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12/5/20 @ 13:00 - Powertrain and Control CMSX004047

∴ I would advise safe limit to be 6200, as is the case with their stock car. However for additional performance, this could be increased to 6500 safely. And in some racing applications, teams may purposely allow this RPM to reach the range in which float occurs as it improves performance by increasing the duration the valve is open for, allowing more air/fuel mixture into the combustion chamber.

98.3%

Epic!

12/5/20 @ 13:00 - Powertrain and Control (MSK00404)

Q3.) $x_0 = 4\text{mm}$ max lift = 10.660mm

$k = 18800\text{N/m} = 18.8\text{N/mm}$ max mass = 0.172kg

At float ~~spring~~

$F_c - k(x_0 + x) = ma$

At full lift $F_c = 0$

$0 = ma + k(x_0 + x)$

$= 0.172a + 18.8(4 + 10.66)$

$= 0.172a + 275.608$

$-275.608 = 0.172a$

$a = \frac{-275.608}{0.172}$

$a = -1602.37\text{m/s}^2$ For float to occur.

6.) ATDC Cam Angle(°)	Valve lift (mm)	Valve Velocity (mm/s)	Valve Acceleration (mm/s ²)
110	~~10.651~~	~~3×10^{-3}~~	
111	~~10.654~~	3×10^{-3}	~~1×10^{-3}~~
112	~~10.658~~	4×10^{-3}	1×10^{-3}
113	~~10.660~~	2×10^{-3}	-2×10^{-3}
114	~~10.658~~	-2×10^{-3}	-4×10^{-3}
115	~~10.654~~	-4×10^{-3}	2×10^{-3}
116	~~10.651~~	-3×10^{-3}	1×10^{-3}

.003

.004

.002

-.002

-.004

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.001

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.001

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$$L(1+0.06) = \frac{111.5}{360} \times \frac{60}{13800} \times \frac{330}{2N}$$

$$L = \left[\frac{111.5}{360} \times \frac{60}{13800} \times \frac{330}{2N} \right] - 0.06$$

For 1st Harmonic ($n=1$)

$$L = 0.162m$$

~~1.62m~~

2nd Harmonic ($n=2$)

$$L = \cancel{0.091m} 0.051m$$

Using the second Harmonic seems more reasonable for use with motorcycle.

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6.) at 10800 RPM

$$L = \left[\frac{111.5}{360} \times \frac{60}{10800} \times \frac{330}{2N} \right] - 0.06$$

for $n=1$

$$L = 0.224m$$

$n=2$

$$= 0.082$$

Using the second harmonic at both 13800 RPM and 10800 RPM would allow for use of a variable inlet system. The variable range would need to be from ~~50mm~~ 51mm to 82mm. This is a nice range.

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e.) The potential energy that could be ~~recovered~~ ^{recovered} is:-

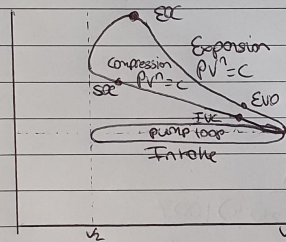
$$Q = mc\Delta T$$

$$= \cancel{682.8} (2.799 \times 10^{-3} + 1.904 \times 10^{-4}) \times 1007 \times 280.491$$

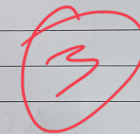
$$= (2.799 \times 10^{-3} + 1.904 \times 10^{-4}) \times 1007 \times (156.28 - 305)$$

$$= 3786.5 \text{ } 3786.37 \text{ J}$$

f.)



* Again, sorry,
my drawing skills
are horrific



1a /

12/5/2020 13:00 - Powertrain and Control (M5K00404)

$$6.) \text{ Air mass} = 0.9 \times 875 \times 10^{-6} \times (3.52 \times 1.0098)$$

$$\frac{32+273}{32+273} - 1.0098 = 2.799 \times 10^{-3} \text{ kg}$$

$$\text{Fuel mass} = \frac{2.799 \times 10^{-3}}{14.7}$$

$$= 1.904 \times 10^{-4} \text{ kg}$$

$$Q = 1.904 \times 10^{-4} \times 44 \times 10^6 \times 0.9$$

$$= 7540.61 \text{ J}$$

$$\Delta T = \frac{Q}{mc}$$

$$= \frac{7540.61}{(2.799 \times 10^{-3} + 1.904 \times 10^{-4}) 1007}$$

$$\Delta T = 2504.91 \text{ K}$$

$$c.) T_4 = T_3 \left(\frac{V_3}{V_4} \right)^{\gamma-1}$$

$$= (682.81 + 2504.91) \left(\frac{1}{10} \right)^{0.35}$$

$$= 1561.28 \text{ K}$$

$$a.) \text{ Using } \frac{P_1 V_1}{T_1} = c \quad \left| \quad \frac{P_2}{P_1} = \frac{T_2}{T_1} \right| \quad \left| \quad \frac{P_2}{P_1} = \left(\frac{V_1}{V_2} \right)^{\gamma} \right|$$

$$P_2 = P_1 \left(\frac{V_1}{V_2} \right)^{\gamma}$$

$$= 2 \times 10^{1.35}$$

$$= 44.77 \text{ Bar}$$

$$P_3 = \frac{P_2 T_3}{T_2} = \frac{44.77 \times (682.81 + 2504.91)}{682.81}$$

$$= 209 \text{ Bar}$$

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Q4.) Fiat 500 87Sc 8v twin turbo 2cyl
 10:1 63.4kW @ 5500 145Nm @ 1900
 1 bar boost pressure.

$$n_{comp} = 1.35$$

$$n_{exp} = 1.31$$

manifold air temp = 32°C @ 2 bars abs

a.) Using $\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1}$

$$T_2 = T_1 \left(\frac{V_1}{V_2}\right)^{\gamma-1}$$

$$= (32+273) \left(\frac{10}{1}\right)^{0.35}$$

$$= 682.81 \text{ K}$$

6.) ~~Fuel mass~~ $\text{Air mass} = 0.9 \times 875 \times 10^{-6} \times (352 \times 1.0018)$

$$\frac{32+273}{35+273} = 0.9998 \quad \text{Air mass} = 1.866 \times 10^{-3} \text{ kg}$$

$$\frac{35+273}{32+273} = 1.0098$$

$$\text{Fuel mass} = 1.866 \times 10^{-3} \times 10^{-1} = 1.866 \times 10^{-4}$$

$$Q = 0.9 \times 1.866 \times 10^{-4} \times 44 \times 10^6 = 7389.36 \text{ J}$$

$$\Delta E_{ncv} = \frac{Q}{1.866 \times 10^{-4} + 1.866}$$

$$p_{air} @ 2 \text{ bar} = 3.52 \text{ kg/m}^3$$

$$\text{Vol eff} = 90\%$$

$$\text{Comb eff} = 90\%$$

$$\text{cal vol} = 44 \times 10^6 \text{ J/kg}$$

$$\text{AFR} = 14.7:1$$

$$\text{Specific heat} = 1007 \text{ J/kg}\cdot\text{K}$$

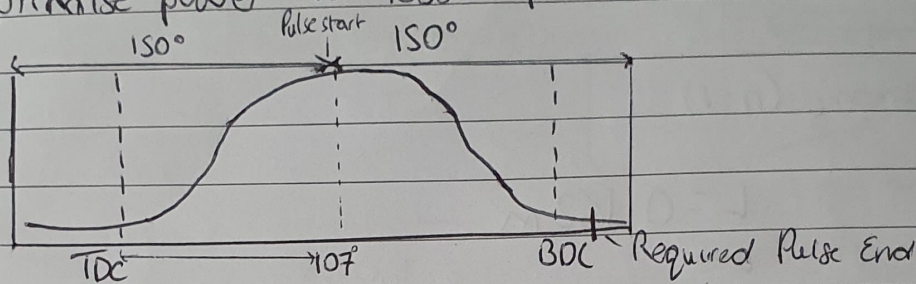
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Q2.) a.) powerband required = 10,000 - 14,000 RPM
 valve duration = 300° MOP = 107° ATDC

a) $\rho = 1.2 \text{ kg.m}^{-3}$
 ω ρ $v_{\text{air}} = 330 \text{ m/s}$

part length = $60 \text{ mm} = 0.06 \text{ m}$

optimise power for 13800 RPM



$$\text{MOP} \rightarrow \text{BDC} = 180 - 107 \\ = 73^\circ$$

$$\text{MIDPOINT BDC} \rightarrow \text{CLOSE} = \frac{73 + 150}{2} \\ = 111.5^\circ$$

(Time for pulse to return)

$$T = N \frac{2L(0.06)}{330}$$

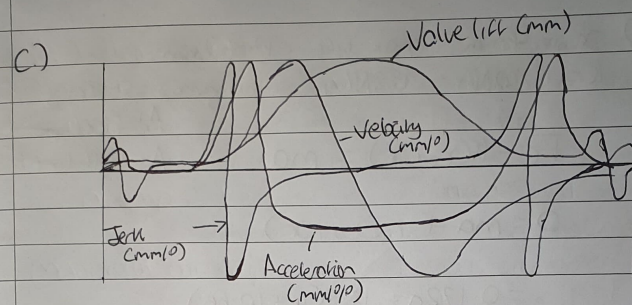
$$T = \frac{\theta}{360} \times \frac{60}{\text{RPM}} = \frac{111.5}{360} \times \frac{60}{13800}$$

(Time for crank to turn θ°)

$$T = T \quad \therefore$$

$$\frac{N 2L(0.06)}{330} = \frac{111.5}{360} \times \frac{60}{13800}$$

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*(Sorry my drawing skills are terrible)

d.)

$$\text{valve } a \frac{(\text{mm/s}^2)}{(\text{mm/s}^2)} = \left[a \frac{(\text{mm/s}^2)}{(\text{mm/s}^2)} \times \frac{6 \text{ RPM cm}^2}{1000} \right] / 1000$$

$$a = \frac{-0.004 \times \left(6 \left(\frac{6200}{2}\right)\right)^2}{1000}$$

$$= -1383.84 \text{ m/s}^2$$

This is 86.36% of max acceleration before float.

e.)

$$-1602.37 = \frac{-0.004 \times 6 \text{ RPM cm}^2}{1000}$$

$$-1602.37 \times 10^3 = -0.004 \times 6 \text{ RPM cm}^2$$

$$6 \text{ RPM cm} = \sqrt{\frac{-1602.37 \times 10^3}{-0.004}}$$

$$6 \text{ RPM cm} = 20,044.81$$

$$\text{RPM cm} = 3335.8$$

$$\therefore \text{RPM cm} = 6672$$

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c.) Rearranging previous equation we get:

$$RPM = \frac{111.5}{360} \times \frac{60 \times 330}{2NCL + 0.06}$$

Harmonic (N)	RPM @ $L = \cancel{0.051m} 0.051m$	RPM @ $L = \cancel{0.082m} 0.082m$
1	/	/
2	13812	10797
3	9208	7198
4	6905	5398
5	5525	4319

The most useful harmonic spread is dependant upon the engine's intended use. As it has been stated that the aim is to optimise the powerband between 10,000 and 14,475, I would argue a length of 0.051m to be most suitable.

However, a variable system of the two lengths would ~~provide~~ further improve midrange performance.

d.) There are ~~sever~~ several differences between intake and pulse tuning. The pulses ~~looked~~ looked at are different in that a +ve pulse ~~at~~ leaves the valve approx 20° after the exhaust valve opens. ~~* continued overed.~~
This ~~be~~ generally means that more ° of turn of the crank must be completed before we want our pulse to return. However with the exhaust gases being a much higher temperature, this means the speed of sound within the system is increased and as a result ~~on~~ the pulses travel faster

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within the system.

* (Continued from previous page)... and a -ve pulse returns mid way between TDC + close as oppose to BDC → close. During Inter tuning the +ve pulse returns.

This is done to prevent reverse flow of unburnt gases out of the exhaust valve during the final phases of combustion. Or by using a step to create an early response pulse which returns before BDC and reduces -ve work as piston moves back up.

Whereas during inter tuning the pulse returns at a time designed to force more air/fuel mixture into the cylinder for combustion.

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