Introduction to propulsion systems HW-1

Basic FBD and Matlab

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September 14, 2012

1 Validation of the problem solved using Matlab

To validate the solution let us take four points on the drive cycle where we should be able to predict roughly if tractive power should be positive or negative.

For this validation, I suggest four points at times, t=10s, 50s, 325s, 375s

Considering,

v - velocity

a - acceleration

M - mass

W - weight = 4100 Lbf

P - density = 0.0378kg/m^3

$F_T - tractiveforce$

$D - aerodynamicdrag$

$R - Rollresistance$

$G - Gradient$

$C_d - CoefficientofDrag = 0.4$

$A - Areaofcrosssection = 2.7m/s^2$

$d - slopeindegrees$

1.1 At t=10s

v = 9.98mph = 4.46ms$^-$1

$a = 2.05ms^-2(FromMATLAB)$

$W = 4100Lbf = 18330N$

$M = W/g = 1860Kg$

From the equation,

$$Ma = F_T - R - D - G \tag{1}$$

$$F_T = Ma + R + D + G \tag{2}$$

D = 0.5 * C$_d * A * P * V^2$

Substituting values given in this equation we get,

D = 0.5*0.4*2.7*0.0378*(4.46^2) = $0.403N$

R = 0.01 * W * (1 + 0.01*(V in mph))

Substituting the values in this equation,

R = 0.01 * 18330 * (1.09) = 199.797N

Hence,

$F_T = Ma + ResistanceForce$

$= 1861 * 2.05 + 199.79 + 0.403 = 4015N$

This value had to be positive as the vehicle is accelerating and also encountering a resistance. The supporting tractive force which is positive supports this fact.

1.2 At t=50s

V = 60mph = 26.82ms$^-$2

$a = 0$

Since the acceleration is zero, the tractive force needs to support resistances only and this tractive force should actually be lower than the previous as there is no acceleration.

D = 0.5*0.4*2.7*0.0378*(26.82$^-$2) = $14.68N$

R = 0.01*18330*(1+0.01*(60)) = 293.28N

$F_T = 0 + 14.68 + 293.28 = 307.96N$

This value meets our expectation of being positive and less than the previous case.

1.3 At t=325s

v = 55mph = 24.58ms^{-}1

$a = 0$

Though the acceleration is zero in this case, there is a gradient of 4 degrees. Therefore, here, the tractive force required should be much greater than the previous case.

G = mgsind = 18330*sin(4) = 1278.64N

D = 0.5*0.4*2.7*0.0378*(24.58^2) = $12.33N$

$R = 0.01 * 18330(1 + 0.01(55)) = 284.115N$

$F_T = 1278.64 + 12.33 + 284.115 = 1575.085N$

1.4 At t=375s

In this case every condition is the same except for the fact that there is a downward gradient. Therefore, this case should result in a neagtive tractive force as gravity is supporting motion here

V = 55mph = 24.58ms^{-}2

$G = -1278.64N(Fromthepreviouscase)D = 12.33NR = 284.115N$

F$_T = -1278.64 + 12.33 + 284.115 = -983N$

Conclusion

As the values predicted are reasonable in each case, I can assign some credibility for the solution obtained in MATLAB.