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Design and Analysis of Stair Climbing Trolley

Nilesh Shinde
Government College of Engineering Amravati

Abstract: ***We are mainly designing a stair climbing trolley so as to reduce or bring ease of physical labour for some of the hard labour sectors in economy like construction sector.***

I. INTRODUCTION

The project is about designing and fabricating a new product of trolley that has multifunction. The vehicle is designed in such a way that it has a tri wheel frame on each side. They are set in a triangular frame pattern. This thesis focuses on the maximum ergonomically beneficial to human beings. The present project related to load carrying equipment of a type that is manually operated by moving upward and downward on flight of stairs. Load carrier is a wheeled mechanism device, and is generally used to carry loads. It is used to reduce human efforts. Load carrier at its inception was a hand truck.

A. Need For Stair Climber Trolley

Lifting heavy objects to upper stores or lifting patients to upper levels from the ground are not painless jobs, especially where there are no lifting facilities (elevator, conveyor, etc.). Moreover, most of the buildings are structurally congested and do not have elevators or escalators. This project can introduce a new option for the transportation of loads over the stairs. The stair climbing hand trolley can play an important role in those areas to lift loads over a short height[5].

B. Design Objectives

1) To The design oftrolley is designed in CATIA VS software ofthree different models and also for tri star frame.
2) To carry out The static structural analysis is carried on them by considering various factors which are as follow-
a) Design
b) Material
c) Load

C. Advantages Of Modified Design

1) Easy Vertical Transportation
2) Smart Approach
3) Material Transport in Buildings
4) More number ofitems is carry at a time
5) Less effect to carry goods
6) More economical and hence affordable by common
7) Compared to other wheel load carriers, the effort required is less in this type.
8) This load camer makes it possible to move unit loads cost effectively, safely and ergonomically [5].

D. Applications of Trolley

1) It can be used in transportation of luggage from one floor to another on stairs in shopping malls (3].
2) It can be used in buildings under construction [5].
3) This mechanism can be used as a stair climbing mechanism for wheelchairs [4].
4) It can be used for material handling [5].

II. LITERATURE REVIEW

Purpose of Research The purpose of this research is toward increasing the autonomy of person's reliant on mobility assistive devices, and to reduce the load on care workers in providing such mobility. The objective of this thesis was to design and test a consumer-grade hand truck capable of climbing stairs.

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Several designs were conceived that would allow a non industrial hand truck to travel over stairs, curbs. or uneven terrains while putting minimal strain on the user. To produce a successful product, these other design options must be examined more closely. Future work on this product should involve design and construction of other prototypes which use different stair-climbing strategies. The project aims to develop a mechanism for easy transportation of heavy load over stairs. The need for such a system has been raised from day to day in our society. Using this vehicle the labor cost can be reduced as well as large amounts of load can be transferred uniformly With less

III. EXPERIMENTATION

Trolley is equipment used to move heavy loads from one place to another. It can reduce the human burden in their daily lives.Trolleys are onen used by those who organize and stock merchandise in retail stores restock. When used properly, trolleys can protect people from having back injuries and other health problems that can result from lifting and carrying heavy loads from up and down the stairs.

The mechanical design of the stair climbing trolley has been developed considering suitable material. Low-cost available material helps to reduce cost of production easily. The trolley and frame design methodology has been outlined. Steps for design process include:

A. Material For Trolley Frame

There are many materials available in the market which will be suitable for trolley frames as well as tri star frames. But the need of both parts are different as material of trolley frame selected must have more load bear capacity, easily weldable, easily available in market with affordable prices, easily machined in lathe , shaper or milling machine while need of tri star frame material is different.So we selected the following materials which can fulfill all the above conditions[29].[30].

Properties	Value or AISI 1020	Value Mild steel
timate Strength Tensile	20 MPa	40 MPa
ield Strength Tensile	50 MPa	70 MPa
oisson Ratio	.29	.303
nsity	.87 g/cm^3	.85 g/cm^y
oung's Modulus	05 GPa	OO C,Pa

Material for Tri-star wheel frame

There are many materials available in the market which will be suitable for trolley frames as well as for tri star frames. But the needs of both parts are different as material of the tri star frame selected must have shock bearing capacity, good machinability, good corrosion resistance, resistance to scratching and high tensile strength. So we selected the following materials which can fulfill all the above conditions[33].[34].[35].

Selected materials for tri star frame are as follows:

i.Stainless Steel Grade 304 ii.Polymethyl Methacrylate power consumption thus our project introduces the altemativc for transportation of load over the stairs. iii.Polyurethane

properties	Stainless Steel Grade 304	MMA	olvurethane
Itimate strength ensile	12 MPa	5 MPa	18 MPa

field strength ensile	05 MPa	17.5 MPa	-250 MPa
enslty	g/cm*	I . 18 g/cm3	1.125
oung's odulus	193 GPa	855MPa	.8-1.1 GPa

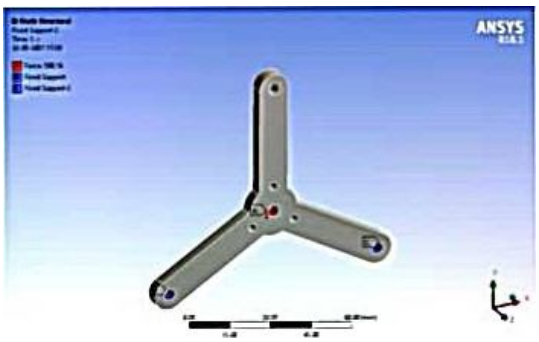
B. Components

Tri star wheel stair climbing trolley consists oftrolley frame , tri star frame, wheel and bearing as the major components.

1) Trolley frame



2) Tri star frame



3) Wheels

4) Bearing



IV. MACHINING OPERATION

A. Cutting Operation

In our design of trolley ,cutting is carried on various parts which arc as follows

1) In trolley frame

For cutting the MS pipe into various dimensions according to a trolley frame.

For this purpose. hand cutter and workshop cutter are used as per dimension of design.

2) In Tristar frame

For cutting the stainless steel grade 304 plate into a tri star frame.

For this purpose. Plasma arc cutting, Flame cutting such as oxy-acetylene arc used. 3. In basc plate of trolley frame- Slots are made on basc plate for the weight reduction of a trolley frame Cutting is done equidistantly on the base plate by Flame cutting.

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B. Pipe Bending

In our design, pipe bending is done On Various parts-

Trolley frame-

1) Pipe bending is to be done near the handle.
2) For this purpose, a workshop bending device is used.

C. Welding

Welding process in our design-

1) It is a very important part ofthc fabrication
2) process.
3) Welding decides the life ofa trolley as good weld can last longer.
4) Welding is used to join all the Ms pipe members, base plate and axle to give the required trolley frame design.
5) For this purpose, Arc welding or TIG (Tungsten Inert Gas) welding is used.

D. Lathe Operation

Lathe operation plays an important role for design of trolley frame and its functions are as follows-

1) Turning of bushes is to be done.
2) Drilling is used to drill the holes.

E. Drilling

In our design of trolley ,cutting is carried on various parts which are as follows-

In tri-star frame- Holes for various sizes can be drilled by drilling process.

1) Hole of 10 mm diameter is to be drilled to attach wheels to the tri star frame.
2) Hole of 47 mm diameter is to be drilled to connect the axle to the tri star frame with the help of bearing.

F. Grinding

Grinding operation is to be done for the fabrication of the trolley at various different parts and they are [50]-

1) Trolley frame- It can be used to make proper curvature for good welding.
2) Base plate of trolley- It is used to remove the material from the plate to make it thin.
3) Tri-star frame- It is used to remove the material at sharp cutting edges and also for providing the fillet and smooth curvatures.

G. Finishing

1) Finishing operation is to be done at the end when all the other options arc completely done.
2) Sharp edges are converted into smooth edges and fillet can be made at required places.
3) Surface finishing of the trolley is to be done so that it should not harm the customer while carrying the load on it.

S. PARAMETRIC CALCULATION:Analysis of Axle I,oad

The Bending Equation for the Beam (Axle) is given by,

$$\frac{M}{I} = \frac{\sigma}{Y} = \frac{E}{R}$$

$$Y = \frac{D}{2} = \frac{0.025}{2} = 0.0125 \text{ m}$$

For Maximum Bending Moment,

By Considering Simply Supported Beam with Uniformly Distributed Load (UDL) , the Shear Force and Bending moment Diagram is shown in figure ,

As you can see from the Above BMI). the Bending Moment is maximum at the Centre of the beam by giving the maximum bending in the beam.

Therefore, Maximum Bending Moment for this Beam can be given by, $\frac{wxL^2}{8} = \frac{981 \times 0.552^2}{8}$ -37.364 Nm

Practically, Maximum Bending Moment ofthe Beam is derived by Considering Factor of Safety (F.O.S) .

Resultant Maximum Bending Moment is calculated as,

$$M = \frac{M*}{F.o.S} = \frac{37.364}{1.5} 37.364 = 24.91 \text{ Nm}$$

Bending Stress ofthe Beam (Axle) is calculated as,

Mxy x 00125(m)

7.676

40.56 x 1M'N/m^2

Converting the value of Bending Stress into MPa(N/mm2),

σ=40. 56 MPa

Tri Star Wheel Design

The Force | a2+b2 Distance Between the centre of Tri-Star wheel and the Centre of its wheel (R) is Derived as, 12.489cm

Applied to Pull the Trollev

Force required to pull the trolley is given by,

$$F = \frac{W \times y}{x} = 160.984 \text{ N}$$

The pulling force required to pull the trolley is 160.984 N.

Weight or Stair C.'irnbinp Trolley :-Wt. of the trolley = { (wt. of the trolley frame) + (wt. of the Tristar framex Nos) +(wt. of the Nos) + (wt. of the Bearings Nos) +(wt. of E lardware Accessories)) (all in kg) = {10 + x 4) + (1.172) } (all in kg)

Wt. of the trolley = 31.5 Kg

The weight ofthc trolley comes to be 31.5 Kg , but considering the approximation of the values,we take the maximum weight of the trolley as 35 Kg.

6.cosr ESTIMATION

Sr no	Parts	Quantity Of Material	Rate (Rs.)	Cost + Machining Cost
1	Trolley frame	10kg	70/kg	700+500=1200
2	Tri-Star frame	2kg	180/kg	360+740=1100
3	Wheel	6	150 each	900
4	Bearing	4	250 each	1000
5	Finishing Cost			300
6		Painting		300
7	Hardware Accessories			200
	TOTAL			5000/-

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V. RESULT AND DISCUSSION

After comparison it is concluded that —

1) For 850 N of load, mild steel gives optimum result than Carbon steel AISI 1020 material for the same load in static structural analysis.
2) Mild steel gives better result for 750N, 800N, 850N of load as compared to Carbon steel AISI 1020 in static structural analysis.
3) Thus after comparison it is concluded that model 3.3.1.3 of mild steel gives optimum design of trolley frame as it shows Very less deformation (O. 1 198mm) for 850N.

VI. FUTURE SCOPE

1) Better wheels can be selected by analyzing the wheel contact is specific.
2) Internal braking system is used as an effective braking system.
3) The same mechanism can be used for wheelchairs providing a high head motor along with a more rigid structure is used.

VII. CONCLUSION

The main aim of the project is stair climbing mechanism (or load carrier with decreasing effort

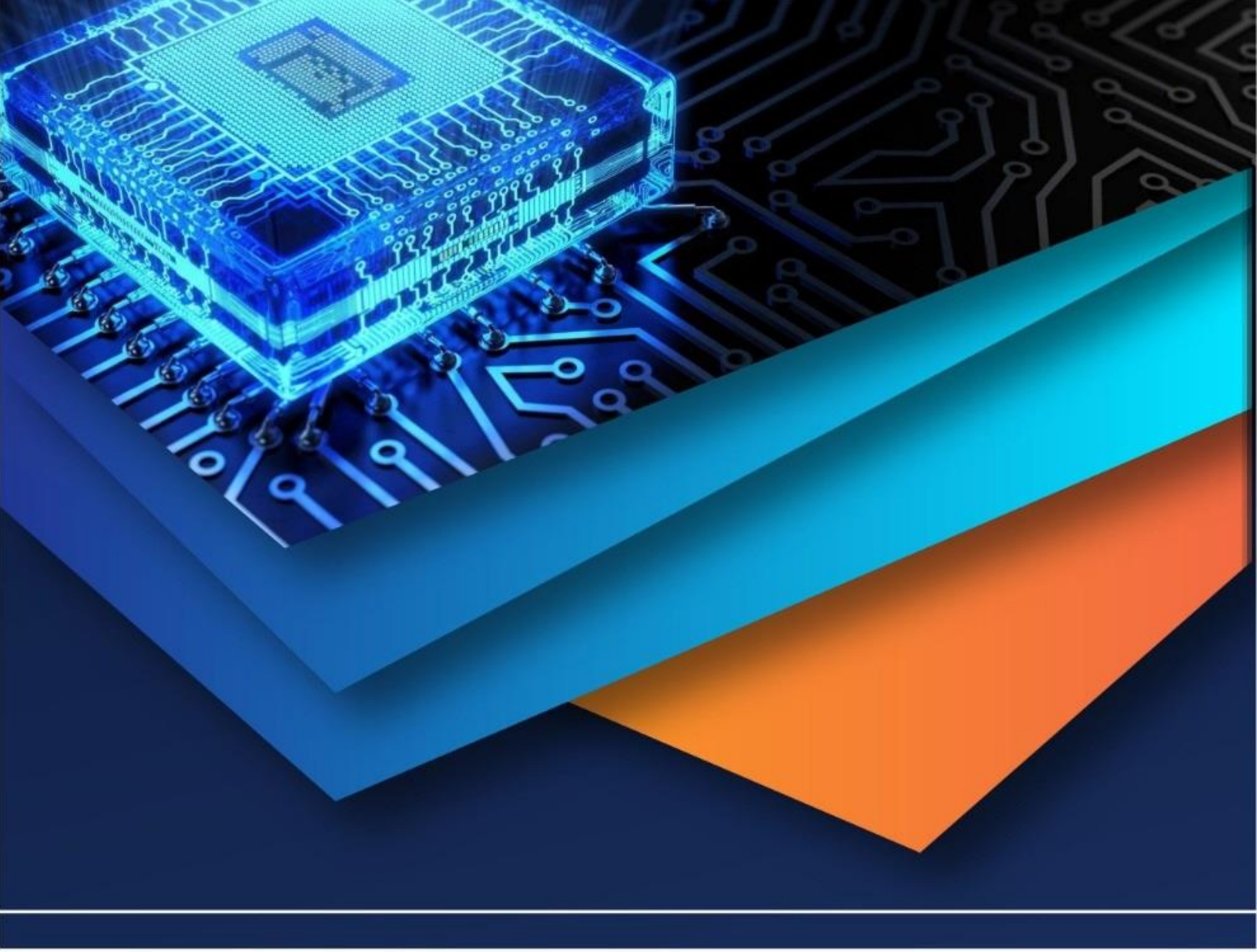
1) Doing better work with lessor effort has been the main objectives of human beings in any field. • The main project as a platfonn wc try to present mechanized stair climbing load carriers with reduced effort.
2) Stair climbing mechanism in stair case load carrier which helps to carry the loads with help to carry the loads with staircase.
3) We completed the project to our best.
4) The main aim ofthe project is stair climbing mechanism for load carrier with decreasing effort
5) Doing better work with less effort has been the main objective of human beings in any field. • The main project as a platfonn wc try to present mechanized stair climbing load carriers with reduced effort.
6) Stair climbing mechanism in stair case load carrier which helps to carry the loads with help to carry the loa&s with staircase.
7) We completed the project to the best of our ability.

REFERENCES

[1] Robert H. Shaffer. "Collapsible Utility Cart", U.S. Patent No. 4,047,724. Mar. 1977, https://patcnts.google.c orWpatent!US40 47724 Afen
[2] Barney, Jay B. *'Strategic Factor Markets: Expectations, Luck, and Business Strategy." Management Science 32 (10), INFORMS , pp. 1231 — 1241, 1986. DOI:10.1287/mnsc.32.10.1231
[3] Karl T. Ulrich; Steven D. Eppinger. Product Design and Development. Tata McGraw-Hill Education, 2003
[4] Woodson, Wesley E., et al. Human Factors Design Handbook : Information and Guidelines for the Design of Systems, Facilities, Equipment. and Products for Human Use. McGraw-Hill, 1992.https://trid.trh.org/view/357534
[5] Sohan Kumawat, MilindSonawane. Shubham Khadangle, Omkar Chavan, B. J. Visputc "AUTOMATIC STAIR CLIMBING TROLLEY" IJSRD vol.6, Issue 02. 2018
[6] B. Ravindar, M. Kiran Kumar, K. Rajashekar, G. Rajkumar "DESIGN AND FABRICATION OF STAIR CLIMBING TROLLEY" JETIR vol. 05, Issue: 09
[7] P. Jey Praveen Raj, P.M. Mohamed Fuge, R. Paul Caleb, G. Natarajan "DESIGN AND FABRICATION OF STAIR CLIMBING TROLLEY" International Journal of Advancement in Engineering Technology, management & Applied Science Vol. 03, Issue 5 May, 2016
[8] Roshan Alaspure, Chaitali Barmase, Snehal Chambhare. Manish Mandhre. Prof. Yogesh G. Joshi (Guide), Fabrication of Stair Climbing Wheel Mechanism: Alternate for lifting goods, International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056 Volume: 03 Issue: 05 | May-2016 www.irjet.net p-lSSN: 2395-0072.
[9] Stair Climbing Vehicle, Md. A. flossain, Nafis A. Chowdhury. Rubaiat J. Linda injan-2010, Published in International Journal Of Research Publications In Engineering And Technology,
[10] Zhang, Q., song, M.M., Xiao, S.G. and Luo, Z. (2017) A Study on Design Method of Intelligent Platform Trolley. IOP Conference Series : Materials Science and Engineering, 274, Article ID: 012135.
[11] Hutasuhut, F. and Erwin (2016) Development of Anthropometric Chair Based on Arm Span, Knee Height, and Sitting llcight for Elderly. International Journal of GEOMATE. I l, 2844-2850.
[12] Shiwarkar, S.S., Pairag, S.D. and Zaveri, S.R. (2018) Design and Fabrication of Easy Handling Trolley. International Research Journal of Engineering and Technology, 5, 1690-1694.
[13] Culvenor, J. (2005) Initial Force and Desirable Handle Height Range When Pushing a Trolley. Journal of Occupational Health and Safety Australia and New Zealand, 21, 341-349.
[14] Kumar, W., Santhiyagu, V., Vasudev, K. and Solomon, D. (2017) Reduction of Discomfort in Pushing an Industrial Trolley Using Ergonomics. LOP Conference Series : Materials Science and Engineering. 263, Article ID: 062042. https://doi.org/10.1088/1757-899>(/263/6/06204
[15] Talapatra, S. and Uddin. M.K. (2018) Some Obstacles that Affect the TQM Implementation in Bangladeshi RMG Sector: An Empirical Study. Proceedings of the 8th International Conference on Industrial Engineering and Operations Management, Bandung, Indonesia, 6-8 March 2018.
[16] Resnick, M.L. and Chaffin, D.B. (1995) An Ergonomic Evaluation of Handle Height and Load in Maximal and Submaximal Cart Pushing. Applied Ergonomics , 26, 173-178. https://doi.org/lO.1016/00036870(95)OOO 14-4

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[17] Endo, Y. and Sakamoto, M. (2014) Correlation of Shoulder and Elbow Injuries with Muscle Tightness, Core Stability. and Balance by Longitudinal Measurements in Junior High School Baseball Players. Journal of Physical Therapy Science , 26, 689-693.
[18] S. Wilkinson, W. (2000) Designing Trolleys for the New Millennia: An Engineering Analysis and Human Factors Concepts Approach. Proceedings ofthe Human Factors and Ergonomics Society Annual Meeting . 44. 405-405. https://doi.org 10.1 177/15419312000.44029131
[19] Adu, G. (2015) Mismatch between Offcc Furniture and Anthropometric Measures in Ghanaian Institutions. Intemational Joumal of Innovative Research in Science, Engineering and Technology, 4, 2687-2693,
[20] Wollesen, B.. Argubi-Wollesen. A., Lcitncr, M., Schulz, S., Keuchel, M., al . (2017) Development and Development of an Ergonomic Handle and Wheel Design for Industrial Transport Carts. Global Environment . Health and Safety , l, 9.
[21] Jung. M.-C.. llaight, J. and Frcivalds, A. (2005) Pushing and Pulling Carts and Two-Wheeled Hand Trucks. International Journal of Industrial Ergonomics , 35, 79-89. https://doi.org/10.1016/i.ergon.2()()4.08.006
[22] Talapatra, S., Uddin, M. , Antony, J., Shivam, G. and Elizabeth, C. (2019) An Empirical Study to Investigate the EtTects ofCritical Factors on TQM Implementation in the Garment Industry in Bangladesh. International Journal ofQuality & Reliability Management . (In Press) 108/1JORM-06-2018-0145
[23] Robert H. Shaffer. "Collapsible Utility Cart", U.S. Patent No. 4,047,724, Mar. 1977, https://patents.20021e.com/patenVUS4047724Nen
[24] Henry Diener. "Manual Utility Cart", U.S. Patent No.Dec. 1985, hopy//patents.google.com/patentfUS4531752A/en
[25] John Grace. "Collapsible and Foldable Cart Having a Stabilization Member", U.S. Patent No. Aug. 1997, https://patents .google.com/patent/U S56263 52A/en
[26] Ed Carlile. "Collapsible Cart Assembly", U.S. Patent No. 4,865,346. Nov. 1989, https://patcnts.google.com/patgnt/US4\fi5346A/en
[27] Hu. Kai, Xiao-qing Gan. "The Manufacturer's Trade-Offbetween Raw Material Quality and Total Cost - With Hog Supply Chains' Feed Quality Selection Strategy for Example.'• 201 1 International Conference on Management and Service Science, IEEE. pp. I —4, 201 1. DOI: 10.1 109/1CMSS.2011.5998332
[28] Hague, R., et al. "Material and Design Considerations for Rapid Manufacturing. Intemational Joumal of Production Research 42 (22), Taylor & Francis Group, pp. 4691- 4708, 2004. DOI: 10.1080/00207840410001733940
[29] Hsueh-Er, C.. "Stair-climbing vehicle, 2008, ▪▪Patent No. US2008164665(Al)", Jan 24.
[30] P.Jey Praveen Raj. P.M.M0hamed Fuge, R.Paul Caleb, G.Natarajan. Design and Fabrication of Stair Climbing Trolley,lSSN NO-2349 3224 Chennai. INDIA.
[31] https://www.researchgate.net/publication/27628850 5 Elastic moduli characterization or wood and wood _products_using_the_Impulse_Excitation_Technique,Fe bruary 2015,DOl: 10.13140!RG.2. I .3074.9608, Report number: ITC-05 ENG Revision 1.3Affiliation: ATCP Physical Engineering, Project: Impulse Excitation Technique.
[32] Carbon steel AISI 1020- R. C. Hibbcler, Mechanics of Materials, 8th Edition -Pearson Prentice Hall (2010)
[33] https://www.researchgate.net/publication/24957445 3_A_comprehensive_fatigue_life_predictive_model_for _electronically conductive adhesive_joints_under_cons tant-cycle_loading Publisher - J. Adhesion Sci. Technol., vol. 20, No. l, pp. 87-104 (2006)VSP 2006.Also available online - www.vsppub.com
[34] https://www.researchgate.nct/publication/41623915 _Inhibition_of_Staphylococcus_epidermidis_Biofilms_ Using_Polymerizable_Vancomycin_Derivatives, SOCIETY1nhibition of Staphylococcus epidermidis BiofilmsUsingPolymerizableVancomycin Derivatives, McKinley C. Lawson PhD, Kevin C. HothBS,Cole A. DeForest BS, Christopher N. Bowman PhD.
[35] https://www.researchgate.net/publicationQ59628857 Reversible Cross- Linking_Microdomain Structure and Heterogeneous_ Reversible Cross- Linked_ by Solid- State NMR, The Journal ofphysical Chemistry B 1 18(4), January 2014
[36] Raundal, A.P.V., Galande, A., Devkar, R. , Jiman, P. and Pathare, B., DESIGN AND MANUFACTURING OF STAIR CLIMBING TROLLEY.
[37] Gondole, P.P., Thakre, K.D. and Moon, H.A., 2016, April. stair climbing hand trolley. In International Journal of Emerging Technologies and Innovative Research JETIR (Vol. 3, No. 4 (April-2016)). JETIR.
[38] Norton, R.L. and Wang, S.S.L.. 2004. Design of machinery: an introduction to the synthesis and analysis ofmechanisms and machines. McGraw-Hill Higher Education.
[39] A.S.Shirwadkar and S.K.Choudhary(2013)," Synthesis.Modeling .Analysis and Simulation of stair climbing Journal of Mechanical Engineering and Robotic Research
[40] Murray J. Lawn (2003) "Modeling ofa stair climbing wheelchair mechanism with high single step capability" in proceedings of IEEE Transactions on Neural Systems and Rehabilitation Engineering 1 1(3). sept. 2003.
[41] Dr. RK. Bansal, A text book of Strength of materials. Laxmi Publications Ltd., 31 December 2011.
[42] RS Khurmi, J.K. Gupta, A, S, Machine design.Chand Publishing House Ltd, pp. 509-557 and pp.996-1020, 2005.
[43] Rakesh Nath."Design and parametric evaluation of a staircase climbing forklift". International Research Journal Of Engineering and Technology (IRJET), July 2020.
[44] Muthanna A.V., M. Sanjay Krishnan. Nasruddin P.N., Pawan Kumar M.. "Analysis of Tristar frame in Stair climbing hand truck". Intemational journal of Engineering science and computing. April 2017.
[45] Dr. P.V. Sanjeeva Kumar. Dr. A Hemanth Kumar, Dr. P. Varaprasad. Intemational Joumal of Applied Engineering Research, 2018.
[46] A. S. Shrivastav and S. K. Choudhary' . "Synthesis, modelling, Analysis and simulation ofstair climbing Mechanism" International Journal of Mechanical Engineering and Robotics Research(IJMERR),October-2013.
[47] Hardik Gangadia,llardik Shukla, Sankct Patel, Milan Jani, Rahul Upadhayay,lshan Thakar,"Design and Modelling of Stair climbing Trolley", SARJAN,SOCET Journal of Engineering & Technology — 2015.
[48] Adesh Ganlande. RanJit Devkar, Pravin jiman , Bhushan Pathare and manufacturing of stair climbing trolley" Intemational Journal of Advance Research in Science & Engineering — 2018. [49] Pothamsetty kasi Rao, "Design ofStair Climbing wheel chair using Tri-wheel Mechanism", International Journal of Mechanical and Production Engineering and Development (IJMPERD) -Aug 2018.
[49] Amber Shrivastav , Aman Kaushal, Devansh Dhar Dubey . Agman Srivastava, Mr. Manabendra Saha , Tri star stair climber, Intemational journal oftrend in Scientific Research and Development, ISSN No-6470, Volume 2, issue 4, June 2018.



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