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Variable Compression & Expansion Technology design & application

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Introduction

This poster represents the key features and results of the authors thesis in which the application and design of specific variable compression designs will be studied and simulated from first principles in the attempt to reverse engineer the world fist production Variable Compression Engine produced by Nissan and apply the design to a Triumph Daytona 675. this was with the aim of proving the claims made of the efficiency and performance enhancement when using the multi-link system.

This study was undertaken due to the increasing emissions stringency in the motorcycle industry which require new and innovative designs preserve the ICE engine.

Main Claims

Key claims of improvement made by Infinity about benefits of VC-turbo compared to it predecessor the Nissan MR20:

- 46% more power an torque
- 44% les friction

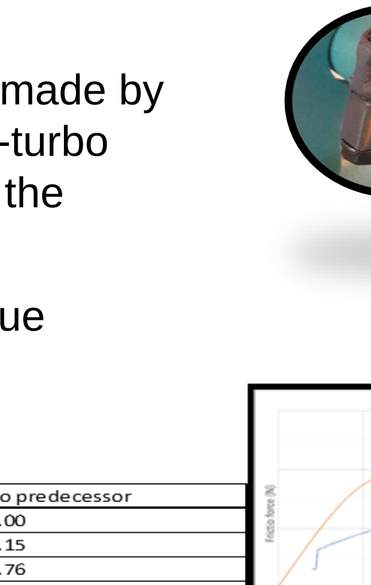
Peformance enhancment of VC-Turbo compared to predecessor	
% More Power from KR20DDET	46.00
% More Torque from KR20DDET	46.15
% More HP from KR20DDET	47.76
% less friction from KR20DDET	44

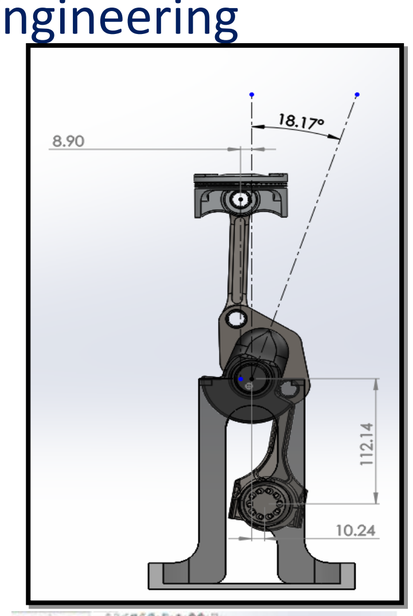
Theoretical Kinematic formulas to be proven

$$F1 = \frac{Net\ force * L1 \sin\theta}{L2(\sin\theta * \sin Alpha) + (\sin\theta * \cos Alpha)}$$

$$Fpin^2 = (Netforce + F1\cos Alpha\ )^2 + F1 \sin alpha^2$$

$$\text{Torque} = \sqrt{Fpin} * Crank\ radius * \sin(CA + \beta)$$





Primarily a CAD study was conducted in Solidworks to revers engineer the multi-link system for the triumph as well as excel engine model to validate the claims made about the benefits of the design and attempt to solve the mathematical formula to determine the kinematics of the multi-link system.

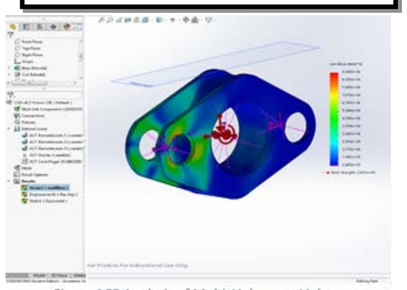
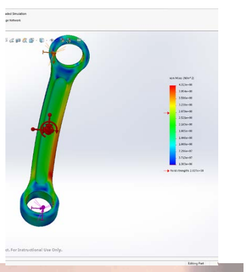
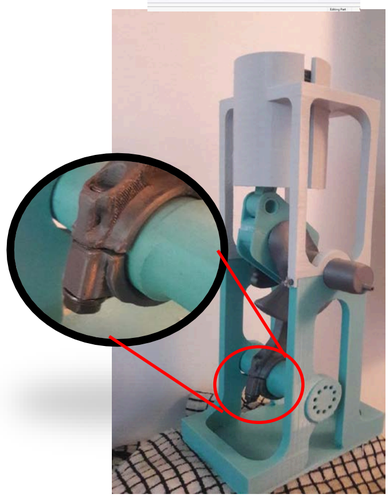


Figure 1 FE Analysis of Multi-Link upper Linkage

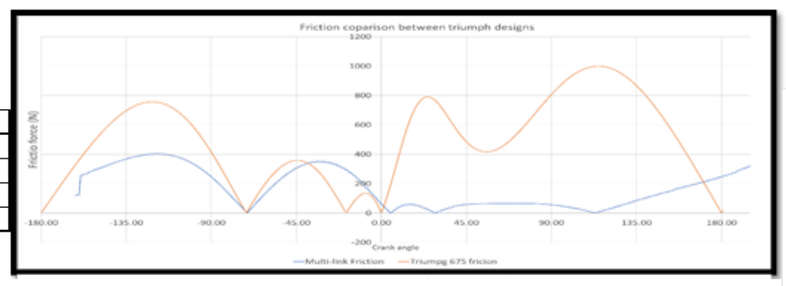
FEA study's determined the designed components passed FE analysis with the exception of the lower-link where failure occurred due to intolerable tensile forces



The FEA study on the author initial design for designed double small end rod however failed all FEA simulations without failure



A rapid prototype was 3D printed for the VCR multi-link Triumph to scale for hands on demonstrations of how the mechanism works and to prove design accuracy as the bolts from a Real Triumph 675 were used in the assembly of the securing rod



The conventional reduction in friction was largely due to the rod angles as well as the reduced friction coefficient due to a DLC mirror-Bore coating used with a coefficient of friction of 0,1 where as the conventional cylinder has a coefficient of 0.55,

The claims validated by the author can be seen blow as the % increase in theoretical average power calculated was withing 3% accuracy of Nissan claims Torque is 8% accurate to claims and friction has a 3% deviation to claimed reduction in friction

% increase in average theoretical Power
43.00982278
% increase in average theoretical Power
38.27464279

Reduction in friction power losss due to multi link on expamsion
%
-47.5256541

Other key results include the formulation of the offset required on the controlling rod to alternate between 8.1:1 CR and 14:1 CR where for max CR the lobe has to be at 0 degrees BDC as seen in the graph and deign schematic below

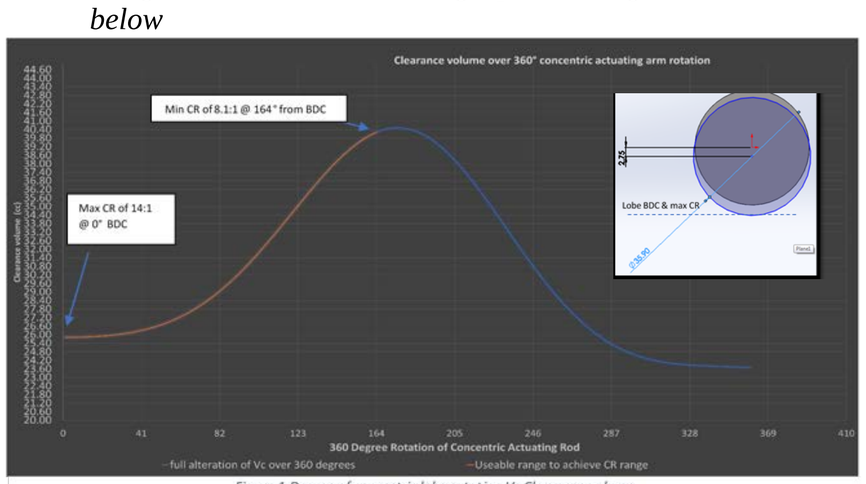


Figure 1 Degree of concentric lobe rotation Vs Clearance volume

The final note worthy results were the thermal efficiency increase of 5.5% due to over expansion with a calculated Expansion Ratio of 9.7:1 via the calculation below where Vs 2 is the swept volume of the expansion stroke this increases thermal efficiency from the same quantity of fuel due to additional expansion volume compared to induction Volume

$$ER = \left(\frac{Vs2}{Vc}\right) + 1$$

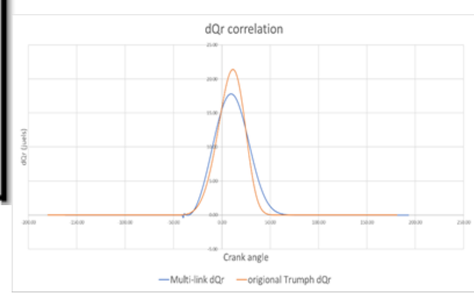


Figure 1 dQr Thermal Efficiency of combustion

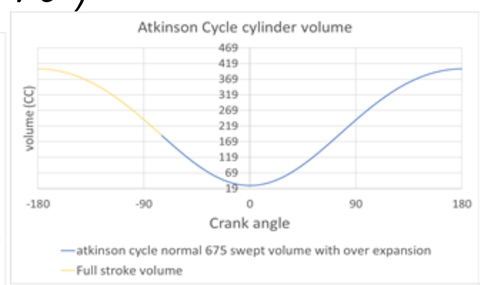


Figure 1 Volume retained after reverse flow Vs full capacity with Otto cycle valve timing

	origional Triumph 675 dQr	Triumph milti-link dQr	% increase or decrease in combustion thermal energy used
	joules	joules	%
sum of dQr over cycle	736.55186	779.87844	5.555555556
max over cycle	21.40506403	17.813421	-20.16256748

Triumph 675 rod angle @ peak pressure	Triumph multi-link Piston rod rod angle @ peak pressure
1.85	-0.35

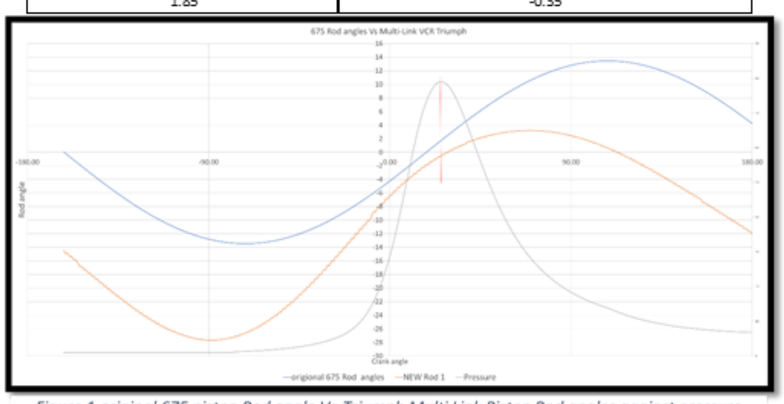


Figure 1 original 675 piston Rod angle Vs Triumph Multi-Link Piston Rod angles against pressure

The figure above demonstrate the reduction in rod angles over the expansion stoke and at Peak gas force with the max angles at firing shown in the table above

Acknowledgements

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