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Design and development of Hybrid vehicle

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Abstract : The automobile industry is on the rise and the population of the world is also rising constantly which means there will be a lot of cars and cars are going to be a basic necessity with the way technology is advancing too. Fossils fuels are main fuels used to power cars. There are many drawbacks of using fossil fuels, the most important one is that they are finite, secondly combustion of fossil fuels create many harmful gases which are fatal to humans and the environment. For the first drawback we have to use fossil fuels in the most efficient way we can. So we have decided to design a hybrid vehicle whose powertrain will run in such a way that the engine will be used in its ideal running cycle most of the time. For this the rear wheels of the car will be powered by an electric motor and the front wheels will be powered by the ICE(internal combustion engine). This will also in turn decrease the emission of harmful gases to the environment.

***IndexTerms* - electric drive, differential power rear drive, hybrid vehicle, bldc motor drive**

I.INTRODUCTION

The front wheel drive will be powered by the ICE, and rear wheel drive will be powered by the electric motors. Our vehicle will make efficient use of the ICE by shifting the power generation to the motor when the power required can not be generated within the ideal running cycle of the engine. The starting acceleration will always be provided by the electric motor. The load will be cut off from the electric motor and shifted to ICE when the ICE is ready to perform in its ideal cycle where fuel wastage is minimal and fuel will be used most efficiently. The reason we have decided to make a hybrid car and not a fully electric one is because the electric motor can not sustain heavy loads for more time efficiently, a minimum of 15% loss in torque starts which will climb up to 90% over a short period of time as speed of motor increases. The electric motor will always start from its peak performance position which will stay constant and then an abrupt decline will start. Whereas the ICE needs some time to get to its ideal cycle and it can sustain high loads for high amounts of time with no loss in efficiency but will gain efficiency over time.

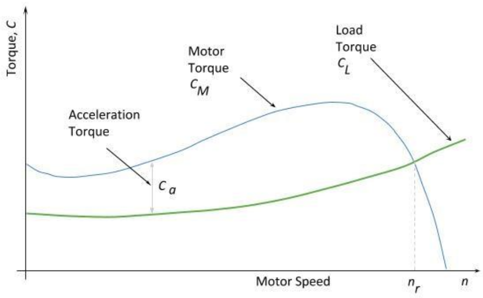


Figure 1. Torque vs Speed graph for motor

As we can see from the graph the torque generated by the electric motor will increase in the start but will decrease abruptly with increase in speed of the motor.

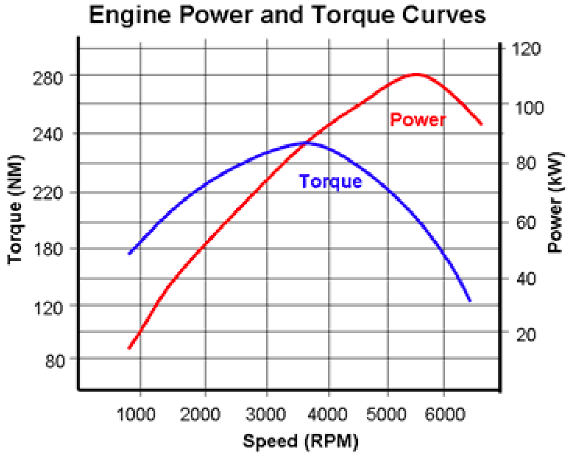


Figure 2. Torque and Power vs Speed graph for ICE

As we can see the torque and power generated by ICE increases with increase in speed. So our main idea is to calibrate the electric motor and engine in such a way that they both will perform mostly in their ideal cycle so the vehicle may perform in its most efficient way.

II. DESIGN OF POWER REQUIREMENT BY ELECTRIC DRIVE

$F_D = c_R mg + (0.5*r*A*V^2)$

Where,

F_D = total drag force
c_R = coefficient of rolling resistance
cD = drag coefficient
m = mass of vehicle [kg]
A = frontal surface area [m^2]
g = 9.8 m/s
r = density of are, 1.2 kg/m^3 @STP

A typical value for the coefficient of rolling resistance is 0.015. The drag coefficient for cars varies, a value of 0.3 is commonly used. The power output requirement can be determined from the drag force given above and the vehicle velocity.

Table 1 Readings of the Alto car Mass-887kg, Area 1.740 m^2

S.N	Speed km/h	Distance (m)	Time (s)	Drag coefficient C_d	Drag force F_d
1	20	200	40.16	0.152	5
2	30	300	59.42	0.324	13
3	40	330	50.79	1.42	187
4	50	400	52.96	0.84	161
5	60	600	60	0.517	153
6	70	700	78	0.457	184
7	80	720	82	0.454	239

$P = F_D V$

Where,

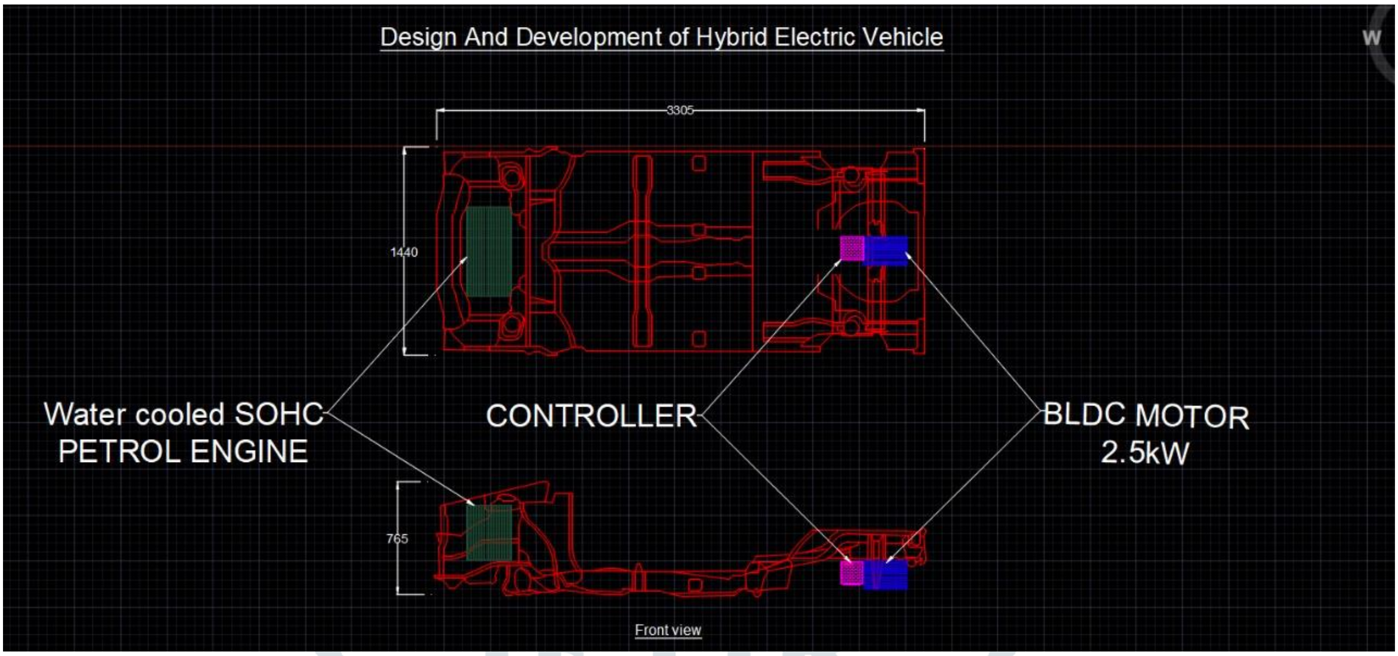
P = power required for acceleration
F_D = 153N
V = 60 kmph

Hence,

P= 153*60
P= 9180 W
P= 9.18 kW

So, the power rating of the electric motor should be at least 9.18 kW if you want to sustain a speed of 60 kmph at this load. The maximum output of the electric motor should be 9.18 kW at the minimum.

III.MODELLING



Parts in motor powertrain:

1. BLDC motor 2.5KW 60/72V 62/52A 4500rpm max
2. Motor controller electronic with pedal
3. Reduction gear set
4. Axles*2
5. Wheel drums*2
6. Protection sheets for axles and gear reduction set connection wheel drum

IV.PROTOTYPING

Assembly of parts in rear wheel drive:

Firstly we assembled the driven shafts to the reduction gear set and then measured the dimensions for making the covers. Then we assembled the covers with the wheel drums with the help of screws, bolts and welding. Then we checked the movement of each part and if anything is obstructing their motion. We made slight modifications according to the problems we faced until free movement was possible. Then we attached the motor to a stand that we built for it through clamps and fixed it sturdily so the motor was fixed properly and would not move and the stand would absorb its vibrations too. After that we fixed the controller of the motor on the other side of the rod with the help of clamps. We made a box-like structure to protect the motor and controller and especially the controller as it is an extremely vital part for the functionality of the motor. If the controller is damaged in any way the motor would stop working as it is an electronically commutated motor. So unlike other dc motors a direct connection to dc supply is not enough for the motor to function. It takes a lot of time to repair the controller so the motor becomes obsolete. Then we attached the pedal control to the controller and took it forward near the gas pedal and placed it such that if the gas pedal is pressed the pedal control for the motor will also be pressed.

Working of power transmission between ICE powertrain and Motor powertrain:

The clutch has to be pressed while turning the ICE on to avoid jerks and maintain a smooth drive. The reason behind pressing the clutch is to disengage the ICE from the gearbox so the pistons stop moving. If the pistons are moving and charge is injected and ignited the power generated would fluctuate a lot due to the initial motion of the piston and cause a lot of jerks which would disrupt the smooth drive. So in order to maintain a smooth drive the ICE needs to be disengaged from the gearbox while it's turning on. When the gear stick is in the neutral position the ICE is not engaged to the gearbox, so while transmission the car has to be in neutral. So when the electric motor is in use the gear stick will be in neutral position. To control the functionality of the ICE we have chosen to use the fuel pump as a switch-type control as if fuel is not injected to the ICE it would not work. ICE needs fuel to function as combustion of charge produces force which moves the pistons which in turn give power to wheels. So the fuel pump will turn on when the switch in the car is shifted to petrol from electricity. The gear stick needs to be in neutral position while switching or the clutch needs to be pressed if the stick is in any gear position.

Control of the motor:

The power for the motor is from the battery supply we set for it and it is controlled by the switch which controls the fuel pump, so when the fuel pump is on the battery supply is off and vice versa. To control the speed of the motor a pedal control is also provided which is placed such that when we press the gas pedal the pedal control for the motor will be pressed too. The battery will turn on when the switch in car is placed on electric mode not petrol mode

Model photos:

Figure 1.

Figure 2.

Figure 3.

Figure 4.

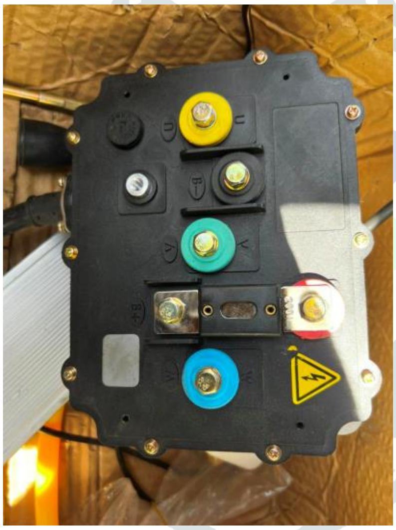


Figure 5.

Description of figures:

Figure 1 shows the full set of the differential which is the combination of shafts, gear reduction set, wheel drums and protection covers for the internal connection for the shafts, wheel drums and gear reduction set. Figure 2 shows the bldc motor connected to the differential. Figure 3 shows the differential mounted on the vehicle through U clamps. Figure 5 shows the controller of the motor.

V.Conclusion

The vehicle can sustain speed upto 50 kmph on the electric drive and it will take upto 7 hours for charging the LA battery set. The battery set can sustain a range of 50 km on a full charge. If we use a lithium ion battery set it can sustain a range upto 300 km on a full charge and it takes only 3-4 hours for the lithium ion battery to get fully charged. We could not use the lithium ion battery set as its cost was upwards of eighty thousand rupees which we could not bear for this project.

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