CALCULATION OF POWER AND TORQUE FOR MAHINDRA ZOR DV 3W

Dimensions - (3100*1460*1762)
GVW - 995 kg ~ 1000kg
Gradeability - 0-7 degree (0 degree is considered)
Air density - 1.2 kg/m^3 @27 degree celsius

Velocity - 0-20 km/hr in 2.3 sec (Uniform velocity is considered)
0.5s – 1.2075 m/s
1s – 2.4152 m/s
1.5s – 3.6230 m/s
2.0s – 4.830 m/s
2.3s – 5.556 m/s

Acceleration – (final velocity – initial velocity)/change in time
Max acceleration – 2.415 m/s^2 (At high velocity acceleration is low and at low velocity acceleration is high. Hence acceleration considered 1.3m/s^2.)

RESISTANCE FORCES

1) Rolling resistance forces(F_{rr}) = GVW*C_{rr} = 1000 * 9.81 * cos(0)* 0.01 = 98.1 N
2) Aerodynamic Drag Force(F_{ad}) = 0.5 * rho *C_d * Area *v^2 = 0.5* 1.2 *0.45* 2.5725 * $(5.556)^2$
= 21.44 N
3)Acceleration Force(F_{acc}) = m*a = 1000* 1.3 = 1300 N
4)Gradient resistance force(F_{gr})= GVW * g * sin(0)* 9.81 = 0 N

Total tractive force(F_{total}) = F_{ad}+F_{rr}+F_{acc}+F_{gr} = 98.1+21.44+1300+0 = 1419.54 N

Tyre – MRF SAVARI LT155 D12
1) Tyre radius(R_w)= Rim radius + sectional height = 152.4+124 = 276.4mm =0.276m

TRACTIVE TORQUE = tractive force *tyre radius = 1968.05*0.276 = 543.18 Nm

Here the flow is of wheel – gear box – motor

<u>CONDITION-1(Taking wheel as base)</u>

Power required to overcome,
1) Drag force(P_{aero}) = F_{aero} * v = 21.44 *5.556 = 119.120 W
2) Rolling resistance(P_{rr}) = F_{rr}*v = 98.1 * 5.556 = 545.43 W
3) Gradient resistance(P_{gr}) = 0
4) Power required for acceleration(P_a)
Work done(W) = Force * displacement = m*a*dis
= m*(v/t)*0.5*a*t^2
=0.5*m*v^2
Now,
Avg acceleration power(P_{acc}) = W / time period = (0.5*m*v^2)/t
= 0.5*F_{acc}*v
= 3611kW @ 20km/hr

Peak acceleration power(Peak P_{acc}) = F_{acc}*v = 1300*5.556
= 7222.8 W(7.2kW)

Total power required to overcome road loads = $P_{aero}+P_{rr}+P_{gr}+P_{acc}$
= 119.120+545.43+0+3611
= 4275.55 W ~ 4.2 kW

Peak power required = $P_{aero}+P_{rr}+P_{gr}$+Peak P_{acc}
= 119.120+545.43+0+7222.8 = 7887.35 ~ 8kW

CONDITION-2(Considering transmission)

WHEEL RPM:

Omega = v/r = 5.556/0.276 [r-radius of wheel]
= 20.129 rad/sec

Now,

N_{wheel}=(omega*60)/(2*3.14) = 192.218 rpm @ 20km/hr (@50km/hr - 480 rpm)

WHEEL TORQUE:

Wheel torque = F_{total}*perpendicular distance(Radius of wheel)
= 1968.05*0.276 = 543.18 Nm

GEAR RATIO :

Gear ratio = (RPS/Top speed)*tyre circumference
= (4000/13.88*60)*(2*3.14*0.276) [@50km/hr the rpm will be 3000]
= 8.3 ~ 8

{FOR gear ratio 10:1
Nm = 10*192.218=1922.18
Tmotor = 543.18/10=54.3
power of motor = 10.86kW}
Now,

Speed of motor(N_m) = gear ratio * N_{wheel} = 4*480 = 1819 rpm ~ 1800 rpm

Torque of motor (T_m) = Peak power*60/(2*3.14*1920) = 8000*60/(2*3.14*1800) = 42.46 Nm

Hence,

By
Rated power is 4.2kW

Hence we consider the maximum power of 8 kW for PMSM motor