Computer Aided Modeling & Cost Estimation Of A Hand Truck

Sagar Shelare, Machchhendra Sonpimple, Trupti Gajbhiye

RTM Nagpur University, Department of Mechanical Engineering,
Priyadarshini College of Engineering, Nagpur, MH, India, PH-+91-9890027265
Sagmech24@email.com

RTM Nagpur University, Department of Mechanical Engineering,
Priyadarshini College of Engineering, Nagpur, MH, India, PH-+91-9423054182
msonpimple@email.com

RTM Nagpur University, Department of Electrical Engineering,
Priyadarshini College of Engineering, Nagpur, MH, India, PH-+91-9579334823
subhshell@email.com

Abstract: The proposed research focused on hand trucks used for transporting heavy load. Objective behind this research is to 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. This can be achieved by taking different parameters such as modification in shape of the assembly, by varying the thickness of the hollow pipe. For this purpose creo parametric 2.0 cad software will be used. The assembly will then test virtually with help of analysis software. Design a better stabilizer leg suspension system for a hand truck that adjusts to fit its terrain and has a customizable angle and height for its user. Designs and analysis of DC-powered, motorized, light material handling equipment. It pivots about an axle to let the hand truck angle vary on hills, ramps or uneven ground. Design a new solution or improve the existing one. This design needs to bolt up to the existing hand truck and provide ample strength, durability, and flexibility. Use an adjustable rate control device such as a spring assisted shock, gas spring or hydraulic shock, or even a simple rubber bushing. The main objective of this project is that to make a modified design in such a way that it operate with Safety more Versatility, Rugged and Reliable. And this achieved by using analytical as well as virtual method.

Keywords: Hand Truck, Computer Aided Modeling, FEA, Comparison.

1. Introduction

The use of powered and non-powered industrial trucks is subjected to certain hazards that cannot be completely eliminated by mechanical means. But by the intelligence practice and common sense, we can optimize the risks which are to be incorporated. It is therefore essential to have competent and careful operators, physically and mentally fit, and thoroughly trained in the safe operation of the equipment and the handling of the loads. Overloading, poor maintenance, load instability, collision with other objects or hurdles are some of the serious hazards for the model. Therefore proposed research will be overcome the above mentioned drawbacks and will be beneficial for the society.

2. Computer Aided Modeling

Modeling is the process of producing a model. A model is similar to but simpler than the system it represents. One purpose of a model is to enable the analyst to predict the effect of changes to the system. On the one hand, a model should be a close approximation to the real system and incorporate most of its salient features. On the other hand, it should not be so complex that it is impossible to understand and experiment with it. A good model is a judicious tradeoffs between realism and simplicity. An important issue in modeling is model validity. Model validation techniques include simulating the model under known input conditions and comparing model output with system output.

The proposed model of Hand Truck is:

Figure 1: *CAD Model of Motorized Hand Truck*

The detailed view of Hand Truck is:

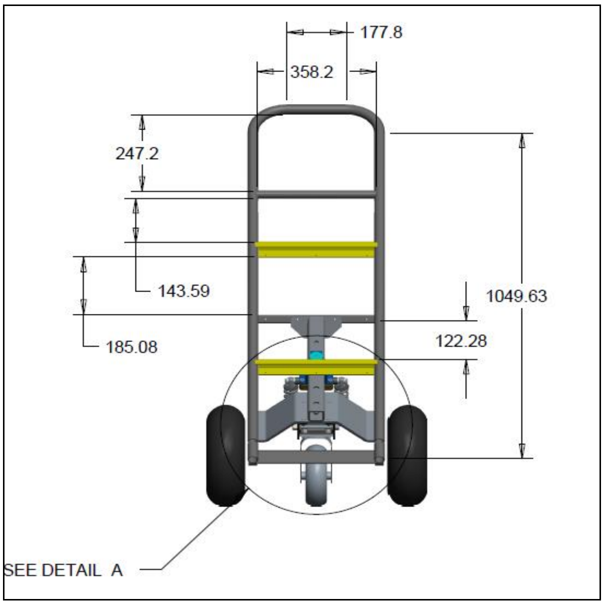

Figure 2: *Detailed Views of Hand Truck*

3. Design Calculation of Hand Truck

3.1 Design of Helical Compression Spring

Various parameters required for designing of Spring are as follows:
Weight of The Machine = 40Kg
Weight Of 1object = 110Kg
Total Weight = 40+110 = 150Kg
Total Weight = 150*9.81 = 1500N
Deflection Of The Spring(μ) = 50 mm
Resultant Shear Stress(Ť) = 350 N/mm^2
Modulus Of Rigidity (G) = 84000 N/mm^2

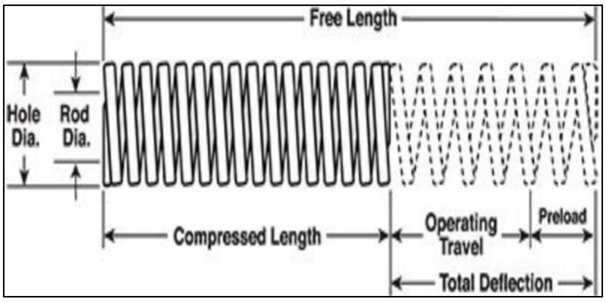

Figure 3: *Helical Compression Spring.*

Stifness of The Spring(K)=$\frac{W}{\mu}$ = $\frac{1500}{50}$= 30N/mm

Spring Index (C) =$\frac{D}{d}$

Where, D=Mean Diameter Of Coil, d=Wire Diameter
D=C*d

Shear Stress Factor Ks=1+$\frac{1}{2C}$ =1.0625

Resultant Shear Stress

Ť=K$_S$*$\frac{8WD}{\pi d^3}$

350=$\frac{8*1500*8}{\pi*d^2}$

d=10mm

D=C*d=80 mm

Deflection μ=$\frac{8WC^3n}{Gd}$

50=$\frac{8*1500*(8)^3*n}{84000*6}$

No. Of Active Coil (n) = 5
Assume Square And Ground Level
Total No. Of Coil(n$_1$) = n+2)=5+2=7
Now,
Solid Length Of Spring (L$_s$) =n$_1$*d =7*6=42mm
Free Length Of Spring (L$_f$) =L$_S$+μ$_{max}$+0.15μ$_{max}$
L$_f$=42+50+0.15*50 =99.5mm

Pitch Of The Coil (P)=$\frac{Lf}{n1-1}$ =$\frac{99.5}{6}$ =16mm

3.2 Design Of Bearing

A typical ball bearing is shown the Figure 4 The figure shown on the right side, with nomenclature, is the schematic representation of the actual bearing .

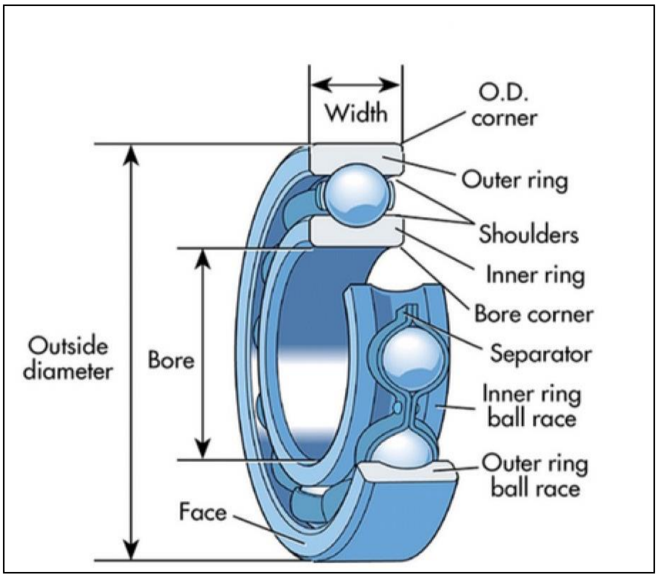

Figure 4: *Ball Bearing with nomenclature*

The load rating of a bearing is given for radial loads only. Therefore, if a bearing is subjected to both axial and radial load, then an equivalent radial load is estimated as,

Pea =PR   or   Pe=XVPr+YPa
Where,
Pe: Equivalent radial load Pr: Given radial load
Pa: Given axial load
V: Rotation factor (1.0, inner race rotating; 1.2, outer race rotating)
X: A radial factor   Y: An axial factor
Width (B) = 23mm   Outside diameter(D)=90mm
Bore (d) = 30mm

By using this parameter we have find bearing no.
Bearing No. =0406   by data book
From bearing no. we have find load capacity
C=33500
Assume bearing life
L$_{10}$=60 million revolution
We know that Bearing life
L$_{10}$= (C/Fe)^3

For 90% reliability k_{ref}=1
60= $(33500/Fe)^3$ ×1 ; Fe=8557N
Equivalent load is 8557N.
Equivalent load
Fe= (XFmr+YFma) ×k0×kp×kr
For deep groove ball bearing e=0.25
We also known that
E<Fma/Fmr
Select, Fma/Fmr =0.47 i.e. 0.47>0.25
Hence X=0.56, Y=1.6
8557= (0.56Fmr+1.6×0.47×Fmr)
8557=1.32Fmr
Fmr =6522N
Fma/6522 =0.47; Fma=3065
For mean axial load is 3065N
For 40% time Fr1=6.5KN, Fa=3.1KN at 300rpm for light shocks.
For 40% time Fr2=6KN, Fa=3KN at 200 rpm for medium shocks.
T1=0.4×60=24sec N1=900/60 ×24=120rpm
T2=0.4×60=24sec N2=200/60 × 24=80rpm
∑N=N1+N2=120+80=200
Fmr= $(Fr1^3×N1+Fr2^3×N2/N)^{1/3}$
= $((6.5×10^3)^3×120+ (6×10^3)^3×0/200)^{1/3}$
For axial load (Fa) = $((fa1)^3*N1+ (fa2)^3*N2/∑N)^{1/3}$
= $((3.1×10^3)×120+ (3×10^3)^3×80/200)^{1/3}$
Fma=3060N
That's why we select shaft speed approximately 200rpm
We select diameter of shaft is 40mm
We know that
Td=π/16 $×(D)^3$×Tmax
For selecting SAE1030 material Sut=527MPA, Syt=296MPA Tmax without key =0.18×Sut
0.3×Syt =0.18*527=94.86MPA
0.3*296=88.8MPA
Ťmax without key=88.8MPA
Ťmax with key =0.75*88.8=66.6MPA<Ťinduce
Td=π/16 $*(40)^3$*66.6=836.9N-mm
Therefore we have calculated design power
Pd=2πNTd/60 =2π×200*836.9*10^3/60 =17.52kw

3.3 Design of Shaft

A shaft is a rotating member usually of circular cross section (solid or hollow), which is used to transmit power and rotational motion. Axles are non rotating member. Considering the shafts to be made of SAE 1030 Power provided by the motor,
p = 1 HP = HP = 746 watts = 0.746KW
Speed of the shaft, N1 =495 RPM.

Design Torque,
T_d = (p× 60)×K_1/(2× π × N_1
Here load factor, K_1 =1.75
T_d= (746 ×60) ×1.75/ (2 ×π ×495) = 25.1978 N-m

Considering c only,
$(T_1 / T_2)_A = e^{\mu\times\theta}$
Since μ= 0.1 for C.I. – C.I. Material pair
And included angle is θ= 180° or π
Thus , $(T_1 / T_2)_A = e^{0.1\times\pi}$ = 1.37
T_{1A} = $1.37(T_2)_A$
$T_d = (T_1 - T_2)_A \times r_A$
→ 25.1978 × 10^3 = $(T_1 - T_2)_A \times r_A$
$N_1D_1=N_2D_2$
R_D=27 mm,N_2=495
By calculating D2=152mm ,r_C=76 mm, T_2=220.8957 N
T_1=565.4932 N
Also,
T_1+T_2=786.3889 N
Considering D only,
$(T_1 / T_2)_A = e^{\mu\times\theta}$
Since μ= 0.1 for C.I. – C.I. Material pair
And included angle is θ= 180° or π
Thus ,
$(T_1 / T_2)_A = e^{0.1\times\pi}$
= 1.37
→ $(T_1)_A = 1.37(T_2)_A$
And
$T_d = (T_1 - T_2)_A \times r_A$
→ 25.1978 × 10^3 = $(T_1 - T_2)_A \times r_A$
$N_1D_1=N_2D_2$
R_D=27 mm,N_2=495
By calculating D2=152mm, rd=27 mm
T_2=2530 N
T_1=3476 N
Also,
T_1+T_2 = 6006 N

Considering vertical forces only for vertical moment diagram:
$R_{AV}+R_{BV}$ =25.05+8.377N
= 33.427N
∑ fy=0
$∑M_A$=0
- R_{BV}*400+8.377*425-25.04*25=0
R_{BV} =7.335 N
R_{AV}= 26.091 N

Moment at points
M_{CV} = 0 M_{AV} = -625.25
M_{BV} = -209.85 M_{DV} = 0

Shear force diagram
F AT C = -25.05N F AT A = 1.041N
F AT B = 8.376N F AT D = 0 N

Considering vertical forces only for horizontal moment diagram,
$R_{AH}+R_{BH}$ =786.3889+6006N
= 6792.3889N
∑ fy=0 $∑M_A$=0
- R_{BV}*400-786.3889*25+6006*425=0
R_{BH} =6332.2256 N R_{AH}= 460.1632 N

Moment at points
M_{CH} = 0 M_{AH}= -19659.7225
M_{BH} =-147750.0025 M_{DH} = 0

Shear force diagram
F AT C = -786.3889N F AT A = -326.2257N
F AT B = 6005.99N F AT D = 0 N

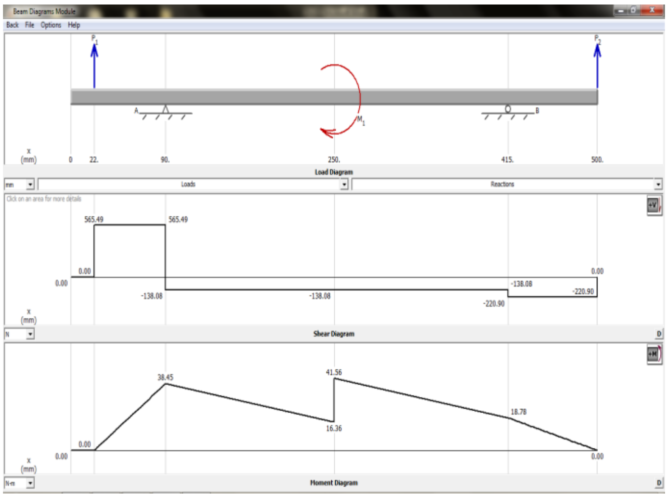

Figure 5: *Bending moment and Shear force diagram for Shaft*

4. Cost Estimation of Hand Truck

Cost Estimation provides the approximate cost for development of the actual hand truck. As per the market survey cost varies from location to another location. The optimized cost of Hand Truck as given in Table 1.

S N.	MATERIAL	COST (Rs)
1	400 rpm based gear motor	15000
2	Spur gear train	3400
3	Padesten bearing	800
4	Brake assembly	1200
5	Tube chasis 10mm hallow pipe	4500
6	Fixture / pallet 4mm Thick sheet	1000
7	Electrical switch 16amp	600
8	Battery 12v 9amp and above	3500
9	Caster wheel	1000
	Total	31,000

5. Results and Conclusion

In this project, we provided methods and modeling techniques that allowed us to deal with different MHSs in a generic manner. Consequently, we showed that generic control of MHSs in different industrial sectors is possible. The use of generic control is two-fold: first, from a scientific perspective, this thesis provides a basis to build a general control theory for MHSs in different industrial sectors. Second, from a practical perspective, we offer an approach for MHSs' supplier that improves on the 147 MHSs' design aspects in terms of system development time, maintainability, and upgradeability. Implementation of this project is having very important aspect in terms of weighing heavy weight. For effective implementation obstacles must be taken care of before initiation and should be backed with action plan to overcome them. This Standard defines the safety requirements relating to the elements of design, operation, and maintenance of low lift and high lift powered industrial trucks controlled by a riding or walking operator, and intended for use on compacted, improved surfaces. Total cost for fabrication is approximately Rs. 31,000.

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