Alternative Powertrain Technology

Module Code: M6X02209

Level 6

11 - May-2020

Deion Atkinson

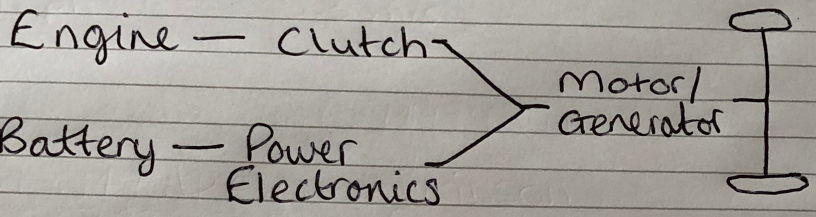
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Question 3

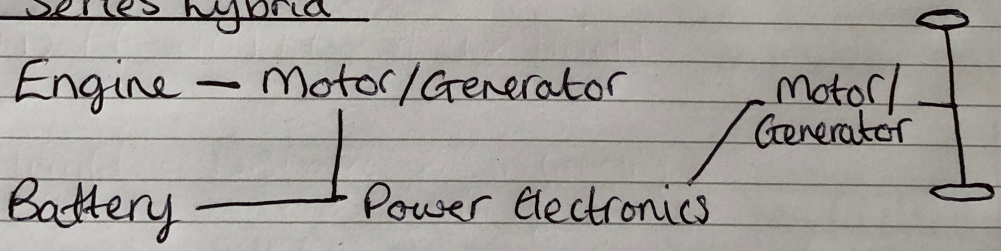
Mass = 1600 kg
Tow limit = 900 kg
Gross weight = 2600 kg

a) Parallel hybrid



This system uses the engine and the motor at either the same time or seperately. Unlike the series hybrid the ICE is connected to the wheels and is usually used when accelerating hard. With this system the wheel can be used to regenerate enery back into the battery using KERS. This is the most commonly used hybrid system.

Series hybrid



This system uses the engine to charge the batteries as it is not connected to the axle. The motor drives the wheels. The energy is supplied in aseries from the engine to the electric motor. Batteries are recharged from the generator. In this system there is no need for complicated transmissions and clutches. This system can be more economical in urban driving conditions due to the use of smaller engines and more use of electrical power. Requirement of more battery storage and larger motor power is a disadvantage.

Question 3

a) Fuel cell hybrid

The fuel cell hybrids have zero emission outputs and are very efficient. This hybrid solution is usually best for stop and go city driving. Fuel cell is a very complicated system compared to the other two hybrid systems. Storage of hydrogen on-board is tricky due to it being cold and ~~under~~ contained in high pressure vessel.

b) Energy Storage

Lithium ion batteries use carbon and highly lithium which can store a lot of energy. The Lion batteries have a very good charge and discharge rate and dont suffer from 'memory effect' as bad as NiMHyd batteries. Lion batteries are also a lot lighter than NiMHyd batteries but dont have the durability in High temperatures and extreme weather conditions. NiMHyd and Lion can store roughly the same amount of energy as each other but the Lion is a better option when ~~so~~ weight is an issue in the vehicle.

Re-fuelling

Diesel and petrol are easily re-fuelled in normal filling stations around the world. Electric charging stations have become more popular and the council could have their own charging unit back at the base.

Hydrogen re-fuelling could be done by having a storage tank near the base. Hydrogen re-fuelling requires adequately sized storage, compressors, a pre-cooling system and dispenser to deliver the fuel. This can be very costly.

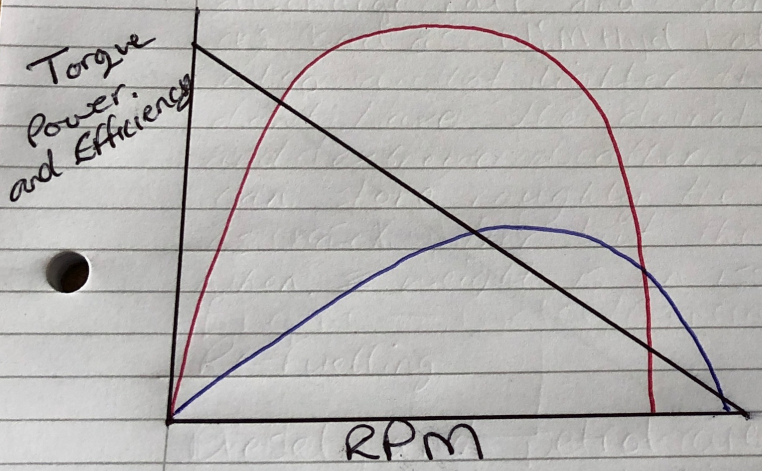
Question 3

b) Electrical Machines

Brushed DC

This type of machine uses brushes to make physical contact with the commutator. When a DC voltage is applied to the brushes it is then transferred into the commutator which powers the windings.

- These machines have a cheap and simple construction
- They can be easily controlled by a switch
- Less efficient than a brushless
- High maintenance compared to brushless
- low life expectancy due to physical contact between brushes, shaft and commutator



- Most efficient at low torque and power
- less efficient ~~than~~ at lower RPM

Question 3

b) Brushless DC motor

Similar to Brushed DC, it alternates the polarity of the windings on the interior. The magnetic fields create a push/pull force on the permanent magnets. The shaft doesnt rotate so the power can be delivered directly to the windings eliminating the need for brushes.

- Longer life span than Brushed DC
- No brushes to replace
- Moderate torque ripple
- low noise
- high torque density
- More cost than brushed
- Requries a more complicated controller/drive



- More efficient at lower speed
- More efficient at high torque and power

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Question 1

$M = 1500\ kg$
$Area = 3m^2$
$Cd = 0.5$
Density of air $= 1.2\ kg/m^3$
Density of gasoline $= 0.755\ kg/1.litre$
$RR = 0.013N$ per N
CVT Eff $= 80\%$ both directions

a) $70\ kph \times \frac{1000}{(60 \times 60)} = 19.4\ m/s$

Aero Resistance $= 0.5 \times 3 \times 0.5 \times 1.2 \times 19.4^2 = 338.7\ N$

Rolling Resistance $= 1500 \times 9.81 \times 0.013 = 191.3\ N$

Total Force $= 338.7 + 191.3 = 530\ N$

Power $= 530 \times 19.4$

Power $= 10282\ W\ (10\ kW)$

b) 5kW

~~Energy =~~

~~Energy =~~

Energy $= 5000 \times 3600$

Energy $= 18,000,000\ J$

$18,000,000 \times (1/0.8) = 22,500,000\ J$ per second

$22,500,000 \div 3600 = 6250\ W$ per hour

$6.3\ kW$ per $h \times 700 = 4410\ g\ (0.44kg)$

$0.44 \times 0.755 = 0.33\ kg/h$

Question 3

d)

ICE - Diesel turbo

- less maintenance
- High torque for towing
- Low CO_2
- Easy to re-fill
- Lower ~~tot~~ Emissions than petrol

Full parallel hybrid

- Towing up-hill both engine and motor can produce the right torque
- Coming down hill KERS can be used to charge the batteries
- low speed cruise the motor can power the wheels

Lithium Ion Batteries

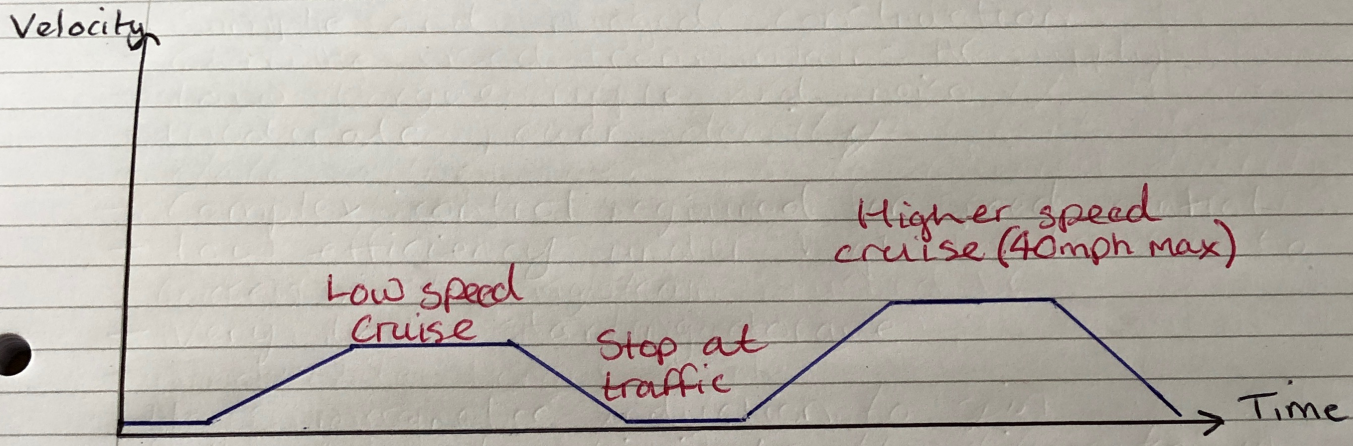
- Lighter for the application
- Good charge and discharge rate
- Low possibility of full discharge in 15 mile radius

Brushless DC Motor

- Most efficient at higher torque
- Less maintenance and costs in the long run
- When towing the motor can be strong and rugged
- Lower noise pollution if they wanted to travel during night time
- High torque density for Gross weight application

Question 3

c) Drive cycle



The van will travel through Swansea and therefore stop in traffic lights and have moments of low speed cruise. Once the van has got to a quieter are it will encounter Moderat speed cruise untill reaching its destination.

- Low power demand but high torque demand when towing a trailer
- No excessive speeds (50mph max) with trailer

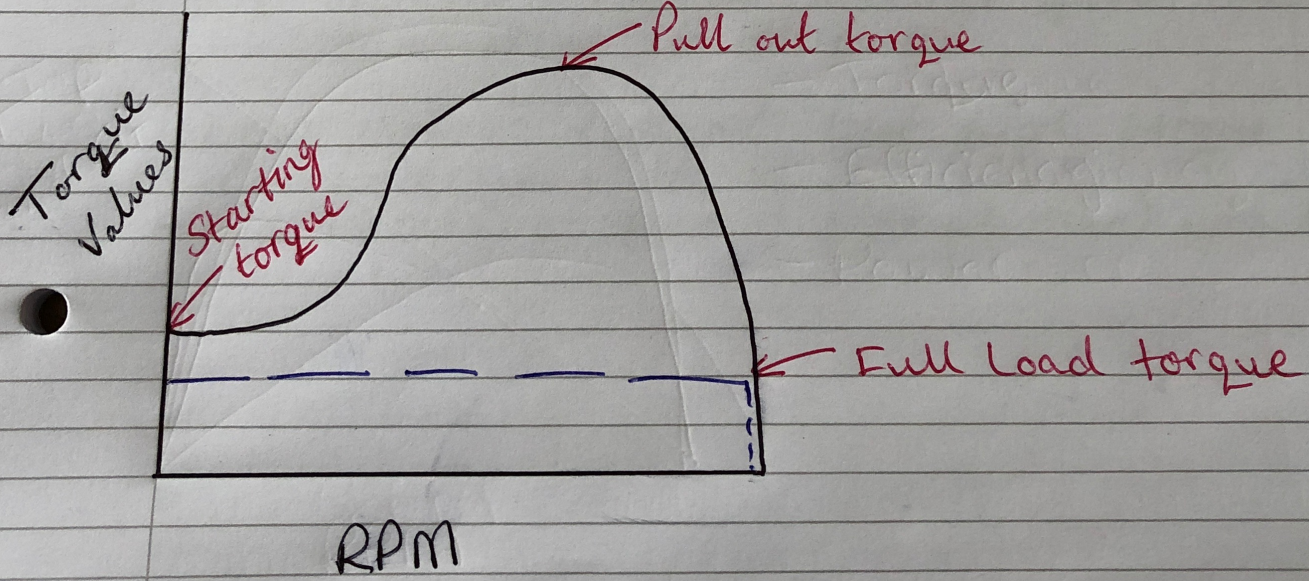
Question 3

b) AC Induction Motor

- Simple and rugged construction
- Can be used from mains AC supply
- Low torque ripple and noise
- Moderate power density

- Complex control required for speed control
- low efficiency under high loads due to losses in the system
- Very low starting torque

- Uses magnetic induction to spin
- Rotor tries to eliminate the difference in motion between itself and the magnetic field



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Question 1

c) 1.2 MJ
90% Efficiency in both directions
55kW @ 255 g/kWh

~~1.2 x (1/0.9) = 1.3 MJ (1300 kJ)~~

d) ~~1.3/55~~ $\frac{1300}{55}$ = 23.6 seconds (24)

e) 1200 kJ @ 90% Efficiency = 1080

1080 kJ @ 80% Efficiency = 864 kJ

Time taken = $\frac{\text{Joules}}{\text{Watts}}$

Time taken = 864 ÷ 55 = 16 seconds

F) Phase 1 + Phase 2 = 40 seconds

3600 ÷ 40 = 90 cycles in 1 hour

g) 90 cycles in 1 hour

1 gram per restart = 90 grams