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Design and Fabrication of Customized Tricycle for Corporeally Challenged People

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Abstract. This paper describes the design and fabrication of a Custom hand-driven Delta frame tricycle. In a developing country like India disability is a major issue. People using tricycles are facing various kinds of difficulties. The commonly faced problems are the requirement of more effort while riding in rough terrains, the chance to roll back while climbing through sloped paths, Carrying the tricycle while travelling and the space occupied by the tricycle. There are many models of tricycles are available in the market to address these issues. Some of the common solutions available in the market are motorized tricycles powered by both solar and electric, Hybrid tricycle and Hand powered. Each of them has its advantages and drawbacks. Though the motorized tricycles are easy to operate and efficient it is not affordable by all and also the maintenance cost is also high. The hand-driven tricycles are simple and affordable by most people and don't require more maintenance. This paper describes the various problems faced by the people using tricycles and their available solutions and the things that can be done to improve the functionality of a hand-driven tricycle.

Keywords: Tricycle, Disability, Handicapped.

1 Introduction

The history of tricycles dates back to the 1680's. A disabled German watchmaker named Stephan Farffler designed and fabricated the first three wheeled wheelchair in order to overcome his disability and to maintain the mobility in 1680.The tricycles are powered by hand cranks. Later in 1789 two French inventors made a three wheeled vehicle which is powered by pedals and they called it as tricycles. In 1876 a new tricycle model named Coventry levered tricycle was proposed by James Starley. The tricycles had two small wheels on Right and a big wheel on left side. Then in 1877 Starley redesigned the tricycle and named it has Coventry rotary which is one of the first rotary chain driven tricycle. The Leicester Safety Tricycle Company build the first front steered tricycle in 1881.During this period there were nearly 120 different models are manufactured by 20 leading manufacturers. Tricycles are used by handicapped people with leg impairment. There are several variants of tricycle available in market. Delta, Tadpole

and Recumbent are the commonly used tricycle models. The delta type trike has two wheels at the back. The tadpole tricycle has two wheels at the front and the Recumbent tricycle is available in both type of configurations in which the sitting position is very low and almost in lying position. The tricycles can be categorized based on the driving source also namely hand riven, electric, solar and Hybrid etc (Kanthi & Kumar, 2020; Kiran et al., 2018; Mohekar et al., n.d.; Sharma & Manocha, 2017; Vasudevan et al., 2020; Zipfel et al., 2009). The electric tricycle has a motor which is powered by the battery. The solar tricycle is almost similar to electric tricycle but the main difference is it is powered by a solar panel. The hand driven tricycles are cheaper and simplest. The hand driven tricycles have various kinds of drive mechanisms like slider crank mechanism, Chain drive Pully belt system and so on.

2 Problem Definition and Objective

Working individuals with disabilities especially living in urban areas who move from one place to another using tricycles experiences many difficulties regularly. It is difficult for people with disabilities to propel the tricycle in rough terrains and inclined paths. They need to put more effort while driving in these types of places. While climbing uphill if they experience any difficulty means they can neither stop nor move forward. In that case they need to retreat to the starting position and need to repeat the same or need someone's help to climb up. Though there are many engines powered and motorized tricycle models available people still stick to the Hand driven tricycle due to economic feasibility. The main objective of the project is to reduce the effort of the disabled people while riding in rough terrains and climbing uphill. This is done by incorporating the variable chain sprocket drive which enables the user to adjust the torque applied as per the requirement. The ratchet and pawl mechanism are used to prevent the vehicle from moving downhill.

3 Methodology

Identification of problem from the existing system is mandatory to carry out the further process. The definition of a problem should not be limited to current conditions or difficulties. Emerging and potential future problems could also be considered. Different ideas for solving the problem are outlined by gathering information from various sources and the best one is chosen. From that, certain required modifications should be done to increase the clarity in the solution. The modelling and designing part are the earlier stages. Suitable materials are selected to fabricate the model. The fabricated harvester is tested for trail in the field. The drawbacks from the testing are noted and the corresponding errors are rectified.

4 Working

The ratchet and pawl mechanism is used to arrest the backward motion of the tricycle wheel. This is done to prevent the tricycle from moving backwards while climbing in inclined paths. This mechanism allows the wheels in only one direction and arrests the motion in opposite direction. The variable chain sprocket drive is used instead of a common chain drive. It enables the user to change the speed and torque requirements by changing the sprocket pair. The tricycle design is modified shown in *figure 4.1* in such a way that the ground clearance is as low as possible so that the center of gravity of tricycle is closer to the ground which improves the stability of the tricycle.

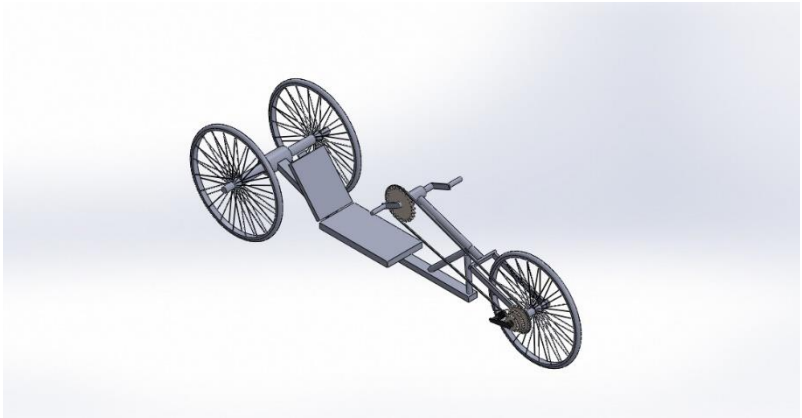

Fig 4.1 Assembled Tricycle Model

5 Design Calculation

Ratchet and Pawl

$$[\sigma_b] = 500kgf/cm^2 = 50N/mm^2$$

Torque $T = F \times d = 100 \times 9.81 \times 0.6 = 588.6\ Nm$

$$T/2 = 294.3Nm$$

$$Z = 20$$

$$\Psi = \frac{b}{m} = 1.5$$

Module $m = 2\sqrt[3]{\left[\frac{M_t}{Z \times \Psi \times [\sigma_b]}\right]} = 2\sqrt[3]{\left[\frac{294.3 \times 10^3}{20 \times 1.5 \times 50}\right]} = 11.62 \approx 12mm$

Tip circle diameter of Ratchet $D = m \times Z = 12 \times 20 = 240mm$

Face width $b = \Psi \times m = 1.5 \times 12 = 18mm$

Peripheral Force $P = \frac{2M_t}{D} = 2 \times \frac{294.3 \times 10^3}{240} = 2452.5N$

Linear unit pressure $p = \frac{P}{b} = \frac{2452.5}{18} = 136.25N/mm$

Circumferential pitch $t = \pi m = \pi \times 12 = 37.70$mm

Normal distance of force P from the critical distance $h = 9mm$

Length of Chord $a = 12mm$

Fillet radius at the Chord $r = 1.5mm$

Normal distance of force P from the critical distance $h_1 = 12mm$

Thickness of collar on pawl pin $a_1 = 6mm$

Diameter of pawl pin $d = 2.71\sqrt[3]{\left[\left[\frac{P}{2[\sigma_b]}\right]\left(\frac{b}{2}+a_1\right)\right]} = 2.71\sqrt[3]{\left[\left[\frac{2452.5}{2\times50}\right]\left(\frac{18}{2}+6\right)\right]}$

$$= 19.42mm \approx 20mm$$

Thickness at bend $x = d = 20mm$

The pawl is checked for eccentric compression or tension

$$\sigma = \frac{6M_{b1}}{bx^2} + \frac{P}{xb} = \frac{6 \times 2452.5 \times 9}{18 \times 20 \times 20} + \frac{2452.5}{18 \times 20} = 12.94N/mm^2 < 50N/mm^2$$

So, our design is safe.

6 Construction

The CAD model is developed based on the design calculations. The ratchet and pawl mechanism is machined. The mild steel square section rods are measured using tape and cut as per the requirements. Then they are welded together to form the frame. Then the other parts such as gear set, wheels, Hand pedal and Ratchet and Pawl mechanism are assembled in place. The assembled model is shown in figure 6.1.

Fig 6.1 Fabricated Model

7 Conclusion

The ratchet and pawl mechanism which is fitted at the rear wheel arrests the backward motion of the wheel and the gear system is also working properly. The fabricated model is then tested in various places and it satisfied the user's requirements. The solutions are the addition of Variable sprocket chain drive and the Ratchet and pawl mechanism to arrest the backward motion.

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