart can be a diagram, diagram or graph that gives an overview of the situation, name the process. It is helpful to visualize various opportunities for change or improvement.

Various process charts are available that are used to record performance. It incorporates various features and resources in better understanding and evaluating the process for the purpose of further development.

Examples of other process charts are: performance chart, flow process chart, multiple task charts.

Project production process:

The importance of process planning is evident in the research above that illustrates the role before making a real model.

The same procedure or steps we will follow to make the work complete. The planning process for producing a powerful suit is described below:

1 Car power 5HP
2 Spindle Speed 70-3600rpm
3 The spindle quill runs 127mm

3. Drilling holes in the plate drill machine will be used: Specification of the machine used: Make: - Prakash Engitech

1 Motor power 1440rpm
2 Spindle Speed 88-2600rpm
3 Spindle flow 250mm
4 Piercing in MS 40mm

4. All parts will be bonded with nuts and bolts Bolt: M8 * 30 bolted bolt, Maximum: 10unit

A following process sheet is created showing the set of instructions to be followed to achieve the desired product.

Case Study:

A case study to calculate the average forearm length and regression equation, to ultimately calculate the force exerted by muscle to carry the load.

Forearm length:

The study carried by the department of anatomy and department of forensic medicine, SOA University, Bhuvaneshwar, India.

In present study the average length of forearm for a height ranging from 165-170cm which is the average height of worker is estimated. This research follows the methodology for estimate the natural height of men. To ensure the accurate results, all the measurements were done by one person to avoid personal errors. The measurements were repeated to avoid errors. The parameters taken were:

- **Stature:** Maximum distance from vertex to floor.
- **Forearm length:** From the tip longest finger to elbow.

Height	**Male**
150-155	2

155-160	28
160-165	35
165-170	85
170-175	38
175-180	25

The equation has the form Y= a + bX, where Y is the dependent variable, X is the independent variable, b is the slope and a is the y-intercept.

The regression equation from table 2 was calculated to be:

Y= -254.03 + 17.45 X

Where, Y= height of individual
-254.03=intercept 17.45=slope X=forearm length
From above study it is clear that the average forearm length for height range 165-170 is 24.05.

Force exerted by muscle to carry load:

Muscles can only contract, so they occur in pairs. In the arm, the biceps muscle is a flexor that is, it closes the limb. The triceps muscle is an extensor that opens the limb. This configuration is typical of skeletal muscles, bones, and joints in humans and other vertebrates. Most skeletal muscles exert much larger forces within the body than the limbs apply to outside world. The reason is clear once we realize that most muscles are attached to bones via tendons close to joints, causing these systems to have mechanical advantages much less than one. Viewing them as simple machines, the input force is much greater than the output force. The figure (a) shows the forearm of worker which carry the load. The biceps exert a force FB.

To support the weight of the forearm and the load, the triceps are assumed to be relaxed. Figure (b) here, you can view an approximately equivalent mechanical system with the pivot at the elbow joint as shown in figure.

Strategy:

These are four forces acting on the forearm and its load. the magnitude of the force of the biceps is FB; that of the elbow joint is FE; that of the weights of the forearm is Wa; and its load is Wb. two of these are unknown (FB and FE), so that the first condition for equilibrium cannot satisfy. But if we use the second condition and choose the pivot to be at the elbow, then the torque due to FE is zero, and the only unknown becomes FB.

Solution:

The torques created by the weights are clockwise relative to the pivot, while the torque created by the biceps is counterclockwise; thus, the second condition for equilibrium (net τ=0)

R2 + R3 = R1FB.

Note that sinΘ=1 for all forces, since Θ=90 for all forces. This equation can easily be solved for FB in terms of known quantities,

FB= R2Wa +R3Wb
*R*1

Entering the known values gives:
FB= (0.1)(2.5)(9.81)+ (0.25)(18)(9.81)
0.04

Which gives: FB= 1104N

Now the combine weight of arm and its load is: (20.5)(9.81)=201.105N

So that the ratio of the force exerted by the biceps to the total weight is:
FB
W*a*+W*b*
= 1104
201.105
= 5.5.

Discussion:

This means that the biceps muscle is exerting a force 5.5 times the weight supported. By using this powered suit the force required to lift the same load is 402.134N and which is exerted by pneumatic cylinder which totally reduce the bicep effort to carry the load.

V. CONCLUSION

From this project we can conclude that, If we use a wind energy suit while carrying a heavy load on small industries, we can avoid worker hazards and can reduce workers' injuries. It is an economical and simple system compared to other techniques such as hydraulic, electric system etc. This system is also useful for a physically disabled person to move limbs in daily work. During the construction of the project we learned about human ergonomics and care if we have to take it while carrying a heavy load. design we

learned different parameters as part of modeling tools, integration tools, delivery etc. We use FlexSim software to design a wind circuit. It is an updated software for designing pneumatic circuit. We also understand the different pneumatic components and their specifications. For calculation purposes we have used the Matlab software. By using the system we make our calculations simpler and easier.

REFERENCES

[1] Nikhil P. Shinde1 *, Daji S.Shinde1, Kirtisen R. Gaikwad1, Mr. Nitin T.More1, Abhijit V. Naik2, "Exo-Skeleton Arm Using Pneumatic Cylinder" MAT Journals 2019, Journal of Mechanical Robotics Volume 4 2

[2] Gopal Krishna U B1, Prajwal Hosmutt H R2, Bharamesh M Nyamagoud2, Mallikarjun V Patil2, Omkar Hunnur2, "Design And Fabrication Of Pneumatic Powered Exoskeleton Suit For Arms", International Research Journal of Engineering and Technology (IRJET), Volume: 05 Story: 04 | Apr-2018

[3] Abdulla Almomani, Faisal Miqdadi, Mustafa Hassanin, Mustafa Samy, and Mohammed Awadallah, "1st Pneumatic Fluidic muscles based on Exoskeleton Suit in the U.A.E", IEEE

[4] R. A. R. C. Gopura, Student Member, IEEE, Kazuo Kiguchi, Member, IEEE, "Upper-Limb Exoskeleton Robots State-of-the-Art-Design and Design Difficulties",: https: // www. researchgate.net/ publication / 224580506, Conference Paper • July 2009

[5] Hiroshi Kobayashi, Hirokazu Nozaki, and Toshiaki Tsuji Department of Mechanical Engineering Tokyo University of Science, "Development of Power Assist System for Caregier by Muscle Suit", Proceedings of the 2007 IEEE International Conference on Mechatronics and Automation August 5 - 8, 2007 , Harbin, China

[6] TADASH MURATA1, HIROHISA HIRAI2, KEN ONISHI3, YOSHIHIRO TAMURA2, SYUHEI KOBORI 2, NAOKI KAZAOKA4, "Development of the Powered Exoskeleton of Hard Work - Robotics and Human Intelligence", Mitsbust Review. 53 No. 4 (December 2016)

[7] Suresh Talur1, Kiran Kumar.P.2, T. Madhusudhan3, "Material Selection in the area of Savonius Vertical Axis Wind Turbine Rotor blade", International Research Journal of Engineering and Technology (IRJET), Volume: 02 Release : 01 | Apr-2015

[8] S. R. Kamat 1, N. E. N. Md Zula1, N. S. Rayme 1, S. Shamsuddin1 and K. Husain 2, "Ergonomics Body Posture on Repetitive and Difficult to Promote Workers' Work in the Aerospace Manufacturing Warehouse1 April 2, Research Warehouse

[9] Biswa Bhusan Mohanty1, Divya Agrawal1, Kunal Mishra2, Pusparaj Samantsinghar2, Prafulla Kumar Chinara1, "Average human height from arm length to people in East India", Journal of Medicine & Allied Sciences, J Med Allied Sci 2013; 3 (2): 72-75