UBC Supermileage Drivetrain Design Project

Team Members: *Clayton Lund, Katherine Babcock, Trevor Fisher, Neil Lanfranchi, Kevan Côté*
Client: *UBC Supermileage Team, Katelyn Currie* ***Faculty Supervisor:*** *Paul Winkleman*

Abstract

The purpose of this project was to design and build a fuel efficient drivetrain for the UBC Supermileage Team's 2015 Urban Concept Car, which was to compete in the Shell Eco-Marathon fuel efficiency competition in April 2015. The proposed and constructed solution is composed of a centrifugal clutch, 20:1 planetary gearbox, and a custom built 2-speed selectable gearbox with an electromagnetic clutch. Mathematical modelling showed that a two stage, gear driven system with minimized shifting losses would provide the optimal acceleration efficiency. The team placed second in this year's Shell Eco-Marathon, with a fuel economy of 324 mpg.

Introduction

The University of British Columbia Supermileage Team (UBCST) is an engineering student team that designs and fabricates vehicles to compete in the Shell Eco-Marathon Americas competition, with the objective of obtaining the highest possible gasoline fuel efficiency. The UBCST required an optimally engineered drivetrain system for their 2015 Urban Concept competition vehicle (see Figure 1) to compete in the Urban Concept category, where the course simulates an urban driving environment.

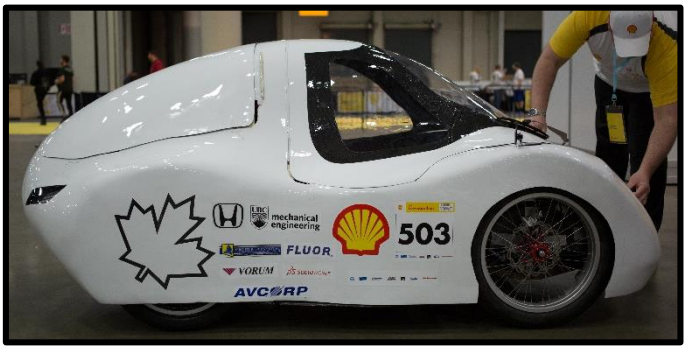

Figure 1: UBC Supermileage Team's 2015 Urban Concept Car - 'Zoticus'

The UBCST needed an entirely new drivetrain, as the previous one was destroyed in a shipping accident. The specialized nature of the Shell Eco-Marathon competition heavily influenced the objectives of the drivetrain design. Firstly, since the goal of the competition is to maximize overall vehicle fuel efficiency, the drivetrain was designed to maximize efficiency as opposed to standard vehicle drivetrains where the focus is more towards power output and durability. Furthermore, the UBCST had found from past competitions that a "burn and coast" strategy (the engine is turned on for a short period of time to accelerate the vehicle, and then shut off and the vehicle is allowed to coast for as long as possible) is the most efficient, so the drivetrain was designed with this in mind. Finally, many of the durability and performance specifications were based specifically on the course the Urban Concept needs to compete on; the course was on city streets with hills included.

Design Overview

The final product, seen in Figure 2 below, consists of both purchased and custom made components. The vehicle's engine, a 50cc Honda with custom fuel injection system, turns the shoe assembly of a centrifugal clutch. The bell housing (1) of the clutch couples to a planetary gearbox (2) with a gearing ratio of

20:1. The output of the planetary gearbox couples to our custom built 2-speed gearing system. First gear (closest to the drive wheel) is a 2:1 ratio, giving the vehicle an output ratio of 40:1 for higher starting torque. The gear on the top shaft is connected to the shaft via key, while the gear on the bottom shaft is coupled via sprag clutch (3), which allows one way motion of the gear relative to the shaft such that the vehicle can coast without back-driving the drivetrain. The second gear is a ratio of 1:1, which will overdrive the first gear when in operation, and is engaged with a shaft mounted electromagnetic clutch (4). The gear on the top shaft is directly coupled to the electromagnetic clutch, while the gear on the bottom shaft is coupled via sprag clutch.

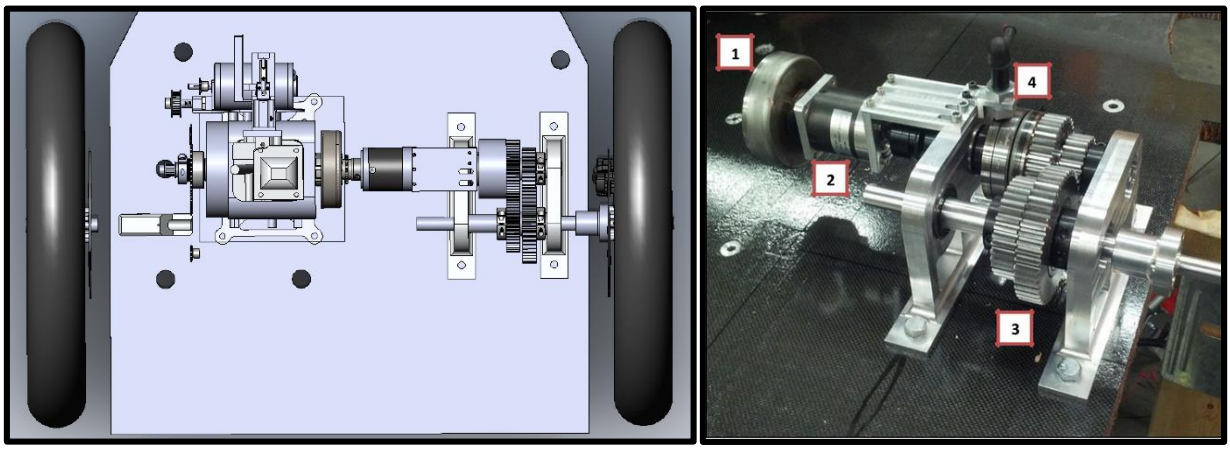

Figure 2: Drivetrain CAD Model and Final Product

The gear shifting must be done with very little drivetrain motion and while no torque is being transferred to avoid damaging the electromagnetic clutch. To achieve this, the driver accelerates in first gear, and then lets off the throttle so that the engine drops back to idling speed and the centrifugal clutch disengages. Once the drivetrain has stopped spinning, the electromagnetic clutch is engaged with a switch on the steering wheel, and the driver proceeds to accelerate in second gear.

Technical Analysis and Testing

An extensive MATLAB model of the acceleration process of the vehicle was developed such that all aspects of vehicle fuel efficiency could be considered equally, including weight, drivetrain losses, shifting losses, and engine operating speed optimization. The final product was tested briefly in the vehicle before being sent to competition, and it performed up to expectations in all regards. In competition, the vehicle achieved a fuel mileage of 324 mpg which put the team in second place. A few minor issues arose through the extensive use in competition, which are covered in the following section.

Conclusion and Recommendations

Overall, the capstone project was a great success. A fully functional 2-stage gearbox was designed to optimize vehicle efficiency, and was implemented in the car within the year, allowing the team to achieve 2nd place in the 2015 competition with 324 mpg.

A few minor recommendations have arisen from the extensive use of the drivetrain during the competition. Looking forward, the UBCST should aim to complete the implementation of the Arduino based control system that stops the electromagnetic clutch from engaging when it is unsafe to do so. This is to ensure that the clutch does not sustain any damage due to driver error. Secondly, the team should look to replace the sprag clutch in the 1:1 ratio gear set with another unit that has a keyway. The current one is press-fit in place, and by the end of competition it was evident that the sprag clutch was slipping in its housing due to the torque transfer.