



Design, Fabrication & Analysis of Exoskeleton - The Chair less Chair using Aluminum Alloy (T6) 6082

Shaik Mubarak Basha¹, Murkur Rajesh², B.Sreenivasa Kumar Reddy³, S.Venkata Krishna⁴

¹P.G Scholar, M.Tech. J.N.T.U.A College of Engineering Pulivendula– 516390, Andhra Pradesh, INDIA

²Asst. Prof, M.Tech. J.N.T.U.A College of Engineering Pulivendula– 516390, Andhra Pradesh, INDIA

³Asst. Prof, M.Tech. J.N.T.U.A College of Engineering Pulivendula– 516390, Andhra Pradesh, INDIA

⁴Deputy Director (Trg./APGU), M.Tech. MSME Tool Room (Central Institute of Tool Design)

Vijayawada– 520007, Andhra Pradesh, INDIA

Abstract: Men & Machine plays a vital role in the Industries, None is Irreplaceable, But Machines are a boon & bane, they work 24x7 without boredom and rest, they don't get tired or requires comforts, Whereas humans work within comfort zones, they require lighting, air-conditioning, seating & healthy working conditions. Assume an employee working for a long hour run of 8-10 hours standing, his energy & enthusiasm to work exhausts, his body aches with pain resulting in decreased productivity and increase in fatigue. In order to overhaul this problem, 'Exoskeleton'- The Chair less Chair is Designed, Well –Crafted, Analyzed & Manufactured using Advanced Simulation & Fabricating Software's such as SolidWorks for Designing, DelCAM-PowerMILL for Manufacturing Simulation, 3-axis CNC-VMC for Fabrication, Ansys Professional for Analysis. In general, An Exoskeleton is a Simple, Mechanical, Wearable device which is used for Human Prosthetic lower limb supporting system. This is ergonomically manufactured using low density & high strength alloys such as Aluminum Alloy (T6)6082.To damp the load pneumatically actuated pressurized damper mechanism is used for aesthetic usage.

Keywords: Exoskeleton; Chair less chair; SolidWorks; Ansys Professional; DelCAM-PowerMILL; CNC-VMC; Prosthetic Support. Pneumatically pressurized Damper, Ergonomic & Wearable's.

I. Introduction

The world is moving into a better with the advancement of technology and manufacturing systems, starting from the Evolution of Human race, Need is the birth of every Invention & Discovery, Similarly Invention of Tool, Wheel, Industrial Revolution due to World Wars played a Significant role in Evolving advanced Manufacturing Methods & Techniques, Humans made Machines, Applied Mechanisms & Principles, Fabricated & Manufactured Tools, Things & Utilities for life. Now we are in a position where Men & Machine share an equal space in almost every aspects, It is a bitter Truth that Machines are Hard & Smart Workers than Humans, they work 24x7 without comfort, rest, boredom & won't get tired, but however they lack decision making & self-thinking ability, No matter how hard the machines are equipped with robotics, automaton & even artificial intelligence -Human support is required in Industries.

Consider an Employee Working for a long run of 8-10 hours of duration in Production. Human's work under comfort zones such as lighting, ventilation, air-conditioning, good seating and proper working conditions. The energy & enthusiasm of employee to work exhausts, his body aches with pain resulting in decreased productivity and increase in fatigue. In order to neutralize & compensate this problem, 'Exoskeleton'- The Chair less Chair is Designed, we have brought up with a solution, The idea of seating on their own place by simple mechanical wearable device, It is a combination of simple machine elements such as links and joints with a damper system (piston & cylinder) using pneumatically pressurized air as working medium.

There are 3 major steps mostly in developing an idea into product, they are simultaneously Design, Fabrication & Analysis, by satisfying these criteria, Exoskeleton has been designed, developed, manufactured and analyzed with respect to modern software's such as SolidWorks for Designing, DelCAM-PowerMILL for Manufacturing Simulation, 3-axis Computer Numerical Control (CNC) – Vertical Machining Centre (VMC) for Fabrication, Ansys Professional for Analysis. Exoskeleton is also crafted using low cost, high strength, light in weight, moderate space and size occupancy factors, so a fine grade of aluminium alloy (T6) 6082 is adopted for manufacturing. To ensure the locking mechanism at regular intervals of angles for every 30°, i.e., from 180° to 90°. It is designed with equitable space of slots by adjustable mechanism. Also to damp the load - a pressurised pneumatically actuated damper is fitted for the frames by means of revolute to sliding pair. Whenever the load is given on damper the piston and cylinder extracts and retracts due to internal locked pressurised air fluid medium.

II. Literature Work

Noonee, a Swiss make start-up based initiative in Zurich, Switzerland, CEO Keith Gunura - Noonee spun out at the NCCR Robotics lab at engineering university initiated a solution to this problem in the form of a wearable Mechatronics system called the Chair less Chair. It's like a mobile exoskeleton that allows people to essentially sit anywhere. Millions of employees who work in factories, production lines, distribution & assembly centres around the world are suffering from muscle related disorders such as long-term back aches and muscle-skeletal disorders due to long working hours of standing on their foot. There are multiple long-term diseases and health related issues that tend to recur, start-up Noonee has created the chair less chair which is worn as an exoskeleton using hydraulic mechanism & electric motor assistance on the back of the legs. With comfortable working conditions comes a healthy and motivated employee. Companies will benefit by helping healthy employees avoid risks of muscle-related diseases and injuries within the workplace and most of all, supporting injured employees back to work faster.

III. Problem Statement

Millions of employees who work in factories, production lines, distribution & assembly centres around the world are suffering from muscle related disorder such as long-term back aches and muscle-skeletal disorders due to long working hours of standing on their foot. If a person is continuously standing for such long hours. Swelling & aches of legs, varicose veins and nocturnal leg pains are some of the frequent problems that occur. People that have to constantly bend and crouch are remained with severe back aches and knee problems.

IV. Problem Definition

Creating an ergonomic, comfortable, compactable and even more productive workplace without extensive changes at the workplace – thanks to the Chair less Chair, this is now possible. All it takes to work in a healthy position is putting on our device just like cricket pads which only requires a few seconds. It provides with an standing and walking facility, it has belt which can be wearable, The Chair less Chair allows you to effortlessly switch between an active instant sitting, seating to standing and sometimes walking capabilities.

V. Significance of the Project

In adverse conditions, exoskeletons are used for walking, standing, sitting and doing work is safe and you're confident enough that you will not fall. While taking at a shorter distances weight & size which occupies space is an important factor, exoskeletons are going to bring more flexibility, mobility, compatibility, reliability and most importantly the confidence.

1. Made up of Aluminium Alloy T6-6082 which is lighter in weight.
2. Piston & Cylinder with Damper Mechanism is used for smooth sliding pair suspension.
3. Ergonomic & Aesthetic Design.
4. Modest, Modern & Mobile machine.
5. Higher strength, Lower density & Less in cost.

VI. Specifications - B.O.M

Sl/No	Component List	Material	Quantity
1	Pneumatically Pressurised Air Actuated Damper	Stainless Steel	2
2	Exoskeleton Frame	Aluminium Alloy 6082	2
3	Adjustable Heel & Locking Mechanism	Aluminium Alloy 6082	2
4	Belt & Buckle	Fabric & Plastic	6
5	Hexagonal Nuts & Bolts	ISO M12x1.5 Steel	6

Table no: 1 Bill of Materials

VII. DESIGN METHODOLOGY

Exoskeletons are defined as Wearable Anthropomorphic Standalone Active Devices which have Mechanical machine elements with simple mechanism in it. Based on the Analytical Statistical data, the study of human skeleton and as per dimensions of Indian wearers; the link lengths of the lower limb of exoskeletons are derived. From these standard design measurements. It is Designed & Modelled in the SOLIDWORKS Software. All the parts are Sketched, Modelled, and Assembled along with Motion Study & Mechanism; The Revolute and Sliding pair Mechanism can also be achieved to check the Visualisation of Machine elements. Analysis is also performed to check the Factor of Safety and Load Bearing Capability.

A. Top Link



Fig no: 1

B. Bottom Link



Fig no: 2

C. Damper Top



Fig no: 3

D. Damper Bottom



Fig no: 4

E. Hexagonal Nut & Bolt



Fig no: 5

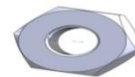


Fig no: 6

F. Adjustable Heel



Fig no: 7

VIII. MATERIAL SELECTION

There are about 20,000 materials in usage, picking out the best and fittest one looks to be like a night mare! We have to select a material which is flexible, lighter, stronger and cheaper. Engineers build things. They make and create possibilities out of materials. Whatever they are capable is about to choose and apply materials effectively. A quick look around a sports shop shows that most rucksack frames are indeed made from aluminum, So far Aluminium alloy 6082 is best for structural applications derived & extracted from Ashby charts and edu-pack simulator software.

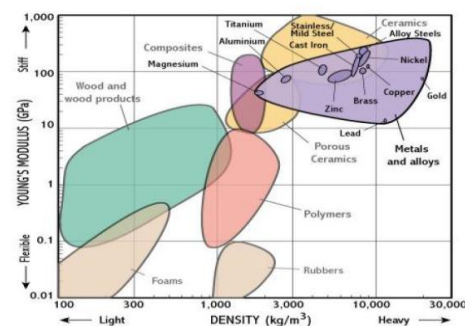


Fig no: 8

IX. Assembly of Exoskeleton

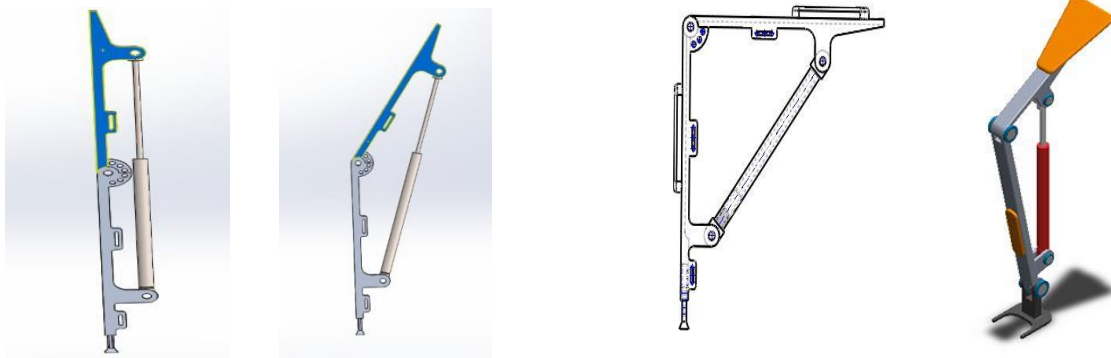


Fig no: 9

X. FABRICATION USING CNC-VMC & DELCAM

Intoduction & Understanding GUI of DelCam(PowerMILL), Working Procedure, Workplane Setup, Wireframe Modeller, Data exchange, Set block of Machining, 3D area clearance data strategy, 2D area clearance Machining & post-processor selection for G&M codes Generation.

Working Environment

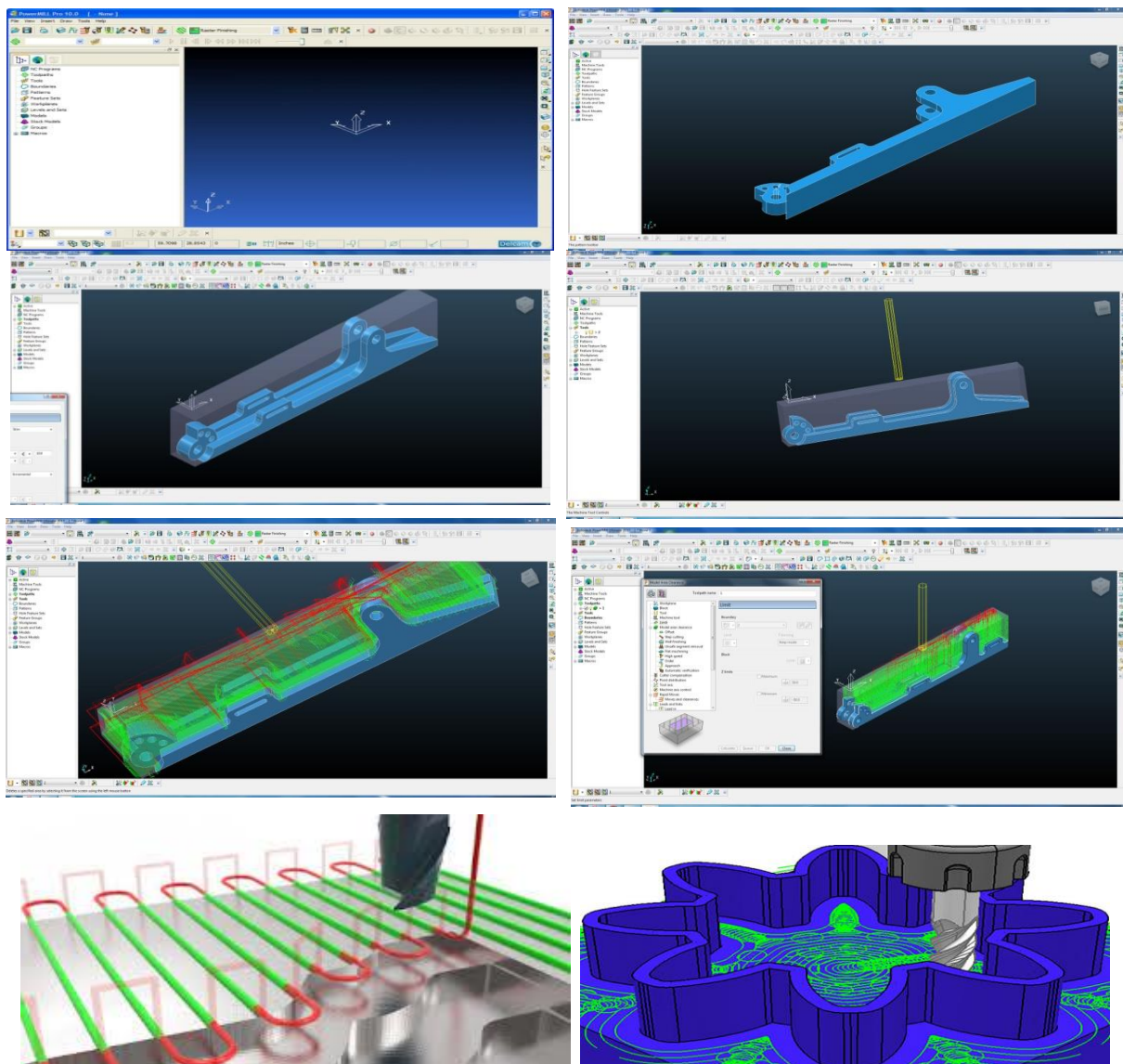


Fig no: 10

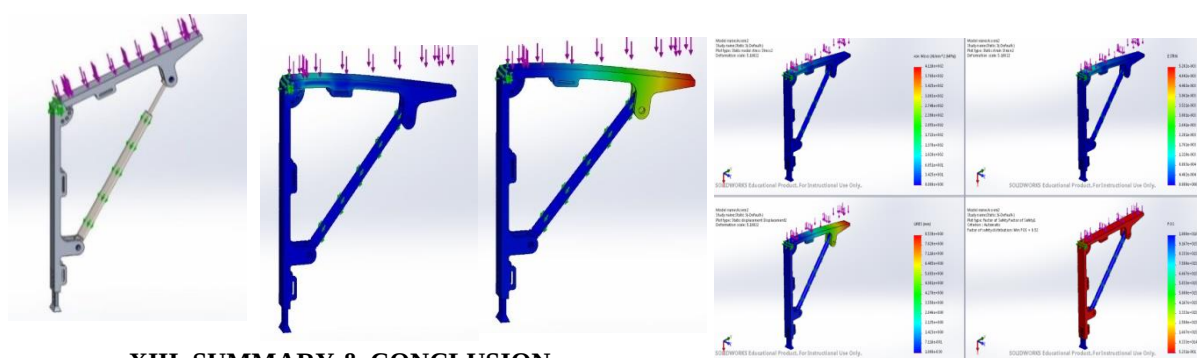
XI. VMC FANUC G&M CODES SAMPLE DATA

*Post processor selection to convert DelCAM file into G&M codes Generation:

%	N190 (MAX Y: 20)	N350 (Holder Links:
:0001	N200 (MAX Z: 8.34055e-015)	Collisions Checked)
N10G91G28X0Y0Z0	N210 (COORDINATE SYSTEM:	N360 (Tool path: Constant
N20G40G17G80G49	WORKPLANE)	Z Finishing)
N30G0G90Z20M03 (SPINDLE	N220 (Datum - Tool Tip:)	N370 (TOLERANCE: 0.02)
START)	N230 (X: -37.500)	N380 (THICKNESS: 0)
N40T1M6 (Tool Change: XX)	N240 (Y: 0.000)	N390 (Tool path Stats:)
N50G54G90	N250 (Z: 20.000)	N400 (LENGTH: 19548.9)
N60 (Tool path Name: 1-	N260 (Number of Flutes: 4)	N410 (TIME: 0/13/2)
5END)	N270 (Tool: ENDMILL)	N420 (LIFTS: 1)
N70 (Output:)	N280 (DIAMETER: 5)	N430G81Z0
N80 (Units: MM)	N290 (Safety Factor:)	N440P0.1,Q0.1(Repeat Canned
N90 (Tool Coordinates: Tip)	N300 (Tool Cutting Moves:	Cycle Recall)
N100 (Tool Number: 1)	Safe No Gouges)	N450M07 (COOLANT OFF:)
N110 (Tool Id: 1-5END)	N310 (Tool Leads: Safe No	N460G91G28Z0
N120 (Coolant: Standard)	Gouges)	N470M05 (SPINDLE STOP)
N130 (Gauge Length: 25)	N320 (Tool Links: Safe No	N480G49H0
N140 (Block:)	Gouges)	N490G28X0Y0 (HOME POSITION
N150 (MIN X: -75)	N330 (Cutting Moves:	RETURN)
N160 (MIN Y: -20)	Collisions Checked)	N500M30 (END OF PROGRAM:)
N170 (MIN Z: -50)	N340 (Holder Leads:	%
N180 (MAX X: 2.77556e-015)	Collisions Checked)	

XII. ANALYSIS & SIMULATION WITH MECHANISM REPRESENTING FACTOR OF SAFETY IN ANSYS PROFESSIONAL

Fig no: 11



XIII. SUMMARY & CONCLUSION

The Exoskeleton of lower limb is well-designed & crafted as an eco-friendly device, it doesn't consumes any power (works without motor, no heavy hydraulic & pneumatic setup required). This chair less chair adds comfort, compact, aesthetic & modular aluminum alloy design, light in weight, mobile & reliable, easy to carry, flexible & adaptable to most working conditions, the objective of this work is to build a project which is used as a instantaneous prosthetic support for human walking, sitting, and seating.

Future works will concentrate on adopting advanced manufacturing methods, mechanism and selection of material i.e., light weight material like alloys of Chromium, Titanium, Aluminum, Composite materials, etc., for higher strength, light in weight and low cost, Casting and Molding can be adopted in upcoming days.

REFERENCES

- [1] <http://www.noonee.ch/index.php/technology//> - page number 8,9
- [2] Walsh C, Endow K, Herr H: "A quasi-passive exoskeleton for leg load-carrying augmentation". Int Jr HR 2007, 4(3): 487-506.
- [3] <https://www.core77.com/posts/27553/who-knew-the-wearable-chair-was-actually-invented-37-years-ago-27553>
- [4] <http://www.cnn.com/2014/08/20/tech/innovation/the-chairless-chair/index.html>
- [5] <https://www.sciencedirect.com/science/article/pii/S0921889016304274>
- [6] <https://ieeexplore.ieee.org/document/7523699/>
- [7] <https://exoskeletonreport.com/product/chairless-chair/>
- [8] <https://exoskeletonreport.com/product/hal-lower-limb/>
- [9] "Mechanical Design of a Hybrid Leg Exoskeleton to Augment Load-Carrying for Walking" (943-664) volume 2.
- [10] <https://www.forbes.com/sites/amitchowdhry/2014/08/24/the-chairless-chair-lets-you-sit-anywhere/#deab4c560577>
- [11] <http://edition.cnn.com/2014/08/20/tech/innovation/the-chairless-chair/index.html>
- [12] Other Sources: Internet, Google.inc, Encyclopedia & Wikipediacorp, GrabCad, Autodesk-Autocad, DassaultSystems-SolidWorks, PowerMILL-DelCam, AnsysProfessional APDL etc.,
- [13]