DUAL STEERED THREE WHEELER FOR DIFFERENTLY ABLED PEOPLE

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Abstract

Transportation has become an integral part of people's everyday life. At certain times, in large countries like India, people are forced to travel more than 200 km from their work place to their place of residence. People with disabilities in limbs have difficulties in travelling and cannot travel these long distances. They use devices such as wheel chair, crutches, and artificial limbs for mobility. These however cannot be used for long distance outdoor transportation. Therefore, the aim of this study is to design and fabricate a 3 wheeler with dual steering system for people with locomotive disabilities and armless people. A greater steering effort is required in the case of a four wheeler compared to a three wheeler. Hence, a three wheeler was selected instead of a four wheeler. In this case, handle bar steering system and leg steering system can be individually steered with hands and legs respectively, enabling its utility people with disabilities in limbs. Sprocket chain system was used in leg steering system. A 98cc Kinetic Honda Engine was used as the power source and the engine was placed towards the rear end of the vehicle. Single Rated and double rated suspension spring was used in the front and rear drive shaft respectively. Sprocket chain system was used in leg steering system. Furthermore, the driver sprocket and the driven sprocket was analysed for the design load using ANSYS.

Keywords: Steering Systems, Disabled People, Three Wheeler Vehicle, Dual Steering System

1. INTRODUCTION:

Disability is the repercussion of an impairment which can be mental, physical, emotional, vision, sensory or an amalgam of these. Disabilities have become a roadblock for disabled people to live a normal life. However, many of these impairments especially physical can affect the function of limbs. These can occur by birth or as a result of accident or an aftermath of a disease. Disabilities can occur in upper limb as well as in lower limb. This can affect the maneuverability of the people greatly. Due to this effect, they stand a great disadvantage in using public as well as private transportation facilities. Due to their disabilities, their level of being employable reduces and it affects them in becoming financially independent. A national level survey conducted in India by the Central Government of India once in ten years revealed that, around 27 million people which are about 2.21% of the Indians are differently abled. Among them, around 14.98 million were men while 11.84 million were women. Thus, the percentage of disabled people in rural area was higher than those in urban areas. A total of 5.43 million people were identified with disabilities in movement which was the highest among other categories such as hearing, seeing etc. in terms of numbers of people affected.

Table 1-1: Population of People with Disabilities

Disabled population by type of disability[1]			
India: 2011			
Types of disability	**Males**	**Females**	**Persons**
Mental retardation	8,70,708	6,34,916	15,05,624
Mental illness	4,15,732	3,07,094	7,22,826
In hearing	26,77,544	23,93,463	50,71,007
In seeing	26,38,516	23,93,947	50,32,463
In speech	11,22,896	8,75,639	19,98,535
In movement	33,70,374	20,66,230	54,36,604
Any other	27,27,828	21,99,183	49,27,011
Multiple disability	11,62,604	9,53,883	21,16,487
Total	**1,49,86,202**	**1,18,24,355**	**2,68,10,557**

Table 1-2: Distribution of Disabilities among residence

Disabled population by sex and residence[1]			
India, 2011			
Residence	**Males**	**Females**	**Persons**
Urban	4578034	3600602	8178636
Rural	10408168	8223753	18631921
Total	**14986202**	**11824355**	**26810557**

People with lower limb disabilities face more difficulties in travelling from one destination to another. Barely one third of the people with lower limb impairments attend school in India. The percentage of graduates among them is even lesser and is just around 6%. However, low level of literacy and lack of expertise in a given field affects the employment of people with lower limb disabilities. It was found that barely 25% of them are employed and the rest are dependent on their family members for their day to day needs

[7].The status of them can be improved by providing them with logistic support .In recent times, several steps such as the allocation of separate seats for differently abled people, and the use of broader steps in public transport has eased their problem to an extent. Md. Shahidul Islam et.al designed and fabricated a solar powered three wheeler for people with lower limb imparities. Here, solar panel was used to tap the solar energy. Batteries were used to store the DC current produced from the solar panels[2]. Madarasz R. et al engineered autonomous wheel chair for people with disabilities in their leg .Here, the indoor mobility of the differently abled people was made easier by using electronic devices such as digital camera, micro computer etc to navigate people from one room to another [3]. Hong et al fabricated a Motor cycle with four wheeled support. It was more fuel efficient and cheaper compared to regular vehicle for disabled. Four wheels ensure better balance compared to conventional two wheeler [4]. Therefore, the prime aim of our paper is to fabricate an auto rickshaw model 3 wheeler with handle bar and leg steering systems enabling people with disabilities in lower and upper limb to overcome the difficulties they have in outdoor transportation. Having provision in the back side, it can *accommodate* up to 4 passengers, further enabling self-employment among different abled.

2. Chassis

The Chassis provides the total frame work for the automobile. The frame is made of ASTM A106 Grade 'B'. The frame is designed to bear the weight of the automobile components, passengers and the road load. The chassis is made with pipe of an outer diameter of 26.5mm and a thickness of 3mm.

S.NO	PARTICULARS	SPECIFICATIONS
1	Wheel base	1910mm
2	Track width	925mm
3	Clearance	220mm
4	Total length of the vehicle	2000mm
5	Total width of the vehicle	1190mm
6	Total height of the vehicle	1730mm
7	Driver cabin	570mm
8	Passenger cabin	750mm
9	Engine cabin	720mm
10	Luggage cabin	300mm
11	Wheel diameter	400mm

Figure 2-1: Chassis Specification

3. Suspension

Being a 3 wheeler, the front axle is designed to accommodate only one person but the rear axle has to bear the load of 3 people. Hence, the design load given to the front axle is set as 150 kg while that to the rear axle is 250 kg. A single rated spring system is used for front axle while for the rear axle, a double rated spring is used. The double rated spring do not have a uniform pitch. Deflection is more uniform in the front while it is not so on the rear side where the impact of bumps is not greatly felt. Hence, helical suspension of 2 stroke Bajaj Auto Rickshaw and the rear suspension of Bajaj Boxer BM 150 were used as front and rear suspension respectively. The tyre of 2 stroke Bajaj Auto Rickshaw was used as the front wheel. The 2 stoke SI engine of Kinetic Honda DX , its hydraulic brake drum and tyre were used as a source of power, braking systems and rear wheel respectively.

4. Steering design

A Dual steering system was designed to facilitate people without hands or legs for transportation.

The two systems are:

1. **Handle Bar Steering System**
2. **Leg Steering System**

3.1 Concept Description of Handle Bar Steering System:

A three wheeler vehicle was used in this system. Handle Bar Steering System used in Auto rickshaws was used in the vehicle. This system is designed for people who have locomotive disabilities. An auto rickshaw handle bar was selected as the model for the Hand Steering System. As the motive of this system is to facilitate the movement of people with disabilities in leg, hence unlike a typical auto rickshaw, there is no leg clutch involved in the system. The handle bar is attached to the stem which in turn is attached to the fork. The handle bar controls the movement of the front wheel which in turn guides the rear wheels. A front fork stem is the backbone of this system and renders support to all appliances such as wheel, axle, suspension, and accelerator handle bar etc. Acceleration is given by an accelerator handle bar on the right side of the handle bar, via accelerator cable connected to the engine. There are two acceleration cables connected to the engine; one for each of the system. The design comprises of a brake Leaver which is attached to the left side of the handle bar. Brake Cables connects the brake leaver to the brake plate. This Brake plate has brake wires coming from both the steering systems. When the brake leaver is pressed, the brake cable connected to the puller rod actuates the brake plate, thus moving it forward and applying braking action on rear wheels. As rear engine is used, brakes drums are attached only to the rear wheels and application of brakes on the rear side would also ensure the cease of motion on the front wheel as well.

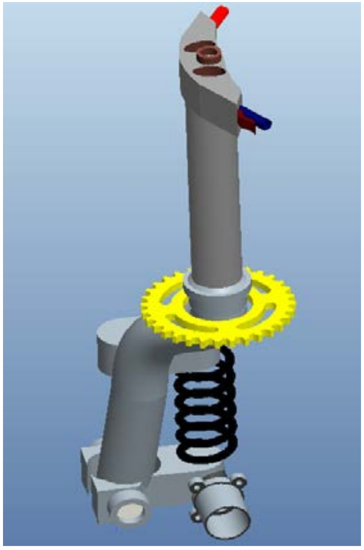

Figure 3.1-1: PRO-E Model of the Handle Bar Steering

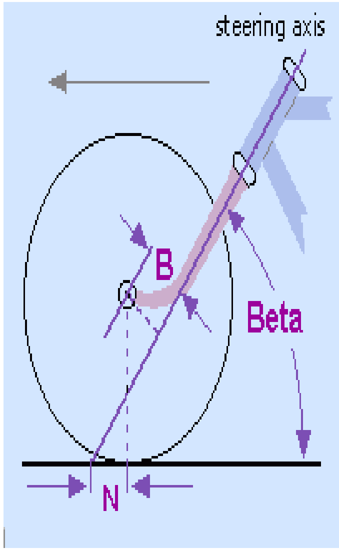

Figure 3.1-2: Design Parameters in the Steering

Where;
N is the Trial
B is the Fork Offset
β is the Head Angle
R is the Radius of the wheel

The standard relations for the above parameters are as given below:

$R = (N \sin\beta + B) / \cos\beta$
(3.1 a)

$B = R \cos\beta - N \sin\beta$
(3.1 b)

$N = (R \cos\beta – B) / \sin\beta$
(3.1 c)

The expression for the Head Angle is given as:

$(R^2 + N^2) \times \cos^2\beta - 2 \times R \times B \times \cos\beta + B^2 - N^2 = 0$
(3.1 d)

Hence β is given as:

$\beta = \cos^{-1}\{[R \times B + \sqrt{(R^2 \times B^2 - (R^2 + N^2) \times (B^2 – N^2))}] / (R^2 + N^2) \}$ (3.1 e)

The diameter of the wheel is 400mm and the trail is found to be 20mm.The fork offset is 50mm. Therefore, from these values, the head angle is determined.

R = 200mm,B = 50mm,N = 20mm

$\beta = \cos^{-1}\{ [(200 \times 50) + \sqrt{(200^2 \times 50^2 - (200^2 + 20^2) \times (50^2 – 20^2))}] / (200^2 + 20^2) \}$

$\beta = \cos^{-1}\{ [10000 + \sqrt{} (10^8 - (40400 \times 2100))] / 40400 \}$
$= \cos^{-1}[(10000 + 3893.58) / 40400]$
$= \cos^{-1} [0.344]$
$\beta = 69.89^0$

Determination of steering angle (ε)

$\varepsilon = \cos^{-1}[\tan\beta / R \sqrt{} ((1 / B^2) - (1 / R^2))]$ (3.1 f)

$= \cos^{-1}[\tan 69.89^0 / 200 \sqrt{} ((1 / 50^2) - (1 / 200^2))]$
$= \cos^{-1}[\tan 69.89^0 / (200 \times \sqrt{} (4\times10^{-4}) - (2.5\times10^{-5}))]$
$= \cos^{-1}[2.73 / 3.87]$
$= \cos^{-1} [0.705]$
$\varepsilon = 45.14^0$

3.2 Concept Description of Leg Steering System

This steering system aids the locomotion of armless people. Here, the entire control of the vehicle can be done by legs itself. Just like Handle Bar Steering system, it also possesses provisions for acceleration and braking. Here also, the front wheel is used for steering purposes, while the rear wheels follows. Sprocket is used for the transmission of motion. Sprocket chain system is sued for the power and motion transmission. Sprocket is a mechanical device having similar appearance like a gear; however, instead of direct meshing, they transmit power by chains. Therefore, the sprocket connected to the handle bar is responsible for the movement of the front axle which is also the driving axle. A chain is used for power transmission of driver sprocket to the driven sprocket. Several Design Constrains such as Total Load ,Tension due to Sagging, Total Load are needed while determining design parameters such as pitch, length of Chain, Sprocket Diameters etc.

Accelerator cable

The steering that is incorporated is a dual type and therefore, the cable from the engine has to be divided into two for both the steering systems. For this, the dual cable applied to the carburetor and pump in the auto rickshaw has been modified. Brazing process has been employed to fix heads to the cables.

Figure 3.2-1: Accelerator cable

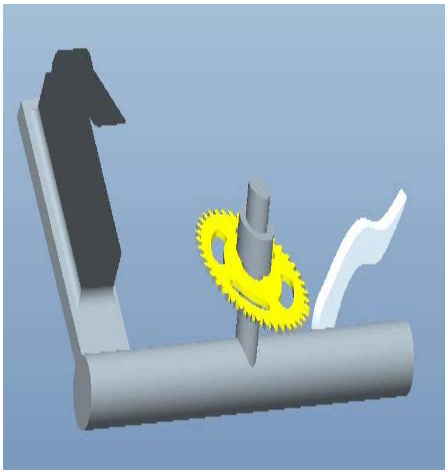

Figure 3.2-2:
PRO E Design of Sprocket Connected assembly of to the Leg Steering System

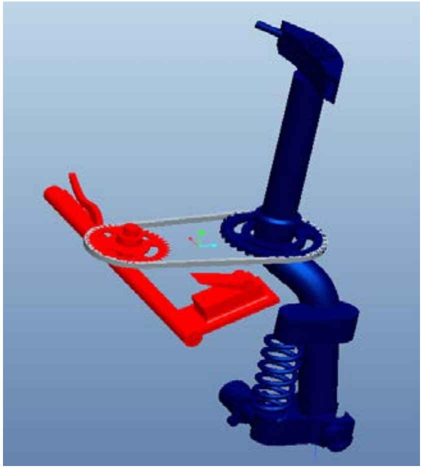

Figure 3.2-3:
PRO E Design of the entire Dual Steering system

Figure 3.2-4: The dual steering system installed in the vehicle

Here,
1 => Hand Brake, 2 => Handle Bar, 3 => Horn, 4 => Accelerator, 5 => Leg Brake, 6 =>Fork, 7 => Driven Sprocket, 8 => Chain, 9 => Leg Accelerator, 10 => Driving Sprocket

Brake Plate Design:

The flat brake plate has 2 inputs. One from the Handle Bar System and the other from Leg STEERING System .The brake wire from the Handle Bar moves the puller rod moving brake plate, there by applying braking action. For the Leg Steering System, a brake pedal is used in place of the brake leaver. This brake plate has a common output to the rear wheels. For this, 2 holes are drilled in the brake plate through which the brake wires passes through to the brake drums in the rear wheels travel.

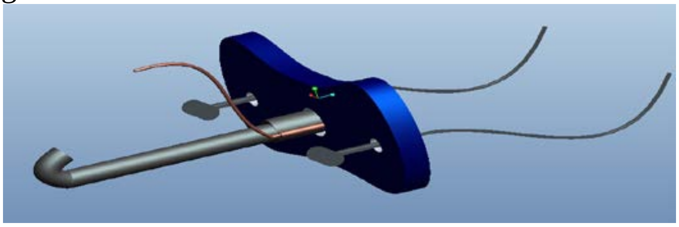

Figure 3.2-5: Design of Flat Plate for Braking System

Design of Leg Steering System:

Table 3.2-a: Specification of Leg Steering System

S.NO	PARAMETERS	VALUES
1	Number of teeth in the driver sprocket	40
2	Number of teeth in the driven sprocket	44
3	Transmission ratio	1.1
4	Standard pitch	12.7mm
5	Chain number	08B-1 / R1278
6	Service factor	2.34
7	Tension due to sagging	8.24N
8	Exact centre distance	291.99mm
9	Length of the chain	1117.6mm
10	Smaller sprocket diameter	168.68mm
11	Larger sprocket diameter	184.83mm

Radius of rotation

The wheel angle

$\delta i = 40^{\circ}$

The radius of rotation,

$R_1 = L \cot \delta i + W/2$

(3.2 a)

$= (1910/\tan 40) + 925/2 = 2738.75$ mm.

The mean radius of rotation about O to centroid,

$R^2 = R_1^2 + G^2 = 2738.75^2 + 1241.5^2$

(3.2 b)

$R = 3008.1$ mm.

Sprockets:

A sprocket is a mechanical gear-like device used for power or force transmission purposes. However, unlike gears, there is no direct contact or meshing, as chain is meshed with the sprockets to facilitate transmission. Sprockets are mainly used in bicycles to transmit force from the pedal to the rear wheel. Here sprockets are primarily used in leg steering system. The driving sprocket is connected to the leg steering rod while it is driven to the fork in the handle bar. The driving and the driven sprocket has 40 and 44 teeth respectively.

4. Sprocket analysis:

Two sprockets were used in the dual steering system. The sprockets are mainly employed in leg steering system. One is fixed to the fork and the other one is attached to the leg steering rod. The number of the teeth on the driver sprocket is 40 and the number of teeth on the driven sprocket is 44. The number of teeth on both the sprockets is very close to minimize steering effort. Considering the Indian terrains, we assumed a load of 200N.

Analysis procedure:

- The side of the sprocket where the chain rests has been analyzed. The sprocket center is constrained to zero degrees of freedom.
- A load of 200N is applied at the sprocket teeth.
- The displacement vector sum of the driver sprocket is shown in Figure 4-1 and 4-2 respectively
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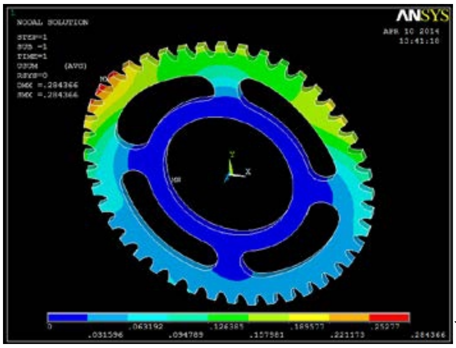

Figure 4-1:Sprocket Analysis of the Driver Sprocket

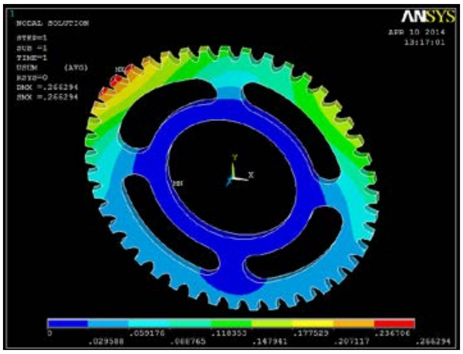

Figure 4-2:Sprocket Analysis of the Driven Sprocket

Inferences:

- The chain meshes only with one half of the sprocket and as such, the impact is high on only one side. The other side of the sprocket experiences minimum impact.

- The maximum displacement in driver sprocket teeth is 0.284366mm and that in the driven sprocket is 0.266294mm.
- The displacement is greater in the driver sprocket when compared to the driven sprocket because the teeth meshing with chain is less in driver sprocket.
- The driver sprocket bears the same amount of force in less number of teeth when compared to the driven sprocket.

Figure 5-1: The complete view of the vehicle

Figure 5-2: The complete view of the vehicle

References:

Office of the Registrar General & Census Commissioner, India, New Delhi, 27-12-2013

Md. Shahidul Islam, Zaheed Bin Rahman, Nafis Ahmad, Designing Solar Three-Wheeler for Disabled People, International Journal of Scientific & Engineering Research Volume 3, Issue 1, January-2012

Madarasz, R. ; Arizona State University, Tempe, AZ, USA ; Heiny, L. ; Cromp, R. ; Mazur, N., The design of an autonomous vehicle for the disabled, Robotics and Automation, IEEE Journal (Volume:2 , Issue: 3), Sept.1986, Pages 117 - 126

Hong, Chang-Zern MD, Motorcycle for Persons with Disabilities, American Journal of Physical Medicine & Rehabilitation : May 2012 - Volume 91 - Issue 5 - p 461

Taken From India Mart Advertisement of TVS Cables http://www.indiamart.com/silcocables/tvs-cables.html

Taken from the calculation of Geometric Relations in a steering system http://www.kreuzotter.de/english/elenk.html

Renu Addlakha, FROM INVALIDATION AND SEGREGATION TORECOGNITION AND INTEGRATION:
CONTEMPORARY STATE RESPONSES TO DISABILITY IN INDIA, CENTRE FOR WOMEN'S DEVELOPMENT STUDIES, Occasional Paper No.55