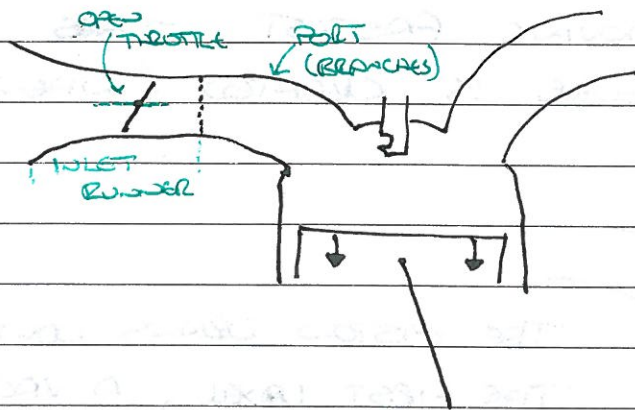


COMPETITION ENGINE PERFORMANCE

18/02/16

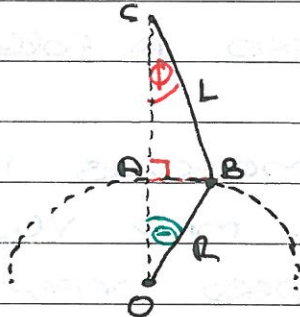
IMPORTANT DESIGN CRITERIA FOR INTAKES -

- LOW AIR FLOW RESISTANCE
- GOOD DISTRIBUTION OF AIR AND FUEL BETWEEN CYLINDERS
- RUNNER + BRANCH LENGTHS THAT TAKE ADVANTAGE OF RAM + TUNING EFFECTS.
- WITH PORT INJECTED SYSTEMS LARGER AND LONGER RUNNERS + BRANCHES, WITH LARGER RIGID BENDS ARE POSSIBLE. POSSIBLE TO TAKE FURTHER ADVANTAGES OF TUNING EFFECTS, GET MORE EVEN RUNNER LENGTHS.



ON THE INTAKE STROKE
MOST OF THE PISTON
MOTION IS DOWNWARDS.
PISTON VELOCITY IS
GENERALLY MAX AT AROUND
 80° ATDC

TO CALCULATE -



$$AB = R \cdot \sin \theta$$

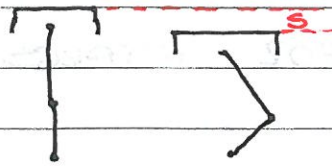
$$AB = L \cdot \sin \phi$$

$$\therefore L \cdot \sin \phi = R \cdot \sin \theta$$

$$\therefore \sin \phi = \frac{R}{L} \cdot \sin \theta$$

$$\therefore \text{CROSS ANGLE } \phi = \sin^{-1} \left(\frac{R}{L} \cdot \sin \theta \right)$$

TO GET PISTON VELOCITY, NEED TO KNOW 'S',
PISTON DISTANCE MOVED.

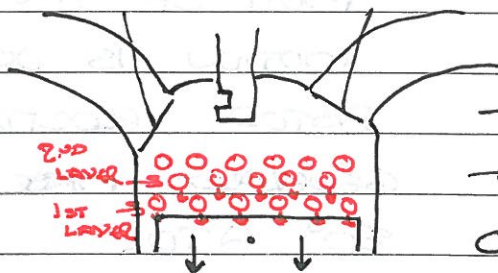


$$s = R + L - R \cdot \cos \theta - L \cdot \cos \phi$$

$$V = \frac{ds}{dt}$$

θ	$\phi = \sin^{-1}\left(\frac{R}{L} \cdot \sin \theta\right)$	$s = R + L - R \cdot \cos \theta - L \cdot \cos \phi$	$V (\text{mm/s})$ ($V_1 = s_2 - s_1$)
0			
1			
2			
3			

THE BEST SUCTION IN THE ENGINE IS WHEN THE PISTON IS FASTEST DUE TO BERNOULLI + LAYER OF AIR ABOVE THE PISTON IS MOVING FASTEST WHEN THE PISTON IS MOVING FASTEST, THIS IS WHEN THE LOWEST PRESSURE IS CREATED (WHEN AIR IS FASTEST).



THE PISTON DRAWS DOWN THE FIRST LAYER, A VACUUM IS CREATED BETWEEN 1ST + 2ND LAYER, A PRESSURE DROP IS CREATED

ACROSS THE SECOND LAYER AND A FORCE IS CREATED.

ACCELERATION OF LAYER 2 OF MOLECULES IS GIVEN BY $F = ma$ $\therefore a = \frac{F}{m}$. THE MAX VELOCITY IS THE SPEED OF SOUND. THE SPEED DEPENDS ON THE MASS OF THE GAS.

MOVEMENT OF THE 2ND LAYER CREATES A VACUUM BETWEEN LAYER 2 + 3 AND SO ON.

EACH STEP REQUIRES TIME TO COMPLETE $\therefore$ THERE IS A LAG TIME BETWEEN PISTON MOVEMENT AND THE PRESSURE CHANGE IN THE INLET.

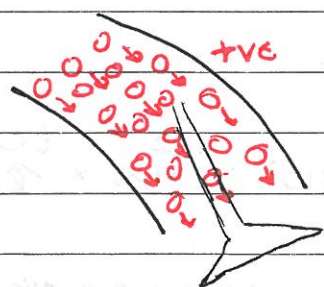
IDEALLY PULSE TUNING USES THESE TO OUR ADVANTAGE (THE DELAYS).

FULL VALVE LIFT (M.O.P) IS GENERALLY AT 110° ATDC, 30° AFTER PISTON V_{max} , WE ASSUME AIR V_{max} AT THE VALVE OCCURS AT M.O.P.

AIM TO GET VALVE FULLY OPEN WHEN THE AIR IS FASTEST $\therefore$ THE SUCTION PULSE (VACUUM EFFECT) IS STRONGEST AT VALVE M.O.P.

THE SUCTION PULSE IS EFFECTIVELY MOVING UP THE INLET FROM THE VALVE TO THE TRUMPET AT THE SPEED OF SOUND. ONCE IT REACHES THE TRUMPET AIR IS SUCKED IN AND CREATES +ve PRESSURE PULSE.

IDEALLY +ve + -ve PULSE ≈ 0.1 BAR.



the pulse travels back to the valve as -ve and return as +ve pulse.

$$T = \frac{2L}{330} \quad \text{WHERE } L = \text{RUNNER LENGTH.}$$

WHILE THE PULSE IS TRAVELLING THE CRANK IS STILL ROTATING AND THE VALVE IS CLOSING.

ASSUME A RACE CAR WHEEL 300° DURATION WITH THE FOLLOWING TIMING -

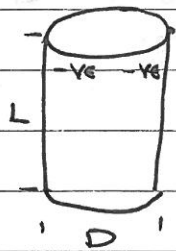
INLET OPEN = 40° BTDC

INLET CLOSE = 80° ABDC

DURATION = $40 + 180 + 80 = 300^\circ$

M.O.P = 110° ATDC

$$L = \frac{330}{2} \times \frac{110}{360} \times \frac{60}{6000} = 504 \text{ mm} - \text{could be too long for performance. too much flow resistance.}$$



EFFECTIVE LENGTH $= L + \frac{D}{3}$, THE DIAMETER ADDS AN END CORRECTION FACTOR $\therefore$ INCREASING THE EFFECTIVE TRUMPET LENGTH.

FLOW RESISTANCE IN A LONG TRUMPET LENGTH MAY CAUSE AN UNHELPFUL PRESSURE DROP. WHAT WE HAVE CALCULATED IS THE FUNDAMENTAL LENGTH, THE 1ST HARMONIC.

TO MINIMISE THE RESISTANCE, SHORTEN THE TRUMPET LENGTH SO THE PULSE RETURNS VERY EARLY.

THIS WAY AS THE +VE PULSE REACHES THE EXPANSION IN THE CYL. IT COLLAPSES, LEAVING A VACUUM BEHIND IT (-VE PULSE). SO NOW THE PULSE IS REFLECTED + REPEATED, THIS IS THE SECOND HARMONIC. POSSIBLE TO TIME THE 2ND HARMONIC FOR 220° IN ORDER TO NOT HAVE AN EXCESSIVELY LONG INLET RUNNER.

THE AIM IS THAT THE FINAL HARMONIC, WHETHER IT IS A 1ST, 2ND, 3RD, 4TH ETC... RETURNS WITH A +VE PULSE BETWEEN BDC AND INLET CLOSING TO REDUCE FLOW REVERSAL.

$$T \text{ for } 2^{\text{ND}} \text{ HARMONIC} = 2 \cdot \frac{2L}{330} \text{ SECONDS}$$

$$T \text{ FOR } N^{\text{TH}} \text{ HARMONIC} = N \cdot \frac{2L}{330} \text{ SECONDS}$$

$$\text{FINAL +VE PULSE NEEDS TO BE BACK AT } 220^\circ$$

$$\therefore N \frac{2L}{330} = \frac{110}{360} \times \frac{60}{\text{RPM}}$$

SO WHAT ABOUT WORKING OUT WHAT RPM A LENGTH IS TUNED FOR? REARRANGE TO -

$$\text{RPM} = \frac{330}{2 \times L} \times \frac{110}{360} \times 60$$

EXAMPLE -

LONG INTAKE LENGTH = 231 mm

SHORT INTAKE LENGTH = 181 mm

HARMONIC	EQN	RPM
S ₁	$\frac{330}{2 \times 1 \times 0.181} \times \frac{110}{360} \times 60$	16700
L ₁	$\frac{330}{2 \times 1 \times 0.231} \times \frac{110}{360} \times 60$	13100
S ₂	$\frac{330}{2 \times 2 \times 0.181} \times \frac{110}{360} \times 60$	8356
L ₂	$\frac{330}{2 \times 2 \times 0.231} \times \frac{110}{360} \times 60$	6547
S ₃	$\frac{330}{2 \times 3 \times 0.181} \times \frac{110}{360} \times 60$	5570
L ₃	$\frac{330}{2 \times 3 \times 0.231} \times \frac{110}{360} \times 60$	4365
S ₄	$\frac{330}{2 \times 4 \times 0.181} \times \frac{110}{360} \times 60$	4178
L ₄	$\frac{330}{2 \times 4 \times 0.231} \times \frac{110}{360} \times 60$	3274
S ₅	$\frac{330}{2 \times 5 \times 0.181} \times \frac{110}{360} \times 60$	3342
L ₅	$\frac{330}{2 \times 5 \times 0.231} \times \frac{110}{360} \times 60$	2619