

## **SWEPT VOLUME**

Imagine a four stroke engine single cylinder capacity one litre

Bore 115mm stroke 96.3mm swept volume of 1000cc.

Imagine a Beare Head with a bore of 75mm and a stroke of 56.5mm a swept volume of 250cc.

Imagine that the combustion chamber volume is 100cc. the trapped volume when both upper and lower main piston are at their closest proximity with the top piston down as far as possible and the main piston at TDC.

### **INTAKE.**

The main large piston is at TDC, the upper smaller piston is at the top of its bore or BDC, so the cylinder volume is 250cc plus 100cc equals 350cc.

As the main piston descends it is increasing volume. At the same time the upper piston is descending reducing volume.

At main piston BDC the main piston has swept 1000cc and the upper piston has descended half its bore as it is synchronized at half the main piston rotational speed. It has swept 125cc and reduced the swept volume by 125cc

Therefore the cylinder volume at main piston BDC is 1000cc add the combustion chamber, add the volume left in the upper piston of 125cc so the total volume is 1225cc

So the swept volume of the intake stroke is 1225cc minus the volume at the start of the intake stroke of 350cc

**875cc**

### **COMPRESSION.**

The cylinder volume is 1225cc

The main piston ascends while the upper piston continues to descend, both pistons are reducing volume.

At TDC main piston has swept 1000cc while the upper piston has swept a further 125cc

Cylinder volume is now 100cc

So the swept volume is 1225 minus 100cc

**1125cc.**

### **EXPANSION**

Cylinder volume is 100cc

The main piston descends while the upper piston ascends.

Both pistons are increasing volume.

At BDC the cylinder volume is main piston 1000cc and upper piston is 125cc.

Total cylinder volume is 1225cc

So the swept volume is 1225 minus 100cc

**1125cc**

### **EXHAUST**

The cylinder volume is 1225

From BDC the main piston ascends reducing volume while the upper piston continues to ascend increasing volume

At TDC the main piston has swept 1000cc, the upper piston has increased volume by 125cc

The total cylinder volume is combustion chamber 100cc and upper piston volume 250cc  
350cc

So the swept volume is 1225 minus 350cc.

**875cc**

The total swept volume over the four strokes is 4000cc  
Intake 875cc add compression 1125cc add expansion 1125cc add exhaust 875cc  
Therefore the nominal average capacity of the Beare cycle engine is

# 1000cc

Similar arguments and dissertations could apply to the miller cycle.

The waters could be muddied somewhat more by considering only the trapped volumes after all the ports have been closed. The Japanese used to apply this principle to two-strokes with corrected compression ratios.

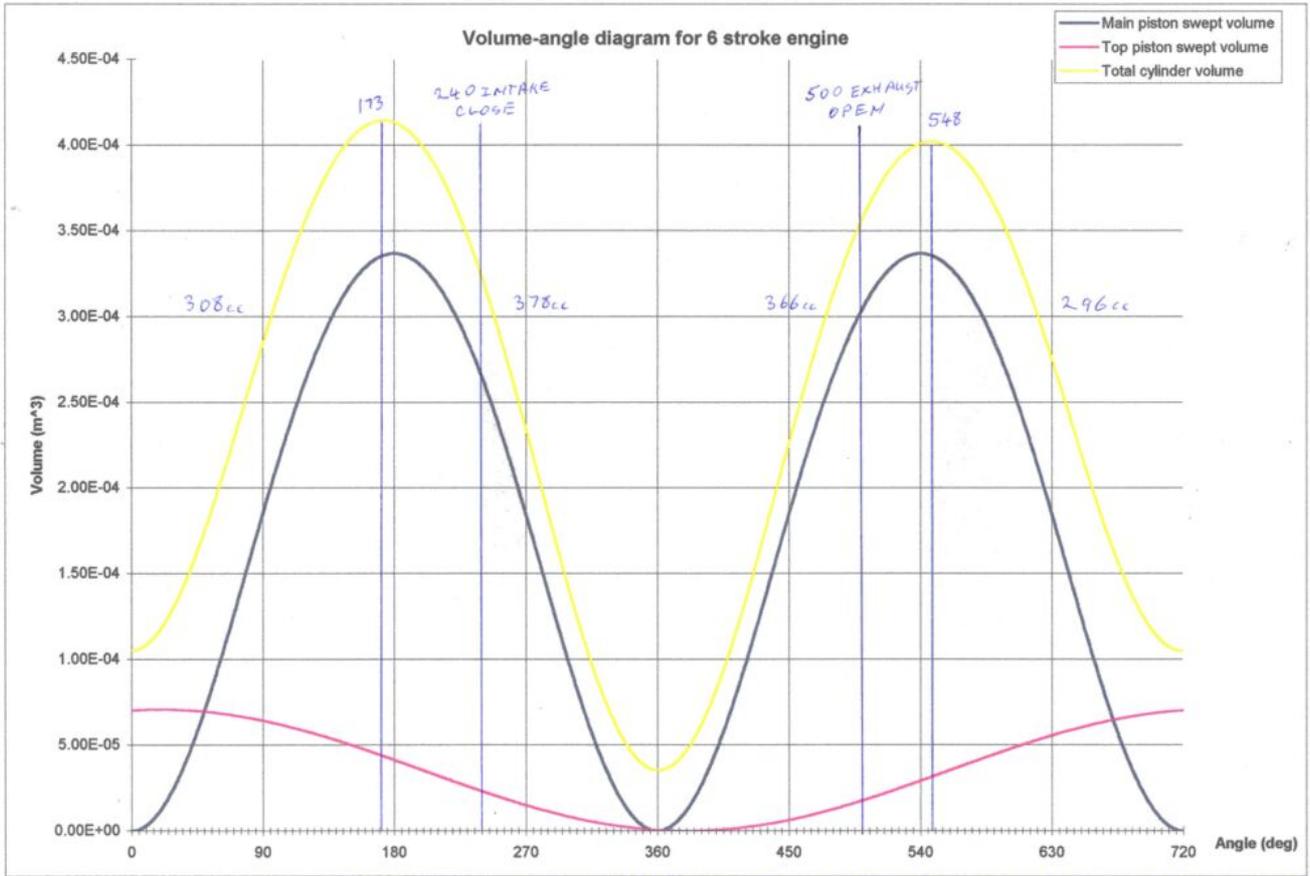
There is a further complication if the upper piston crank is delayed or advanced in its rotational relationship with the main crank, or if it is a conventional crank and con rod or a scotch yoke drive. All have effects on the swept volume in regards to crank angle position.

But the net results are that the Beare cycle has advantages in gaining efficiency, pumping losses are reduced as less energy is expended to suck intake and pump out exhaust. And more energy is extracted during the expansion stroke. The expansion stroke being the largest change in swept volume, because of port timings, means that the Beare head, dual opposed piston cylinder head has similarities to the Atkins cycle and Miller cycle but is subtly different and perhaps deserves the name of Beare cycle.

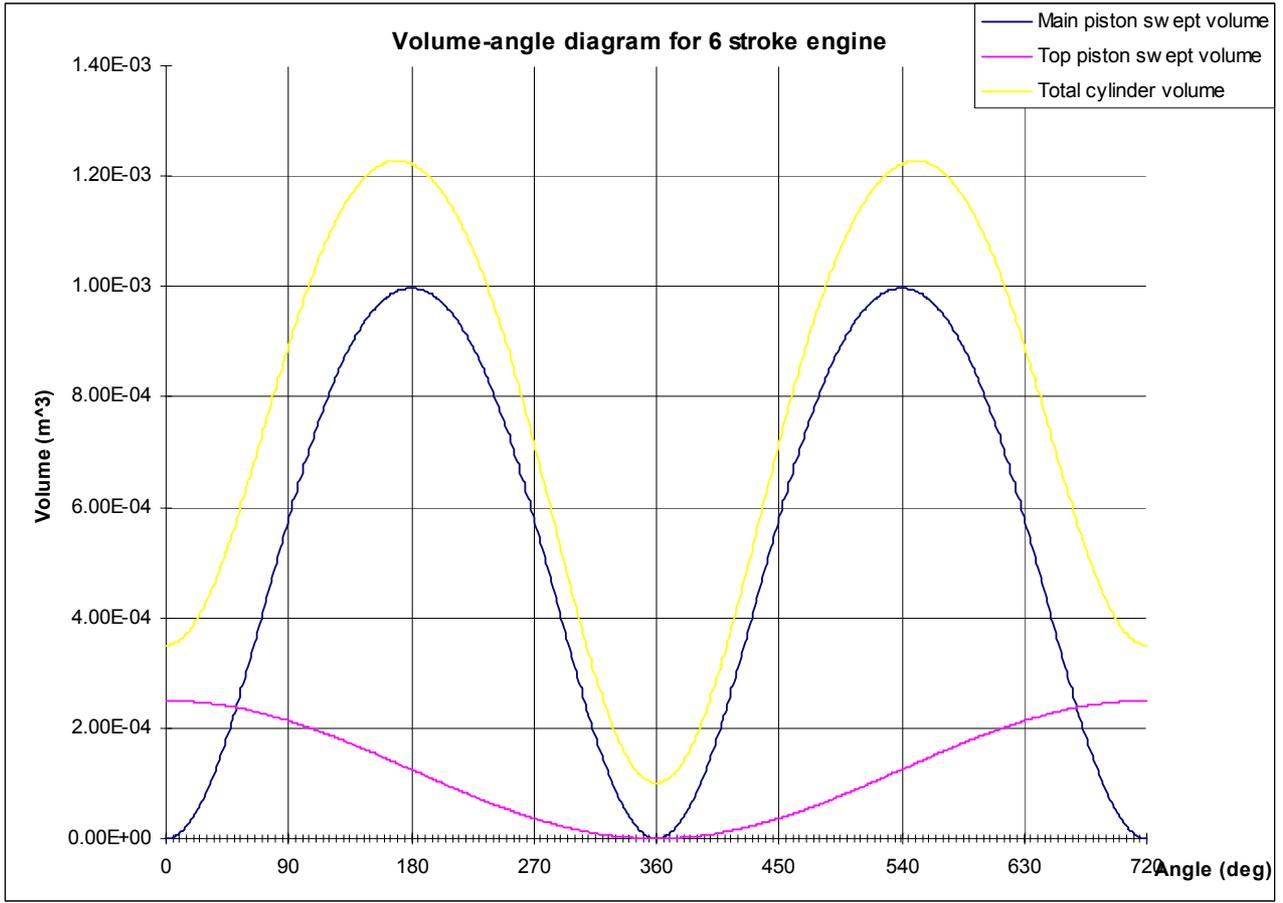
If the upper piston is delayed in its rotational relationship by about 20 degrees the maximum volume no longer occurs at BDC but is at 173 main crank degrees on intake and maximum volume occurs at 548 for expansion and minimum volume occurs at 361 and the rate of change in volume during combustion is less than the conventional four stroke maintaining a closer relationship to the theoretical ideal of constant volume combustion.. and therefore higher maximum cylinder pressures are achieved even though the compression ratio and open throttle cranking cylinder pressure may be the same as the conventional four stroke.

Volume-Angle Chart 8

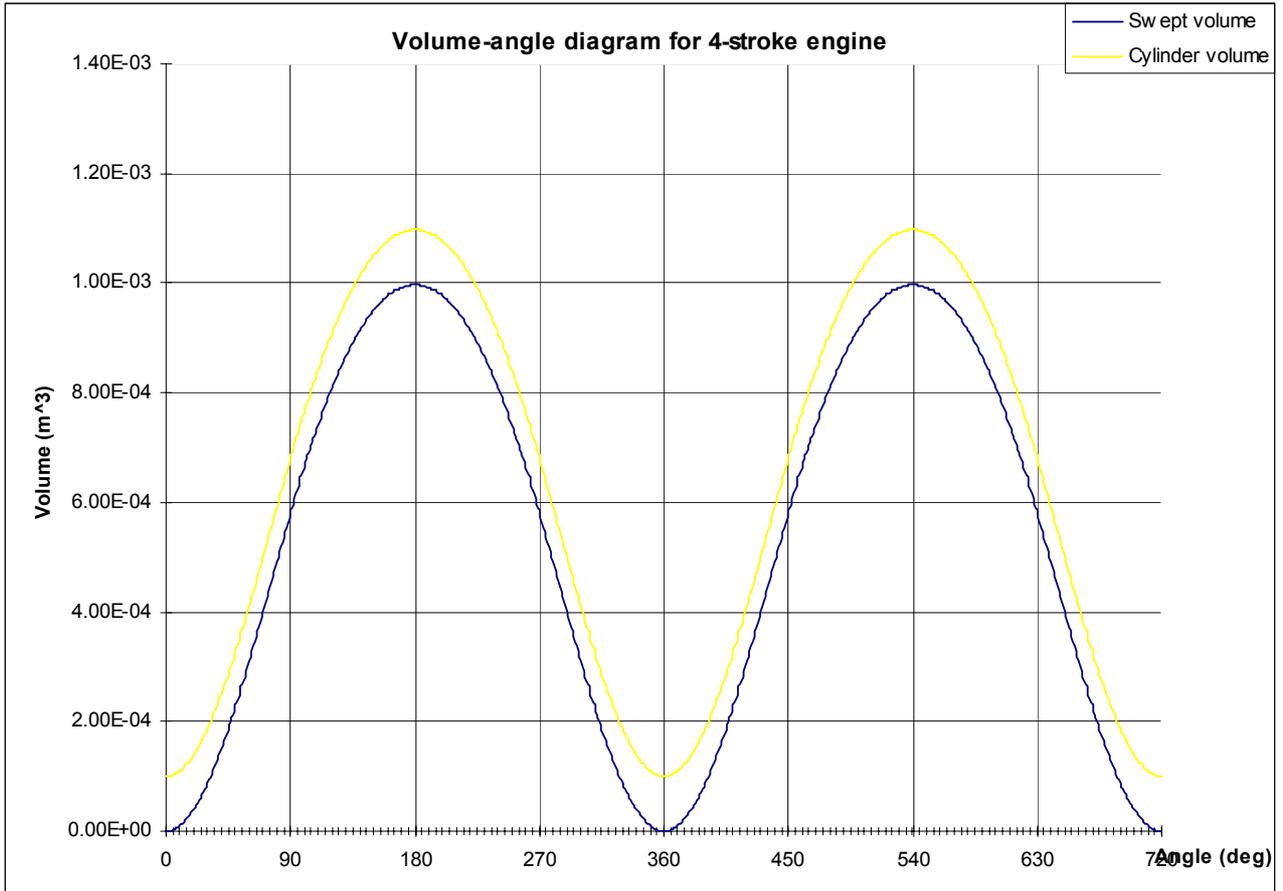
DUCATI BEARE PROTOTYPE 5



EXPANSION STROKE CHANGE IN VOLUME FROM 360 TO 500 IS GREATER THAN THE CHANGE IN VOLUME OF THE INTAKE STROKE 0 TO 173 AND THE CHANGE IN VOLUME OF THE COMPRESSION STROKE 240 TO 360 AND EXHAUST 548 TO 720



Angle volume graph for Beare 1000cc



Angle volume graph for 1000cc four-stroke