Design and Fabrication of Patient Transferring Device

[1]SanjuKumar Pujari, [1]Sathisha T, [4]Sachin, [1]Revan Swamy, [2]N Nagasuresh Babu
[1]Student, [2] Assistant Professor
School of Mechanical Engineering, REVA University, Bangalore, India.

Abstract: Patient transferring device is a mobility aid which allows the person to transfer the patient from one location to the other. This project designed in such a way that could transfer the patient with critical injuries, stroke, paralysis, infectious diseases, disabled person and other health related problems from wheel chair to the hospital bed with the aid of only one nurse especially while transferring a patient lying on the wheelchair cum stretcher to the adjacent hospital bed effortlessly and efficiently. The design of the project includes modelling, calculations for selection of standard cross-section material used for the chassis of the device, gear design, kinematic calculation on the connecting rods which takes part in the conversion of wheelchair to stretcher/ straight bed and vice-versa. The main focus of this project is to design a patient transferring device where no physical contact between patient and the wheelchair operator is seen while transferring the patient to any bed from the wheelchair.

***Key words* – Mobility aid, wheelchair, straight bed, design.**

I. INTRODUCTION

In today's modern generation people are rushing for a very comfortable and effortless lifestyle irrespective of the job they are doing. Some of those examples which one can take are advanced home appliances which are ubiquitous in the modern era, which makes it easier for people to enjoy fulfilling and interesting daily lives. And not only in the kitchen appliances but advancement in effortless job is boosting rapidly in various manufacturing industries while handling the warehouse or moving the raw materials during the production by means of various material handling equipment which are again meant to reduce the effort by worker, advancement in hotel management, introduction of vending machine to dispense items in this busy modern era is again a very good example of effortless job.

So, in the similar way this project mainly focuses on the concept of transferring a patient at hospitals from moving wheelchair to bed and vice-versa effortlessly. In the hospitals generally if the patient is too heavy or is a senior citizen in that case nurses has to put so much of effort to transfer a patient to the bed smoothly which requires roughly 2-3 person for that job.

In some of the scenario the patient will be suffering from severe injuries such as burn injuries, spinal cord injury, soft tissue injury, swollen muscles, bone dislocations due to accidents, patient who have fractured femur, the patient which has gone through any surgery, especially the patient who is suffering from an infectious disease like coronavirus disease(COVID-19), Ebola and so many of such deadly diseases where touching the diseased person is a serious concern and which can affect the health of nurse.

The design is made by keeping in the mind that any minute displacement or any sort of movement to patient body especially in severe burn injuries may lead to discomfort and painful to the patient. Hence to solve the problems related to transferring a patient from moving chair to bed, we have come up with an idea of patient transferring device. The device is designed in such a way that the patient can be transferred from wheel chair to the bed and vice-versa with a reduced human intervention. This device is designed in such a way that it can be folded to a wheelchair as well as into a straight bed. Now the question arises that what is the need of conversion of wheelchair to bed and again from bed to wheelchair even though there are patient trollies available in the market? The reason is that, not in every case the patient will be suffering from the health problems wherein he or she cannot walk at all. There might be some cases of minor injuries such as toe injury, hand injury (fractures or other accidental injuries), diabetes, etc. in which patient has to be shifted to other wards or hospitals and the space constraint is unfavorable to carry the patient, at that point of time patient bed need to be converted to chair in order to reduce the length of the device. The design of this device is simple and very much suitable for almost all range of height of beds at hospitals.

II. LITERATURE REVIEW

1. In this paper author has designed and fabricated pneumatically powered stretcher-chair convertible device with movable support segments in an attempt to help such patients and caregivers. This helps the caregiver avoid heavy lifting situations that put their back at risk of injury. The caregiver can merely shift the patient from a bed on to the device while the device is in the form of a stretcher. Then the device can be converted into a wheelchair automatically with a press of a button. This can be done in the reverse direction as well, when the patients in sitting in the wheel chair can be converted to a stretcher smoothly for the purpose of diagnosis etc.
2. Author in this paper tries to understand various issues regarding mobility equipment, the better design will be an asset for medical field and helping hand for disabled individual. The present project proposes a development of wheelchair cum stretcher with ability to transfer patients from normal staircase also with automated electronic control over stretcher cum wheelchair for

movement and functioning. Self-proceed wheels invention was created enormous demand in the market and it was better helping aid for the disabled individuals. These will be one of the walking aids which can help with impaired ability to walk using wheelchairs for the disabled peoples.

3. This paper describes the design and fabrication of a multipurpose Stretcher for patients. They are required to design and create a multipurpose stretcher which uses gears and belts for lateral movement and hydraulic jacks for adjustment of the height of the beds. The stretcher will be controlled manually with a wheel for lead screw and an extension lever for hydraulic jacks using legs. Currently the stretcher is only designed for linear movement. However, plans to incorporate maneuverability and other functions can be implemented after the first stage of the development achieves success.

4. The author was intended to develop a concept for an automated wheelchair convertible stretcher, with the motivation of saving space and precluding exertion by the patient. Adopting various methods helped us identify the various issues of the topic, importance of safety and significance of materials and manufacturing process involved in the whole product. From the identified needs ergonomic design, mechanism and safety were prioritized by them. The conversion feature of this device makes patient transfer easier. This device combines the concept of patient mobility and patient transfer.

III. OBJECTIVE

- Designing an efficient way of transferring a patient from wheelchair cum bed to the adjacent bed with minimal human efforts. Transfer of patient is done by smooth rolling of patient lying bed over the adjacent hospital/ home/ any other bed.
- Determination of standard dimension for Stainless Steel material which is to be used in the fabrication of patient transferring device. And also to determine the various load acting on other parts of the device by virtue of patient weight and the weight of the material being used for fabrication in order to design the suitable spur gear which is operated in conversion of wheelchair to bed and vice-versa.

IV. ABOUT THE DEVICE

The patient transferring device consists of primary and secondary bed. Both primary and secondary beds are divided into three parts viz. Backrest, Sitting portion, Leg rest. The primary bed is one which consists of cushions and the secondary bed is the one which is made up of metallic frame. Primary bed rests upon secondary bed and can be detached while transferring the patient. It has the rollers attached at the base to guide it to the adjacent bed thus, helping in transferring of patient along with primary cushioning bed. The secondary bed which is made of metallic frame is fixed to the device and only helps in conversion of wheelchair to bed and from straight bed to wheelchair. This conversion is made possible by the connecting rods which are attached to the backrest and leg rest of the metallic frame which in turn is attached to the rack at the bottom of device which is driven by a rotating spur gear.

Primary bed is made up of L-shaped metallic frame, plywood and soft cushions. It is the actual bed upon which patient will be resting and is placed upon hospital metallic/ wooden beds. The rollers are the part of primary bed and it is not detachable from it. The major components of this device are backrest, leg rest, sitting portion, connecting rod, rack & gear, screw jack, wheels and supporting wheels.

V. DESIGN SPECIFICATIONS OF THE DEVICE

Design specification includes the dimensions and material used for various parts of the patient transferring device. Table-1 shows the design specification of the device.

The chassis of the patient transferring device considered in this project is stainless steel-440C.

Table-1: Design specification.

Components	Material	Dimension in mm.
Backrest (metallic)	Stainless Steel	Length: 882.50 Width: 760
Sitting Portion (metallic)	Stainless Steel	Length: 465 Width: 760
Leg rest (metallic)	Stainless Steel	Length: 482.50 Width: 760
Wheels (big)	Rubber/ Plastic	Diameter: 250 Width: 60
Backrest metallic support	Aluminium alloy	Width: 25 Depth: 20
Screw jack	Cast iron/ Mild steel	Max. extended height: 228.75 Min. retracted height: 44.12
Total length of bed	---	1830
Width of bed	---	760
Total length of chair	---	1162.75
Ground clearance	---	100
Height of seat base from ground	---	450
Gear (20° full depth involute)	Mild steel	54 (mean diameter)

VI. WORKING PRINCIPLE:

The working of this patient transferring device is simple. It has basically two beds one bed is called as primary bed and the other one is called as secondary bed. These two beds are further divided into three main parts viz. Backrest, sitting portion and leg rest which are connected with each other by means of hinges. The secondary bed is the bottom structure of the patient transferring device to which connecting rods, wheels, handles and rack and gear assembly are attached. It is only meant for the purpose of locomotion, and conversion of wheelchair to bed and vice-versa. Where in the primary bed comprises of motion arrestors, guiding rollers, cushions and other supporting miscellaneous parts. There is an incorporation of screw jack is made in between primary and secondary bed which rests on secondary bed and supports the primary bed directly while transferring the primary bed or while lifting the primary bed in order to match the height of the adjacent bed upon which the patient has to be transferred.

The primary bed is the surface upon which the patient will be sitting or lying when the device is in wheelchair or straight bed position respectively. During the conversion of wheelchair to bed or bed to wheelchair the primary bed is made to rest on secondary bed but supported by the screw jack itself. The primary bed is convertible whenever it rests on the secondary bed which facilitates the patient to have both sitting position and sleeping position. Assembly of the modelled patient transferring device is done using CREO version-6 software and shown in figure-1.

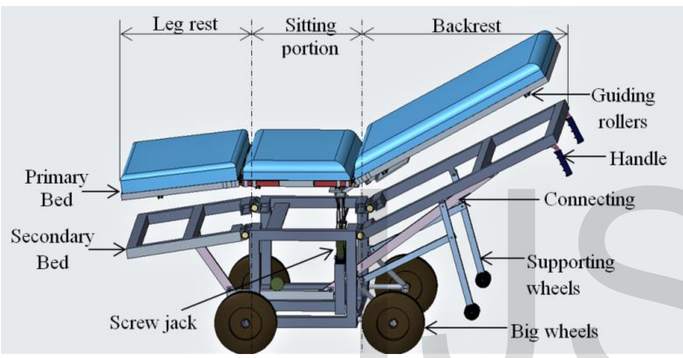

Figure-1: Assembly of the device

During the working of the patient transferring device firstly the gear is made to rotate with certain speed for a time period of 5 seconds. By this the rack which is meshed with the gear slides upon the rail which is fixed to the chassis of secondary bed. This rack is in turn connected with the connecting rods which supports the backrest and leg rest of the device. Referring to the figure-1 when the gear is rotated in clockwise direction the rack moves towards left by pushing and pulling the connecting rods at leg rest and backrest side respectively. Due to this process the wheelchair is converted into straight bed. Now the motion arrestors are pulled up manually by caretaker to arrest the motion between the sitting portion, backrest and the leg rest of the primary bed. After arresting the sitting portion with other parts of primary bed, the caretaker now has to lift the primary bed with the help of screw jack to adjust the height of the primary bed with the height of the adjacent bed upon which the patient has to be transferred along with the primary bed. Soon after adjusting the height of the primary bed now the caretaker have to push the primary bed on the adjacent lying bed to complete the process of transferring the patient. Finally the primary bed carrying the patient will be transferred smoothly with the aid of guiding rollers which are attached to the primary bed.

If the patient has to be loaded back to the patient transferring device, the above procedure is repeated once again in reverse order. But one should keep in mind that the motion arrestors have to be released while converting the stretched bed into chair position.

VII. DESIGN CALCULATIONS:

1. HUMAN WEIGHT DISTRIBUTION:

- Average weight of human body= 70-80kgs.
- Weight of human body with over-weight=~120kgs.
- Including FOS of 20kgs for person weighing 120kgs= 140kgs.
- Weight of M.S frame being used= 20kgs (approx.).
- Weight of other miscellaneous items acting on the supporting column= 30kgs (approx.).
- Therefore, total load acting on the supporting column= 140+20+30= 190kgs.
- Weight distribution of human body at various section of device is given in Table-2.

Table-2: Human weight considerations.

Different Part of Human Body	Weight In (%)	Weight of Human Body Parts (Kg) (If we suppose weight is 140 KG)
Trunk(Chest, Back and Abdomen)	67.87	95.04
Thigh	11.34	15.87
Head	7.30	10.22
Lower leg	6.33	8.86
Upper arm	2.70	3.78
Forearm	1.85	2.59
Foot	1.95	2.73
Hand	0.66	0.924

2. DETERMINATION OF STANDARD CROSS-SECTION FOR SUPPORTING BARS:

As discussed in above section, the total weight or total load = 140 + 50= 190kgs.

$\Rightarrow$Total weight = 190×9.81×1000 = 1863900~1900000N

Weight acting on each bar = $\frac{1900000}{4}$ = 475kN

Ultimate strength of SS-44OC = 1000MPa

Taking Factor of Safety = 1.25

WKT,

$$FOS=\frac{\text{Ultimate stress}}{\text{Allowable stress}} \quad (2.1)$$

$$\Rightarrow 1.25=\frac{1000}{\text{Allowable stress}}$$

$$\Rightarrow \text{Allowable stress}=\frac{1000}{1.25}$$

$$\Rightarrow \text{Allowable stress}= 800\text{MPa}$$

Since,

$$\text{Allowable stress} = \frac{\text{Force}}{\text{Area}} \quad (2.2)$$

$$\Rightarrow \text{Area} = \frac{475000}{800}$$

$\therefore$ Area= 593.75 mm^2.

Hence, hollow steel with square cross-section having 40mm outer length & 31mm inner length with thickness of 4.5mm is feasible to use for designed load.

$\therefore$ Safe cross-section area of hollow bar = $40^2 - 31^2$ = 639mm^2.

3. KINEMATIC ANALYSIS:

During the conversion of device from wheelchair to straight bed the connecting rod bears certain amount of fluctuating load at certain angles. In this section dead weight of backrest and leg rest is calculated first followed by the kinematic analysis and finally the maximum load is considered to design the gear.

- **Load from Backrest:**

Weight of SS material:

$\because$Density (ρ) = $\frac{Mass(M)}{Volume(V)}$ = 7800kg/m^3 —— (Std. value)

$$\rho = 7.8\times 10^3 \text{kg/m}^3 = \frac{M}{V} \quad (3.1)$$

Volume of Backrest metal frame = Cross-sectional area × Total length of material used.

$= (40\times40 - 31\times31)\times3300$

$= 2.1279\times10^6$ mm^3= 2.1279×10^{-3} m^3

From Equation3.1: $7.8\times10^3 = \frac{M}{2.1279\times10^{-3}}$

$\Rightarrow$ M = 16.597kg.

Weight of material at Backrest = 16.597×9.81= 162.822N.

Weight of human upper body part:

Mass of human upper body part from table-2 = 95.04kg.
Weight of the human upper body part = 95.04 × 9.81
= 932.4324N.

Weight of the cushioning and other miscellaneous:

Mass of cushioning and other miscellaneous is 3.5kg (approx.)
Weight of cushioning and other miscellaneous = 3.5× 9.81
=34.335N.

Finally,
Total load from the Backrest = Weight of SS material + Weight of human + Weight of cushion. = 162.822+932.342+34.335
=1429.499≈ 1430N.

Kinematic Analysis on Connecting rod supporting Backrest:

As per the values obtained by the above calculations the net force acting on connecting rod is 1430N which is shown in figure-2

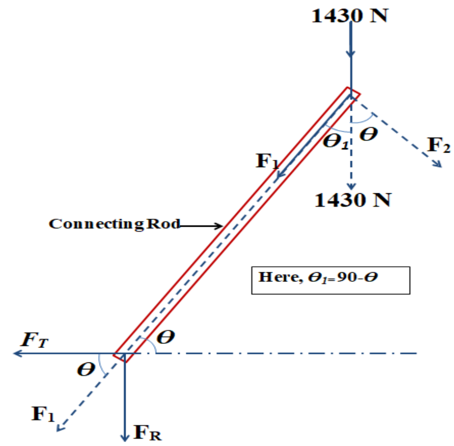

Figure-2: Reaction forces on connecting rod at Backrest

According to the above figure Equations for F_1, F_2, F_T, F_R is given as follows:

F_1= 1430×$Sin\theta$. (3.2)
F_2= 1430×$Cos\theta$. (3.3)
F_T= F_1×$Cos\theta$. (3.4)
F_R= F_1×$Sin\theta$. (3.5)

Where,
F_T= Tangential force on gear.
F_R= Radial force on gear.
θ= Ranges from 11.2° to 73.65°.

The values for F_1, F_2, F_T, F_R are found and tabulated in Table-3.

Table-3: Tabular column for backrest.

Iteration	Angle (θ) in Degree	F_1 in (N)	F_2 in (N)	F_T in (N)	F_R in (N)
1.	11.2	289.98	1400.2	58.80	283.9
2.	18.58	455.63	1355.4	145.17	431.8
3.	25.46	614.72	1281.1	264.25	555.0
4.	32.34	764.96	361.68	409.20	646.3
5.	39.22	904.18	1107.0	571.71	700.4
6.	46.1	1030.3	991.56	792.44	714.4
7.	52.98	1141.7	860.99	911.59	687.4
8.	59.86	1236.6	718.02	1069.4	620.9
9.	66.74	1313.7	967.71	1206.9	518.8
10.	73.65	1372.1	402.55	1316.6	889.2

By the above tabular column it can be predicted that maximum tangential load acting from the backrest on gear is 1316.67 N at

73.65°.

- **Load from the leg rest:**

$\because$Density (ρ) = $\frac{Mass(M)}{Volume(V)}$ = 7800kg/m^3 ----- (Std. value)

$$\rho = 7.8\times 10^3 \text{kg/m}^3 = \frac{M}{V}$$

Volume of Leg rest metal frame= Cross-sectional area × Total length of material used

$= (40\times 40 - 31\times 31)\times 2530$

$= 1.6167\times 10^6$ mm^3

$= 1.617\times 10^{-3}$ m^3.

From Equation3.1: $7.8\times 10^3 = \frac{M}{1.617\times 10^{-3}}$

$\Rightarrow$ M = 12.6126 kg.

Weight of material at Leg rest = 12.6126×9.81 = 123.73N.

Weight of the human leg part:

Mass of the human leg part = 9.12kg.

Mass of the human leg part = 9.12× 9.81 = 89.4672N.

Weight of the cushioning and other miscellaneous:

Mass of the cushioning and other miscellaneous =3kg (approx.)

Weight of the cushioning and other miscellaneous = 3×9.81 =29.43N

Finally,

Total load from Leg rest = Wt. of the SS material + Wt. of the Leg. +Wt. of the cushioning.

= 123.73 + 89.4672 + 29 .43

= 242.627N.

Kinematic Analysis on Connecting rod supporting Leg rest:

As per the values obtained by the above calculations the net force acting on connecting rod is 242.62 N which is shown in figure-3.

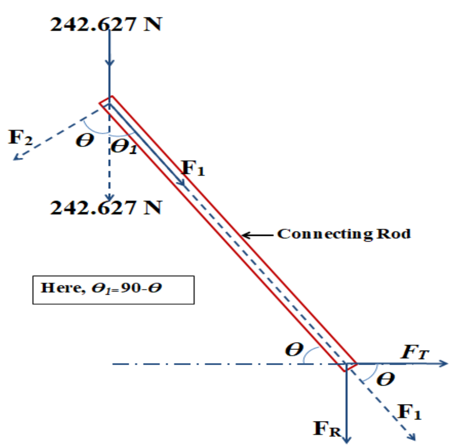

Figure-3: Reaction forces on connecting rod at Leg rest

From the above figure Equations for F_1, F_2, F_T, F_R is given as follows:

$F_1 = 242.627\times Sin\theta$. (3.6)

$F_2 = 242.627\times Cos\theta$. (3.7)

$F_T = F_1\times Cos\theta$. (3.8)

$F_R = F_1\times Sin\theta$. (3.9)

Weight of the SS material:

Where,

F_T= Tangential force on gear.

F_R= Radial force on gear.

θ= Ranges from 24.08° to 76.19°.

The values of F_1, F_2, F_T, F_R are found and tabulated in Table-4.

Table-4: Tabular column for leg rest.

Iteration	Angle (θ) in Degree.	F_1 in (N)	F_2 in (N)	F_T in (N)	F_R in (N)
1.	24.08	98.991	221.50	90.37	40.38
2.	30.59	123.46	208.85	106.27	62.82
3.	37.1	146.35	193.53	116.72	88.27
4.	43.61	167.34	175.66	121.16	115.42
5.	50.12	186.18	155.56	119.37	142.37
6.	56.63	202.62	133.45	111.45	169.21
7.	63.14	216.44	109.61	97.79	193.08
8.	69.65	227.47	84.37	79.10	213.22
9.	76.19	235.60	57.91	56.27	228.75

By the above tabular column it can be predicted that maximum tangential load acting from the leg rest on gear is 121.16 N at 43.62.

Hence, now it can be concluded that the total tangential load acting on the gear is the summation of the maximum tangential force from backrest and leg rest.

i.e.: Load on gear = Load from backrest + load from leg rest

=1316.67 + 121.16 = 1437.83 N.

4. POWER, TORQUE & SPEED OF THE GEAR:

For conversion to happen from wheelchair to bed and vice-versa the rack connecting to the connecting rods must displace through a distance of 280 mm in 5 seconds.

Data: (as per design)

Displacement of the rack= 280mm= 0.280m.

Force = 1437.83 N ----- (by kinematic analysis)

Time for displacement= 5secs.

Radius of pinion= 25mm = 0.025m (assumed diameter).

$$\because \text{Power} = \frac{\text{Work}}{\text{Time}} = \frac{\text{Force}\times\text{Displacement}}{\text{Time}} \quad (4.1)$$

$\Rightarrow$Power= (1437.83)*0.280/5

$\Rightarrow$Power= 80.5W.

Now,

Torque (T) = Force × Radius of pinion. (4.2)

$\Rightarrow$T= 1437.83 × 0.025

$\Rightarrow$T= 35.9 N-m.

Also WKT,

$$\text{Power} = \frac{(2\times\pi\times N\times T)}{60} \quad (4.3)$$

$$\Rightarrow 80.5 = \frac{(2\times\pi\times N\times 35.9)}{60}$$

$\Rightarrow$N= 21.413 rpm.

$\therefore$ For one second speed of Gear or Pinion = $\frac{21.413}{60}$ = 0.356rps.

5. GEAR DESIGN:

Gear is an essential part of the device since it takes part directly in the conversion of wheelchair to the straight and vice-versa. The design is made for spur gear with 20° full depth involute.

Data: (as per design)

Displacement of rack= 280mm.

Time taken to displace the rack= 5secs.

For 20°full depth involute, no. of teeth on pinion (z_1) =18.

WKT,

$$\text{Velocity (V)} = \frac{\text{Displacement(D)}}{\text{Time(t)}} \quad (5.1)$$

$\Rightarrow$ V=280/5= 56mm/sec.

Also,

Velocity (V) = angular velocity (ω) × radius of pinion (r_1) (5.2)

[Assuming radius of pinion (r_1) = 25mm]

$\Rightarrow V = \omega \times r_1$

$\Rightarrow 56 = \omega \times 25$

$\Rightarrow \omega = \frac{56}{25}$ = 2.24 rad/sec.

$$\text{Speed of pinion } (N_1) = \frac{\omega}{2\pi} \quad (5.3)$$

$\Rightarrow N_1 = \frac{2.24\times60}{2\pi}$

$\Rightarrow N_1$= 21.39rpm.

Keeping the velocity ratio (i) = 1.

No. of teeth on gear (z_2) = i×z_1= 1×18

Lewis form factor for 20° full depth involute pinion is given by,

$$y_1 = 0.154 - \frac{0.912}{z1} = 0.154 - \frac{0.192}{18} = 0.103. \quad (5.4)$$

$$y_2 = 0.154 - \frac{0.192}{z2} = 0.154 - \frac{0.192}{18} = 0.103. \quad (5.5)$$

- **Identifying the weaker member:**

Allowable stress of pinion & gear material σ_o= 207MPa.

Particulars	Allowable stress (σo) in MPa	Lewis form factor(y)	σo × y in MPa	Remarks
Pinion	207	0.103	21.32	Weak
Gear	207	0.103	21.32	-

Design should be done based on pinion.

- **Design:**

a) Tangential tooth load:

$$F_t = \frac{9.55\times106\times P\times Cs}{N\times r} \quad (5.6)$$

In the above equation,

P= Power= 80.5W

C_S= Service factor= 1.5 [for medium shocks of 10 hr/day service].

N= N_1 = 21.39rpm

$$r = r_1 = \frac{d1}{2} = \frac{m\times z1}{2} = \frac{m\times18}{2} = 9m \quad (5.7)$$

Equation5.6 $\Rightarrow F_t = \frac{(9.55\times10^6\times80.5\times10^{-3}\times1.5)/(21.39\times9m)}{(21.39\times9m)}$

$\Rightarrow F_t = \frac{5990.143}{m}$ (5.8) [where m= module]

b) Lewis equation for tangential tooth load:

$$F_t = \sigma_o \times b \times y \times p \times K_v \quad (5.9)$$

Let us take the following factors:

- Lewis form factor(y)= 0.103 [from Equation5.4 & 5.5]
- Face width(b) = 10m (5.10)
- Pitch (p) = πm (5.11)
- $C_v = K_v$ = Velocity factor

Equation5.9 $\Rightarrow F_t$= 207 × 10m × 0.103× πm × K_v

$\Rightarrow F_t = 669.81 m^2 K_v$ (5.12)

Equate equations (5.12) & (5.8),

$\Rightarrow 669.81 m^2 K_v = \frac{5990.143}{m}$

$\Rightarrow m^3 K_v$ = 8.943 (5.13)

Now to find module for pinion and gear consider the mean velocity (V_m) as,

$$V_m = \frac{\pi\times d1\times N1}{60000} = \frac{\pi\times m\times18\times21.39}{60000} = 0.0201m \quad (5.14)$$

Module (m) = $\sqrt[3]{2\times(m^3)Kv}$ [K.Lingaiah data handbook]

$\Rightarrow m = \sqrt[3]{2\times 8.943}$

$\Rightarrow m$= 2.6 ≈ 3mm

Equation-7 $\Rightarrow V_m$= 0.0201×3= 0.0603 mm/sec.

For $V_m \le$ 7.5 m/sec, $K_v = C_v = \frac{3}{3+Vm}$ [table-xyz/ Pg. no-abc](ref-databook)

$\Rightarrow K_v = \frac{3}{3+0.0603}$ = 0.98

$\Rightarrow m^3 K_v = 3^3\times0.98$= 26.486 (5.15)

For safe design, Equation (5.15) > (5.13)

Hence, Suitable module is 3mm.

- **Dimensions:**
  - Pitch diameter of pinion (d_1) = $m\times z_1$= 3×18= 54mm.
  - Pitch diameter of gear (d_2) = $m\times z_2$= 3×18= 54mm.
  - Face width (b) = 10×m= 10×3= 30mm.
  - Pitch (p) = $\pi\times m$ = π×3= 9.4247mm.
  - Tangential tooth load (F_t) = $\frac{5990.143}{m} = \frac{5990.143}{3}$ = 1996.714 N.
  - Addendum of both pinion & gear (h_a) = 1×m =1×3= 3mm.
  - Dedendum of both pinion & gear (h_f) = 1.25×m = 1.25×3= 3.75mm.
  - Addendum diameter of pinion = d_1+2h_a = 54+2×3= 60mm.
  - Addendum diameter of gear = d_2+2h_a = 54+2×3= 60mm.
  - Dedendum diameter of pinion = d_1-2h_f = 54 -2×3.75= 46.5mm.
  - Dedendum diameter of gear = d_2-2h_f = 54 -2×3.75= 46.5mm.

[Refer K.Lingaiah data handbook for the formulas mentioned above]

RESULTS & DISCUSSION

1. Section-2 of design calculations shows the calculation for determining the standard cross section area of the material to be used in the supporting rod of the device which is $639mm^2$ having 40mm and 3mm of length and breadth respectively.

2. Section-3 of design calculations gives the calculations for the kinematic rods (i.e. connecting rod) and determination of maximum tangential load acting on the gears is done in order to design the gear. Figure-4 and Figure-5 shows the variation of tangential load due to the deflection of connecting rods at particular angles.

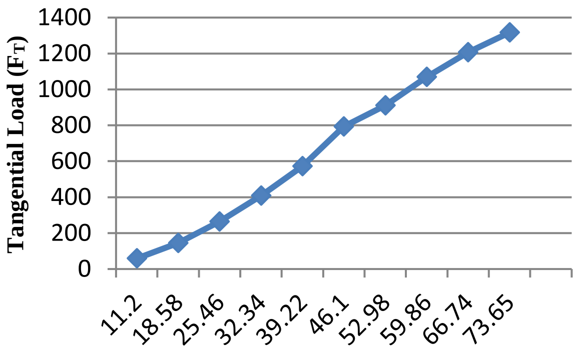

Figure-4: F_T v/s θ

- From the above figure it can be concluded that the tangential load acting on the gear attains maximum value when the connecting rod is deflected to an angle of 73.65°.

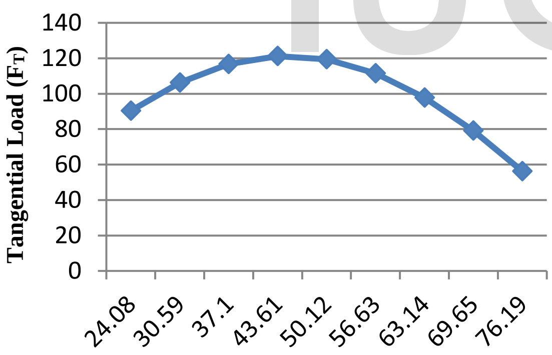

Figure-5: F_T v/s θ

- From the above figure it can be concluded that the tangential load acting on the gear attains maximum value when the connecting rod is deflected to an angle of 43.61°.

3. Section-4 of design calculations represents the determination of power, torque and speed the gear based on displacement of rack and the time duration while conversion of wheelchair to bed and vice-versa.
   The above mentioned parameters can be determined by taking the rack displacement of 280mm and time duration of 5 seconds and the results obtained are as follows:
   Torque= 35.9 N-m.
   Power= 80.5 W.
   Speed= 21.413 rpm.

4. Finally based upon the kinematic analysis and determination of power, torque, speed the design of gear has done and its parameters are listed as follows:

- Pitch diameter of gear = 54mm.
- Face width = 30mm.
- Pitch = 9.4247mm.
- Tangential tooth load = 1996.714 N.

CONCLUSION

This project is intended to develop a concept of wheelchair convertible stretcher with the motivation of reduced number of operating nurses while transferring, avoiding physical contact with patient and the wheelchair operator while transferring to the bed side by, and prevent exertion of patient as well as by making sure that the patient does not get hurt. The mechanism and safety of patient were our main priorities while designing the stretcher cum wheelchair. This project also includes various calculations for designing the device in order to avoid failure of the device by considering appropriate factor of safety, human load considerations, and other factors to have smooth and effortless operation during the transfer of patient.

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1. Rashid Ahmed K.1, Safar Abdul Razack1, Shamil Salam1, Vishnu Prasad K.V.1, Vishnu C. R.2 B. Tech Scholar, Department of Mechanical Engineering, KMCT College of Engineering, Calicut, India1 Assistant Professor, Department of Mechanical Engineering, KMCT College of Engineering, Calicut, India2.
2. Arunkumar S M1, Abhijith P K2 , Haneepsab A Karoshi3 , Chetan C4 1234 (Department of Mechanical Engineering, Bangalore Technological Institute, India).
3. Arunkumar K N, Charan Kashyap K, Chirag B C, Kausthubh R, Keerthan J.
4. Smitesh Bobde1,Ninad Borkar2, Saurabh Apte2, Shubham Ghuguskar2 1Assistant Professor, Department of Mechanical Engineering, Dr. Babasaheb Ambedkar College of Engineering and Research, Nagpur, Maharashtra. India. 2Student, Department of Mechanical Engineering, Dr. Babasaheb Ambedkar College of Engineering and Research, Nagpur, Maharashtra. India.
5. Sumedh J. Suryawanshi1, Dr. K. Janardhan Reddy2 1M-Tech CAD-CAM, SMBS, VIT University, Chennai 2Associate Professor, SMBS, VIT University, Chennai.