Stair Climbing Hand Trolley

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Abstract: **A hand truck with the ability to climb stairs would decrease the possibility of injury from having to lift a wheeled cart or its contents over an obstruction. If successful, this device should provide increased safety both in the home and in the workplace. Also, it is hoped that a simple stair-climbing device such as this one might increase public acceptance of other, more complex stair-climbing devices such as wheelchairs.**

Keywords**: gudgeon pin, stair, hub, and bearing**

I. INTRODUCTION

The present invention relates to hand trucks intended for transporting heavy load and more particularly, to an improved and simplified hand truck which is adopted to move heavy loads easily up and down from the stair; with the help of this truck we can lift the load easily up and down from stairs. Due to this the man effort is reduced and time to lift the load is also reduced.
The project problem statement is to fabricate something that can handle goods for transportation across stair case.
After studying various options it was decided to build a hand truck that could be carry load across stair, also it was decided to power it manually so as to keep it in reach of many users. This will enable efficient handling of goods across stairs with less human energy .Details of various steps involve in project work are discussed in further chapter .

PROBLEM IDENTIFICATION

Before delving into the theory behind complex stair-climbing mechanisms, it should first be noted that it is possible to climb stairs using an ordinary wheel. The large wheels necessary for this task make this method of stair-climbing somewhat undesirable. Also, the climbing motion produced by simply rolling over stairs is a jarring motion rather than a smooth one. In addition, the frictional force between the wheel and the edge of the stair must be sufficient to allow the wheel to grab and roll over the stair. A friction coefficient oftoo small a magnitude will cause the wheel to slip against the stair rather than climb.A problem with prior art hand trucks or carrying carts is that is difficult for the operator to keep the truck under control when going down the stairs, and it is even more difficult to move heavy loads up on stairs because the operator is substantially pulling the load and the truck. It is common to have braking device operable to help prevent the truck from running away during its movement down the stairs. Another problem with existing hand trucks and carrying carts is that they are unsatisfactory for transporting heavy products. The trucks typically have pair of ground engaging wheels which wear quickly because of the heavy loads bearing downwardly directly on the wheels. The wheels develop flats spots and other irregularities on their exterior surfaces which make it difficult for the operator to maneuver the truck after extended use.

LITERATURE REVIEW

OVERVIEW

The stair-climbing hand truck is designed to reduce liability rather than increase it. Conventional hand trucks work well on flat ground, but their usefulness decreases when it becomes necessary to move an object over an irregular surface. Package deliverymen, for example, often find it necessary to drag loaded hand trucks up short flights of stairs just to reach the front door of a building. The entire purpose of using a conventional hand truck is to avoid having to lift and carry heavy objects around. Lifting a hand truck up the stairs defeats the purpose of the device, since the user must provide enough upward force to lift the entire weight of the cart and its contents. We have done market survey to collect the information regarding the utility of this .machine for small scale industries and other cottage industries customers. Also we carried away the market survey to see the raw material cost along with the finished product of the material required to fabricate our unit. We referred different books and journals along with the periodicals, industrials magazines to collect the information regarding our unit

1. HANDELING LARGE ,BULKY.OR AWKWARD ITEM

The information searched on the handling large, bulky or awkward item give the information that when implementing risk controls at your workplace, you must look at your hazards, assess the risk, and determine whether the risk can be eliminated or reduced as far as reasonably practicable. The *Occupational Health and Safety (OHS) Act 2004* (s. 35) from 1 January, 2006, will place a duty on employers to consult with employees, so far as is reasonably practicable, in this process. Your health and safety representatives (HSRs) and employees will often be the best source of information and ideas on workplace design, layout, work methods and new technology when looking at ways to manage risks arising from handling large, bulky or awkward items. They will also be able to identify whether the proposed solutions will lead to the introduction of other risks.
You should also consider involving people such as designers, consultants, suppliers and purchasing officers, particularly when looking at ways to influence what occurs in the supply chain upstream and downstream of your workplace. The criteria for 'large, bulky or awkward' items used in this Guide are items weighing 25kg or more and having one dimension 500mm or more. However, you may find the principles in this Guide will help make your work safer, even if the items you handle do not fit these

criteria. In looking at ways to eliminate or reduce the risk in consultation with your employees, you should consider the three elements below. Bear in mind that these are not necessarily discrete steps, and that the most practicable method to control risks in your situation may involve a combination of redesigning or repackaging, using mechanical aids, and/or team lifts.

It is expected that in most cases, team lifting would be the least preferred or a short-term solution, or used to supplement the handling of items where other ,non-manual handling methods have been investigated and applied where reasonably practicable. The information contained in this Guide is indicative and will not necessarily cover every workplace situation. Consideration must always be given to the Occupational Health and Safety *(Manual Handling)* Regulations 1999 *('Manual Handling Regulations 1999')*, when ascertaining the most practicable risk controls for your particular situation. These mechanisms are made by INDG398 and published in10/13. But in these mechanisms the disadvantage is that it is very large in construction so in our project we overcome these problems and made very robust mechanism.

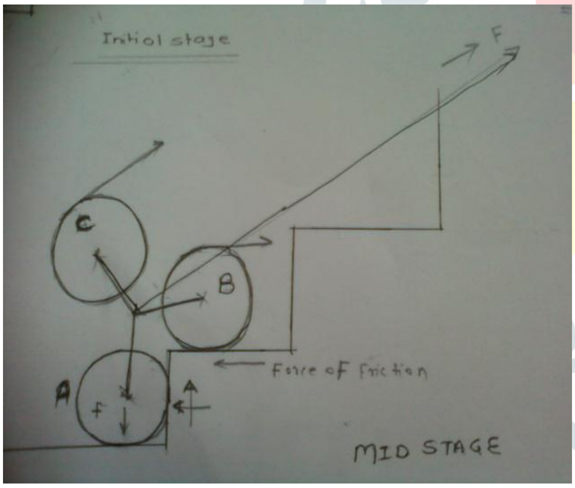
2. STAIR CLIMBING TRANSPORTER

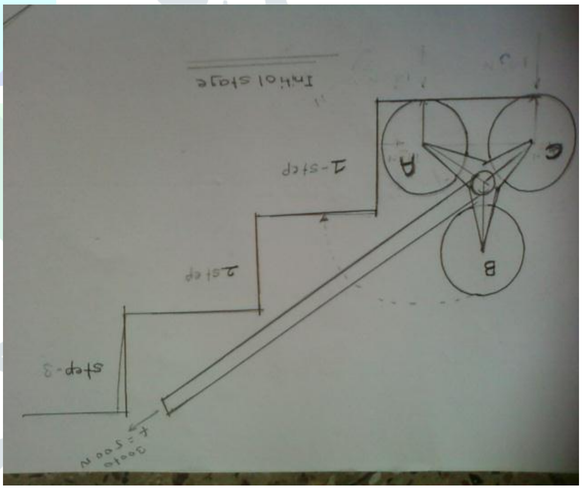
The information searched on stair climbing transporter gives us the information that it is a combination of rigid or restraining bodies so shaped and connected that they move upon each other with definite relative motion. A machine is a collection of mechanisms which transmits force from the source of power to the load to be overcome, and thus performs useful mechanical work. Robotics is the area of automation which integrates the technology in variegated fields like mechanisms, sensors & electronic control systems, artificial intelligence and embedded systems. The synthesis of mechanisms is the very first step in any robot design depending upon its application. These mechanism is very costly so we make a very cheaper transporter.

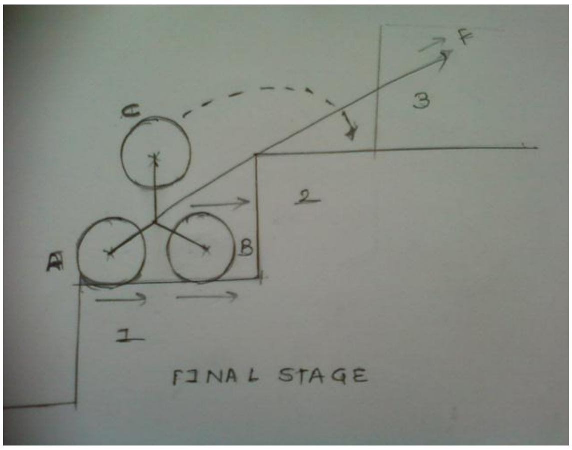
3. LIFTING AND HANDLING AIDS

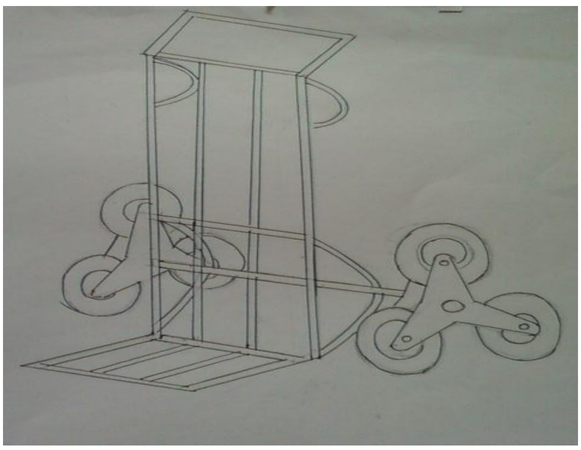
The information searched on Lifting and handling aids gives the information that how to transport the load from one place to another. Frequent and heavy lifting and handling can cause back injuries. But using lifting and handling aids can remove or reduce that risk and keep workers healthy and at work. This guidance is intended for managers, employees and their representatives and others involved in the selection of lifting and handling aids.In these mechanism they made a simple traully which help to transport the large load but it cannot help to carry a load from stair so in our project made atraully which help to carry a load from stair easily.It make very noise at working site these problem is solve in our project.

PROCESS METHODOLOGY









II. When a man will pull the handle of truck, the wheel 'A' will fix in corner which is made by the ground and step 1. After that when man will pull handle again the wheel 'B' will fixed in corner which is made by step 1 and step 2. Again man pull the truck, the wheel 'C' will fixed to the position at corner of step 2 & step 3 and so on. This working is repeated again and again while climbing on stairs vice versa.

DESIGN OF EXPERIMENT

OVERVIEW

We made stair climbing hand truck of

- Height – 4 feet.
- Lower frame 38 X 38 cm.
- Length of each arm of trigonal geometry 15 cm.
- Diameter of shaft 15 mm.

TECHNICAL DATA

Following part are used in the fabrication of project work named "stair climbing hand truck".

- Square bar cast iron pipe.
- Round bar shaft SAE 1030
- Rubber rest.
- Caster wheels (industrial rubber).
- Iron plate.
- Long guzzon pin.

We use following data while designing our hand truck:

Shaft: In general, a ROTATING member used for the transmission ofPower.

Axle: Generally a STATIONARY member used as a support for rotating Members such as bearings, wheels, idler gears, etc.

Spindle: A short shaft, usually of small diameter, usually rotating, e.g. Valve spindle for gate valve, but consider also the headstock spindle of a lathe, which is quite large and usually has a wholeright through its center.

Stub shaft: A shaft which is integral with an engine, motor or prime moverand is of suitable size, shape and projection to allow its easy connection to other shafts.

DESIGN STEPS

ASSUMING DATA:

N= 43 RPM

Weight=W=539N

Power=P=Weight * velocity

P=539*v

P =539N * V (m/s)

But, V= (ΠDN)/60

Here assume, D=0.01m

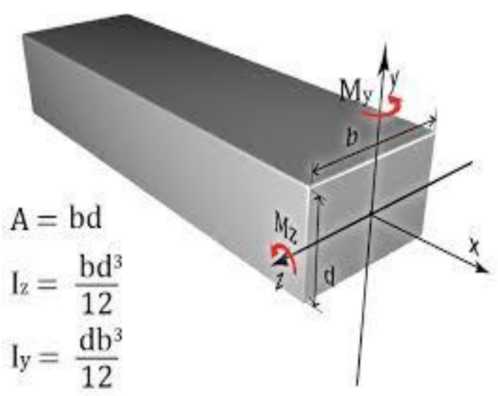
V= (π*0.01*43)/60

V=0.0225 m/s

Therefore, P=539*0.0225

P=12.12 Watt

DESIGN OF SHAFT:



Step: 1 Design Torque, T_d, N-m

$T_d = (60*P*K_l)/ (2\Pi N)$

Where, K_l=1.0

T_d= (60*12.12*1.0)/2π43
T_d=2.69 N-m

Step: 2 Reaction calculations:
∑FY =0
V_A-270sin45-270sin45+VD=0
V_A+VD=381.83N ………. (1)
Taking moment about A,
∑M_A=0
270sin45*80+270sin45*380-VD*460=0
V_D=161.03N
Put this value in eqn 1
V_A+161.03=381.83
V_A=220.8N

HORIZONTAL BENDING MOMENT CALCULATION:
Taking B.M. about A
M_A=0
B.M. at B, M_B
M_B=0
B.M at C, M_C
M_C=270cos45*300
M_C=57275.64N-mm
B.M. at D, MD
M_D=270cos45*380+270cos45*80
M_D=15764.42N-mm
VERTICAL BENDING MOMENT CALCULATION:
Taking V.B.M at A, V_A
V_A=0
Taking vertical B.M at B, V_B
V_B=220*80
V_B=17664 N-mm
Taking V.B.M at C, V_C
V_C=220*380-270sin45*300
V_C=26628.35 N-mm
Taking V.B.M at D, V_D
V_D=220*460-270sin45*380-270sin45*80
V_D=13745.33 N-mm
RESULTANT BENDING MOMENT CALCULATION:
R_{MA}=0
R_{MB}= $(02+17664^2)^{1/2}$ =17664 N-mm
R_{MC}= $(57275.64^2 + 26628.35^2)$ =63163.02 N-mm
R_{MD}= $(15764.422 + 13745.33^2)^{1/2}$=20915.33 N-mm
Taking maximum resultant bending moment:
M=R_{MC} =63163.02 N-mm
MATERIAL FOR SHAFT:
Assume shaft material as SAE-1030
S_{ut}=527 N/mm^2
S_{Yt}=296 N/mm^2
S_{ys}=183 N/mm^2
Assume factor of safety is 1
Bending stress, 6_b=S_{yt}/F.O.S
=296/1
=296 N/mm^2
TMAX=0.30 S_{yt} or t_{MAX}=0.18 S_{ut}
=0.30*296 or =0.18*527
=88.8 N/mm^2 or =53.28 N/mm^2
So take
t_{MAX}= 88.8 N/mm^2
For solid shaft,
t_{MAX}=$16*10^3/\Pi d^3 * (M^2 + T_D^2)^{1/2}$
88.8==$16*10^3/\Pi d^3 * (63.1632+2.69^2)^{1/2}$
d=15.36 mm

Take standard diameter as
d=16 mm
checking failure of bending stress
6_b =M/Z
=63.163*10^3/ (π/32)*16^3
=177 N/mm^2
6_b =177 N/mm^2 < 296 N/mm^2
So our design is safe.

SELECTION OF BEARING

Journal length l/d
From data book table no.XIII-4 page no.129

Bearing pressure (P) mPa	Suitable viscosity Z mPa-S	Minimum Zn/P
1.5	50	50

c/R	l/d	Maximum (PxV) mPa x m/min
0.001	1.0 – 2.0	50

Selecting l/d=1
Therefore l=d
P= W/(l x d) =540/ (50 x 50)
=0.216 mPa
0.216 mPa< 1.5 mPa
So O.K
Rubbing velocity
V = πdN / 60
= (π x 40 x 43) / (60 x 1000)
= 0.1125 m/sec
= 6.75 m/min
P x V =1.8225
1.458 < 50
So O.K
Radial clearance
C = (KR+0.002) mm
Selecting material for bearing.

Bearing material	Min Sommer fled no. S	Constant K
Tin base babbits	0.06	0.0005

d = 2 R
R = 50/2 = 25
C = (KR+0.002) mm
C= (0.005 x 25 + 0.002) mm
C=0.127 mm
R/C = 25/0.127
=196.85
Absolute Viscosity Z mPa
Z= P_t x ZK x 10^{-3}
P_t = P_{1j} – 0.00064
= 870-0.00064
P_t= 869.99

ZK = 41 for 15^0 C
Z = 869.99 x 41 x 10^{-3}
Z = 35.66
Sommer fled no. S.
S = (Z_n / P) $(R/C)^2$ x 10^{-9}
Assuming oil temperature
$t_{oil} = 80^0$ C
$t_a = 40^0$ C
$t_{oil} = 2 (t_b - t_a) + t_a$ ……………………………………………….Table no. XIII-1(14)
$t_b = (t_{oil} + t_a) / 2$
= (80+40)/2
=60 ^{0} C
A=projected area of journal
=40 x 40 x 10^{-6}
=1.6 x 10^{-3} m^2
Now H_d= KA (t_b-t_a)
For (t_a-t_b) = 20^0 C
K (t_b-t_a)/1.8 x 10^3=2.2 ……… for well veltinate bearing
K=(2.2 x 1.8 x 10^3) / 20 = 198 N/mm^2
H_d=K x 2.5 x 10^{-3} x 20
=198 x 2.5 x 10^{-3} x 20
=0.0018
(R/C) x μ = 32.066
For (R/C) x μ = 32.066
S = 0.15
Now grade of oil.
S = (Z_n/P) x $(R/C)^2$ x 10^{-9} =0.15
Z_n / P =32.70
Zn / P =32.70 < 50
So our design is safe .
For Z=1.78 ≈ 2 Light lubricating oil is used.

Coefficient of friction

For thick film lubrication =0.326(Z_n/P)(R/C) x 10^{-9} + t = 2.00 x 10^{-3}.
Coefficient of friction for marginal lubrication
= {(C1C2)/306} x $(P/V)^{1/2}$
But Zn/P = 32.70
P=32.70 / (35.11 x 0.716)
P = 1.2807
C_1=4 , C2= 1
= {(4 x 1) / 306} x $(1.2807 / 0.1125)^{1/2}$
= 0.044
Minimum film thickness;
h_m= 0.0040 mm……………….for low speed T-XIII-5 Pg. no.130
P-V limit for bearing
P x V = 120 m/min ……………..for Rotor T-XIII-4 Pg.no.129.
Heat generated
H_g = μ w V
= 9.9 w
Heat dessipited
H_d= KA $(tb-t_a+16)^2$
=1.6 x 10^{-3} x $(60-40+16)^2$
=0.5391
Temperature of oil
t_{oil} =2(t_b-t_a)+t_a
=2 (60-40) + 40
$t_{oil} = 80^0$ C
We did not use bearing because bearing is unable to take continuous stud load on it, and maintenance cost and repair cost is so much high, so we will not use bearing. We have used hub instead of bearing.

HUB DESINGS: -

di = internal diameter = 16 mm
Dh = Hub diameter = 2di
=2 x 16
= 32 mm
Dh≈50 mm
Length of hub Lh = (2 to 2.5) di
= 2.5 x di
=2.5 x 16
= 40 mm
≈50
Failure of hub
Considering shear failure (t)
Material C.I.SAE 30
Sys = 98, F.O.S = 3
t max = 98/3 = 32.66 N/mm^2
t = P/A = 540/ (π x (50^2-16^2)/4)
t = 0.306 N/mm^2
t max = 32.66 > 0.306 N/mm^2
So our design of hub is safe.

CONCLUSION

The project work thus carried out exhibits expected result, and carried load across the stair very easily thus climbing across stairs transportation of goods very easily.

This type of project work can be of very much use for industrial use, dispatched with new household.

REFERENCE

[1] Engineering Mechanics by R.S.KHURMI (120-122, 130-135,231-233) publicated by S.Chand publication.
[2] Design Data Book by B.D.SHIVALKAR (35, 39, 113,178) publicated by Denett and Co.
[3] http://www.ehow.com/facts_7194290_stair-climber-trolley.html
[4] http://www.ferret.com.au/c/Rotacaster-Wheel-Limited/Hand-Trucks-and-Stair-Climbing-Trolleys-p17151
[5] https://www.google.co.in/search?q=images+of+hollow+rectangular+shaft&espv=2&biw=1360&bih=667&source=lnms&tbm=isch&sa=X&ved=0ahUKEwi63ta7gePLAhWJPo4KHXa_DqoQ_AUIBigB#tbm=isch&q=images+of+plastic++wheel
[6] https://www.google.co.in/search?q=images+of+hollow+rectangular+shaft&espv=2&biw=1360&bih=667&source=lnms&tbm=isch&sa=X&ved=0ahUKEwi63ta7gePLAhWJPo4KHXa_DqoQ_AUIBigB
[7] https://www.google.co.in/webhp?sourceid=chrome-instant&ion=1&espv=2&ie=UTF-8#q=application+of+stair+climbing+hand+trolley