

# Design and Modeling of Drum Handling Equipment

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## Abstract

This paper presents the use of drum handling equipment in the industries to reduce worker for drum handling. Material handling effect on human studied in this paper. Also study different material handling equipment used in industries.

**Keywords: Industries, Material Handlings, Material Handling Hazards**

## I. INTRODUCTION

In many industries raw material and finished product handled in 210Lit. Drum. They handle drum manually. In work place drum transported, lifted, Loaded, tilted etc. manually. Handling heavy load manually takes more time, also it is hazards and risky. In small pharmaceutical company around 25 different type of raw material use. It is in liquid form which is taken out from 210lit. Drum by loading on horizontal stand. Company requires effective material handling equipment to solve material handling problem.

Manual drum handling equipment is used to do various function like transport, tilting, lifting, loading, unloading etc. In small industries or work shop drum barrel is handled manually which takes more time and more worker. Handling drum manually without using any equipment is hazards.

Manual handling is transporting or supporting of a load by one or more workers. It includes the following activities: lifting, holding, putting down, pushing, pulling, carrying or moving of a load.1 The load can be an animate (people or animals) or inanimate (boxes, tools etc.) object.

Manual handling occurs in almost all working environments (factories, warehouses, building sites, farms, hospitals, offices etc.). It can include lifting boxes at a packaging line, handling construction materials, pushing carts, handling patients in hospitals, and cleaning.

## II. CONCEPT

In this, following objectives are to be carried out –

- 1) To minimize worker for Drum transporting, loading, unloading, lifting and tilting process.
- 2) To study material handling equipment for Drum handling.
- 3) To study the lifting and loading effect on human.
- 4) To study the ergonomic of material handling.
- 5) To Design modified drum tilting mechanism.
- 6) To fabricate prototype model.
- 7) Testing and conclusion.

## III. LITERATURE REVIEW

Literature review areas of research considered in the past, to be explained the approaches used & the new ideas. It is an assignment of previous task done by some authors and collection of information or data from research papers published in journals to progress our task. It is a way through which we can find new ideas, concept. There is lot of literatures published before on the same task; some reference papers are taken into consideration from which idea of the project is taken, the other reference will we discussed later.

- 1) Work Safe victoria: In this title “A Guide to Manual Handling in the Food Industry” explains material handling in food industries. The Guide demonstrates both Work Safe’s and the industry’s expectations on how to best reduce the risk of musculoskeletal disorders arising from manual handling in the food industry
- 2) Work Cover: In this title “Manual Handling Resources” Explain better use material handling equipment for the different application like in cleaning of floor, storing easy method etc. Also explain how to reduce work load and maximize safety.
- 3) Environment, Health, and Safety: In paper title “Safe Manual Material Handling” by University Of California explain frequent lifting, carrying, pushing, pulling, lowering and raising materials by hand. Staff who lift or perform other materials handling tasks may be at risk for back or other injuries.
- 4) Rajib Kumar Bhattacharjya In this title “Engineering Mechanics“Explain Truss , forces , torque and friction in Engineering mechanic.
- 5) European Agency for Safe and health in his title “Hazard and risks associated with manual handling in the workplace” Explain the risk associated with manual material handling at work place. Also explain back injury due to load handling.
- 6) Health and Safety Executive. In His title “Making the best use of lifting and handling aids” Explain the how to use the material handling equipment for various application in industries. by–www.hse.gov.uk/pubns/indg398.htm.
- 7) Clyde Material Handling. In His title “Material Handling Solution for the Food & Pharmaceutical Industries” Explain the use of material handling equipment in pharmaceutical industries. And also explain requirement of in material handling in pharmaceutical industries.
- 8) California Department of Industrial Relations In this Title “Manual Material Handling” written for managers and supervisors in industries that involve the manual handling of containers. It offers suggestions to improve the handling of rectangular, square, and cylindrical containers, sacks, and bags. “Improving Manual Material Handling in Your Workplace”
- 9) Work Safe Victoria In this Title “Safety by design” Explain The transportation of goods plays a major role in Australia is national and international activities. This booklet helps to identify some of the potential risks and provides solutions and tips to help reduce injuries in the transport industry.
- 10) R. A. Gujar1, S. V. Bhaskar “Shaft Design under Fatigue Loading By Using Modified Goodman Method” In this paper, shaft employed in an Inertia dynamometer rotated at 1000rpm is studied. Considering the system, forces, torque acting on a shaft is used to calculate the stresses induced.

#### IV. RESEARCH METHODOLOGY

The research methodology will cover follows.

- 1) Sufficient literature related to manual drum handling equipment is available.
- 2) Initially effect of manual handling of loading, lifting, transporting etc. on human being is studied from the available literature.
- 3) Existing machine for manual drum handling equipment will be studied thoroughly.
- 4) Advantages of drum handling equipment using in pharmaceutical industries and automobile work shop are studied.
- 5) Ergonomic of material handling be studied.
- 6) Design of modified drum tilting, racker(stacker) mechanism will be made.
- 7) Simulation with help of software will be made. Also modified fabricated model will be prepared. The conclusion and future scope of work will be discussed in the end.

##### A. Problem Identification

- 1) Problem of taking out different type chemical (around 25 types) from Drum in Pharmaceutical industries.
- 2) Problem for Loading of oil barrel on the rack in compact space at Automobile work shop.
- 3) Reduce worker from 4 to 1 for doing work of Drum tilting.
- 4) Problem of Back pain while lifting load.
- 5) Danger of Muscular injury while handling drum manually.
- 6) It should non-reactive to chemical used in the company.
- 7) Limitation of safe load lifting capacity for human.
- 8) There is no proper holding arrangement on drum

#### NOMENCLATURE

Sr. No.	Symbol	Meaning
1.	W	Total weight to be tilt
2.	M1	load force
3.	M2	effort force
4.	MR	Multiplier Ratio

5.	$T$	Torque
6.	$E$	Modulus of elasticity
7.	$N$	Speed of shaft in rpm
8.	$d$	Diameter of the shaft
9.	$N_g$	Velocity of gear
10.	$P$	Power
11.	V. R.	velocity ratio
12.	$\lambda$	Lead angle
13.	$t_w$	Tooth on worm
14.	$\phi_n$	Pressure angle
15.	$T_g$	Tooth on gear
16.	$p_d$	Design Power
17.	$p_r$	Rated Power
18.	$k_l$	Load factor
19.	$D_g$	Diameter of gear
20.	$V_p$	pitch line velocity of gear
21.	$m$	module
22.	$F_t$	Tooth load
23.	$F_B$	Beam strength
24.	$F_d$	Dynamic load
25.	$\eta$	Efficiency of worm gear drive
26.	$b$	Face width of gear
27.	$Q1$	Heat Generated
28.	$Q2$	Heat Dissipated
29.	$A$	heat dissipation area
30.	$L$	Length of the muff
31.	$d_o$	outer diameter of the muff

## V. DESIGN CALCULATION

### A. Calculation for Drive System

By lever and fulcrum Mechanism



Where  $M_1$ =load force (N, lb)

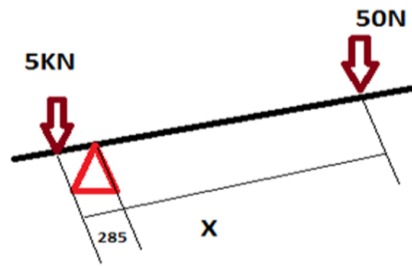
$M_2$ = effort force (N, lb)

$a$  =distan. From load force to fulcrum (m,ft)

$b$  =distan. From effort force to fulcrum (m,ft)

Calculating length of lever for lift drum of weight 500 kg (5KN)

Consider Effort to work 50N



$$M_1 \times A = M_2 \times b$$

$$5\text{KN} \times 285 = X \times 50\text{N}$$

$$X = 28500\text{mm}$$

To reduce X distance we use drive system.

**B. Now Calculate Gear Ratio**

$$\text{Output Torque} = \text{MR} \times \text{Input Torque}$$

Where

$$\text{Multiplier Ratio} = \text{Driven/Driver}$$

$$\text{Torque } T = \text{Force} \times \text{Radius (Units are Nm)}$$

Torque equals Force multiplied by Distance

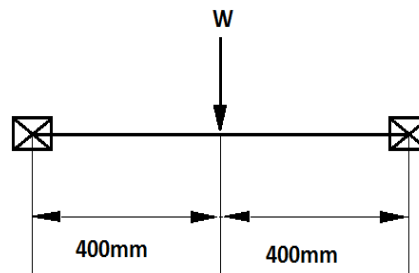
$$\begin{aligned} \text{Output Torque} &= \text{Weight of drum} \times \text{C.G. from support} \\ &= 4.9\text{KN} \times .285\text{m} \\ &= 1.396\text{KNm} \end{aligned}$$

$$\begin{aligned} \text{Input Torque} &= \text{force} \times \text{length of handle} \\ &= 50\text{N} \times .5\text{m} \\ &= 25 \text{ Nm} \end{aligned}$$

$$\begin{aligned} \text{Output Torque} &= \text{MR} \times \text{Input Torque} \\ \text{MR} &= 1396/25 \\ \text{MR} &= 55.84 \end{aligned}$$

Design Drive for MR (Gear Ratio)

**C. Design of the Shaft**



Mass of Drum 500 Kg

Mass of Drum 500 Kg

$$\text{Weight of drum} = 500 \times 9.81 = 4.9 \text{ KN}$$

$$\text{Moment of inertia } I = (\pi D^4) / 64$$

Where D= Diameter of shaft

$$L = 759\text{mm}, a=b=379.5(\text{distance between two bearing})$$

SAE 1030 steel used for the shaft  $E = 79 \times 10^3 \text{ MPa}$

Find Deflection in the shaft ( $\delta$ )

$$\delta = w \times a^2 \times b^2 / 3EIL$$

$$\delta = (4.9 \times 10^3 \times 379.5^2 \times 379^2 \times 64) / (3 \times 79 \times 10^3 \times \pi \times d^4 \times 759)$$

$$\delta = 1152.1 \times 10^4 / d^4$$

$$N = 945 / (\delta)^{1/2}$$

$$N = 120\text{rpm}$$

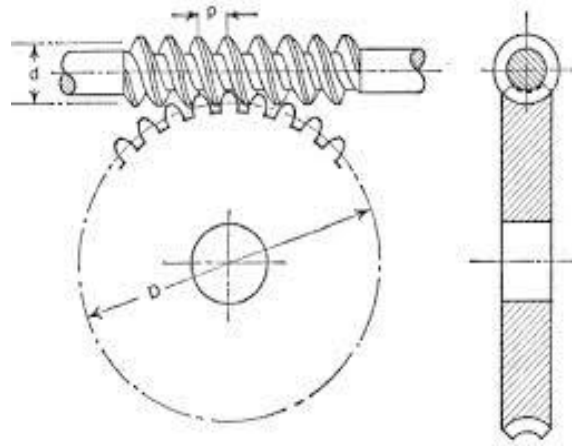
Design shaft

$$240 = 945 \times d^2 / (10^2 \times (1152.1)^{1/2})$$

$$d = 30\text{mm.}$$

Diameter of the shaft  $d = 30\text{mm}$

**D. Calculation of Worm and Gear Drive**



Load  $W = 500\text{Kg} = 500 \times 9.81$   
 $= 50\text{KN}$

Velocity of gear  $N_g = 4 \text{ rpm}$

Power  $P = \left( \frac{50 \times 4}{60 \times 9.81 \times 94} \right)$   
 $= 3.8 \text{ KW}$

From T- XV-6 ( D. M. E) Selecting  $t_w=1$  For velocity ratio 36 & above ,

$T_g = t_w \times V. R.$   
 $= 1 \times 50$   
 $= 50$

From T-XVI-6 Lead angle  $\lambda = 6^\circ$  per worm tooth and minimum  $9^\circ$   
 Lead angle  $9^\circ$

For Compact design ,

$\lambda = \tan^{-1} \sqrt[3]{\frac{N_g}{N_w}}$

Assume  $\lambda = 14^\circ$  – Lead Angle

Pressure angle,  $\phi_n$

From T-XVI-16

For  $\lambda = 12^\circ - 20^\circ$ ,  $\phi_n = 20^\circ$

Now calculate Design Power ( $p_d$ ) Watts

From T-XVI-15 (D. M. E.)

$(p_d) = (p_r) \times k_1$

Where  $(p_r)$ = Rated Power, Watts

$k_1$  = Load factor, Table XI-5 (D. M. E.)

$k_1$  for line shaft = 1.75

$(p_d) = 3.8 \times 1.75$

$= 6.65\text{KW}$

Let the module of the gear be ‘m’ mm

$\therefore D_g = T_g \times m, \text{ mm}$

$= 60 \times m$

$V_p = \pi \times D_g \times N_g$

$V_p = \pi \times \frac{60m}{1000} \times \frac{4}{60}$

$V_p = .012\text{ m/sec.}$

Tooth load  $F_t(\text{N})$

$F_t = \frac{V_p p_d}{V_p}$

Where  $V_p$ = pitch line velocity of gear m/sec

$= \frac{6.65 \times 10^3}{.012\text{m}}$

$F_t = \frac{554.166 \times 10^3}{\text{m}} \text{N}$

From T. No. XVI-18

Beam strength by lewis eq<sup>n</sup>

$$F_B = S_0 \cdot C'_v \cdot b \cdot y \cdot m$$

Where

$S_0$  = Basic strength, table no. T-XVI-10

$C'_v$  = Velocity Factor

$Y$  = Modified Lewis form factor

$b$  = Base width of gear

Material of construction

Worm – SAE 3120steel

Gear – Ph bronze SAE 65,  $S_0 = 84$

$C'_v = .75$  (trial value)

$b = 2.38 \times \pi \times m$

$= 7.47m$

$Y = .314 + 0.0151(\theta_n - 14.5^\circ)$

$= .397$

$F_B = 84 \times .75 \times 7.47 \times 0.397m^2$

$\therefore F_B = 193.58m^2$

Equating  $F_B$  to  $F_t$

$$193.58 m^2 = \frac{554.166 \times 10^3}{m}$$

$\therefore m = 17.19\text{mm}$

From T-XVI

Selecting standard module of 16mm

$\therefore D_g = 60 \times 16 = 960\text{mm}$

$V_p = .012 \times 16 = 0.192 \text{ m/sec}$

$C'_v = (6/(6+16)) = 0.79$

From XVI -19

$b = 2.38 \times \pi \times 16 + 6.25$

$= 125.8\text{mm}$

$$F_t = \frac{554.166 \times 10^3}{m}$$

$$= \frac{554.166 \times 10^3}{16}$$

$F_t = 34.63 \times 10^3$

$\therefore F_B = 193.58m^2$

$= 193.58 \times (16)^2$

$= 49.55 \times 10^3$

$\therefore F_B > F_t$

So design is o.k.

To check for wear

$$F_d = \frac{F_t}{C'_v}$$

$= (34.63 \times 10^3) / 0.79$

$F_d = 43.83 \times 10^3 \text{ N}$

From T-XVI-15

Limiting wear strength (N)

$F_w = D_g \times b \times K_2$

Where

$b$  = face width of gear

$K_2$  = Load stress factor from table T-XVI-17

For Ph- Bronze

$K_2 = .70\text{MPa}$

$F_w = 960 \times 125.8 \times .7$

$= 84.537 \times 10^3$

As  $F_w > F_d$

So Design is o.k.

From T-XVI-19

$D_w$  = Pitch Diameter of shaft

$= 2.4 \times \pi \times 16 + 27.5$

$= 148.137$

From T-XVI-16 (D. M. E.)

$$C = \frac{D_g + D_w}{2}$$

$$= \frac{960 + 148.137}{2}$$

$$C = 554.06\text{mm}$$

To Calculate Temp. rise  $\Delta T$

$V_R$  = Rubbing velocity

$$= \frac{\pi D_w N_w}{\cos \lambda \times 10^3}$$

$$= \frac{\pi \times 148.13 \times 240}{\cos 14 \times 10^3}$$

$$V_R = 115.10\text{m/min}$$

Efficiency of worm gear drive,  $\eta$

$$\eta = \frac{\cos \theta - \mu \tan \lambda}{\cos \theta + \mu \cot \lambda}$$

Where

$$\tan \theta = \tan \phi_n \times \cos \lambda$$

$\mu$  = Coefficient of friction  $V_R^{0.28}$

From T-XVI-6

For med speed 10-170

$$\mu = \frac{0.132}{V_R^{0.28}}$$

$$\mu = 0.034$$

From T-XVI-15

$$\tan \theta = \tan \phi_n \times \cos \lambda$$

$$\tan \theta = \tan 20^\circ \times \cos 14^\circ$$

$$\theta = 19.44^\circ$$

$$\eta = \frac{\cos(19.44) - 0.034 \times \tan(14)}{\cos(19.4) + 0.034 \cot(14)}$$

$$\eta = 0.865$$

Heat Generated in Worm gear

$Q_1$ , Watts

$$Q_1 = (1 - \eta) (P_R)$$

$$= (1 - 0.865) \times 3.8 \times 10^3$$

$$= 513\text{W}$$

Heat Dissipated  $Q$  Watt

$$Q_2 = K.A.\Delta t$$

Where

A= heat dissipation area

$$K = .4 \times 10^3 \text{W/mm}^2$$

t= Temp rise

$$A = (\pi \times D_g^2) / 4 + d_w \cdot L_w$$

$$L_w = (4.5 + 0.2 \times 2) \pi \times 16$$

$$= 246.30\text{mm}$$

$$A = (\pi \times 960^2) / 4 + 148.18 \times 246.30$$

$$= 76.031 \times 10^4 \text{mm}^2$$

$$Q_2 = K.A.\Delta t$$

$$= 0.4 \times 10^3 \times 76.031 \times 10^4 \times \Delta t$$

$$= 304.12 \times \Delta t$$

Putting  $Q_1 = Q_2$

$$513 = 304.12 \Delta t$$

$$\Delta t = 1.68^\circ$$

This is within limits of about  $40^\circ$  so o.k.

The Proportion of worm and gear are

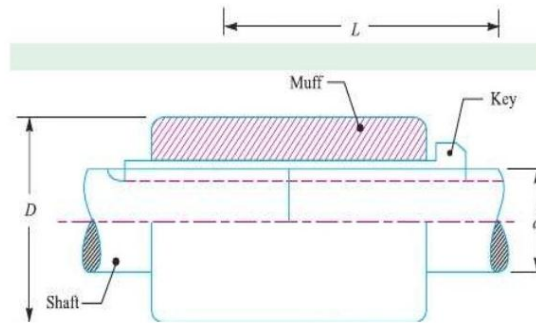
$$D_w = 148.18\text{mm}, \quad l_w = 246.30\text{mm}$$

$$D_g = 960\text{mm}, \quad b = 125.8\text{mm}$$

$$m = 16\text{mm},$$

$$t_w = 1, \quad t_g = 60$$

### E. Design of Coupling



The outer diameter of the muff,  $D$ , the length of the muff,  $L$ , and the bolt diameter  $d_b$  are the dimensions required to be determined for split muff coupling. These dimensions can be calculated from following empirical relations with shaft diameter,  $d$ .

$$d_o = 2 \times d + 13$$

$$= 2 \times 30 + 13$$

$$d_o = 73 \text{ mm}$$

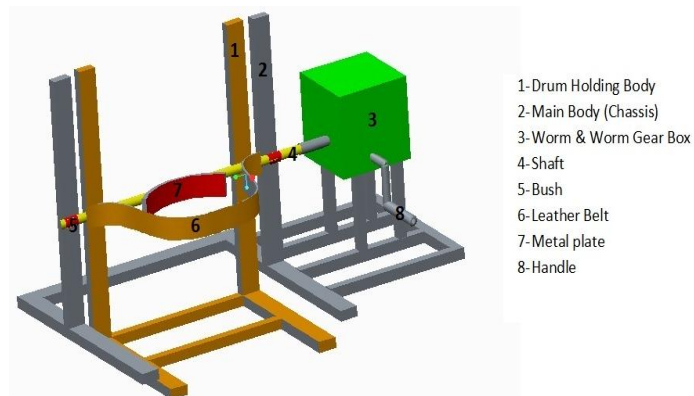
Length of the muff

$$L = 3.5 \times d$$

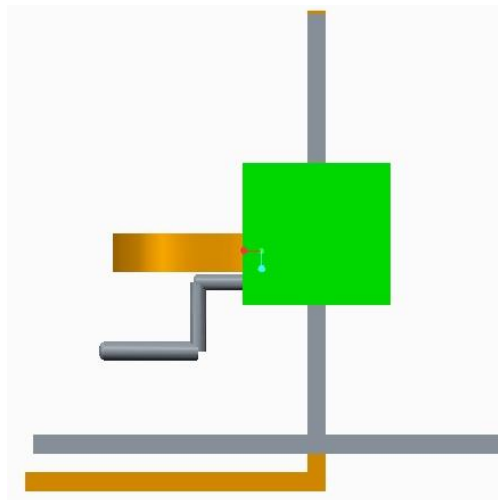
$$= 3.5 \times 30$$

$$= 105 \text{ mm}$$

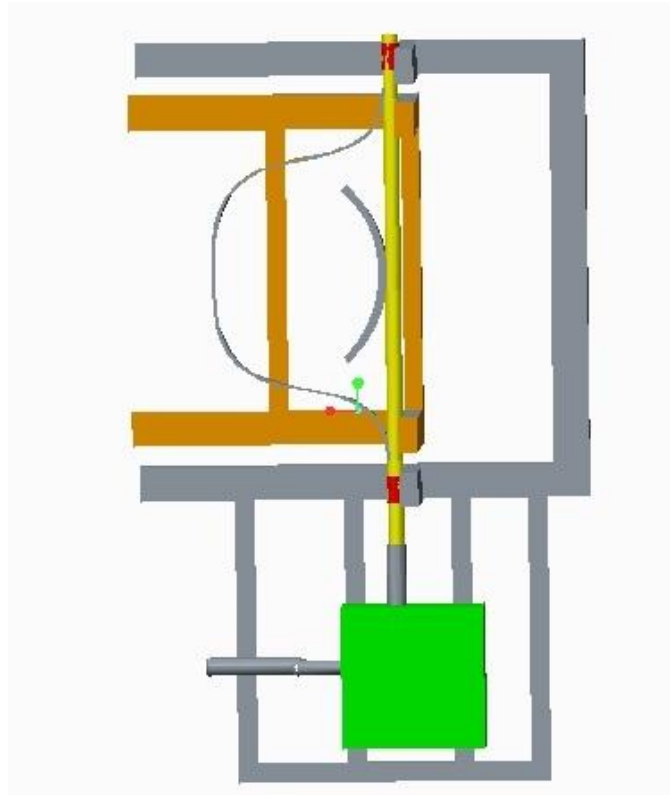
### F. Cad Model



### G. Side View



## H. Top View



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