Design and Construction of a Motorized Tricycle for Physically Challenged Persons

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Abstract

The design and fabrication of a motorized tricycle for physically challenged persons was carried out. The aim was to improve on already existing tricycles, which are simple assembles of bicycle parts with no design specification. Anthropometric data were used to determine the lengths and size of the body parts of human being as well as the body weight. The most important part of the design is the incorporation of the fuel powered system which was added to improve the efficiency of the tricycle and to make life more comfortable for the physically challenged persons. A spark ignition automatic single speed two- stroke engine was chosen for this design and consideration was also given to the weight of the user in which a maximum weight of 75kg was used. The tricycle also has manual drives to assist in emergency situations and to supplement the power drive.

Keywords: *Disabled persons, anthropometric data, fuel powered system, shaft, chain, wheel, brake.*

Introduction

Disability could be caused by injuries sustained mainly from motor accidents or during turnkey project work or in manufacturing industries as well those caused naturally. Due to the enormous number of disabled people in the society, a motorized tricycle has been fabricated and designed to specification. The tricycle enables the user to travel a long distances within a short period of time, with ease and without any constraints. The design of a motorized tricycle is an improvement on the existing ones, Hollowenko (1961). It is carried out to benefit the user conveniently, physically, and comfortably such that when a little effort is exerted, a greater output (movement) is achieved as a result of the fast transmission generated by the motorized system.

The project's goal is to provide a good living condition for people considered to be physically challenged (disabled), to transport themselves around their environment. A fuel-powered engine which incorporates the gear system was included in the design. Shaft of specified design and bearings were also included for proper transmission.

Design Consideration

Keyserling *et al*. (1992) showed that trunk flexion, lateral bending, twisting increases muscular stress and in vertebral disc pressure, while long hours of sitting leads to increase risk of back pain and muscular fatigue, an adjustable seat was provided. Proper care was taken to ensure the comfortability not to worsen the condition of the disabled person.

Disabled persons are faced with the task of climbing high terrain or accelerating down it. This is actually due to the step-up drive of the tricycle since greater torque is required during hill climbing (Dreyfuss 1967). To alleviate this problem a chain sprocket drive has been included in the design so as to achieve a better torque. Some of the component parts of the tricycle are: chains, footrest, wheel, rims, spokes, sprockets and chain assembly, seat, shaft, and brakes.

Design Analyses and Calculations

Shaft Design

The combined bending moment of the most critical section of the shaft is given by

$$M_B = \sqrt{M_{bv}^2 + M_{bh}^2}\,, \qquad (1)$$

where:
M_{bv} = the bending moment due to vertical loading;
M_{bh} = the bending moment due to horizontal loading.

From Eq. (1), M_B is determined to be 1,632 N.m.

The shaft diameter can be determined by

$$d^3 = \frac{16}{\pi S_s}\sqrt{(K_b M_b)^2 + (K_t M_t)^2}\,, \qquad (2)$$

where:
M_t = torsional moment (N.m);
M_b = bending moment (N.m);
K_b = combined shock and fatigue factor applied to bending moment;
K_t = combined shock and fatigue factor applied to torsional moment;
S_s = Allowable stress for shaft without keyway, MN/m^2.

From Eq. (2), the shaft diameter is determined to be 24 mm.

Torsional moment can be determined by

$$M_t = \frac{9{,}550 \times K_w}{\text{rev/min}}\,, \qquad (3)$$

where:
K_w = power output of the engine;
rev/min is speed of the shaft.

The engine power is 2.98 kW and the speed of the engine is 300 rev/min. From the Eq. (3), the torsional moment is determined to be 94.99 N.m.

Determination of Required Power

The required power for the tricycle to move over rough terrain is given as:

$$P = \frac{Wv}{3.733}\,, \qquad (4)$$

where:
P = power (W);
W = weight of the tricycle (N);
v = optimum linear speed (m/s).

From Eq. (4), the power required to drive the tricycle is determined to be 2,627.38 W.

Determination of Angular speed

The angular speed is determined from

$$\omega = \frac{2v}{d}(rad/s)\,, \qquad (5)$$

where d = diameter of the shaft.

From Eq. (5), the angular speed is determined to be 31.5 rad/s.

Determination of Rotational Speed

The rotational speed is given by

$$\mu = \frac{60\omega}{2\pi}(r.p.m.)\,. \qquad (6)$$

The rotational speed is determined using Eq. (6) to be 300 r.p.m.

Determination of Driving Torque (Manual)

The driving torque is given by

$$T = \frac{P}{\omega}\,. \qquad (7)$$

The driving torque is determined using Eq. (7) to be 83.4 N.m.

Determination of Driving Torque (Power Drive)

The driving torque for the power drives can also be determined using Eq. (7), where P is the engine power which is 2,984 W.

Using Eq. (7), the driving torque is determined as 94.97 N.m.

Determination of the Maximum Shear Stress on the Shaft (Manual Drive)

The shear stress on the shaft can be determined from

$$\tau_{\max} = \frac{16T}{\pi d^3}\,, \qquad (8)$$

where:
T is the torque (N.m); and
d is the diameter of the shaft (mm).

From Eq. (8), the maximum shear stress is determined to be 72.82 MN/m^2.

Determination of the maximum shear stress (Power drive)

The shear stress on the shaft for the power drive can also be determined from Eq. (8) to be 34.99 MN/m^2.

Determination of Braking Forces

The maximum retarding force without skidding is given by

$$F_{\max} = \mu_{tr}\omega, \quad (9)$$

where μ_{tr} is the co-efficient of friction between tyre and road.

The maximum braking force is determined in Eq. (9) to be 858.2N

Determination of Energy during Braking

The energy dissipated during braking is expressed as

$$B_b = \frac{W}{2g}(u^2 - v^2), \quad (10)$$

where: W = portion of weight for which the brake is exerted; u = initial velocity (m/s); v = final velocity (m/s).

The energy dissipated during braking is determined using Eq. (10) to be 2,296 J.

Determination of Fuel Tank Capacity

A cylindrical fuel tank structure is chosen because of its low surface area for a given volume and the ease of emptying the tank. The volume of fuel in tank is assumed to be equal to the volume of the cylinder making the tank. This can be expressed as

$$\pi r^2 l = r_f{}^2 L, \quad (11)$$

where: r = radius of fuel tank; l = length of fuel tank; r_f = radius of the cylinder making the tank; L = length of the cylinder making the tank. The volume is taken as 5,000 cm^3.

Using Eq. (12), the radius of the tank is determined to be 73 mm.

Determination of Oil Tank Capacity

The volume of oil tank

$$V_0 = \pi r_0{}^2 l_0, \quad (12)$$

where: r_0 = radius of oil tank; l_0 = the length of oil tank.

The radius of oil is determined using Eq. (12) to be 46 mm.

Testing and Results

It was discovered that the transmission shaft was rotating within the wheel hub, causing the tricycle not to move at the desired speed. This was corrected by incorporating a locking mechanism to lock the hub to the shaft thus preventing slippage.

It was also discovered that the speed the tricycle travels when on power drive is considerably higher than that of the manual drive.

Conclusion

The objectives of the design and fabrication of a motorized tricycle using available local materials was successful to a great extent and it was discovered that the tricycle will lessen the burden of the disabled people due to its affordability.

One innovation that distinguishes this tricycle from the other existing ones presently in Nigeria is that it is dual driven, both manually and fuel powered. The existing ones in Nigeria are manually driven.

References

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