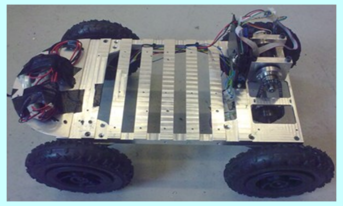
DESIGN AND MANUFACTURE OF A FLYWHEEL DRIVING SYSTEM FOR AN ELECTRICALLY POWERED VEHICLE

1. Background

A flywheel can be used as a kinetic energy storage device. The energy can be stored when the flywheel is speeded up and rotating. The faster the rotation is, the more the energy stored. The advantages of flywheel energy storage are:

- Relatively high energy efficiency
- Long lifetime
- Short charge time
- Environmentally friendly



In order to learn and explore flywheel energy storage and driving technology in a car system, an extra flywheel driving device was suggested to design and build based on an a pre-built vehicle (shown above).

2. Design Objectives

The design is to build and test a flywheel driving system parallel to the existing electrical motor driving system and further to:

- Drive the vehicle by sharing driving power with the existing motor, or to drive the vehicle individually and extend the travelling (settling) time of the vehicle.
- Investigate the use of the flywheel driving device in the existing vehicle
- Summarize the performance and give the further adaptations to improve the design and possible usages of flywheel driving in the modern vehicles.

3. Flywheel Driving Concept

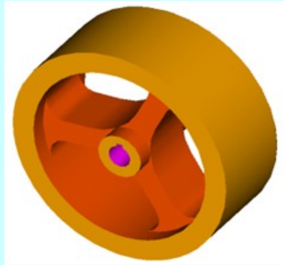
A chain-sprocket driving concept is applied in the design. It allows the flywheel energy to be transferred to the vehicle shaft through a chain-sprocket transmission with a certain speed reduction. The main advantages of using a chain-sprocket transmission design are:

- No significant redesign required on the existing vehicle
- Easy to manufacture and maintain

Driving Procedures:

1. Let the flywheel be disengaged from the vehicle driving system, and thus charge the flywheel to 700 rpm or a little higher.
2. Accelerate the vehicle to 0.5 m/s by an external force. The flywheel is still disengaged in this step;
3. Engage the flywheel to drive the vehicle till it stops once the vehicle speed reaches 0.5 m/s. The flywheel should be the only power source in this step.

4. Flywheel & Transmission Design



The flywheel is designed as a rim-wheel with three arms by using mild steel. The hollow design enable to offer a larger moment of inertia and subsequently a longer setting time of the vehicle.

Two chain-sprocket systems are utilized with a gear ratio of 12.2: 1

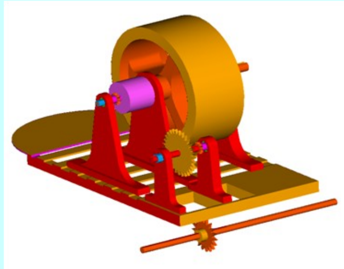
Key Parameters:

Weight: *7 kg*; Moment of Inertia: *0.0579 kgm2*
Outer Radius: *0.1m*; Inner Radius: 0.*0106m*
Thickness: *0.08m*; Theoretical Setting time: *58 seconds*

5. Driving System Design

Design Objectives:

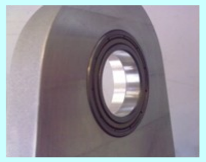
- to charge the flywheel to the required speed that is 700 rpm
- to engage the flywheel to drive the vehicle by using a clutch
- to reduce to speed by the ratio 12.2: 1 by using the chain-sprocket transmission
- to be assembly- friendly.



Four sub-designs have carried out. They are named *front driving design, middle driving design, wheel driving design and flywheel-charging design respectively*. The assembly of the first threes sub-designs are shown in the figure next. Among them, the flywheel-charging design is to charge the flywheel by using an external power source. The front driving design is mainly aimed to support the flywheel and engage the flywheel in the driving transmission by using a clutch. The middle driving and wheel driving designs are basically chain- transmission designs, which help to transfer the flywheel power to the vehicle rear wheels and reduce the transferred angular speed to fit the vehicle speed.

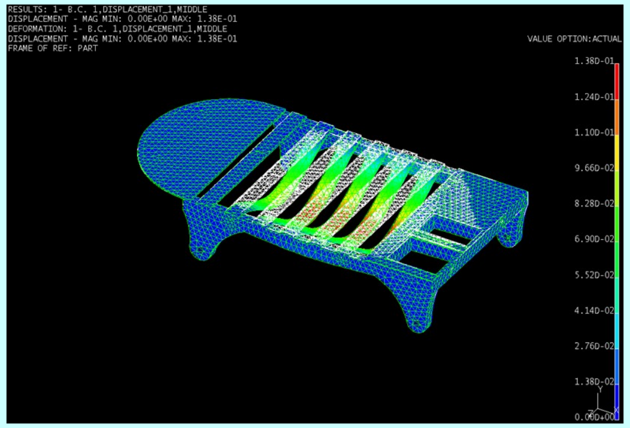
Fixing & Fastening:

Common integrating methods have been used to integrate the parts, such as keys and screws. Bearings are fixed into the bearing holes with a Loctite adhesive.

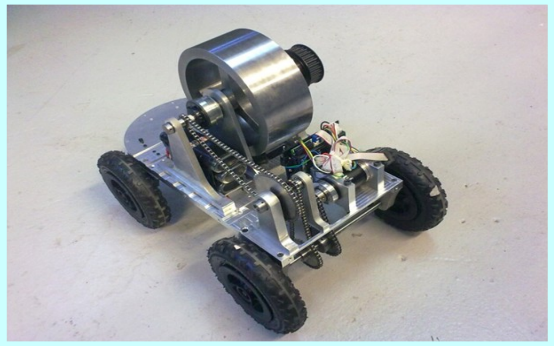
   

6. Stress Analysis on Chassis (FEA)

With an significant mass added on the chassis, stress analysis has been done by simulating the behaviour of the chassis under structural loading conditions. NX Ideas 6 has been used to do this. The final results show the chassis is able to support all the added weight with a proper safety factor of 1.55.



7. Final Tests & Conclusions



By following the driving procedures, an average settling time of 33.29 seconds has gained from the tests, while the theoretical value is 58 seconds. The error mainly came from the viscous friction of bearing rotations, which increased the vehicle deceleration by 1.7 times during flywheel driving process.

All in all, a flywheel has shown its advantages to be a reliable energy storage device in a vehicle through this project. However, due to its feature of supplying only decaying energy, it would be a good choice to use the flywheel as an assistant energy supplier or an instant energy storage device in a vehicle.

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