RCV Engines Limited - UK

The Development of a Rotating Cylinder Valve 4-stroke Engine for 2-Wheeler Applications

RCV 4-Stroke Engines for 2-Wheelers
Presentation Contents

- 2-Wheeler Engine Requirements
- The RCV Engine Concept
- RCV 2-Wheeler Engines
- RCV Handheld Engine Concept
- Future Development Plans

2-Wheeler Engine Requirements

Overview of the Global Market

- Global market exceeds 25 million units with major markets for all capacities, as follows:
  - China 40%
  - India 20%
  - ASEAN 16%
  - EU 10%
  - USA 5%
- Utility models less than 150cc account for more than 90% production
- 2-stroke engines were popular in utility applications – but have been replaced over the last decade by 4-strokes with lower exhaust emissions at a cost premium
  - **– is there an effective 2-stroke replacement ?**

Future Legislative Events

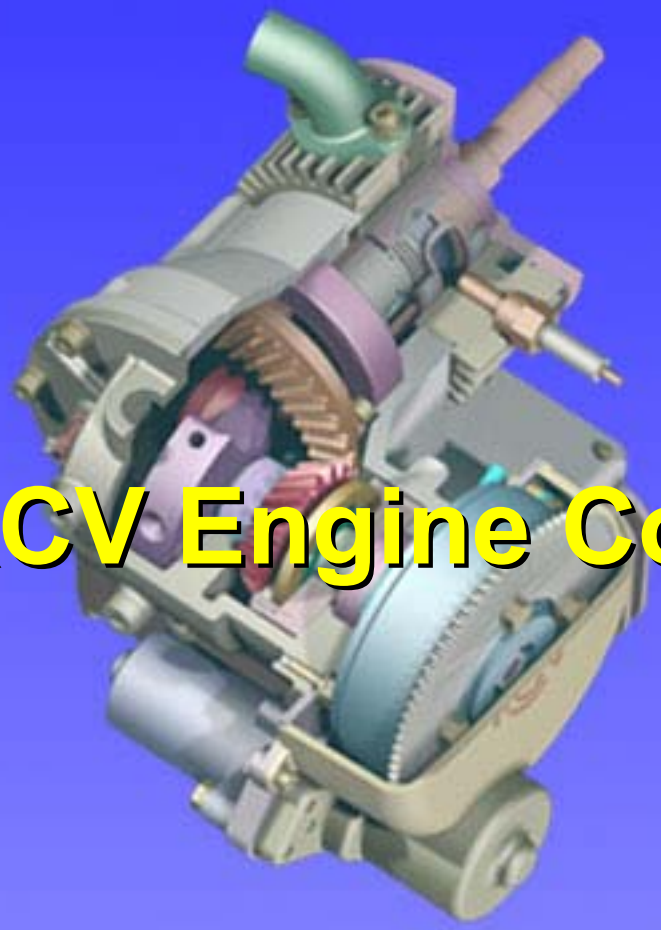
- Exhaust emissions legislation will continue to drive 2-wheeler engine development

- Future Legislation (CO, HC, NOx)
  - EURO3 - new drive cycle with cold start + OBD + durability + anti tampering
  - India 2005 – 1.5 g/km CO,
    – 1.25 g/km HC + NOx

- CO_2 Legislation
  - Legislation not defined - will be monitored from 2006 in Europe - reduction required could be 25%?
  - Fuel consumption is important for utility motorcycle markets – such as India

Utility 2-Wheeler Engine Requirements

	Criteria	Requirement
SPECIFICATION	Cost	Lowest manufacturing cost
	Emissions	Achieve legislation at minimum additional cost
	Fuel/oil	Deposit control - service intervals
	Noise	Legislative requirements - good sound quality
	Oil consumption	Low consumption with no leaks
	Power	High power with wide torque band
	Production	Repeatable performance in production
	Reliability requirement	>30,000 km
	Temperature	-10°C to +40°C with easy starting
	Weight	Low weight - for economy and handling
FUNCTION	Abuse	Over-speed and dirt tolerance
	Environment	Extreme and diverse conditions-water and dust
	Maintenance	Good serviceability with simple tools
	Multi product application	Scooter, step-through and motorcycle
	Package	Compact to suit all existing vehicles



The RCV Engine Concept

RCV – Introduction

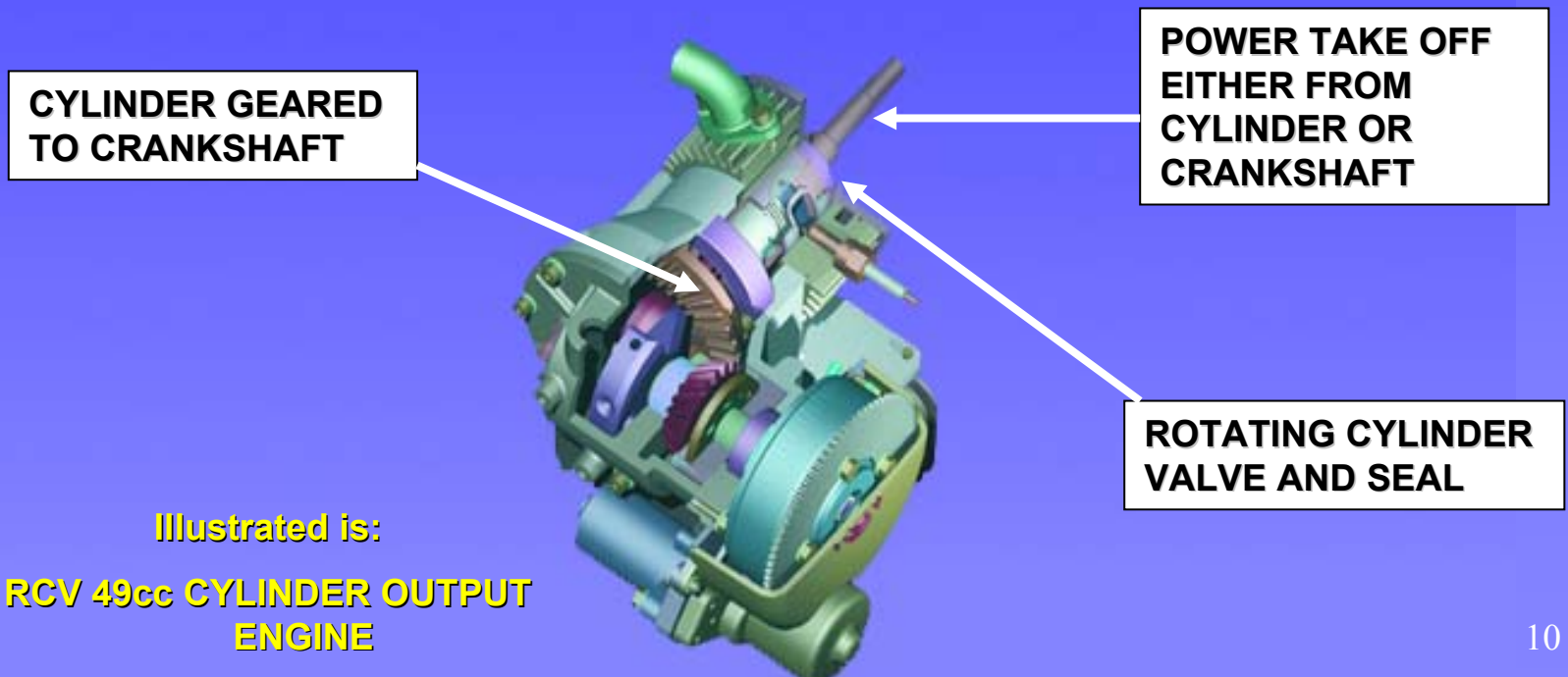
- RCV Engines is a UK based company established in 1997 to commercially exploit the Rotating Cylinder Valve engine concept invented by Keith Lawes
- RCV commenced production with a model aircraft engine, today RCV manufactures a range of methanol fuelled engines from 10cc to 20cc with more than 6,000 engines operating in over 50 countries worldwide
- RCV are currently developing prototype gasoline and JP8 fuelled engines for unmanned air vehicles (UAV), hand held tool and 2-wheeler applications

Rotary Valve Engines - Background

- Sleeve and rotary valve engines have been developed since the 1920's for improved mechanical durability, reduced noise and unrestricted engine breathing
- Sleeve valve engines had advantages of:
  - Reduced losses compared to poppet valves
  - Reduced piston friction
  - Improved detonation resistance
- Rotary valve engines by Cross and Aspin showed advantages of improved volumetric efficiency but with problems of high oil consumption and poor valve durability
- GV Technology (SAE 891793) overcame these issues with a rotary valve conversion of the Yamaha XT500 engine which achieved vehicle fuel consumption reductions of 30% with improved torque.
- Non of these sleeve or rotary valve technologies have demonstrated a production or packaging advantage

RCV – the Concept

- Cylinder rotates around piston at half crankshaft speed
- Single port in the rotating cylinder passes fixed radial inlet and exhaust ports to provide the valve function
- The rotating cylinder is effectively combined with the rotary valve in a single component – hence the name **RCV**
- The RCV concept is simple with compact package and reduced component count compared to a 2-valve 4 stroke

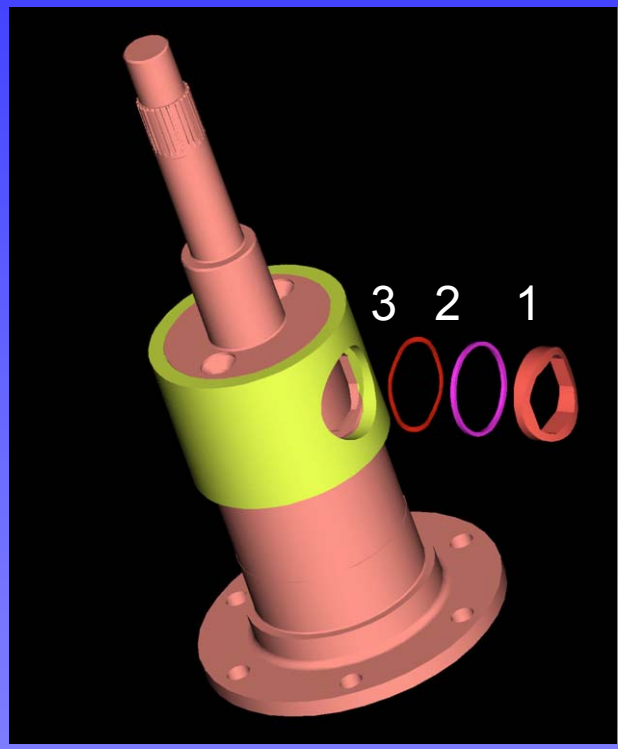


Illustrated is:

RCV 49cc CYLINDER OUTPUT ENGINE

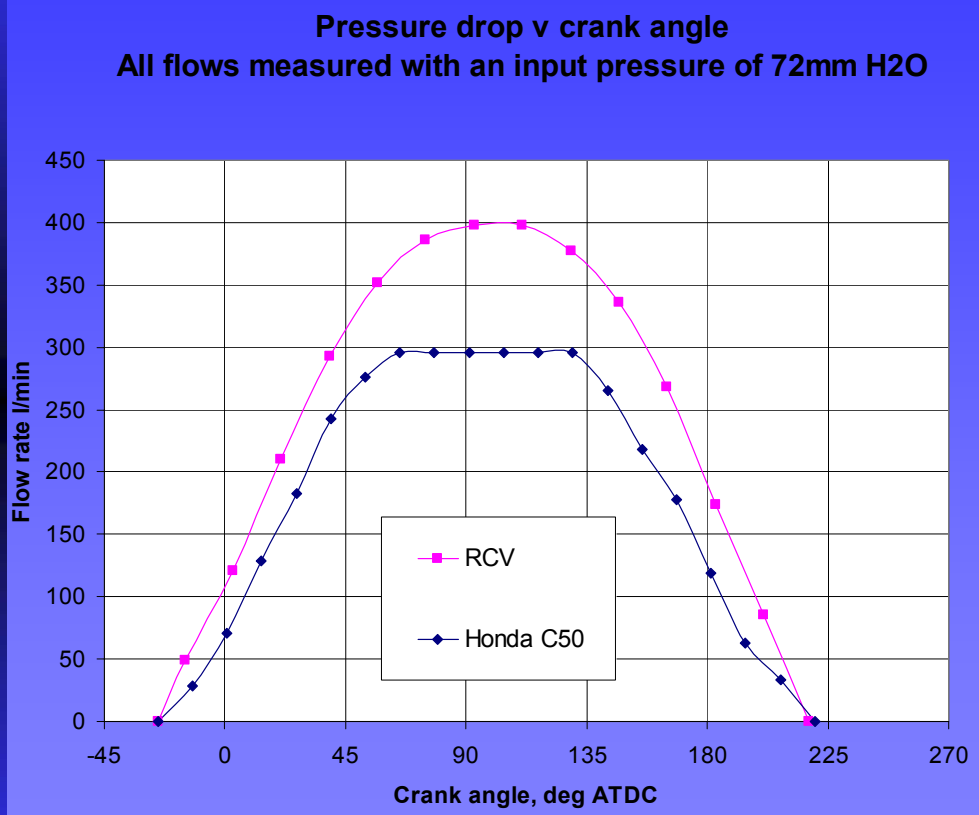
RCV - Valve Seal Design

- RCV have developed a floating seal concept with minimum blow-by, wear and friction. A floating seal can accommodate production tolerance variations and thermal distortions
- The seal incorporates:
  1) Solid compression seal – dynamic seal using wave spring and cylinder pressure
  2) Piston ring type seal - forms seal at rear of compression seal
  3) Wave spring – provides static sealing force
- Compression seal based on similar material to piston rings – similar operating environment



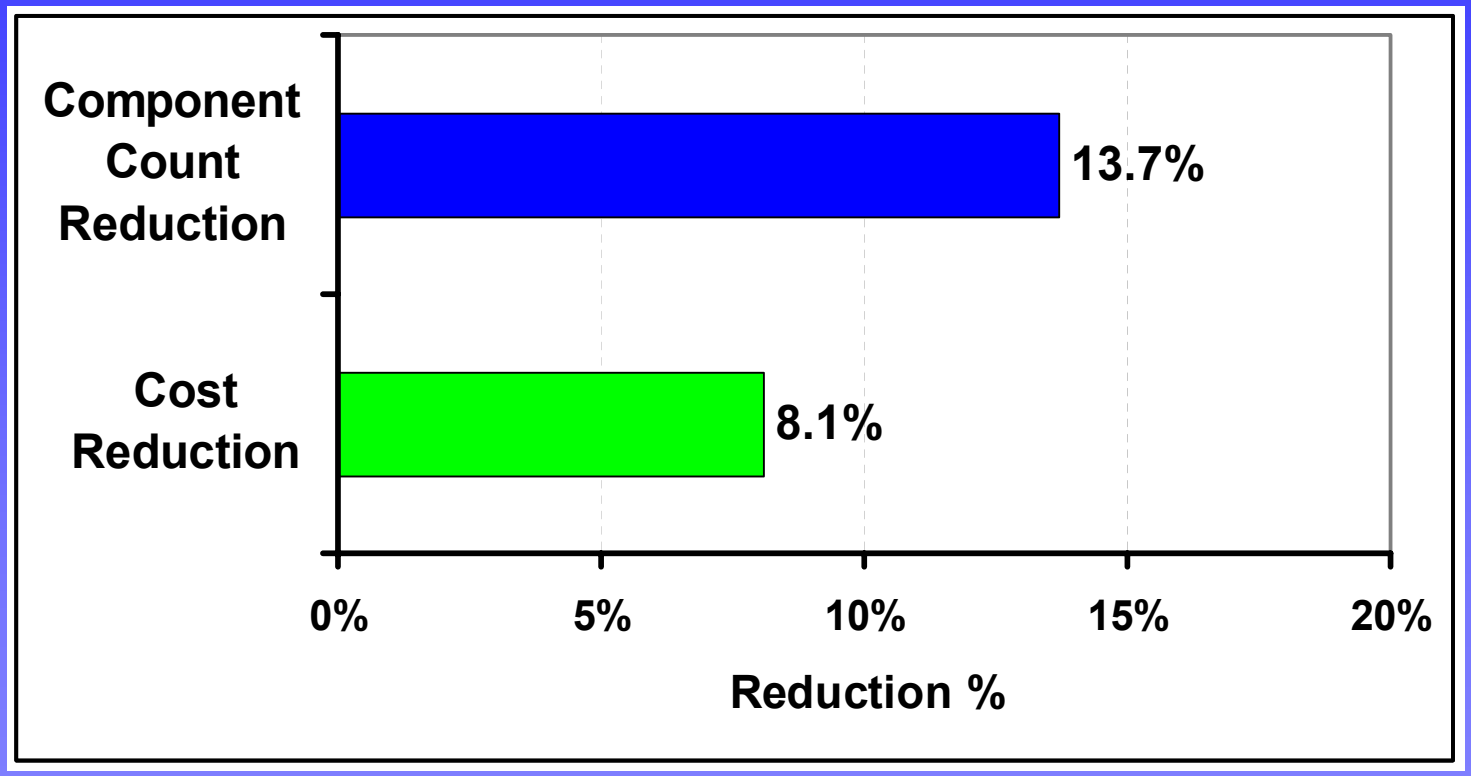
RCV 49cc Prototype Engine Valve Seal

RCV 49cc Prototype Engine Valve Flow Performance



- Large unrestricted port area (290mm²)
- 50% higher flow area compared to a typical 4 stroke 2 valve engine
- High flow capacity enables valve overlap to be minimised without sacrificing power
- Typically torque levels are 85% of max between 3000 and 9000 rpm
- Still larger areas are possible, up to 400mm²

RCV Crankshaft Output Engine Cost/Component Count



- RCV Estimates – based on a bill of materials comparison of a 125cc 4 stroke 2 valve air cooled scooter engine converted to a crankshaft output RCV engine

RCV - Technical Advantages

- Reduced friction and fuel consumption
  - Rotating cylinder provides continuous piston lubrication
  - Elimination of valve train – net advantage considering seal losses – efficiency benefits particularly at part load
- Improved volumetric efficiency
  - Unrestricted port with large effective valve area
- Efficient 4 Stroke combustion system
  - Exhaust emission legislation compliance with conventional 4 stroke motorcycle after-treatment technology
- Improved Assembly and Maintenance
  - Cylinder height similar to a 2-stroke engine
  - Low component count; simple assembly
  - No cam chain or valve lash clearance to adjust
  - No valve bounce at over-speed operation

RCV 2-Wheeler Engines

RCV 2 – Wheeler Engines

- RCV have been developing prototype engines for 2-wheelers since 1999
- RCV initially developed a cylinder output 49cc engine for scooter applications
- RCV have overcome several development issues and tested both cylinder output and crankshaft output versions of the 49cc engine

RCV – Prototype Motorcycle Engines
49cc Prototypes

- Series 1 – cylinder output proof of concept
- Series 2 – cylinder output vehicle application

- Series 2A – crankshaft output
  - 4.3 bhp achieved
  - Excellent valve durability

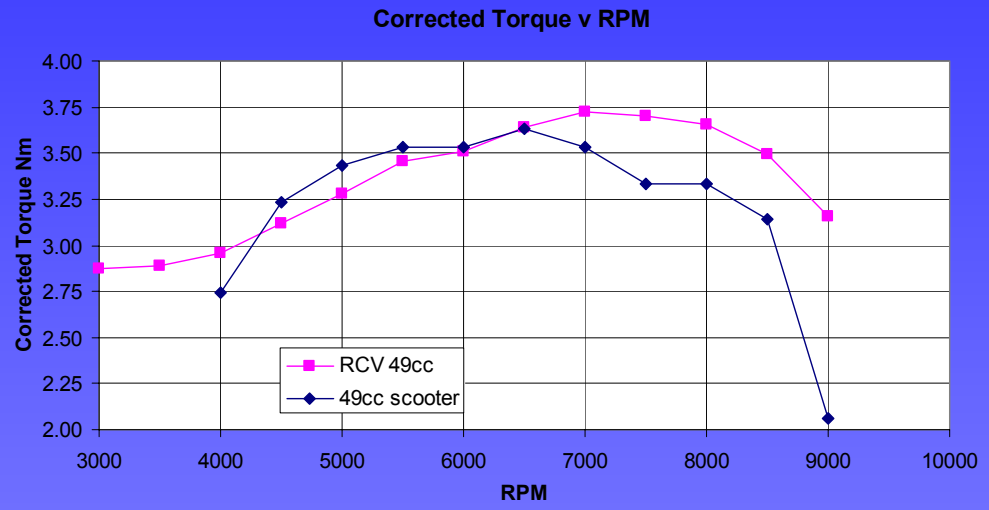
RCV - Motorcycle Engines Crankshaft Output Concepts

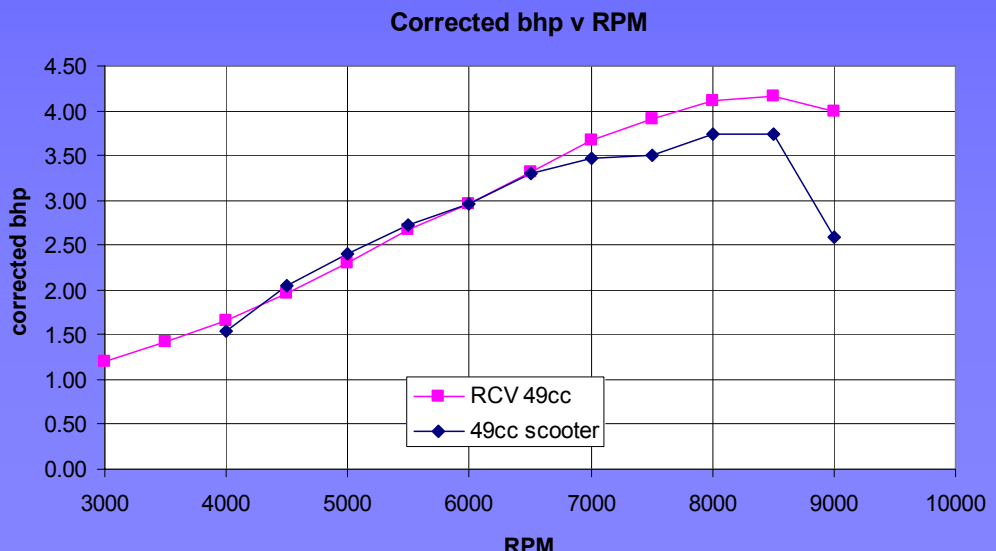
- Cylinder output versions offer the greatest potential for cost savings – but requires the development of a completely new engine with greater risk for manufacturers
- RCV are focusing on crankshaft output versions for 2-wheelers
  - Retains existing crank-train and transmission
  - Packaging compatible with existing vehicles
  - Cylinder height reduction – 40mm for 125cc

RCV - Development Issues

ISSUE	SOLUTION
Blow by	Floating valve seal + repositioned spark plug
Fuel/oil deposits	Direct cylinder oil cooling
Oil consumption	Revised cylinder/crankcase oil distribution
Seal wear	Use of piston ring technology for seal materials
Unstable idle	Revised seal design

RCV 49cc Crankshaft Output Engine Performance





TEST VENUE - RICARDO

- Engine performance verified at Ricardo Consulting Engineers

PERFORMANCE

- Max torque
  3.7Nm @ 7000 rpm
- Max power
  4.2bhp @ 8500
- Min BSFC 290 g/kWh

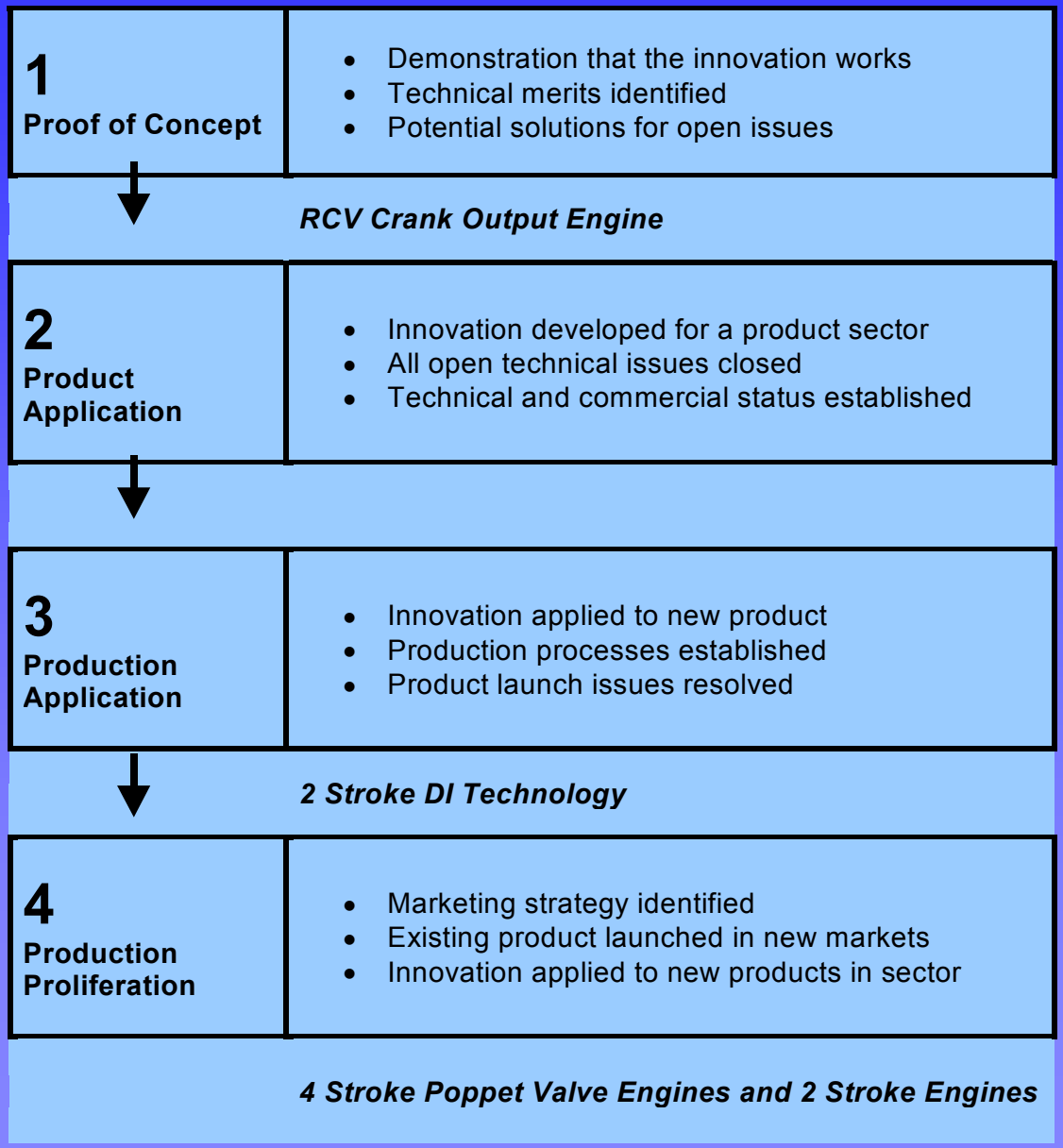
EMISSIONS AT 3%CO

- HC = 13 g/kWh
- NOx = 12 g/kWh

Air-cooled motorcycle engines compared to 2 valve SOHC 4-stroke

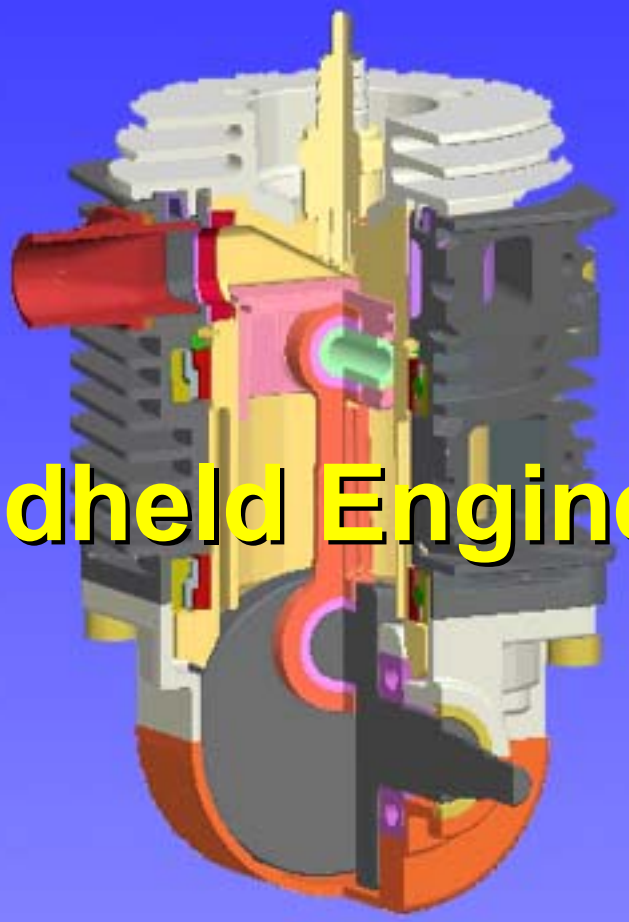
	2 Stroke	2 Stroke DI	RCV 4 Stroke
Cost	✓✓	xx	✓
Engine size	✓✓	o	✓✓
Emissions	xx	✓	o
Fuel economy	xx	✓✓	✓✓
Noise	x	x	✓
Power	✓✓	✓✓	✓
Servicing	✓✓	xx	✓
Weight	✓✓	✓	✓

RCV Technology – Status of Development



RCV Motorcycle Engine Status

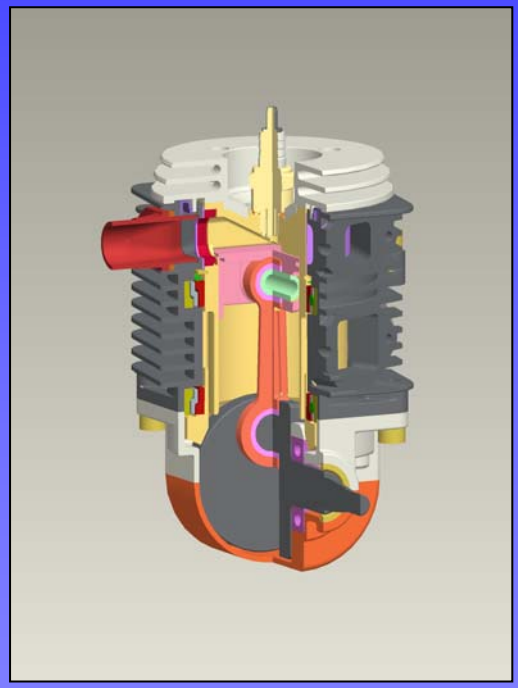
	Criteria	RCV Status
SPECIFICATION	Cost	Less components compared to standard 4-strokes
	Emissions	Initial results indicate similar levels to standard 4-stroke - conventional after treatment technology applies
	Fuel/oil	Not an issue on development engines - requires confirmation on vehicle prototype
	Noise	Not an issue with crankshaft output design
	Oil consumption	Acceptable oil consumption measured
	Power	Acceptable performance with development potential
	Production	Component value engineering outstanding
	Reliability requirement	Durability to be confirmed on vehicle prototypes
	Temperature	Cold starting performance to be confirmed
	Weight	Competitive weight - aluminium cylinder being investigated
FUNCTION	Abuse	Overspeed not an issue
	Environment	To be confirmed by testing
	Maintenance	Easy engine to build and disassemble - no valves to adjust
	Multi product application	Possible with crankshaft output concept
	Package	Similar cylinder height to a 2 stroke



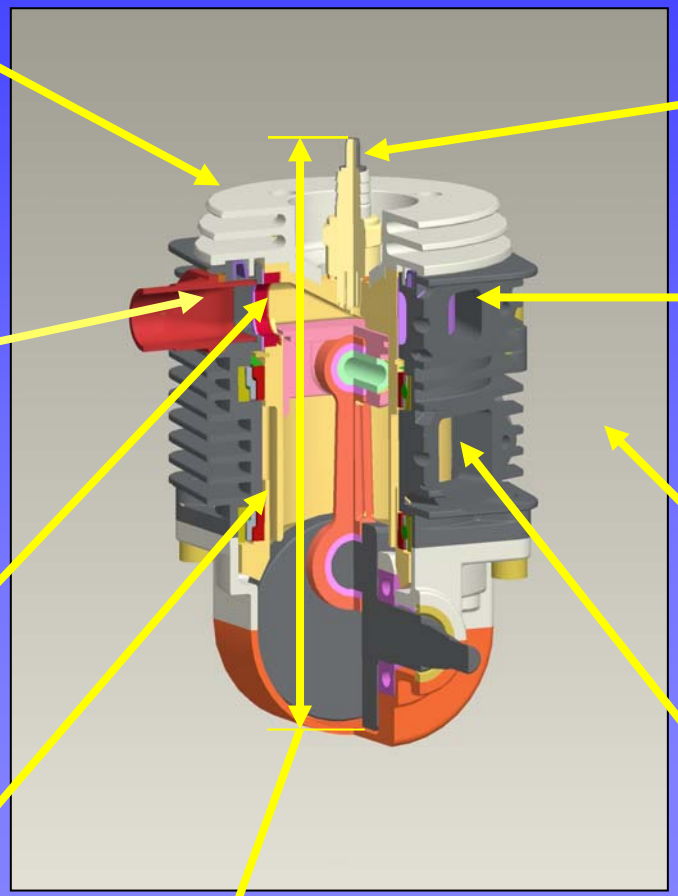
RCV Handheld Engine Concept

RCV Handheld Engine Concept

- 4 Stroke cycle – EPA Phase 2 emissions potential
- Fuel/mix lubricated allows multi-position operation
- Crankcase supercharged – high power to weight ratio
- RCV valve – high engine speed potential
- Compact packaging – fits in 2 stroke package
- Low maintenance and easy to service



RCV Handheld Engine Features



ROTATING HEAT SINK

CENTRAL ROTATING SPARK PLUG

INSULATED EXHAUST PORT

INTAKE PORT

INTAKE REED VALVE (NOT SHOWN) ALLOWS STD. CARBURETTOR LOCATION

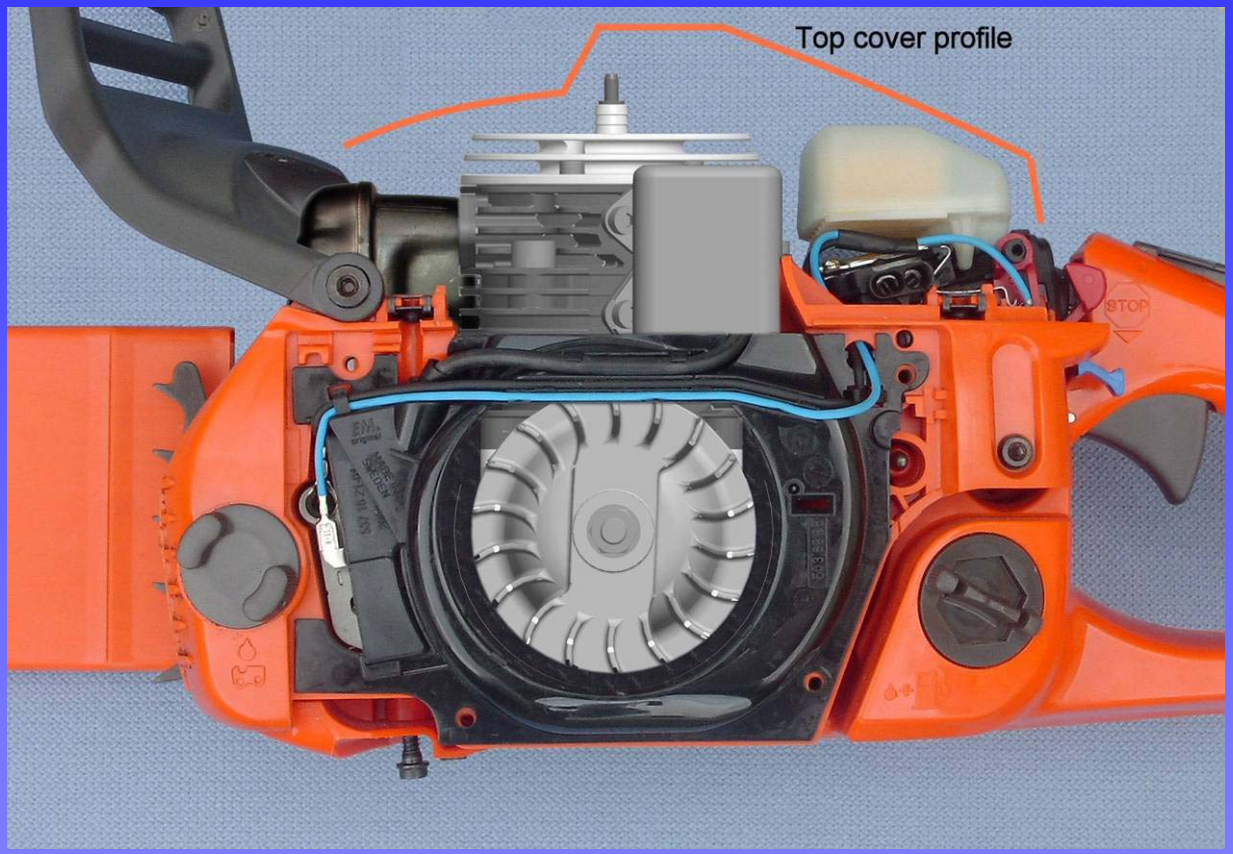
RCV DYNAMIC VALVE SEAL

REED VALVE TO TRANSFER DUCT

FUEL/OIL TRANSFER DUCTS IN CYLINDER

COMPACT ENGINE HEIGHT – SIMILAR TO 2-STROKE

RCV Handheld Engine Concept



- RCV handheld engine concept packages into an existing chainsaw layout with carburettor and exhaust positions unchanged

Future Development Plans

RCV – Development Plans 2004

- RCV 2-Wheeler Engines
  - Proof of concept phase completed
  - 125cc motorcycle demonstrator to be built to establish technical and commercial advantages
- RCV Handheld Engines
  - Proof of concept engine prototype to be built
  - Poppet valve 4-stroke technology is unsuitable for chainsaw applications where 2-strokes have emissions issues and catalysts create a fire hazard

Summary

RCV have developed a new 4-stroke engine concept with benefits over current 2-stroke and 4-stroke engine designs

- Application possibilities include: 2-wheeler, forest & garden, industrial, generators, marine, & aero products
- RCV have ongoing development plans aimed at reducing the technology risk for commercial production applications
- The advantages of RCV technology are:

✓ Low cost
✓ Fuel efficient
✓ High Power
✓ Low maintenance
✓ Protected by international patents
✓ Compact package

Conclusion

RCV 4-stroke technology has the potential to become an effective 2-stroke replacement with improved fuel efficiency compared to traditional poppet valve 4-strokes