



Full Length Research Article

FACTS OF AN AERODYNAMICALLY DESIGNED AUTOMOBILE

*Atharva Kale

B.Tech In Aerospace Engineering Amity University Mumbai, India

ARTICLE INFO

Article History:

Received 11th November, 2016
Received in revised form
14th December, 2016
Accepted 22nd January, 2017
Published online 28th February, 2017

Key Words:

Aerodynamically,
Designed,
Automobile.

Copyright©2017, Atharva Kale. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

ABSTRACT

Every F1 team must decide how much fuel their aerocars will start each race with as well as the laps on which they to refuel and change Tires
Total race time= Time to reach First stop+Time for first stop +Time to end of race

INTRODUCTION

The only reason stopping for fuel is quicker than starting with enough fuel to finish the race is because the average mass of a car which refuels during a race is lower than when it doesn't. When the car is lighter it takes less time to complete a lap. The reason behind this is as follows:

Essentially, Newton's second law ($F = ma$) applies to the car as it travels around the track. From this, we can see that if mass goes up but forces remain unchanged then accelerations must Reduce and lower accelerations mean increased lap times. In reality, it is slightly more complicated all of the forces don't stay the same when fuel load (and hence car mass) changes. Tyre frictional forces ($F = mN$, where m is the coefficient of friction and N is the normal force) change substantially, but Aerodynamic forces stay largely the same (lift and drag) and these are large. However, the net effect is that a heavy car (i.e. one that is full of fuel) takes longer to get around the track.

MATERIALS AND METHODS

Formulas for Calculating Carburetors CFM
Engine size (cid) x maximum RPM / 3456 = CMF
CMF @ 100% Volumetric efficiency (example: 250 CID x 6000RPM = 2,100,000 / 3456 = 608 CMF)

Formulas for Calculating Performance Convert between 1/4 mile and 1/8 mile ET's:

$$1/4 \text{ mile ET} = 1/8 \text{ mile ET} \times 1.5832$$

(Thanks to Bobby Mosher for this formula)

$$1/8 \text{ mile ET} = 1/4 \text{ mile ET} / 1.5832 \text{ (thanks to Bobby Mosher for this formula)}$$

Calculate 1/4 mile ET and MPH from HP and Weight

$$ET = ((\text{Weight} / \text{HP})^{.333}) * 5.825$$

$$\text{MPH} = ((\text{HP} / \text{Weight})^{.333}) * 234$$

Calculate HP From ET and Weight

$$\text{HP} = (\text{Weight} / ((\text{ET}/5.825)^3))$$

Calculate HP From MPH and Weight

$$\text{HP} = (((\text{MPH} / 234)^3) * \text{Weight})$$

Formulas for displacement, bore and stroke

$$\pi/4 = 0.7853982$$

$$\text{Cylinder volume} = \pi/4 \times \text{bore}^2 \times \text{stroke}.$$

$$\text{Stroke} = \text{displacement} / (\pi/4 \times \text{bore}^2 \times \text{number of cylinders}).$$

*Corresponding author: Atharva Kale

B.Tech In Aerospace Engineering Amity University Mumbai, India

Formulas for compression ratio

$(\text{CylVolume} + \text{ChamberVolume}) / \text{Chamber Volume}$
 cylinder volume = $\pi/4 \times \text{bore}^2 \times \text{stroke}$
 chamber volume = cylinder volume / compression ratio - 1.0
 displacement ratio = cylinder volume / chamber volume
 amount to mill = $(\text{new disp. ratio} - \text{old disp. ratio} / \text{new disp. ratio} \times \text{old disp. ratio}) \times \text{stroke}$
 Formulas for piston speed
 piston speed in fpm = $\text{stroke in inches} \times \text{rpm} / 6$
 rpm = piston speed in fpm $\times 6 / \text{stroke in inches}$

Formulas for brake horsepower

Horsepower = $\text{rpm} \times \text{Torque} / 5252$
 Torque = $5252 \times \text{Horsepower} / \text{Rpm}$
 brake specific fuel consumption = $\text{fuel pounds per hour} / \text{brake horsepower}$.
 Bhp loss = $\text{elevation in feet} / 1000 \times 0.03 \times \text{bhp at sea level}$

Formulas for indicated horsepower & torque

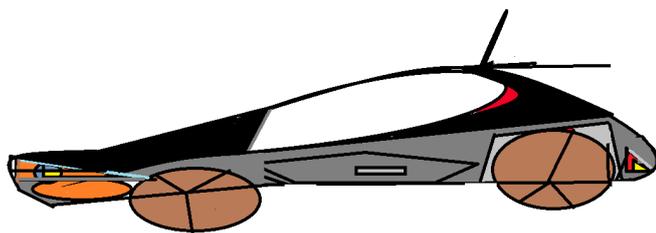
Horsepower = $\text{mep} \times \text{displacement} \times \text{rpm} / 792,000$
 Torque = $\text{mep} \times \text{displacement} / 150.8$
 $\text{Mep} = \text{hp} \times 792,000 / \text{displacement} \times \text{rpm}$
 $\text{mep} = \text{hp} \times 792,000 / \text{displacement} \times \text{rpm}$
 Mechanical efficiency = $\text{brake output} / \text{indicated output} \times 100$

Friction output = indicated output - brake output

taxable horsepower = $\text{bore}^2 \times \text{cylinders} / 2.5$
 Formulas for air capacity & volumetric efficiency
 Theoretical cfm = $\text{rpm} \times \text{displacement} / 3456$
 Volumetric efficiency = $\text{actual cfm} / \text{theoretical CFM} \times 100$
 Street carb cfm = $\text{rpm} \times \text{displacement} / 3456 \times 0.85$
 Racine carb cfm = $\text{rpm} \times \text{displacement} / 3456 \times 1.1$

Formulas for tire size & their effect

Effective ratio = $(\text{old tire diameter} / \text{new tire diameter}) \times \text{original ratio}$.
 Actual mph = $(\text{new tire diameter} / \text{old tire diameter}) \times \text{actual mph}$



A typical Aerodynamic Car Model

Formulas for g force & weight transfer

Drive wheel torque = $\text{flywheel torque} \times \text{first gear} \times \text{final drive} \times 0.85$
 Wheel thrust = $\text{drive wheel torque} / \text{rolling radius}$
 $g = \text{wheel thrust} / \text{weight}$
 Weight transfer = $\text{weight} \times \text{cg height} / \text{wheelbase} \times g$. lateral
 acceleration = $1.227 \times \text{radius} / \text{time}^2$
 Lateral weight transfer = $\text{weight} \times \text{cg height} / \text{wheel track} \times g$
 Centrifugal force = $\text{weight} \times g$

Formulas for shift points rpm after shift = ratio shift into / ratio shift from \times rpm before shift

Driveshaft Torque = flywheel torque \times transmission ratio

Formula for instrument error

Actual mph = $3600 / \text{seconds per mile}$.

speedo error percent = $(\text{difference between actual and indicated speed} / \text{actual speed}) \times 100$

Indicated Distance = odometer reading at finish - odometer reading at start

Odoerror percent = $(\text{difference between actual and indicated distances} / \text{actual distance}) \times 100$

Formulas for MPH RPM gears & tires

$\text{mph} = (\text{rpm} \times \text{tire diameter}) / (\text{gear ratio} \times 336)$
 $\text{rpm} = (\text{mph} \times \text{gear ratio} \times 336) / \text{tire diameter}$
 $\text{Gear ratio} = (\text{rpm} \times \text{tire diameter}) / (\text{mph} \times 336)$
 $\text{Tire diameter} = (\text{mph} \times \text{gear ratio} \times 336) / \text{rpm}$

Formulas for weight distribution: percent of weight on wheels = $\text{weight on wheels} / \text{overall weight} \times 100$
 Increased weight on wheels = $[\text{distance of cg from wheels} / \text{wheelbase} \times \text{weight}] + \text{weight}$

Formulas for center of gravity

cg location behind front wheels = $\text{rear wheel weights} / \text{overall weight} \times \text{wheelbase}$
 cg location off-center to heavy side = $\text{track} / 2 - [\text{weight on light side} / \text{overall weight}] \times \text{track}$
 cg height = $[\text{level wheelbase} \times \text{raised wheelbase} \times \text{added weight on scale} / \text{distance raised}] \times \text{overall weight}$

RESULTS AND DISCUSSIONS

How long will it take to reach the first pit stop?

Let us assume – Fuel Consumption
 $C = 3 \text{ kg/lap}$ How much slower our lap time is for every kg of fuel on board (also called the “weight effect”)
 $E = 0.03 \text{ sec} / (\text{lap kg})$

Time to complete a lap with 1lap of fuel on board

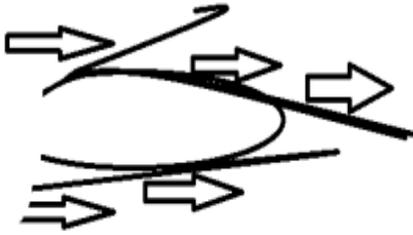
$t_1 = 100.045 \text{ sec}$
 Using this, we can calculate how much slower the car goes for every lap's worth of fuel we have on board

How long will the pit stop on lap 20 take?

Again, we have the following data from the scenario:
 Total number of laps $L_{end} = 50$
 Stop lap $L_2 = 20$
 Time to add one lap of fuel $t_f = 0.5 \text{ sec}$

Extra time to complete a lap with a pit stop but without refueling

$t_p = 20 \text{ sec}$
 Fuel consumption $C = 3 \text{ kg/lap}$



Air Molecule movement

Using this data, we calculate

50 20 30 laps of fuel= =it will take 35 seconds more to complete the lap with the pit stop on lap 20./roughly.

How long will it take to complete the rest of the race after the pit stop on lap 20?

This time we begin with 30 laps of fuel and have 30 laps to complete.....

Conclusion

AT a microscopic level the air molecules looks like a ball of electrons. So does a molecule of any randomly moving body. When the body bumps into air molecule, the electrons repel each other.

The air molecule has less mass than body, so air molecule bounces away, but energy and momentum are conserved, i.e. the air molecules gain some and the body loses some.

Acknowledgements

Some IMPORTANT facts- The sensation driving of a F1 car lies in their braking power which is 5 times higher than their acceleration power. It's not a vacuum behind the car that makes it hard for the aeropackage of the other, it is the windshadow that consists of turbulent air streams. The aero package of the car driving behind needs a clean stream of air to work efficiently. If a car drives too close up to another car, the car loses downforce. This seems weird, but the driver of the leading F1 car will feel the car in the back as well. The car in the back changes the downforce of the car in the front also.

REFERENCES

Basic Engineering Mathematics, John Bird, 2007, published by Elsevier Ltd.
 Engineering Mathematics, Fifth Edition, John Bird, 2007, published by Elsevier Ltd.
 The Royal academy of Engineering.
