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Modification of Clutch and Gearing Systems of A Developed Tricycle For Paraplegics

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Abstract

There are various tricycles, both the locally fabricated and imported of different designs in the market. However, majority of these are not adequately designed primarily for the paraplegics. The initial developed tricycle for the paraplegics had problems of actuation of the clutch. Therefore, this research modified the gear and clutch systems and as well as engine of developed tricycle for the paraplegics. The gear, clutch, brake and steering mechanism are designed for hand operation and are positioned ergonomically for the paraplegics. The components of the modified tricycle includes; the gear, clutch, chassis and the frame. The headroom, legroom and forward arm reach were established as: 767.7mm, 540mm and 761.7mm respectively based on the already existing anthropometric data. The tricycle was designed to have a mass of 280 kg, engine power output of 2.2 kW (3 HP), driving torque of 1.19 Nm and optimal linear velocity of 22.22 m/s with compression ratio of 10:1. The tricycle has an hydraulically adjustable chair and can accommodate three extra persons besides the driver (the paraplegic). Performance evaluation on the improved mechanism: clutch and gearing system was done through test driving at different terrain.

Keywords: Paraplegics, Tricycle, Ergonomics, Anthropometric

INTRODUCTION

The paraplegics in the society have not been accorded with the same opportunities as their able body counterpart. Most of these paraplegics have hidden potentials in business, government, education and so on, but mobility has been a big challenge for them. Even those that were actively engaged before their predicament as a result of accident were forcefully disengaged from the active service as a result of mobility problem. (Marino, 2007) The wheel chair which is the major form of mobility available for them cannot only travel a long distance but also can not travel up a modest inclines without excessive fatigue or physical strain. Companies like Greenspeed in Australia produced Hand crank tricycle powered by hand for paraplegics; this tricycle has the same associated problem as above,(Krovt,1994) In order to

alleviate poverty and over dependency of the paraplegics to the community, they could be orientated to engage in daily activities such as delivery services, food vending, airport cargo handling, recycling collection, mail and child transport with the aid of tricycle with significant greater fuel efficiency and good stability designed primarily for the convenience of paraplegics, (Van Valkenburgh et al, 1982).

The tricycle often abbreviated to "trike" is a three- wheel vehicle which has been in use since the early t19thcentury. The various forms of propelling these tricycles include: Pedals, Steam and Internal combustion engine. This automobile is justifiable for the use of paraplegics in that it is inherently lighter than four wheel because bump twisting loads need not to be resisted in three wheel;. Also a three wheel vehicle allows a more efficient aerodynamic enclosure than four wheel in that either the front or rear wheel may be tapered more gradually and in mass production, a three wheel is less expensive because of the elimination of the redundant wheel, tyre, brake and suspension components and assembly time(Ayodeji,2009).

This research solves the problem of actuation associated with the existing tricycle and also produces a locally and affordable fabricated tricycle ergonomically designed for paraplegics as compare with the expensive imported tricycle.

MATERIALS AND METHODS

The initial developed tricycle was extensively assessed to know the necessary areas of modifications. The initial preliminary assessment carried out shows limitation in the clutch and gearing system.
A new clutch and gearing system were designed and fabricated to improve on the performance of the existing tricycle. Also, to solve the actuation problem observed in the existing tricycle, smaller capacity engine was selected to replace the old one. The gear, clutch, and brake system were design for hand operation for the comfort of the targeted users, the paraplegics. The results of an existing anthropometric data were used in designing the leg room, headroom, forward arm reach during fabrication. The major components such as the paraplegics' seat, position of gear and break were ergonomically considered during the design and fabrication. Performance evaluation on the improved mechanism: clutch and gearing system was done through test driving at different terrains by paraplegics and able body men using performance characteristics such as speed, maximum distance covered at a given time, reliability, stability and efficiency of fuel consumption.

DESIGN PROCEDURE

This modified tricycle was constructed with a motorcycle petrol engine with an engine displacement of 200cc; the hand controlled clutch produced the necessary pressure to propel the engine. Also the modified tricycle used double gear box, one for engine to select gear 1 to 4, while the other gear for propeller connected to the axle which controls the reverse and forward movements.

Design Analysis and Calculation

Weight of the tricycle =280 kg
The weight of the paraplegics with three passengers of average weight of 60 kg =240 kg
Total reaction on the tricycle when fully loaded = mg
Tr = mg (1)
Mass X Acceleration due to gravity mg = 5200N
The angular speed ω is determine with equation 2

$$\omega = \frac{2v}{d} \text{ (rad/sec)} \quad (2)$$

where d = diameter of the shaft = 0.024m
v =linear speed for stability= 80km/hr =22.22m/s
ω = 1851 rad/sec
Determination of the rotational speed n

$$n = \frac{60\omega}{2\pi} \quad (3)$$

n = 17679r.p.m

The power output of the Engine used= 2.2kW

$$\text{Torsional moment} = M_t = \frac{9550Kw}{rev/\min} \quad (4)$$

Where kW = power output of the engine =2.2kW

rev/min = speed of the shaft = 17679rev/min

M_t = 1.19Nm

The combine moment of the shaft is determined by

$$M_b = \sqrt{(M_{bv}^2 + M_{bh}^2)} \quad (5)$$

M_{bv} =Bending moment due to vertical load = 80Nm

M_{bh} = Bending moment due to horizontal loading =90Nm

M_b is calculated to be 120Nm

The shaft diameter is determined by

$$d^3 = \frac{16}{\pi s_s}\sqrt{(K_b M_b)^2 + (K_t M_t)^2} \quad (6)$$

M_t = Torsional moment (1.19Nm)

M_b= Bending moment (120Nm)

K_b= Combine shock and fatigue factor applied to bending moment= 1.25

K_t= Combine shock and fatigue factor applied to torsional moment =1.25

S_s= Allowable stress for shaft without keyway 55 X 10^6N/m^2

The diameter of the shaft is calculated as 24mm =0.024m

Required power for the tricycle to move over rough terrain is determined by

P = Wv/3.733 (7)

P = power (Watt)

W = weight of the tricycle(N) = 2800N

v = optimal linear speed(m/s) =22.22m/s

Power required by the tricycle to move over a rough terrain is calculated to be 166665 Watt = 16.67kW.

Determination of Driving Torque T

T = P/ω (8)

Engine power P = 2200Watt

T = 1.19Nm

Determination of the maximum Shear stress on the shaft

$$\tau_{max} = \frac{16T}{\pi d^3} \quad (9)$$

Where = T =Torque (Nm) d = diameter of the shaft (mm)

τ_{max} = 0.438MN/m

Fuel tank capacity is determine by

Volume=lbh (10)

Where l= Length =370mm, b= Breadth =320mm and h =Height =100mm

The capacity of the petrol tank is calculated to be 11840000mm^2 =11.84litres

ERGONOMIC CONSIDERATION OF THE COMPONENTS DURING FABRICATION

Passenger space: This is the space between the passenger's seat and driver seat. This space is large enough to accommodate 3 passenger and allow them enter the tricycle conveniently

Passenger's seat: The passenger's seat consists of the skeletal metal frame welded to the floor of the tricycle chassis. The skeletal part is covered with soft wooden seat with foam and leather cloth attached to give a moderate cushion effects to the passengers

Interior Safety: All sharp and injurious edges are avoided, adequate passenger restraint and freedom from structural contact injury is provided to minimize the possibility of injury or death in case of auto crash

Ingress and Egress: The spacing is given prime consideration, this is to allow the paraplegic driver and the 3 passengers to enter into and alight from the tricycle easily under normal and emergency situations.

Crash protection: The body of the tricycle was fabricated with pure iron sheet, bar and pipe to protect the driver and the passenger and minimize injury sustained in case of any auto crash.

Road illumination: The tricycle is designed with head lamps to allow the paraplegic to move about at night .

Identity lights: Two front pointers and two rear indicator lights (trafficators) are incorporated to indicate when the driver intends to turn also a breaking light is designed to indicate to other vehicles when the paraplegics intends to stop.

Ease and safety of maintenance and service: The Tricycle is easy and not expensive to maintain any broken or damaged part can easily be repaired or replaced

Driver space: This particular tricycle was designed for paraplegics; seat is large enough to allow the paraplegic to more freely without any itching.

Driver seat: The seat is designed for to give room for necessary vertical adjustment with the aid of hydraulic jack

Gear system: The motorcycle engine was used for the fabrication of the tricycle consequently the leg operated gear was successfully redesigned to hand control gear

Main floor unit: The floor unit is designed so that the paraplegic and the passengers' feet standing on it experience no transfer of vibration or stress to the knee or the whole body

Engine position: The engine is held firm by the chassis and position beneath the floor unit in between the driver seat and passenger seat.

Luggage space: This is located at the rear part of the tricycle the space is free from heat generated by engine. The engine is fixed in a location far away from the luggage space thereby keeping the luggage free from being affected by heat

Suspension Springs: This is incorporated in the design to reduce the velocity of the vertical displacement of a vehicle caused by the irregularity of the road surface

Bumper: This is designed to give aesthetic look to the tricycle and also to cover the suspension system from environmental factors such as dirt

Vehicle Roof: The tricycle is roofed to shield the paraplegics and the passenger from high intensity of sunlight and rain

Electrical and Lightly system: These are the auxiliary systems incorporated in the design of the tricycle. They include: Electric horn, head lamp, speedometer, Break lamp, Indicator lamps, Battery and ignition key.

RESULTS AND DISCUSSION

A new clutch and gearing system were designed and fabricated to improve on the performance of the existing tricycle. Also, to solve the actuation problem observed in the existing tricycle, smaller capacity engine was selected to replace the old one. The gear, clutch, and brake system were design for hand operation for the comfort of the targeted users, the paraplegics. The major component parts such as the paraplegics' seat, position of gear and break were ergonomically considered during the design and fabrication. Material selection of each component of the tricycle was carried out as well as the cost estimate of producing the tricycle.

The tricycle has a total length of 2800 mm, width range 800 mm-1200 mm, overall height of 1670 mm, and minimum ground clearance of 200 mm. The capacity of the tricycle engine and its mass are 200 cc and 18kg respectively. The rated output power is 2.2 Kw (3HP) and the compression ratio is 10:1 The tricycle is designed to operate within the town as a cab to convey passengers; the tricycle is reliable as it has the capacity to perform specific function assigned to it at a given period of time without recording any failure. The modified tricycle was evaluated by carrying out some physical and stability tests, this stability test was done by test riding the tricycle at different terrains by paraplegics and able body men.

The maintenance of tricycle is now easy and at considerable low cost, any damage part can be replaced easily and the replaceable parts are readily available in the market. For good performance, the tricycle engine has good fuel economy in consumption; it has a high mechanical efficiency, good compression ratio. The two stroke engine used in the fabrication has advantages of simple design and low cost. The design of some parts such as the leg room, headroom and forward arm reach was based on the result of the existing anthropometric data collected and analyzed at 90% confidence level.

CONCLUSION

This research work solves the problem of actuation associated with the existing tricycle by redesigning the tricycle with a smaller capacity engine and motorcycle engine was used particularly for this purpose. The leg controlled gear of the engine was successfully re-designed for hand operation; even though the existing tricycle was not leg controlled, also a new clutch system was designed to improve on the performance of the existing tricycle. The major components such as the paraplegics' seat, position of gear, clutch and brake were ergonomically considered for during the design and fabrication. Material selection of each component of the tricycle was carried out. This research produces a locally and affordable tricycle designed primarily for the comfort of paraplegics as compared with expensive imported ones. This will no doubt aid the mobility of the paraplegics to engage in their daily business.

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Drawing Showing Dimension and Labeling of Major Component Parts of the Tricycle

Figure 1. 3D view of the Tricycle

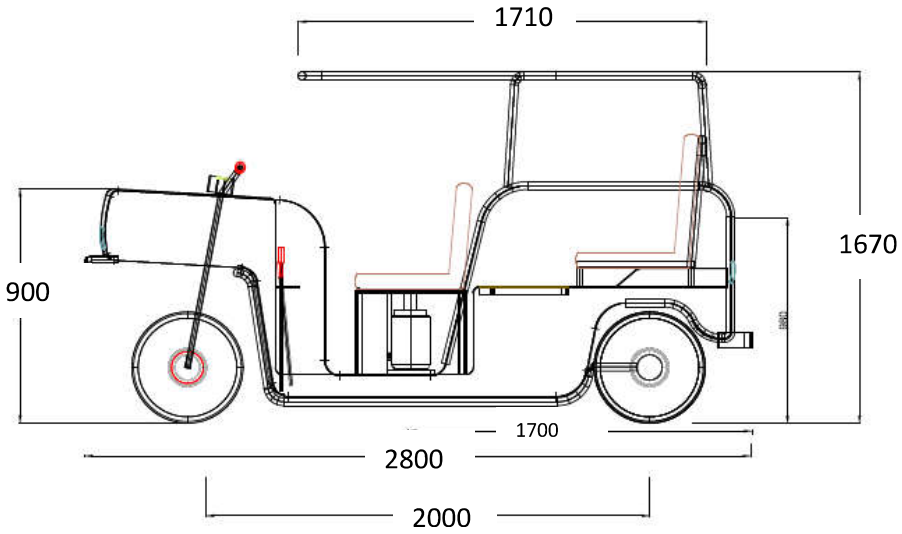

Figure 2: 3D view and Dimension of the Tricycle

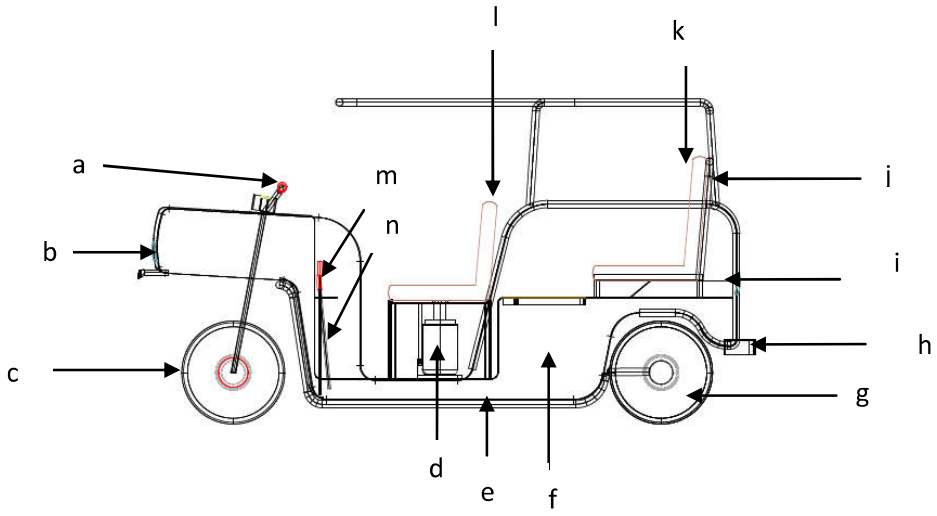

Figure 3: Labeling of the major components of the Tricycle

a	Handle bar	h	Rear bumper
b	Front bumper	i	Boot position
c	Front tyre	j	Vehicle roof frame
d	Hydraulic Jack	k	Passenger's seat
e	Chassis	l	Driver's seat
f	Engine position	m	Gear handle
g	Rear tyre	n	Brake handle

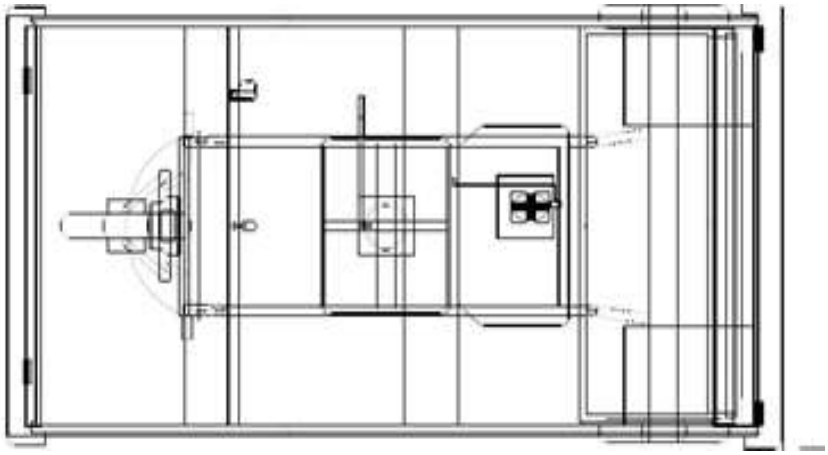

Figure 4 Top view of the Tricycle

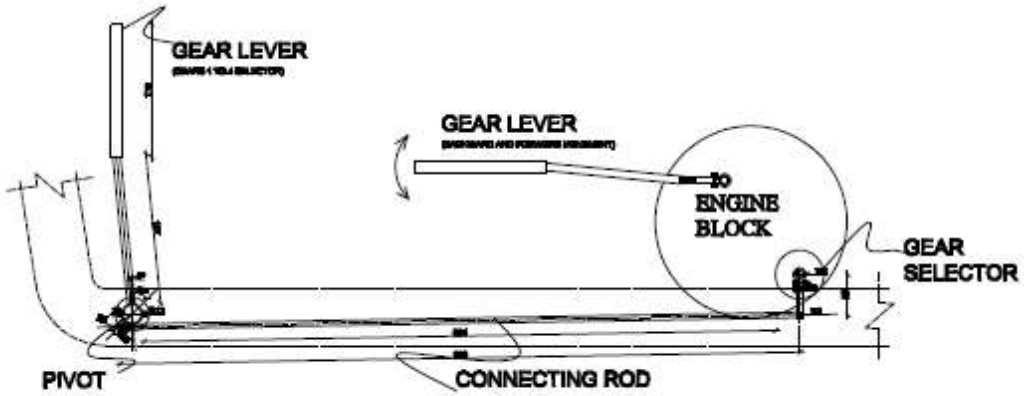

Figure 5. Exploded view (clutch and gearing mechanism) of the Tricycle

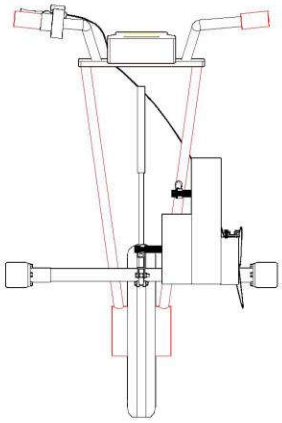

Figure 6. Side View

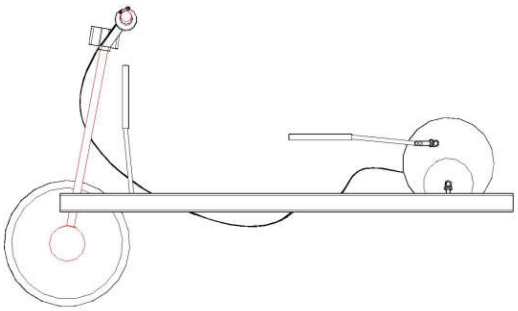

Figure 7 Front View

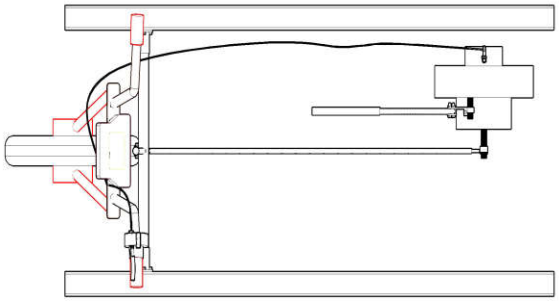

Figure 8 Plan View

Handle bar

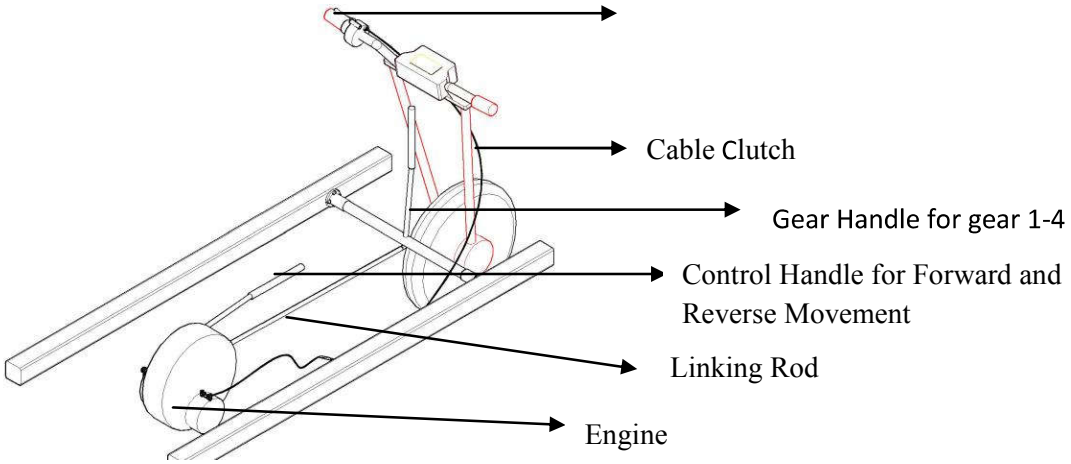

Figure 9 AutoCAD Drawing of the Modified Mechanism (clutch and gear)

Figure 10 Side and Back View of the Tricycle